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Control of Postharvest Fruit Decays in Relation to Residues of 2,6-Dichloro-4-nitroaniline and Difolatan

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Field spray applications in 1961 on peach and apricot indicated lasting residual activity of DCNA under the California environment of high temperature with no rain, and high activity of residual DCNA against *Rhizopus stolonifer* with 1 and with 0.5 pound of DCNA in 100 gallons of water. Some activity against *R. stolonifer* was observed with 1 pound of captan and of folpet. DCNA activity was comparable with that of captan and folpet on *Monilinia fructicola* on peach and apricot, but not on apricots that showed little to no DCNA residue after seven days.

Field sprays in commercial peach orchards during 1962 showed that three sprays of DCNA were more effective in control of *Rhizopus* rot of peaches than were one or two sprays when peaches were subsequently ripened in chambers held at 20° C and 80 per cent relative humidity. When treatments resulting in similar DCNA residues at harvest were compared, consistent reduction of *Monilinia* rot was shown only with the three spray applications. Dip treatments with 'Halford' peaches showed control of *Rhizopus* rot with a residue of 4 ppm DCNA and of *Monilinia* rot with a residue of a mixture of 28.4 ppm DCNA and 13 ppm Difolatan.

Residue analyses of field-sprayed peaches indicated the average half-life of DCNA to be about six days (half of original residue was present) under the arid environment of California when sprays were applied approximately four weeks before harvest.

Following canning, the peaches showed trace amounts of DCNA, but Difolatan could not be detected by the method of analysis used.

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INTRODUCTION

POSTHARVEST RIPENING of fruits in controlled atmospheres results in a canned product of higher quality (Leonard, Luh, and Claypool, 1956–1957).[2] Unless decay-causing organisms are controlled, however, fruits cannot be storage ripened with any assurance that they will be fit for canning. Two fungi, *Rhizopus stolonifer* and *Monilinia fructicola,* cause rots in stone fruits that result in major economic losses. *Rhizopus* rot has been controlled by 2,6-dichloro-4-nitroaniline (DCNA) (Ogawa, Lyda, and Weber, 1961; Ogawa and Uyemoto, 1962). The compound is effective in inhibiting mycelial growth, including that of aerial mycelia, and in suppressing sporulation (Ogawa *et al.,* 1963). *Monilinia* rot control with DCNA has been reported effective in small-scale tests on peaches (Dewey and MacLean, 1962; Cappellini and Stretch, 1962).

During 1961–1962 we attempted to correlate the residual DCNA, on fruits that had been dipped or field sprayed, with the degree of disease control. Captan, Difolatan, folpet, and DCNA-Difolatan mixtures were compared.

MATERIALS AND METHODS

The spray applications and performance tests were conducted in California; many of the residue analyses were made by The Upjohn Company, Kalamazoo, Michigan.

Preliminary trials were made on 'Red Haven' peach fruits in the experimental orchard of the University of California at Davis and on 'Royal' apricot trees in a commercial orchard. More extensive trials were made on 'Fay Elberta' and 'Halford' peaches in commercial orchards provided either by the California Freestone Growers' Association or through the Cling Peach Advisory Board.

The chemical formulations used were dilutions of 50 per cent DCNA (2,6-dichloro-4-nitroaniline), 50 per cent captan (n-trichloromethyl-mercapto-4-cyclohexene-1,2-dicarboximide), 50 per cent folpet (n-trichloromethylthiophthalimide), and 50 per cent Difolatan (N-(1,1,2,2-tetrachloro-ethylsulfenyl)-cis-Δ-4-cyclohexene-1,2-dicarboximide). All are proprietary compounds—DCNA of The Upjohn Company, the others, of the California Chemical Company. All

[1] Submitted for publication September 12, 1963.
[2] See "Literature Cited" for citations referred to in the text by author and date.

TABLE 1

AVERAGE REDUCTION IN LESION DIAMETER ON *RHIZOPUS STOLONIFER*-INOCULATED PEACHES AND APRICOTS, AND AMOUNT OF DCNA RESIDUE, AFTER TREATMENT WITH DCNA, CAPTAN, AND FOLPET

Variety	Time between spraying and harvest	Average lesion diameter on untreated fruit*	Spray material per 100 gallons					
			0.5 lb DCNA		1 lb DCNA		1 lb captan	1 lb folpet
			Av. reduction in lesion diameter	Amount of residue	Av. reduction in lesion diameter	Amount of residue	Av. reduction in lesion diameter	Av. reduction in lesion diameter
	days	*mm*	*per cent*	*ppm*	*per cent*	*ppm*	*per cent*	*per cent*
'Red Haven' peach..	1	38.9†	92.0	10.3	100.0	25.9	19.0	34.0
	4	71.5	62.8	3.8	88.7	14.3	18.0	2.5
	7	55.0	45.5	1.3	84.0	6.1	9.0	5.5
	11	40.5	31.5	<0.9	74.3	4.9	14.0	15.5
'Royal' apricot......	1	21.1‡	40.7	3.1	38.5	10.0	7.2	22.0
	4	53.6	31.8	1.4	67.8	4.1	22.7	4.2
	7	19.6	0.0	<1.4	18.8	2.4	2.7	2.7

* These measurements represent data taken after 40.5, 44, 42, and 36 hours of incubation at 25° C, on 1, 4, 7, and 11 days after treatment, respectively.
† Average of 10 inoculations.
‡ Average of 14 inoculations.

chemical concentrations are expressed on the basis of active ingredients. Half-life denotes the point at which only half of the original chemical residue can be detected. Sprays were applied with a hand gun on a hydraulic sprayer at 500-psi pressure. Each apricot tree received 6 gallons of spray; each peach tree received 8 gallons. No rain occurred during the experimental period.

PRELIMINARY TRIAL

During 1961 'Red Haven' peach and 'Royal' apricot trees were sprayed individually, to drip stage, with either 0.5 or 1 pound of DCNA, or 1 pound of captan, or 1 pound of folpet, in 100 gallons of water. Five single-tree replications were used for peach and seven for apricot. All fruits were mature at the beginning of the experiment; by the eleventh day after spraying, they were slightly overripe. Five peaches and seven apricots were harvested from each tree 1, 4, 7, and 11 days after application of spray. Both cheeks of each fruit were injured with a 1-mm diameter glass rod, and inoculated with 1,600 to 2,400 spores of *Rhizopus stolonifer* or *Monilinia fructicola,* in a water suspension. The fruit was then placed in a saturated-atmosphere, plastic chamber kept at 25° C. Lesion diameters were measured after 40 hours. Fruits for residue analysis were collected and shipped by air to The Upjohn Company, Kalamazoo, Michigan.

Results of Preliminary Trial. DCNA reduced *Rhizopus*-induced lesions on peaches and apricots more than did either captan or folpet, except on apricots harvested 7 days after being sprayed with 0.5 pound DCNA (table 1). *Rhizopus* rot control was better on peaches than on apricots. Residual deposit of DCNA was higher on peaches. The half-life of DCNA was about 4 days on peach and 3 days on apricot. Apparently about 10 ppm of residual DCNA are required to give about 90 per cent reduction in development of *Rhizopus* lesions on peaches. Possibly a higher DCNA residue on apricots could provide similar control.

Table 2 shows the percentage reduction of *Monilinia fructicola* lesions by DCNA, captan, and folpet. On peaches, treatment with 1 pound of DCNA per 100 gallons reduced lesion development more than did either 1 pound of captan or folpet, or 0.5 pound of DCNA. One pound of captan and 1 pound of folpet

TABLE 2

AVERAGE REDUCTION IN LESION DIAMETER ON *MONILINIA FRUCTICOLA*-INOCULATED PEACHES AND APRICOTS, AND AMOUNT OF DCNA RESIDUE, AFTER TREATMENT WITH DCNA, CAPTAN, AND FOLPET

Variety	Time between spraying and harvest	Average lesion diameter on untreated fruit*	Spray material per 100 gallons					
			0.5 lb DCNA		1 lb DCNA		1 lb captan	1 lb folpet
			Av. reduction in lesion diameter	Amount of residue	Av. reduction in lesion diameter	Amount of residue	Av. reduction in lesion diameter	Av. reduction in lesion diameter
	days	*mm*	*per cent*	*ppm*	*per cent*	*ppm*	*per cent*	*per cent*
'Red Haven' peach..	1	21.6†	83.8	10.3	92.1	25.9	83.8	79.6
	4	36.2	57.5	3.8	69.8	14.3	47.2	26.8
	7	18.8	34.5	1.3	67.6	6.1	38.3	56.5
	11	14.2	7.5	<0.9	55.0	4.9	32.4	15.0
'Royal' apricot......	1	36.2‡	67.8	3.1	78.6	10.0	78.6	84.1
	4	32.0	22.5	1.4	39.0	4.1	83.6	65.2
	7	16.2	0.0	<1.4	4.8	2.4	54.3	85.8

* These measurements represent data taken after 40.5, 44, 42, and 36 hours of incubation at 25° C, on 1, 4, 7, and 11 days after treatment, respectively.
† Average of 10 inoculations.
‡ Average of 14 inoculations.

were equally effective on fruit harvested immediately after spray application. Captan and folpet gave variable disease control on peaches harvested on the fourth, seventh, or eleventh day after spray application. Performance of captan and folpet treatments on apricots was equal to or better than that of either 0.5 or 1 pound of DCNA. Again, 1 pound of DCNA was superior to 0.5 pound. On both peaches and apricots, 10-ppm residue resulted in 70 to 80 per cent reduction in lesion development.

LARGE-SCALE TRIALS

During 1962, randomized plots of 36 'Fay Elberta' and 36 'Halford' peach trees were used. Ten fungicidal treatments were replicated three times on 24 trees of each cultivar. Fruits from the remaining 12 trees in each group were used as controls and for dip treatments with fungicides. Concentrations of DCNA used were 0.5, 1, and 2 pounds in 100 gallons of water. A mixture containing 1 pound each of DCNA and Difolatan was also tested. The sprays were applied approximately two weeks and four weeks before harvest, and on the day of harvest. Dipping treatments were made immediately after harvest. Individual boxes were immersed in suspensions of either 750-ppm DCNA or 1,260-ppm Difolatan, or a mixture of both fungicides at those concentrations.

Fruits for residue analyses were collected immediately after each spray, again just before each succeeding spray, and before being canned. Fruits were canned by the Department of Food Science and Technology at Davis. Residue analyses of DCNA were made by The Upjohn Company, and by the Agricultural Toxicology and Residue Research Laboratory at Davis, according to the method developed by Kilgore *et al.* (1962). Difolatan residue analyses were made only by the University of California. No interference between DCNA and Difolatan occurs in analyses of this mixture.

Five boxes of 'Fay Elberta' peaches (125 fruits per box) were harvested from each tree on August 9, stored at 0° C for three days, and ripened at 20° C, 80 per cent RH (relative humidity) until examination on September 9. The fruits tested 14 pounds on a Magness-Taylor pressure tester ($^{5}/_{16}$-inch tip) at harvest; by August 15 the pres-

TABLE 3

DISEASE ON NATURALLY-INFECTED 'FAY ELBERTA' PEACHES FIELD SPRAYED WITH DCNA AND DCNA-DIFOLATAN AND STORED AT 20°C AND 80 PER CENT RELATIVE HUMIDITY FOR 28 DAYS, AND DCNA RESIDUE ON FRUITS BEFORE HARVEST AND AFTER CANNING

Spray material	Pounds per 100 gal applied at following days before harvest			DCNA residue at harvest*	Average amounts of diseased fruit†			DCNA residue on canned fruit*
	24	13	0.25		Total disease‡	*Rhizopus* rot	*Monilinia* rot	
				ppm	*per cent*	*per cent*	*per cent*	*ppm*
DCNA-Difolatan (1:1)	2	2	2	19.0	59.1 a	1.5 a	0.3 a	0.11
DCNA	2	2	2	34.0	75.7 abc	5.6 a	0.3 a	<0.01
DCNA	2	2	0	30.7	72.3 abc	3.5 a	0.5 a	<0.01
DCNA	0	0	2	15.2	64.1 ab	5.3 ab	3.7 ab	<0.01
DCNA	1	1	1	14.1	78.1 bcd	3.1 a	1.9 ab	<0.01
DCNA	1	1	0	2.8	83.6 cd	6.2 a	1.7 ab	<0.01
DCNA	0	0	1	12.1	82.6 cd	5.9 ab	2.7 ab	<0.01
DCNA	0.5	0.5	0.5	8.1	90.7 d	7.7 ab	2.9 ab	<0.01
DCNA	0.5	0.5	0	1.1	83.7 cd	23.6 bc	14.5 c	<0.01
DCNA	0	0	0.5	3.8	90.7 cd	5.1 a	7.7 bc	<0.01
				25.0§				1.0§
Control	...	...	...		84.0 cd	26.6 c	12.8 c	

* Sensitivity of DCNA residue analyses is 0.01 ppm.

† Data were converted to arc sin$\sqrt{\text{percentage}}$ for statistical treatment. Duncan's multiple-range test was used. Statistical groupings ($P = 0.05$) for vertical comparison are shown by letters following the numbers. Values having a letter in common do not differ significantly.

‡ Includes decay caused by *Alternaria*, *Penicillium*, and *Botrytis*.

§ Difolatan residue. Sensitivity of Difolatan residue analyses is 1.0 ppm.

sure was 1.5 to 5 pounds. At that time, samples of the fruits were removed for canning on August 16.

Four boxes of 'Halford' peaches (100 fruits per box) were harvested from each tree on August 31 and immediately placed in a chamber held at 20° C, 80 per cent RH. Fruits for canning were harvested on August 29 and canned the next day. The fruits at that time registered between 2 and 5 pounds pressure on the Magness-Taylor pressure tester.

Results for 'Fay Elberta.' After three days in the ripening room, no disease showed on 'Fay Elberta' peaches that had been stored previously at 0° C for three days. After eight more days in the ripening room, the untreated fruits revealed 3.3 per cent total disease, accounted for primarily by 2.4 per cent *Rhizopus* rot and 0.5 per cent *Monilinia* rot. No significant differences in amount of disease appeared between the controls and the treatments at this time. After 17 more days in the ripening room, the fruits showed considerable decay and some shriveling (table 3). These performance data do not express typical conditions, and will be of use only in guiding the conclusions made in future tests. Abundant *Alternaria, Botrytis,* and *Penicillium* were isolated from decaying fruits in similar proportions on all treatments and on the control. The correlation between DCNA residue and performance was established only for control of *Rhizopus* and *Monilinia* rots. Total decay was least on fruit treated with a mixture of 1 pound each of DCNA and Difolatan, although the results were not significantly different from those of the 2-pound DCNA treatments. Other treatments gave no indication of total decay control. Control of *Rhizopus* rot on all treatments that resulted in over 2.8 ppm DCNA residue was significantly better than on the control fruit. Control of *Monilinia* rot was similar to that obtained for *Rhizopus* rot. Residue of 1.1 ppm DCNA, obtained by two applications of 0.5 pound of DCNA, failed to control

TABLE 4

DISEASE ON NATURALLY-INFECTED 'FAY ELBERTA' PEACHES DIPPED IN EITHER DCNA, DIFOLATAN, OR A MIXTURE OF BOTH AT TIME OF HARVEST, AND STORED AT 20°C AND 80 PER CENT RELATIVE HUMIDITY FOR 28 DAYS

Treatment	Average amounts of diseased fruit†			Residue on canned fruit	
	Total disease‡	*Rhizopus* rot	*Monilinia* rot	DCNA	Difolatan
	per cent	*per cent*	*per cent*	*ppm*	*ppm*
DCNA (750 ppm)*	76.4 NS	5.7 NS	0.7 a	<0.01	....
Difolatan (1,260 ppm)*	77.9 NS	16.1 NS	0.3 a	....	<1.0
DCNA (750 ppm) and Difolatan (1,260 ppm)*	61.7 NS	6.9 NS	0.1 a	0.07	<1.0
Control	84.4 NS	26.7 NS	12.8 b	....	....

* Active ingredient. 750 ppm DCNA and 1,260 ppm Difolatan are of equal molar concentration.

† Data were converted to arc sin$\sqrt{\text{percentage}}$ for statistical treatment. Duncan's multiple-range test was used. Statistical groupings (P = 0.05) for vertical comparison are shown by letters following the numbers. Values having a letter in common do not differ significantly. NS indicates no significance.

‡ Includes decay caused by *Alternaria, Penicillium,* and *Botrytis.*

either *Monilinia* or *Rhizopus* rot. In canned products, residues of both DCNA and Difolatan were below or only slightly above the detectable range.

The dip treatments of 'Fay Elberta' peaches (table 4) did not show significant control of *Rhizopus* rot by DCNA although DCNA treatments gave lower percentages of rot than did Difolatan treatments. Because of the variability, between replications, in the percentage of decay from the Difolatan treatment, statistical analysis omitted the Difolatan data. This resulted in significant differences, at the 1 per cent level, between control and DCNA or DCNA-Difolatan treatments. *Monilinia* rot was controlled by DCNA, Difolatan, or a mixture of both. Residue of the chemicals in canned fruits was below the sensitivity of the Difolatan test and near the sensitivity of the DCNA analysis technique.

Results for 'Halford.' Fruits were placed in the ripening room immediately after harvest. Table 5 shows the average amounts of total diseases in various treatments, 5, 8, and 11 days after harvest. The mixture of 1 pound each of DCNA and Difolatan, applied three times, resulted in the least decay after 8 and 11 days in the ripening room. The residue analysis showed 30 ppm of DCNA and 14 ppm of Difolatan. Three applications of DCNA at 2 pounds per 100 gallons gave disease control equal to that of the mixture, after 5 and 8 days' incubation, and produced the same DCNA residue. After 11 days, the mixture treatment and the three applications of 1 or 2 pounds of DCNA gave equal control, although the residue from the 1-pound DCNA treatment was one third less than that from the other treatments.

Control of *Rhizopus* rot was significant on all treatments at the 11-day storage period (table 5). The DCNA-Difolatan mixture consistently gave the lowest per cent decay, but at the three disease-evaluation dates, the treatments of three applications of DCNA, and the mixture of DCNA and Difolatan gave equal control of *Rhizopus* rot. The amount of control was closely related to the amount of DCNA residue on fruits. Judging from the data, over 10 ppm of DCNA effectively control *R. stolonifer* on 'Halford' peach.

After 5 days in the ripening room, no significant differences between treatments for *Monilinia* control were apparent (table 5). After 8 days in the ripening room, three spray applications of DCNA and a mixture of DCNA-Difolatan spray afforded *Monilinia* rot control; after 11 days, the DCNA-Difolatan mixture and the 1- and 2-pound DCNA

TABLE 5

AMOUNTS OF TOTAL DISEASE, *RHIZOPUS* ROT, AND *MONILINIA* ROT ON NATURALLY-INFECTED 'HALFORD' PEACHES FIELD SPRAYED WITH DCNA AND DCNA-DIFOLATAN MIXTURE AND STORED AT 20°C AND 80 PER CENT RELATIVE HUMIDITY

Spray material	Pounds per 100 gal applied at following days before harvest:			Residue at harvest		Average amount of disease*†			Average amount of *Rhizopus* rot†			Average amount of *Monilinia* rot†			Residue after storage		Residue after canning	
	27	11	0.25	DCNA	Difol-atan	5 days after storage	8 days after storage	11 days after storage	5 days after storage	8 days after storage	11 days after storage	5 days after storage	8 days after storage	11 days after storage	DCNA‡	Difol-atan§	DCNA‡	Difol-atan§
				ppm	*ppm*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*ppm*	*ppm*	*ppm*	*ppm*
DCNA-Difolatan (1:1)............	2	2	2	30.0	14.0	3.7 a	10.2 ab	20.8 a–d	0.6 a	0.7 a	1.6 a	3.1 a	9.2 a–c	17.0 a–d	7.3	17.0	0.38	1.0
DCNA............	2	2	2	30.8	....	4.8 a	13.1 a–c	29.8 c–e	0.8 a	2.2 ab	3.9 ab	3.8 a	9.1 a–c	25.5 c–g	....	....	<0.01	....
DCNA............	2	2	0	11.6	....	11.1 ab	25.5 b–e	53.4 f–i	3.3 ab	4.8 a–c	10.3 a–e	7.0 ab	18.6 a–e	38.3 g–i	....	....	<0.01	....
DCNA............	0	0	2	12.6	....	20.0 a–d	37.8 d–f	69.1 i–k	6.5 a–c	9.6 a–e	18.1 e–g	14.0 a–d	26.3 d–g	45.0 h–k	....	....	<0.01	....
DCNA............	1	1	1	10.4	....	2.9 a	11.0 ab	30.8 c–e	1.1 a	2.3 ab	3.5 ab	1.8 a	7.9 ab	21.1 b–f	....	....	<0.01	....
DCNA............	1	1	0	4.0	....	27.8 c–e	50.3 f–h	80.8 j–m	9.6 a–e	13.8 c–f	24.1 g–i	18.7 a–e	34.4 e–h	53.9 jk	....	....	<0.01	....
DCNA............	0	0	1	3.4	....	37.5 d–f	64.2 h–j	87.9 lm	14.2 c–f	20.3 f–h	28.0 h–j	24.8 c–g	40.5 g–j	58.2 k	....	....	<0.01	....
DCNA............	0.5	0.5	0.5	4.4	....	9.8 ab	26.7 b–e	54.0 f–i	1.3 a	2.7 ab	7.9 a–d	5.6 ab	18.5 a–e	38.1 g–i	....	....	<0.01	....
DCNA............	0.5	0.5	0	1.8	....	32.2 d–e	56.1 g–i	84.5 k–m	17.0 d–g	23.8 g–i	36.3 jk	18.4 a–e	36.5 f–i	50.3 i–k	....	....	<0.01	....
DCNA............	0	0	0.5	1.8	....	20.7 a–d	40.3 e–g	76.0 jk	11.8 b–f	18.3 e–g	34.8 jk	9.6 a–d	21.1 b–f	39.8 g–j	....	....	<0.01	....
Control.........	...	...	...	....	....	43.3 e–g	68.9 ij	93.8 m	29.8 ij	42.6 k	59.9 l	15.5 a–d	26.2 d–g	37.8 g–i	....	....	<0.01	....

* Includes decay caused by *Alternaria*, *Penicillium*, and *Botrytis*.

† Significance of mean comparisons for 5, 8, and 11 days was calculated together. Data were converted to arc $\sin\sqrt{\text{percentage}}$ for statistical treatment. Duncan's multiple-range test was used. Statistical groupings ($P = 0.05$) for vertical comparison are shown by letters following the numbers. Values having a letter in common do not differ significantly.

‡ Sensitivity of DCNA residue analyses is 0.01 ppm.

§ Sensitivity of Difolatan residue analyses is 1.0 ppm.

TABLE 6

AMOUNT OF DISEASE ON NATURALLY-INFECTED 'HALFORD' PEACHES DIPPED IN EITHER DCNA, DIFOLATAN, OR A MIXTURE OF BOTH, STORED AT 20°C AND OVER 80 PER CENT RELATIVE HUMIDITY

Treatment	Residue after dipping		Average amount of disease†‡			Average amount of *Rhizopus* rot†			Average amount of *Monilinia* rot†			Residue after storage		Residue after canning	
	DCNA	Difolatan	5 days after storage	8 days after storage	11 days after storage	5 days after storage	8 days after storage	11 days after storage	5 days after storage	8 days after storage	11 days after storage	DCNA	Difolatan	DCNA	Difolatan
	ppm	*ppm*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*ppm*	*ppm*	*ppm*	*ppm*
DCNA (750 ppm)*	4.0	....	41.7 c	74.9 ef	88.3 fg	3.3 a	4.3 a	4.6 a	37.8 cd	69.1 e	82.3 e	5.7	....	<0.01	....
Difolatan (1,260 ppm)*	....	8.0	52.2 cd	71.9 ef	85.5 e–g	24.3 b	28.7 bc	36.3 cd	23.4 bc	38.7 cd	48.3 d	....	7.0	....	<1.0
DCNA–Difolatan*	28.4	13.0	3.8 a	24.2 b	46.8 c	0.3 a	1.2 a	2.3 a	3.0 a	13.9 ab	39.1 cd	5.0	2.0	0.11	<1.0
Control	....	....	43.3 c	68.9 b–e	93.8 g	29.8 bc	42.6 d	59.9 e	15.5 ab	26.2 bc	37.8 cd	....	....	....	....

* Active ingredient, 750 ppm DCNA and 1,260 ppm Difolatan are of equal molar concentration.

† Data were converted to arc $\sin\sqrt{\text{percentage}}$ for statistical treatment. Duncan's multiple-range test was used. Statistical groupings ($P = 0.05$) for vertical comparison are shown by letters following the numbers. Values having a letter in common do not differ significantly. NS indicates no significance.

‡ Includes decay caused by *Alternaria*, *Penicillium*, and *Botrytis*.

TABLE 7

RESIDUE AND HALF-LIFE OF DCNA AND DCNA-DIFOLATAN ON FIELD-SPRAYED 'FAY ELBERTA' AND 'HALFORD' PEACHES

Spray material and amount applied	'Fay Elberta' peach						'Halford' peach					
	Residue		Half-life*	Residue		Half-life*	Residue		Half-life*	Residue		Half-life*
	At time of spraying (24 days preharvest)	11 days after spraying		At time of spraying (13 days preharvest)	13 days after spraying		At time of spraying (27 days preharvest)	16 days after spraying		At time of spraying (11 days preharvest)	11 days after spraying	
	ppm	*ppm*	*days*	*ppm*	*ppm*	*days*	*ppm*	*ppm*	*days*	*ppm*	*ppm*	*days*
DCNA (2 lb/100 gal)	57.2	10.3	4.4	72.8	30.7	10.4	21.7	6.1	8.7	25.8	11.6	9.4
DCNA (1 lb/100 gal)	32.4	2.6	3.0	22.1	2.8	4.4	15.2	4.1	8.5	14.8	4.0	5.8
DCNA (0.5 lb/100 gal)	9.4	0.9	3.2	8.6	1.1	4.4	5.4	0.9	6.2	3.7	1.8	10.6
DCNA–Difolatan (1:1 lb/100 gal)	25.4	8.5	6.8	24.6	7.5	7.6	15.0	10.0	28.0	32.0	12.0	7.8
	32.0†	10.0†	....	31.0†	17.0†	....	11.0†	4.0†	....	17.0†	18.0†	....

* Days after chemical application when half of original residue was present. Half-life determined by extrapolation from curves of previous data.
† Difolatan.

treatments applied three times gave the best, and equal, control. The treatments that were best for control of *Monilinia* rot had 10 ppm to 30 ppm DCNA residues.

With dip treatments on 'Halford' peach (table 6), the mixture of DCNA and Difolatan of equal molar concentrations (.0036M) gave significant total disease control, while neither compound alone, at that concentration, gave control. For *Rhizopus* rot, DCNA and DCNA-Difolatan mixtures gave better control than did Difolatan alone. However, the latter does show some merit in control of *Rhizopus*. Difolatan gave significantly better control of *Monilinia* rot than did DCNA after 8 and 11 days in the ripening room; the DCNA-Difolatan mixture was superior to either component alone. The control fruits, which were not dipped in water in this test, showed less disease than did fruit in the DCNA or Difolatan treatments. The superiority of the DCNA-Difolatan mixture could be related to the high DCNA residue at harvest.

Half-life of DCNA and DCNA-Difolatan on peaches. The average half-life of DCNA on 'Fay Elberta' peaches was 3.5 days when residue resulted from spray applications 24 days before harvest, and 6.4 days when it resulted from spray applications 13 days before harvest (table 7). On 'Halford' peaches the average half-life of DCNA was 7.8 days when field sprays were applied 27 days before harvest, and 8.6 days when applications were made 11 days before harvest. The DCNA-Difolatan mixture resulted in a somewhat higher half-life of DCNA residue.

DISCUSSION

Variabilities in performance and amounts of chemical residue were relatively small on fruit sprayed with fungicides from hand guns on a hydraulic sprayer in the field. A continuous air-carrier sprayer might have given more uniform spray coverage and deposit, but to make such an application with an experimental fungicide in a commercial orchard would have required considerably more trees. Hand gun-sprayed plots indicated correlation between DCNA residues and fruit decay.

More than one DCNA application on peaches before harvest proved advantageous in controlling *Rhizopus* and *Monilinia* rots. Less DCNA residue was found on fruits given three sprays of 0.5 pound per 100 gallons than on those given one or two sprays of 2 pounds of DCNA, but disease control in both instances was nearly equal. Better coverage and greater deposit of fungicide on fruits or possible effect of DCNA on the pathogen may account for these findings.

Mixtures of DCNA and Difolatan increased the deposit and half-life of DCNA and could account for the better controls achieved with the mixture than with DCNA sprays alone. The specificity of the chemical on the pathogens was shown. About 10 ppm of Difolatan reduced *Monilinia* rot, and 10 ppm of DCNA were effective against *Rhizopus*. Nineteen to 30 ppm of DCNA controlled *Monilinia* rot. One answer to disease control of fruits under storage or ripening conditions may be mixtures of fungicides that are specific for pathogens such as *Rhizopus, Monilinia, Gilbertella, Botrytis, Alternaria, Aspergillus, Penicillium,* and *Cladosporium.* In this way, high concentrations of chemicals on fruit can be avoided.

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