Chemical Defoliation of Fig Nursery Stock Using Ethephon, Harvade, and D-WK Surfactant[1]

W.A. Dozier, Jr., C.H. Gilliam, and J.W. Knowles[2]
Department of Horticulutre
Alabama Agricultural Experiment Station
Auburn University, AL 36849

Abstract

Application of harvade (2,3 Dihydro-5, 6-dimethyl-1, 4-dithiin 1,1,4 tetroxide) and ethephon (2-chloroethyl phosphonic acid) in combination with Dupont-WK (D-WK) surfactant (principle functioning agent the dodecyl ether of polyethylene glycol) resulted in significant leaf abscission of *Ficus carica*. Two applications at weekly intervals of 200 ppm harvade or 400–800 ppm ethephon in combination with 2% D-WK surfactant resulted in acceptable defoliation without plant injury in two tests. In one test, defoliation was achieved with lower rates of harvade or ethephon but significant plant injury occurred. Plant injury was as great with D-WK applied alone as with the addition of harvade or ethephon.

Index words: Harvade, ethephon, Dupont-WK surfactant, leaf abscission, *Ficus carica*, defoliation

Introduction

Use of a chemical defoliant to induce early leaf abscission would result in a more efficient system of producing fig (*Ficus carica* L.). These sub-tropical plants are produced from field-rooted, hardwood cuttings placed in the field in late winter or early spring. Cuttings produce roots during April and May and start vegetative growth in late May and early June. They grow rapidly, are very succulent in the fall, and as a result are susceptible to cold injury from the first frost. Therefore, the plants must be dug and stored in a protective building prior to the occurrence of freezing temperatures.

Before the plants can be dug, however, all leaves must be removed from the plants. Currently, the leaves are manually stripped from the plants since natural leaf drop doesn't occur until after the occurrence of freezing weather. Hand defoliation is expensive, causes skin irritation to employees from leaf exudates, is time consuming, and results in damage to the bark and buds.

The need for a reliable, non-damaging chemical defoliant for fruit nursery stock is well documented (1, 2, 3, 4, 6). Promising research results using ethephon, harvade, and D-WK surfactant to defoliate other species of fruit nursery stock have been reported (4). Species and cultivars varied considerably in sensitivity to the defoliants, both in leaf abscission and plant injury. The amount of leaf abscission and plant injury for a particular defoliant was dependent on the number of applications and application rate. Starch storage and vegetative growth the following spring was less with early defoliation (1).

This study was conducted to determine the effects of harvade, ethephon and Dupont's D-WK surfactant on chemical defoliation and stem and bud damage of Celeste fig trees.

Materials and Methods

1981 container-grown trees. In 1981, rooted cuttings of Celeste fig were potted in 7.6 l (#2) containers in June and grown outside in full sun. The potting mix was pinebark and sand (4:1 by vol.) amended on a m^3 (yd^3) basis as follows: 3.6 kg (6 lb) of dolomitic limestone; 2.4 kg (4 lb) of Esmigran® (micronutrient), 0.6 kg (1 lb) of superphosphate; and Aqua-Gro® (wetting agent). Osmocote® 18N-2.5P-10K (18-6-12) was topdressed 3 wk after potting at the rate of 15 g (0.529 oz.) per container.

Spray applications of defoliants were applied to runoff using a hand held sprayer. Two applications of the defoliants were made, the first on October 21 and the second on October 28. Harvade and ethephon were each applied at rates of 200, 400, 800, and 1,600 ppm with Dupont's D-WK surfactant added to each treatment at the rate of 2% (v/v). All leaves remaining on the plants were removed by hand on November 15 and the plants were placed in a cooler held at 3°C (38°F) to satisfy the plant's chilling requirement. Plants were removed from the cooler on January 15 and placed in the greenhouse to initiate vegetative growth. The plants were evaluated for terminal bud injury resulting from the spray treatments on March 5, 1982.

1982 container-grown trees. In 1982, container plants were grown and handled with the same procedures used in 1981. Defoliants were applied either as single or double application of treatments. The single application treatments and the first application of the double application treatments were applied on October 4, 1982, and the second application of the double application treatments was applied on October 19, 1982. Treatments were applied to the point of runoff with a hand held sprayer. Harvade was applied at the rates of 50, 100, 200 and 400 ppm. Ethephon was applied at rates of 200, 400, 800, and 1600 ppm. All defoliant treatments contained 2% D-WK surfactant (v/v). A nontreated control was maintained in the study. Plants were rated for percent defoliation and injury on October 19. On October 28 the plants were placed in a cooler and held at 3°C (38°F) until January 2, 1983, when they were moved to a greenhouse for forcing new growth. The plants were evaluated for shoot dieback and number and length of new shoots on February 24, 1983.

[1]Received for publication November 4, 1986; in revised form March 30, 1987.

[2]Professor, Associate Professor, and Research Associate, Department of Horticulture, resp.

1982 field-grown nursery stock. In 1982, field grown fig nursery stock was treated with one or two applications of defoliants to the point of runoff with a hand held sprayer. The single application treatments and the first application of the double treatments were applied on October 14 and the second application of the double treatments was applied on October 21. At each treatment date, harvade was applied at rates of 100, 200, and 400 ppm and ethephon was applied at rates of 100, 200, and 300 ppm. Each treatment of the defoliants contained 2% D-WK surfactant (v/v). A non-treated control and a 2% D-WK surfactant (v/v) treatment were included in the study. On October 28, the plants were rated for percent defoliation, dug and potted in #2 containers using the same medium used in the 2 previous tests. The plants were placed in a cooler and held at 3°C (38°F) until January 2, 1983, when they were moved to the greenhouse to force new growth. Data were collected on shoot dieback and number and length of new shoots on February 24, 1983.

Treatments in each experiment were replicated 4 times with 10 plants per replication in a randomized complete block design. Data were analyzed by analysis of variance, and treatments were compared with linear contrasts and orthogonal polynomials (5).

Results and Discussion

Defoliation. The results of these investigations indicate that fig grown under nursery conditions can be successfully defoliated with either ethephon or harvade combined with D-WK surfactant. Defoliation was rapid, with most leaves abscissing within 7–10 days after application of the defoliants. In 1981, complete defoliation was achieved with all harvade treatments, while a linear response to ethephon rates occurred (Table 1). The three higher rates of ethephon resulted in adequate defoliation, because all but the small, younger leaves near the shoot terminals were defoliated.

In 1982, the lower rates of harvade resulted in nearly complete defoliation following 2 applications (Table 2). However, one harvade application was not as effective as 2 applications and the percentage of defoliation achieved was linear with single rates of application. The 800 and 1600 ppm ethephon treatments applied twice resulted in effective defoliation. Two applications of 200 and 400 ppm ethephon resulted in 75 and 83% defoliation with no apparent plant injury. There was a linear response for defoliation from the ethephon rates applied twice but not with the single application.

In the 1982 field study, all harvade treatments resulted in 100% defoliation (Table 3). Ethephon was not as effective a defoliant as harvade except where ethephon was applied twice at the 300 ppm rate. Greater defoliation resulted from 2 applications of ethephon than one, at all rates of application. A linear response to rate of ethephon application was evident for both one and two applications. A high degree of defoliation occurred from the D-WK surfactant treatment.

Plant injury. Injury that occurred was not evident until the following spring when the plants initiated growth. In the case of container grown plants, injury did not occur the first season and was only slight the second season. Since the injury that did occur was slight, removal at the time of transplanting would have little effect on future plant shape or size. In the spring following treatment, terminal injury was evident on plants treated with 400, 800, and 1600 ppm treatments of harvade (Table 1). However, no injury was evident in the ethephon + D-WK or D-WK surfactant only

Table 1. Effect of harvade, ethephon and Dupont-WK (D-WK) surfactant on defoliation and plant injury of container-grown Celeste fig nursery stock, 1981.

Chemical	Rate (ppm)	% Defoliation	% Terminals[z] injured	Length of injury (cm)
Harvade	200	100.0	0.0	0.0
	400	100.0	13.3	2.4
	800	98.8	62.6	4.9
	1600	100.0	62.0	6.3
Ethephon	200	33.8	0.0	0.0
	400	83.8	0.0	0.0
	800	93.8	0.0	0.0
	1600	98.8	0.0	0.0
Water	0	1.2	0.0	0.0
D-WK	2%	42.5	0.0	0.0

Statistical Analysis

Comparison	% Defoliation	% Terminals injured	Length of injury
Water vs. others	**[y]	**	**
D-WK vs. others	**	**	**
Harvade vs. Ethephon	**	**	**
Harvade linear	NS	**	**
quad.	NS	**	**
Ethephon linear	**	NS	NS
quad.	**	NS	NS

[z]The number of shoot terminals from the previous season's growth and the length of dieback was determined on March 5, 50 days after placing the plants in the greenhouse to force new shoot growth.

[y]** interactions significant at the 0.01 level; * interactions significant at the 0.05 level using the F test.

Table 2. Effect of harvade, ethephon, and Dupont-WK (D-WK) surfactant on defoliation and plant injury of container-grown Celeste fig nursery stock, 1982.

Chemical	Rate (ppm)	% Defoliation		% Terminals injured[z]		Length of injury (cm)[z]	
		1 appl.	2 appl.	1 appl.	2 appl.	1 appl.	2 appl.
Harvade	50	45.0	97.5	26.0	54.8	5.4	3.8
	100	51.2	96.2	29.9	61.6	5.4	3.6
	200	73.8	96.2	55.0	88.1	5.7	5.8
	400	71.2	98.8	65.0	93.3	4.8	8.1
Ethephon	200	18.8	75.0	0.0	38.7	0.0	5.1
	400	16.2	82.5	0.0	49.3	0.0	2.8
	800	18.8	98.8	5.3	83.9	1.2	7.0
	1600	30.0	98.8	18.8	96.4	3.4	5.8
D-WK	2%	2.5	2.5	12.7	5.2	1.8	0.6

Statistical Analysis

Comparison	% Defoliation			% Terminals injured			Length of injury		
	Total	Within 1 appl.	Within 2 appl.	Total	Within 1 appl.	Within 2 appl.	Total	Within 1 appl.	Within 2 appl.
No. applications	**[y]	—	—	**	—	—	*	—	—
D-WK vs. others	**	**	**	**	NS	**	*	NS	*
Harvade vs. Ethephon	**	**	*	**	**	NS	**	**	NS
Harvade linear	**	**	NS	**	**	**	NS	NS	NS
quad.	NS	*	NS	NS	NS	NS	NS	NS	NS
Ethephon linear	**	NS	**	**	NS	**	NS	NS	NS
quad.	NS	NS	**	NS	NS	NS	NS	NS	NS
Chem. X appl.	**	—	—	**	—	—	NS	—	—

[z]The number of shoot terminals from the previous season's growth and the length of dieback was determined on February 24, 54 days after placing the plants in the greenhouse to force new shoot growth.

Table 3. Effect of harvade, ethephon, and Dupont-WK (D-WK) surfactant on defoliation and plant injury of field-grown Celeste fig nursery stock, 1982.

Chemical	Rate (ppm)	% Defoliation		% Terminals injured[z]		Length of injury (cm)[z]	
		1 appl.	2 appl.	1 appl.	2 appl.	1 appl.	2 appl.
Harvade	100	100.0	100.0	86.7	66.7	32.1	39.5
	200	100.0	100.0	100.0	100.0	45.5	57.4
	400	100.0	100.0	100.0	86.7	47.2	54.4
Ethephon	100	31.7	66.7	60.0	86.7	2.0	26.4
	200	60.0	91.7	60.0	100.0	14.8	16.9
	300	75.0	96.7	60.0	100.0	11.4	27.0
Water	0	5.0	6.7	33.3	20.0	6.8	6.3
D-WK	2%	56.7	93.3	93.3	100.0	24.2	34.7

Statistical Analysis

Comparison	% Defoliation			% Terminals injured			Length of injury		
	Total	Within 1 appl.	Within 2 appl.	Total	Within 1 appl.	Within 2 appl.	Total	Within 1 appl.	Within 2 appl.
No. applications	**[y]	—	—	NS	—	—	**	—	—
Water vs. others	**	**	**	*	**	**	**	*	**
D-WK vs. others	NS	**	NS	*	NS	NS	NS	NS	NS
Harvade vs. Ethephon	**	**	**	NS	**	NS	**	**	**
Harvade linear	NS	NS	NS	NS	NS	NS	NS	NS	NS
quad.	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ethephon linear	**	**	**	NS	NS	NS	NS	NS	NS
quad.	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chem. X appl.	**	—	—	NS	—	—	NS	—	—

[z]The number of shoot terminals from the previous season's growth and the length of dieback was determined on February 24, 54 days after placing the plants in the greenhouse to force new shoot growth.

[y]Interactions significant at the 0.01 level; * interactions significant at the 0.05 level using the F test.

treated plants. Plant injury was related linearly to harvade rates.

In the 1982 container study, plants treated with all rates of harvade exhibited injury to the shoot terminals. The amount of injury was linear to the rate applied for both one and two applications. The single application of 200 and 400 ppm ethephon did not result in any plant injury, but slight injury was evident from the 800 and 1600 ppm single application treatments. All ethephon rates applied twice resulted in injury to the shoot terminals and the degree of injury was linear with rates.

Slight defoliation occurred from the 2% D-WK surfactant only treatment, and injury to the shoot terminals was evident. However the injury was greater with the single application than with the two applications of D-WK surfactant.

Injury was greater with the 1982 field grown material; all defoliation treatments resulted in a high degree of injury to the shoot terminals. This was probably due to the occurence of rain accompanied by growth late in the season following an extended dry spell. The terminal growth of the field grown plants was still succulent, whereas the container grown plants had hardened off. Less injury occurred from a single application of ethephon than from a single application of harvade. However, the percentage injury to shoot terminals did not differ between ethephon and harvade as a result of the two applications of each material. The length of shoot dieback was less for ethephon treatments than for harvade treatments. There were no significant effects from harvade or ethephon with respect to the number and length of new shoots or time of initiation of growth the spring following treatment (data not shown).

A good chemical defoliant has been reported to be one that would result in at least 50% defoliation in 2–3 weeks, inexpensive and easy to apply, and not injurious to the treated plant (6). Defoliation studies conducted with harvade plus D-WK surfactant and ethephon plus D-WK surfactant have achieved these goals on other fruit nursery stock, such as applies, peaches, pears, and cherries (3, 4). Our data concur in that greater than 50% defoliation occurred in 7–10 days and injury was less than from normal pruning at planting (except 1982 field study). Therefore, it appears these harvest aids have potential for defoliation of fig nursery stock, but the plants should be sufficiently hardened off prior to treatment application. The best treatments were 2 applications of harvade at 200 ppm and ethephon at 400–800 ppm which resulted in complete defoliation of the container grown nursery stock and 2 applications of harvade at 100 ppm and ethephon at 200 ppm which resulted in complete defoliation of the field grown stock. Higher rates of ethephon than harvade were necessary to achieve adequate defoliation. In general, less plant injury occurred from ethephon than from harvade.

Significance to the Nursery Industry

Field-grown fig was successfully chemically defoliated with 2 applications of harvade at 100 ppm or ethephon at 200 ppm. Each defoliant treatment should contain 2% D-WK surfactant (v/v). Chemical defoliation eliminated the expensive and time consuming process of hand defoliation and eliminated skin irritation for employees from leaf exudations. Damage to the nursery stock from the defoliates was generally less than observed to bark and buds as a result of hand defoliation. Terminal injury from the defoliants was restricted to the upper portion of the shoot that is normally removed at transplanting and there were no treatment effects on number of vegetative shoots developing or shoot vigor the following spring.

(**Ed. Note.** This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and federal authorities.)

Literature Cited

1. Abusrewil, G.S., F.E. Larsen, and R. Fritts, Jr. 1983. Prestorage and poststorage starch levels in chemically and hand-defoliated 'Delicious' apple nursery stock. J. Amer. Soc. Hort. Sci. 108:20–23.

2. Knight, J.N. 1983. Chemical defoliation of nursery stock using chelated forms of copper and iron. J. Hort. Sci. 58:471–476.

3. Larsen, F.E. 1973. Successful defoliation of nursery stock with chemicals. Proc. Intern. Plant Prop. Soc. 23;62–70.

4. Larsen, F.E. and G.D. Lowell. 1977. Tree fruit nursery stock defoliation with harvest aid chemical and surfactant mixtures. HortScience 12:580–582.

5. Steel, R.G. and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill. N.Y. pp. 336–376.

6. Still, S.M. 1976. Defoliation of nursery stock for early harvest. Proc. Intern. Plant Prop. Soc. 26:255–259.