Rapidly precooling blueberries to 2°C significantly reduced the amount of decay that developed subsequently during the 21° holding period that followed the 3-day (Table 1) and 10-day (Table 2) simulated transit periods. After 3 days at 10°, despite low incidences of decay, there was significantly less decay in the PC berries than in the NPC berries that took 48 hr to cool to 10° (Table 1). After an additional 24 hr at 21°, the PC berries had 60 to 80% less decay than the NPC berries, even when the latter were cooled to the ambient temperature in 24 hr. When the berries were held 48 hr at 21° after storage, the PC berries still had significantly less decay than NPC berries that had been cooled to 10°. A constant temperature of 2° resulted in substantially less decay than any other treatment after 48 hr at 21°.

Blueberries precooled to 2°C and stored at that temperature for 10 days, to simulate surface transport to prospective European markets, had significantly less decay after cold storage than NPC berries that had been cooled to 2° in 48 hr (Table 2). Slightly less decay was found in the PC berries than in the NPC berries cooled to 2° in 24 hr. Test shipments of fresh blueberries to distant domestic markets conducted by the USDA required 48 hr to reach an average berry temperature of 13.5° from the initial 27° (unpublished data). Thus, in the average container load (1920 trays), berry temperatures probably would not reach 2° in 48 hr and decay could be higher than reported here.

Following the transfer to 21°C, the PC berries had significantly less decay than the NPC berries even when the latter fruits had been cooled to 2° in 24 hr (Table 2). After 48 hr at 21°, the PC berries still had more than a third to nearly a half less decay than the NPC berries. The benefits of precooling probably would have been more striking if we had cooled the NPC berries more slowly, as would occur in an actual commercial shipment. The PC berries were still marketable despite the relatively long storage period and the 48 hr at 21°, since 15% defective fruit is permissible (1). Other researchers have accepted 20% defects as a marketable limit (1). Despite moisture condensation on berries when transferred from 2° to 21° in our tests, the bloom did not appear adversely affected. Whether or not decay was enhanced because of the condensate is questionable (7).

Rapidly precooling fresh blueberries to a temperature just above freezing and maintaining that temperature appears best for suppressing decay development and preserving the marketability of the fruits. Gray mold accounted for most of the decay in blueberries in these tests. Very little alternaria and anthracnose were seen. Rapid precooling and the 2°C storage temperature were especially beneficial in the longer storage tests because the shelf life of this highly perishable commodity was lengthened to 12 days which suggests that surface transport of fresh blueberries to foreign markets may be feasible.

Table 1. Postharvest decay of precooled and non-precooled blueberries following storage at 2° or 10°C, and after holding at 21°.

		Decay (%)					
		Stored 3 days at 10°C		Additional holding at 21°C			
				24 hr		48 hr	
Treatment	Hours to 10°C	1976	1977	1976	1977	1976	1977
NPC	24	2.0 a[z]	3.3 a	6.6 b	9.2 c	24.9 c	26.2 d
NPC	48	3.8 b	4.7 b	15.0 c	17.8 d	32.0 d	32.9 e
PC	24	1.9 a	2.7 a	2.6 a	3.5 a	13.6 b	15.9 b
PC	48	1.5 a	3.0 a	2.9 a	5.4 b	15.4 b	21.9 c
PC[y]		0.9 a	1.8 a	1.8 a	2.5 a	2.5 a	7.4 a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.
[y]Held at 2°C continuously.

Table 2. Postharvest decay of precooled and non-precooled blueberries following storage at 2°C and after holding at 21°.

		(%) Decay					
		Stored 3 days at 10°C		Additional holding at 21°C			
				24 hr		48 hr	
Treatment	Hours to 10°C	1976	1977	1976	1977	1976	1977
PC	2	1.8 a[z]	2.1 a	3.5 a	4.0 a	12.9 a	11.8 a
NPC	24	2.0 ab	4.3 b	6.8 b	6.9 b	21.7 b	18.6 b
NPC	48	4.1 b	4.4 b	7.3 b	8.1 b	23.8 b	21.9 b

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Literature Cited

1. Ballinger, W. E., E. P. Maness, and W. F. McClure. 1978. Relationship of stage of ripeness and holding temperatures to decay development in blueberries. J. Amer. Soc. Hort. Sci. 103:130–134.
2. Ceponis, M. J. and R. A. Cappellini. 1978. Chemical control of postharvest rots in New Jersey blueberries. Plant Dis. Rptr. 62:154–156.
3. Ceponis, M. J., J. Kaufman, and W. H. Tietjen. 1973. Decays of New Jersey blueberries in marketing channels. Plant Dis. Rptr. 57:487–488.
4. Galletta, G. J., W. E. Ballinger, R. J. Monroe, and L. J. Kushman. 1971. Relationship between fruit acidity and soluble solids levels of highbush blueberry clones and fruit keeping quality. J. Amer. Soc. Hort. Sci. 96:758–762.
5. Harvey, J. M. and W. T. Pentzer. 1960. Market diseases of grapes and other small fruits. U. S. Dept. Agr., Agr. Handb. 189, p. 2–3.
6. Hruschka, H. W. and L. J. Kushman. 1963. Storage and shelf life of packaged blueberries. U. S. Dept. Agr., Mrtg. Res. Rpt. 612.
7. Schulze, C. P., M. J. Ceponis, and R. A. Cappellini. 1981. The influence of "sweating" on postharvest decay of blueberries. Phytopathology 71. (In press)

HortScience 16(5):657–659. 1981.

Effect of BA and GA on Fruit Drop of Citrus[1]

Wang Dayuan[2]

Institute of Citrus, Chinese Academy of Agriculture Sciences, ChungKing, The People's Republic of China

Additional index words. fruit-set, orange, *Citrus sinensis*, mandarin, *Citrus reticulata*

Abstract. **Application of gibberellic acid (GA) and 6-benzylamino purine (BA) on whole trees of 'Washington Navel' orange (*Citrus sinensis* [L.] Osbeck) during anthesis caused flower thinning and increased leaf size of the spring growth flush. BA sprayed on whole trees at the young fruit stage induced premature initiation of the summer growth flush and resulted in serious fruit drop. Application of BA on the surface of individual young fruit of 'Washington Navel' orange and 'Satsuma' mandarin (*C. reticulata* Blanco) prevented postbloom drop, but not June drop. Neither GA nor BA had any influence on fruit-set of "Jeng" orange.**

Dropping of flowers and fruit is a serious problem in citrus, especially in seedless cultivars. According to Erickson et al. (4), the flower and young fruit drop percentages in 'Washington Navel' orange (based on the total number of flowers) are: flower buds 48.5%; flowers 16.7% young fruit with pedicel (postbloom drop) 31.4%; and young fruit abscised without pedicel (June drop) 3.2%.

Though temperature (3), light intensity (11) and girdling (8) can influence fruit drop of citrus, many researchers suggest that these factors act through plant growth regulators (1, 3, 10). It has been demonstrated that GA plays a significant role in preventing fruit

[1]Received for publication October 20, 1980.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[2]Visiting Scientist, Department of Botany, University of Florida, Gainesville, FL 32611.

The author wishes to express appreciation to Professor R. K. Soost and Professor Indra K. Vasil for their valuable suggestions and assistance.

Table 1. Effect of BA and GA application during anthesis on leaves, twigs and fruit-set of 'Washington Navel' orange.

Concn (ppm)		Total no.	Fruit set[z]	Leaf size (cm)[y]		Leaf-	No. dead
GA	BA	of flowers	(%)	Length	Width	drop[x]	twigs[w]
0	0	15,232	0.98	10.2	4.6	20	0
100	0	16,170	0.34*	11.5*	5.0**	193	140
0	100	24,439	0.13**	12.0*	5.2**	42	18
0	400	17,463	0.08**	11.8*	5.4**	32	1
100	400	20,397	0.08**	13.0**	5.8**	160	75

[z]Determined on May 10.
[y]Based on 200 leaves.
[x]No. of fallen leaves per tree on April 24.
[w]No. of withered twigs per tree on April 24.
*, **Different from control at 5% (*) and 1% (**) level by LSD.

drop of citrus (2, 6, 7, 9), but there is little information concerning the influence of cytokinins on growth and development. We applied BA and GA, together and separately, on 3 citrus cultivars in order to determine BA effect on fruit set.

The experiments were carried out in the orchard of the Institute of Citrus, CAAS, ChungKing, China, in 1972 with 7-year-old 'Washington Navel' orange trees, and 8-year-old 'Satsuma' mandarin and 'Jeng' orange trees, all grafted on Poncirus trifoliata (L.) Raf. All plant growth regulator solutions contained 0.1% of a nonionic wetting agent.

Whole tree sprays prior to and during anthesis. Twenty 'Washington Navel' orange trees were divided into 5 groups according to vigor and number of flowers. The design was a randomized block with 4 single-tree replicates and 5 treatments: 100 ppm BA, 400 ppm BA, 100 ppm GA, 400 ppm BA + 100 ppm and GA and control. Trees were sprayed on March 20 (flower bud stage), April 17 and 24. The total number of flowers was counted before treatment and the percentage of fruit set, number of withered twigs and fallen leaves, and the length and width of leaves of the spring flush were determined after treatment.

Whole tree sprays at the young fruit stage. Eight 'Washington Navel' trees with similar vigor were divided into 2 groups, each with 4 trees. One group was sprayed with 400 ppm BA on May 2 and 8 when the fruit was very young. The first treatment was made about 5 days after petal fall. The other group served as the control. The total number of fruit of each tree was determined before treatment. The number of summer flush sprouts and percentage of fruit set were determined after treatment.

BA and BA + GA applied to selected fruit. One hundred pairs of young fruit of similar size and tree position were selected for each treatment. One of each pair was treated while the other was used as the untreated control. The treatments were 400 ppm BA, 800 ppm BA and 400 ppm BA + 50 ppm GA for 'Washington Navel' orange. The first application was on May 12 when the average fruit diameter was 0.5–0.6 cm. The remaining applications were done on May 17, May 30, and June 13. Fruit-set was determined at intervals after treatment.

Spraying BA, GA or BA + GA on whole trees did not increase fruit set but resulted in flower and fruit thinning. The 400 ppm BA and 400 ppm BA + 100 ppm GA treatments had the greatest thinning effect. The percentage of fruit set in the 2 treatments determined on May 10 was only 8% of that of the control (Table 1). All treatments increased the leaf area of the spring flush, but 400 ppm BA and 400 ppm BA + 100 ppm GA were most effective. Spraying GA or BA + GA resulted in serious withering of twig and leaf drop.

Spraying BA on whole trees at the young fruit stage increased and accelerated the summer growth flush and resulted in the dropping of all young fruit. The percentage of fruit set for control was 3.3% while that of BA treatment was zero 18 days after treatment. The number of sprouts of the BA treatment was 297 while that of the control was 22.

Application of BA or BA + GA to individual young fruit decreased postbloom drop and increased fruit set. The percentage of fruit set on May 23 (11 days after treatment) was 95% for the 400 ppm BA treatment and 91% for the 400 ppm BA + 50 ppm GA treatment, both much higher than the 21% of the control (Fig. 1). After late May most young fruit, both BA treated and control, turned yellow, beginning at the navels, then separated from the pedicel and dropped. By mid- or late July most of the fruit had dropped, although the fruit set percentage of the BA application was still higher than that of control. The BA + GA treatment had a different effect than BA alone. During June drop, which occurred after late May in 1972, only a few young fruit dropped from the pedicel with BA + GA treatment. The fruit set percentage with application of BA + GA was far higher than that of the control and therefore the numbers of harvested fruit were greater. Young fruit treated with BA or BA + GA were dark green, large and had thicker pedicels than the controls. The effect produced by BA treatment alone was slightly less than that by BA + GA treatment. BA prevented postbloom drop in 'Satsuma' mandarin as in 'Washington Navel' orange, but there was no effect of BA treatment on fruit-set, fruit shape, or size in 'Jeng' orange.

It is known that fruit-drop in citrus has 2 phases: postbloom drop and June drop, and that plant hormones play an important role in citrus fruit set. We do not know if the response of both fruit drop phases to plant hormones is the same or not. Recently, Garcia et al. (5) reported that BA increased the fruit set of 'Clementine' mandarin, but not as much as GA. They reported no difference in response to BA and GA on the 2 phases of fruit drop. Our results indicate that BA has a great influence on postbloom drop but not on June drop. BA + GA, however, can prevent both postbloom drop and June drop, similar to the effect of GA alone. We believe that the mechanisms of the 2 phases of fruit drop are different from each other. Our results also showed that the effect of BA on postbloom drop varied with the cultivars and the organ treated. The effect of BA on 'Washington Navel' orange and 'Satsuma' mandarin is obvious, but no effect could be observed on the seeded 'Jeng' orange. When BA was applied

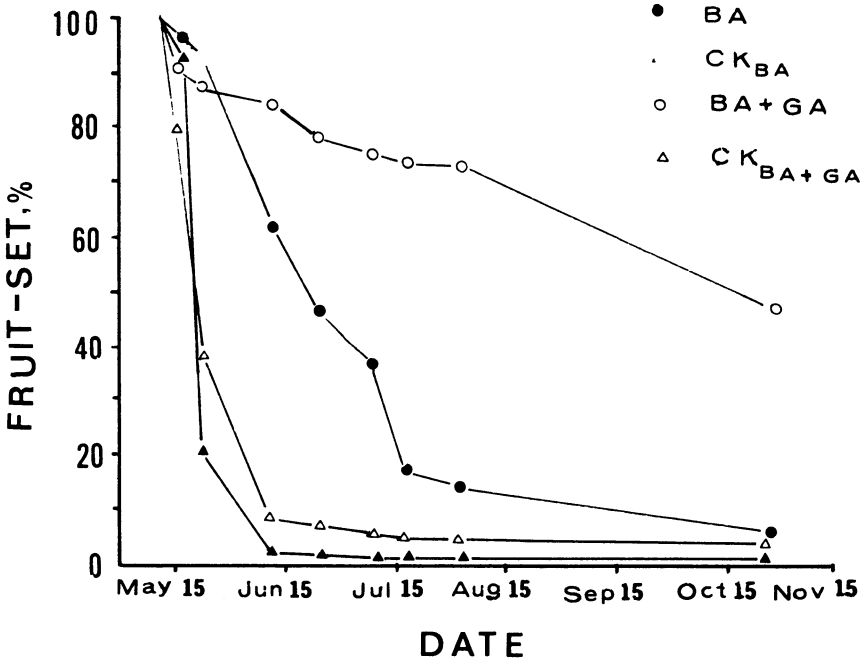

Fig. 1. The effect of BA and BA + GA on fruit-set of 'Washington Navel' orange.

to the whole trees, either the spring flush leaves were enlarged or summer growth flush sprouts were induced to grow earlier. BA prevented postbloom drop only when it was applied directly to the surface of fruit.

Literature Cited

1. Coggins, Jr., C. W. and H. Z. Hield. 1968. Plant growth regulators. p. 371–388. In: W. Reuther, L. D. Batchelor, and H. J. Webber (eds) The Citrus Industry, Vol. 2. Div. Agr. Sci., Univ. of California, Berkeley.
2. Del Rivero, J. M., P. Veyrat and D. Gimez de Barreda. 1969. Improving fruit set in 'Clementine' mandarin with chemical treatment in Spain. Proc. 1st Intern. Citrus Symp., Vol. 3. p. 1121–1124.
3. Erickson, L. C. 1968. The general physiology of citrus. p. 86–126. In: W. Reuther, L. D. Batchelor, and H. J. Webber (eds.) The Citrus Industry, Vol. 2. Div. Agr. Sci., Univ. of California, Berkeley.
4. Erickson, L. C. and B. L. Brannaman. 1960. Abscission of reproductive structures and leaves of orange trees. Proc. Amer. Soc. Hort. Sci. 75:222–229.
5. Garcia-Martinez, J. L. and M. A. Garcia-Papi. 1979. The influence of gibberellic acid, 2,4-dichlorophenoxyacetic acid and 6-benzylaminopurine on fruit-set of 'Clementine' mandarin. Scien. Hort. 10:285–293.
6. Hield, H. Z., C. W. Coggins, Jr., and M. J. Garber. 1958. Gibberellin tested on citrus. Calif. Agr. 12(5):9–11.
7. Iwasaki, T., M. Nichiura, T. Schichijo, and Y. Iba. 1962. Studies on the control of alternate bearing in citrus. VII. Effect of cross pollination and spraying of chemicals in blooming or young fruit period on fruit-set of "Washington Navel" orange. J. Jap. Soc. Hort. Sci. 31:101–108.
8. Krezdorn, A. H. 1961. Girdling to increase fruit set — use it cautiously. Citrus Ind. 42(7):20–21.
9. Krezdorn, A. H. and M. Cohen. 1962. The influence of chemical fruit set sprays on yield and quality of citrus. Proc. Fla. State Hort. Soc. 75:53–60.
10. Monselise, S. P. and R. Goren. 1978. The role of internal factors and exogenus control in flowering, peel growth, and abscission in citrus. HortScience 13:134–138.
11. Reuther, W. 1973. Climate and citrus behavior. p. 287–333. In: W. Reuther, L. D. Batchelor, and H. J. Webber (eds.) The Citrus Industry, Vol. 3. Div. Agr. Sci., Univ. of California, Berkeley.

HortScience 16(5):659–660. 1981.

Levels of Dichlorvos on Calimyrna Figs[1]

Thomas E. Archer[2]

Department of Environmental Toxicology, University of California, Davis, CA 95616

Additional index words. 2,2-dichlorovinyl dimethyl phosphate, DDVP, residue, pesticide, insecticide, acaricide, *Ficus carica*

Abstract. **Residues of 2,2-dichlorovinyl dimethyl phosphate (dichlorvos) on Calimyrna figs (*Ficus carica* L.) declined to <5 ppb by day 6 after trees were pressure sprayed with 2,805 liters/ha at a rate of 2.24 kg Vaponite 2 a.i./ha for control of dried fruit beetle (*Carpophilus hemipterus* L.) and *Drosophila* spp. and fruit were sampled at 0, 1, 2, 4, 6 and 10 days. Very little residue (<5 to 33 ppb) was detected on fresh figs after multiple applications of 2.24 and 4.48 kg a.i./ha. All of the ground-dried figs had significant residues. About 90.9% of the residues were removed after dehydration. Dichlorvos residues were on the surface of the figs but were not easily removed by surface wash only. Residues were absorbed in the surface cuticle materials of the figs and surface waxes must be dissolved to successfully remove the residues from the plant material.**

Dichlorvos (DDVP, Vapona) is an organic insecticide-acaricide effective as a fumigant, stomach, and contact poison. Some of the pests controlled by this chemical are ants, aphids, mites, mealybugs, ticks, drosophila, centipedes, flying moths, other small flying insects, flies, fleas, gnats, spiders, wasps, and roaches. It is also utilized in sprays on animals, animal shelters and greenhouses (2). Use of dichlorvos on figs is one of the few applications on raw agricultural commodities.

Dichlorvos is registered for use on processed figs, but it has not been registered for control of insects on fresh or dried figs. The purpose of these experiments was to determine the residues of dichlorvos after multiple applications to Calimyrna fig trees for the control of dried fruit beetles and *Drosophila spp.*

An experiment to ascertain the disappearance of dichlorvos residues on the figs over a period of time after a single spray application consisted of 3 replications of single tree plots centrally located in a commercially producing fig orchard located in central California. Trees were sprayed with 2,805 liters/ha at a rate of 2.24 kg a.i./ha with Vaponite 2 Emulsifiable 22.8% (0.242 kg dichlorvos a.i./liter) applied with an air-blast pressure sprayer at the beginning of fruit harvest in August 1979. One kg of residue samples and untreated controls were collected 0, 1, 2, 4, 6, and 10 days after treatment, frozen and stored for analysis at −10°.

Two rates, 2.24 kg a.i./ha and 4.48 a.i. kg/ha were used in a second experiment. The lower dosage is the effective rate of application for pest control. Spray was applied to single-tree plots with 3 replicates, including untreated controls, at the beginning of harvest, August 15, and subsequently at 5-day intervals for a total of 5 applications per treatment of 2.24 and 4.48 kg a.i./ha. Five samplings of both fresh fruit and ground-dried fruit were collected and analyzed for dichlorvos residues. Fresh figs were collected from the trees just prior to each spray application and the ground dried figs were collected just prior to multiple dichlorvos applications. Samples were frozen immediately after collection and stored for analysis at −10°.

Frozen ground-dried samples were thawed, rinsed with running tap water for about 5 min, and placed in a dehydrator at 43° to 49° for 24 hr or until the moisture content was 15 to 17% as determined by drying in a vacuum oven. Samples were repackaged and stored frozen at −10° for residue analysis.

Partially thawed figs were chopped, 25 or 50 g weighed and blended with 1 ml of 12N hydrochloric acid, 250 g anhydrous sodium sulfate and 200 ml mixed pentanes (b.p. = 30–60°C). The solvent was decanted into a round-bottomed boiling flask; the remaining solid material was rinsed 3 times with 50 ml pentanes and combined. One hundred ml water was added to the pooled solvent and the mixture evaporated *in vacuo* at 25–30° to remove the pentanes. The water bath temperature should not exceed 32° to prevent loss of dichlorvos by evaporation.

The aqueous layer was filtered through Whatman #41 filter paper into a 1 liter separatory funnel, 50 g sodium chloride added, and partitioned three times with 50 ml pentanes which were combined. One ml of a polyethylene glycol-acetone solution (1:100 v/v) was added to the pooled pentanes to prevent dichlorvos evaporation losses and the mixture was evaporated *in vacuo* at 25–30° to 1 ml. The sample was quantitatively transferred to a 6.5 ml sedimentation tube with pentanes and the final volume was adjusted by slow evaporation of the solvent under nitrogen gas while in a thermostatted water bath at 25–30° so that 1 µl would contain 25 to 500 mg fig extractives for GLC analyses, depending upon ppb dichlorvos present.

Gas-liquid chromatography and an alkali flame ionization detector were used to determine dichlorvos residue levels (1). The method, as modified in this laboratory is applicable for the quantitative analysis of dichlorvos in or on fig fruit down to 5 ppb. The gas chromatograph was an Aerograph Model 600B equipped with an alkali flame ionization detector and containing a 76 cm x 31 mm (2.5 ft x 1/8 inch) glass coiled column packed with 5% OV-101 on Chromosorb G, 110/120 mesh, DMCS. Operating parameters were injector temperature, 160°C, column temperature, 115°, detector temperature, 115°, hydrogen flow 30 ml/min., air flow 180 ml/min., carrier gas N_2 flow 30 ml/min, and attenuation 4. The recorder was a poten-

[1]Received for publication December 18, 1980.

The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[2]The author thanks William W. Barnett, Farm Advisor of Fresno County, Calif. for furnishing field-treated samples and Sharon Wong, Marlene Weiss, Toynette Johnson and Harvey Moyer for specific technical assistance. This work was partially funded by the IR-4 project, USDA/SEA/CR.