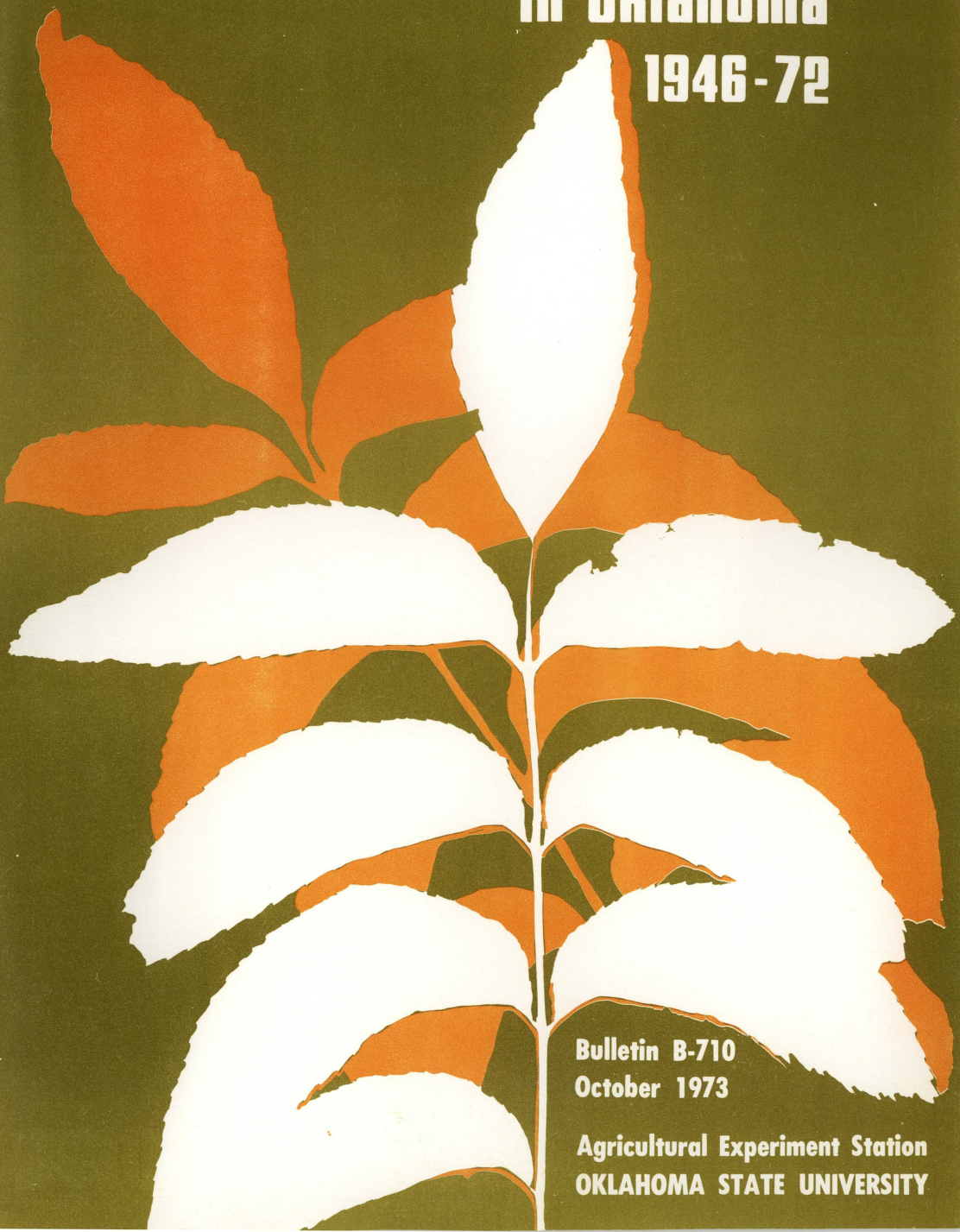
Control of Pecan Scab in Oklahoma 1946-72



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CONTENTS

Fungicide Formulations

Trade name	Active ingredient	Recommended rate/100 gallons of spray mix
	(Percent)	
Cyprex 65W	65 dodine	8 oz.
Cyprex 80W	80 dodine	6.5 oz.
Du-Ter	47.5 triphenyl tin hydroxide	8 oz.
Manzate D	80 maneb plus a zinc salt	2 lbs.
Manzate 200	80 maneb and zinc ions	2 lbs.
Dithane M-45	80 maneb and zinc ions	2 lbs.
Dithane Z-78	78 zineb	2 lbs.
Parzate C	76 zineb	2 lbs.
Polyram 80WP	80 "metiram"	2 lbs.
Benlate 50WP	50 benomyl	6 oz.

- Fungicides do **not** need to be applied during very long dry periods.
- When very rainy periods or long dew periods occur, the trees should be sprayed about every 14 days except for Benlate which need be applied only every 4-5 weeks.
- Spraying should begin early in May and end in early September.

NOTE:

- **None of the suggested materials should be used where meat or dairy animals will be grazing.**
- **Cyprex may injure foliage of trees of the Moore or Van Deman cultivars.**
- **The suggested materials are compatible with wettable powder formulations of suggested insecticides.**
- **If liquid formulations of insecticides are to be used, first determine if the mixture is compatible.**

Control of Pecan Scab In Oklahoma, 1946-1972

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Pecan scab, caused by the fungus, *Fusicladium effusum* (37), is a limiting factor in the production of pecans throughout most of the pecan belt of the United States. Scab causes considerable loss of nuts and foliage from unsprayed treees of susceptible cultivars (varieties). Infection by spores of the fungus occurs during periods when rains and dew periods are frequent.

Primary infections first appear as olive brown to black pin point lesions on the nuts or on the veins on the undersides of leaflets. The pin point lesions enlarge and may coaleace. Later with the occurrence of secondary lesions resulting from infections caused by spores produced on the primary lesions, large areas of the leaflets or nuts may be blackened (Fig. 1). On nuts, lesions frequently become sunken causing malformations and nuts of highly susceptible cultivars may become black and drop prematurely. Infected nuts that don't drop are usually of poor quality and may be unmarketable.

Because the fungus overwinters in diseased nut shucks and twigs, it is necessary to follow a spray program each season and an effective spraying program is required for commercial production of nuts from scab-susceptible trees during most seasons. Effective scab control programs have been developed through many years of research with promising new fungicidal materials.

Most of the screening research with new fungicidal formulations was conducted by R. H. Converse and G. L. Barnes, former and present pecan pathologists, respectively, of the Department of Botany and Plant

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Pathology. Other testing was done by H. A. Hinrichs, Horticulture Department, at various locations in the state.

Though various requirements varied the research program in Oklahoma from year to year, some procedures were usually very similar. Depending on the age of trees (and corresponding size), 25 to 35 gallons of spray mix were applied to individual trees at each spraying date. Frequency of application varied with the type of experiment and usually ten trees per treatment were used. Appropriate insecticides were applied at recommended times and rates for insect control. Hydraulic spray machines were used in the early work but a speed sprayer (John Bean 703 CP) was used in more recent years.

This publication reports results of 26 years of research on pecan scab control in Oklahoma and describes the fungicidal materials used, the test results, and the spray programs and sanitary practices currently suggested to achieve control of scab and some other diseases of pecans.

Fungicide Tests

1946-1952

Various fungicidal sprays and dusts were first applied to pecan trees for control of pecan scab in the humid southeastern United States during 1909 by Waite (43). Bordeaux mixture (reaction products of copper sulfate and hydrated lime in water) (38) was found, in early tests, to be very effective though somewhat phytotoxic (25). A reduction in the amount of lime used in preparation of the mixture was found to prevent injury (15). Even though it has several disadvantages, Bordeaux mixture is still included on lists of suggested materials in the southeast.

In the southwestern pecan areas, Bordeaux mixture was first tested in Texas during the early 1940's (40). Ray (39) tested it in Oklahoma during 1945 and 1946 and found it effective. Ray's results were confirmed by Hinrichs (29,30) and Hinrichs and Bieberdorf (33,34) during the 1946, 1947, and 1948 seasons in Oklahoma. It was found in Texas that even low-lime Bordeaux mixture sometimes injured pecan leaves and nuts during very hot, dry weather and increased aphid populations (40). In addition, preparation of Bordeaux mixture is time consuming and sometimes messy. A more suitable fungicide was needed for control of pecan scab.

Beginning in the late 1940's many new fungicidal compounds were synthesized by chemists in various industrial firms and several of the more promising ones were evaluated for pecan scab control by a number of investigators. Hinrichs and Bieberdorf (34) reported on the successful

Figure 1.—Pecan scab lesions on nuts of the Burkett cultivar.

control of scab in Oklahoma with ziram[1] during the 1947 season. Earlier, Cole (14) had demonstrated the effectiveness of ziram for scab control in Louisiana and Georgia during the 1946 and 1947 seasons, respectively. During 1948, Cole (15) reported that ferbam was not as effective as Bordeaux mixture during the 1942, 1943, and 1946 seasons in Georgia.

The first testing of ferbam for scab control in Oklahoma was made by Hinrichs (30) in 1949, but it was not as effective as ziram or Bordeaux mixture. In the same test, a formulation of zineb (Parzate) provided poor control, and ziram in another test during the same season, but under very wet conditions, was ineffective. During 1950, Rosberg (40) in Texas found that another zineb formulation (Dithane Z-78) provided control equivalent to that provided by Bordeaux mixture and provided better control than that given by either ferbam or ziram. Differences in formulation between the two zineb products at the time may have accounted for the failure of one of them to provide control in the Oklahoma test by Hinrichs. Both formulations have provided excellent control in many subsequent tests by investigators in several states, and were subsequently suggested for grower use. Rosberg (40) also noted

[1]Coined names, trades names and manufacturers of all commercial fungicides mentioned in this report are presented in Table 1. Mention of a trade name does not constitute a guaranty or warranty of the product named and does not signify that it is approved to the exclusion of other comparable products.

Table 1. Commercial and experimental eradicant and protectant fungicides used in pecan scab control tests at Paden or Stillwater, Oklahoma, 1946-1972.

Trade Name	Coined name and percent active ingredient	Manufacturer (abbreviated name)
Corona CM220	80% monocalcium arsenite	Pittsburgh Plate Glass
Elgetol	19% sodium dinitroortho-cresolate, 5% sodium butyl naphthalene sulfonate, and 2% sodium chromate	Standard Agr. Chem. Co.
Dormant Fungicide	37% sodium pentachlorophenate and 5.5% sodium salts of other chlorophenols	United Chem. Co.
Bordeaux mixture	Reaction products of copper sulfate and hydrated lime in water	Prepared on farm
Zerlate	76% ziram (zinc dimethyldithiocarbamate)	du Pont
Niacide Z	59.8% ziram plus 5.2% mercaptobenzothiazole	Niagara
0-3818B	2.8 parts zineb + 1.0 part NICl · $4H_20$	Rohm & Haas
Fermate	76% ferbam (ferric dimethyldithiocarbamate)	du Pont
Dithane Z-78	76% zineb (zinc ethylenebis dithiocarbamate)	Rohm & Haas
Parzate	65% "	du Pont
Parzate C	76% "	du Pont
Manzate	70% maneb (manganese ethylenebis dithiocarbamate)	du Pont
Thylate	65% thiram (tetramethylthiuram disulfide)	du Pont
Thioneb	50% polyethylene thiuram disulfide)	U.S. Rubber
Phaltan	50% folpet (N-trichloromethyl thiophthalimide)	Calif. Chem.
Dyrene 50WP	50% 2,4-dichloro-6-(o-chloro-anilino) triazine	Chemagro
Cyprex 65WP	65% dodine (n-dodecyl guanidine acetate)	Amer. Cyanamid
Amobam	41% diammonium ethylene bis dithiocarbamate	Roberts Chemicals
Dibam A	41.7% ammonium dimethyl dithiocarbamate	Roberts Chemicals
OCMM-1763	50% 2-chloroacetaldehyde (2,4- dinitrophenyl) hydrazone	Olin Mathieson
GC-2466	50% mucochloric anhydride	Allied Chem.
Polyram 80WP	80% of 5.2 parts by weight (83.9%) of ammoniates of ethylene bis (dithiocarbamato) zinc with 1 part by weight (16.1%) of ethylene bis (dithiocarbamic acid) bimolecular and trimolecular cyclic anhydrosulfides and disulfides	Niagara

Table 1. Continued

Trade Name	Coined name and percent active ingredient	Manufacturer (abbreviated name)
Dithane M-45	80% coordination product of manganese ethylene bis dithiocarbamate and zinc ions.	Rohm & Haas
Manzate D	80% maneb plus a zinc salt	du Pont
TC-90	48% copper salts of fatty and rosin acids	Tenn. Corp.
Du-Ter 20W	20% triphenyl tin hydroxide	Thompson-Hayward
Du-Ter	47.5% triphenyl tin hydroxide	Thompson-Hayward
Brestan 60	50-54% triphenyl tin acetate plus 20% maneb	Amer. Hoechst
Kocide 101	87% cupric hydroxide	Kennecott
Manzate 200	80% coordination product of zinc and manganese ethylene bis-dithiocarbamate	du Pont
Difolatan	80% cis-N-(1,1,2,2,-tetrachloroethyl thio-4-cyclohexene-1,2-dicarboximide	Chevron Chem.
F-1991	50% benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate)	du Pont
Benlate	"	du Pont
Cyprex 80W	80% dodine (n-dodecyl guanidine acetate)	Amer. Cyanamid
EL-273	10% α-(2,4-dichlorophenyl)-α-phenyl-5-pyrimidinemethanol	Elanco
Topsin M	70% dimethyl 4,4'-o-phenylene bis (3-thioallophanate)	Pennwalt

that smaller aphid populations developed in zineb-sprayed trees than on Bordeaux-sprayed trees.

1953-1957

Many new fungicide formulations were tested during the 1953-1957 period by R. H. Converse for efficacy as eradicant (contact) or protectant materials for control of pecan scab. All test materials were applied with a single nozzle spray gun operated from a conventional hydraulic spray machine operated at 600-800 psi.

F. effusum survives the winter months in masses of thick walled cells (stroma) formed in lesions on twigs, nut shucks and leaflets. During the spring, spores are abundantly produced on the stroma. Several workers have investigated the possibility of control of pecan scab by attempting

Table 2. Increase in scab on nut shucks of Squirrel cultivar trees sprayed with dormant season eradicants followed by full season protectant applications of Zerlate. (Modified from Converse (20).

Fungicide treatment					
Eradicant formulation (March 21, 1953)	Protectant formulation (Full season)	Number of lesions per nut			Percent area scabbed on mature nuts
		June 25	July 28	Aug. 28	Sept. 25
Corona CM220 3 lbs/100 gals.	Zerlate, 2 lbs/100 gals	0	3.70	45.6	21.4
Elgetol 1 gal/100 gals.	"	0	2.44	72.1	29.7
United Chemical Dormant Fungicide 4 lbs/100 gals.	"	0	1.15	70.5	34.1
None (Check	—		6.22	183.3	47.6
LSD (5%)			5.46	51.0	
LSD (1%)				73.4	

to kill the stroma by application of eradicant materials during the dormant period. Converse (20) reviewed the work through 1953.

The results from the early trials with Bordeaux mixture, lime sulfur and dinitrophenolic compounds indicated that even though they killed the sprayed stromata in the trees they did not prevent development of scab during the growing season. Stromata on fallen nut shucks and twigs on the orchard floor produced sufficient spores to initiate the disease cycle. Other workers used eradicants during the dormant season plus a reduced summer protectant program but did not achieve control any better than that provided by a full summer protectant program. Additional eradicant type materials were evaluated by Converse (21,22) during the 1953-57 seasons with comparable results. Graves (27) had comparable results in Mississippi during 1958. Because of the lack of demonstrated effectiveness of any programs including an eradicant, no work with eradicants was planned.

Converse (19) tested zineb and maneb in a comparative test with Bordeaux mixture in a test of protectants during the 1953 season on the Barney Brown (formerly George Spraberry) farm near Paden, Oklahoma[2]. All of the test materials provided good control during this dry season (Table 3). During 1957, Converse (23) compared the effective-

[2]Fungicide trials have been conducted continuously on this farm since 1953 on scab-susceptible Western and Squirrel trees. The cooperation of Mr. George Spraberry, present manager, and the help of Ralph Molsby, Claude Hughes and Bob Moseley, successive operators, is greatly appreciated and hereby acknowledged.

Table 3. Effectiveness of certain protectant fungicides for pecan scab control on Western cultivar trees, 1953.[1]

Fungicide formulation	Lbs./100 gals. of spray material	Percent area of shucks of mature nuts with scab lesions
Dithane Z-78	2	1.2
Manzate	2	1.3
Bordeaux mixture (copper sulfate + lime)	6+2	1.6
Zerlate	2	6.1
None (Check)	—	62.4

[1]Date from Converse (19).

ness of maneb, zineb, ziram, thiram, folpet, Dyrene 50W and Thioneb as protectants. All of the dithiocarbamic acid derivatives (maneb, zineb and ziram) and Dyrene 50W provided excellent control during this relatively dry season. Folpet provided fairly good control, but thiram and Thioneb were not very effective (Table 4), and all three materials were withdrawn from further testing.

1958-1972

All of the materials tested from 1958 through 1962 were applied with a single-nozzle spray gun from a conventional hydraulic spray machine operating at 600 to 800 psi. Approximately 20 gallons of spray were applied to each mature tree at each spraying date. All materials

Table 4. Effectiveness of certain protectant fungicides for scab control on Western cultivar pecan trees, 1957[1]

Fungicide formulation[2]	Pounds of formulation per 100 gallons of water	Average percent area of nut shuck scabbed
Dyrene 50W	3.0	0.0
Manzate	2.2	0.2
Dithane Z-78	2.3	0.5
Zerlate	2.0	0.7
Phaltan	2.0	1.9
Thioneb	1.5	3.4
Thylate	2.3	4.4
None (Check)	—	12.9

[1]Date from Converse (23)
[2]Sprayed five times

tested from 1963 through 1972 were applied with a conventional speed sprayer (John Bean CP 703) equipped with a pecan volute to ensure good coverage of trees from top to bottom. Approximately 25 gallons of spray were applied to each mature tree at each spraying date during the 1963-1967 seasons. Beginning in the 1968 season 25 and 30 gallons of spray were applied to each test tree at each spraying.

During the very wet 1958 season, Barnes (1,2) tested zineb, ziram, and maneb formulations and Dyrene 50W at Paden. Dyrene 50W and zineb provided excellent control, maneb gave poor control and ziram was relatively ineffective (Table 5). The results with zineb, ziram and maneb agree with those obtained by Large (35) in Florida during many years of testing. After the 1958 test, zineb formulations were recommended for scab control in Oklahoma and the ziram and maneb formulations were withdrawn from the list of materials suggested for use because of their poor performance in Oklahoma, and other states (35), under very wet conditions.

During 1959, a new fungicide, dodine, which had provided excellent scab control in Georgia during 1958 (16,17) was tested in Oklahoma along with zineb, ziram, Dyrene 50W, Amobam, Dibam A and Bordeaux mixture (3,4). Dyrene 50W, dodine, Bordeaux mixture and zineb provided excellent control but Amobam, Dibam A and ziram were ineffective (Table 6). Though dodine and Dyrene 50W were effective in this, and in previous tests, they could not be suggested for use on pecans during the 1960 season because residue tolerances and application limitations on pecans were not yet established by the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA).

Table 5. Effectiveness of certain protectant fungicides for controlling scab on Squirrel cultivar pecan trees, Paden, Oklahoma, 1958.

Fungicide formulation[1] (1.5 pounds active ingredient/100 gal. of spray material)	Weight of 50 nuts with shucks[2] (grams)	Average shuck surface scabbed[2] (percent)	Nuts per pound (11/21)
Dyrene 50W	269.9	22	113
Parzate	222.9	20	114
Manzate	123.9	60	162
Zerlate	36.4	96	207
None (Check)	10.4	100	0[3]

[1]Eight application: 5/7, 6/2, 6/27, 7/9, 7/30,, 8/12, 9/2 and 9/18.
[2]Ten nuts from each of five trees per treatment. Samples obtained on 10/6.
[3]Nuts were so diseased and small and had such tightly-adhering shucks that samples could not be obtained.

Table 6. Effectiveness of certain protectant fungicides for scab control on Western cultivar pecan trees in Oklahoma, 1959.

Treatment[1]			
Fungicide formulation	Rate/100 gallons of spray material	Scab control rating (foliage and nuts)[2]	Average number of nuts per pounds[3]
Fungicide	3 lb.	Excellent	58
Parzate + Standard Superla Summer Oil	3 lb. + 1 pt.	Excellent	67
Dithane Z-78	3 lb.	Excellent	57
Tank mix zineb (nabam + $ZnSO_4$)	2 qt. + 1125 lb.	Excellent	74
Zerlate	3 lb.	Very Poor	112[4]
Niacide Z	4 lb.	Very Poor	124[4]
Tank mix ziram (Dibam A + $ZnSO_4$)	1 qt. + 1.25 lb.	Poor	93[4]
Bordeaux mixture ($CuSO_4$ + lime)	6 lb. +2 lb.	Good	78
Dyrene 50W	4 lb.	Excellent	64
Cyprex 65W	1 lb.	Excellent	84
Cyprex + Standard Superla Summer Oil	1 lb. + 1 pt.s	Excellent	62
Dibam A	1 qt.	Very Poor	146[4]
Amobam	1 qt.	Very Poor	108[4]
None (Check)	------	------	215[5]

[1]Two-week schedule. Nine applications (4/24, 5/7, 5/20, 6/3, 6/18, 7/2, 7/16, 7/31 8/14)
[2]Determined in October.
[3]Nuts collected, weighed and counted on November 5 and 6. Disease-free Western variety nuts will usually average between 60 and 65 nuts per pound.
[4]Nuts only partially filled and not marketable.
[5]Unfilled nuts with tightly-adhering, scab-blackened shucks.

During the 1960 season, three fungicides (zineb, dodine, and Dyrene 50 W) singly and in conjunction with an adjuvant (spreader-sticker or sticker), were evaluated for scab control (5). Adjuvants are usually relatively inert materials added to a spray mix to improve the physical characters of the toxicant by improvement of the physical factors to increase effectiveness of the toxicant (41). Each fungicide alone, and in conjunction with an adjuvant, provided equivalent commercial control (Table 7). The addition of an adjuvant, at the rates tested, did not improve the efficiency of any of the fungicides. Because of its effective-

Table 7. Effectiveness of certain protectant fungicides for scab control on Western cultivar pecan trees at Paden, Oklahoma, 1960.

Fungicide formulation	Rate/100 gallons of spray	Application interval	Average no. of nuts/lb.[1] (11/8/60)
Parzate	3 lb.	2 wk.[2]	58
Cyprex 65W	1 lb.	"	61
Dyrene 50W	4 lb.	"	58
Parzate	3 lb.	3 wk.[3]	63
Cyprex	1 lb.	"	64
Dyrene 50W	4 lb.	"	67
Parzate + Plyac	3 lb. + 2 oz.	"	61
Parzate + du Pont Sticker Spreader	3 lb. + 2 oz.	"	59
Parzate C + Esso LO-3328	3 lb. + 1 qt.	"	62
Cyprex + Plyac	1 lb. + 2 oz.	"	67
Cyprex + P.e.p.s.	1 lb. + 8 oz.	"	65
Dyrene + Plyac	4 lb. + 2 oz.	"	62
Dyrene + P.e.p.s.	4 lb. + 8 oz.	"	63
Dithane Z-78 + P.e.p.s.	3 lb. + 8 oz.	"	62
None (Check)	------	------	90[4]

[1]Disease-free Western variety nuts usually average between 60 and 65 nuts per pound.
[2]Eight applications: 5/9, 5/23, 6/6, 6/20, 7/5, 7/18, 7/29, and 8/15.
[3]Five applications: 5/10, 5/31, 6/21, 7/12, and 7/29.
[4]Nuts incompletely filled and non-marketable.

ness, and FDA and USDA approval for use on pecans, dodine was added to the list of suggested materials for scab control in Oklahoma during 1961.

Results from tests conducted during the 1961 and 1962 seasons confirmed the effectiveness of zineb and dodine fungicides (Tables 8 and 9) whereas two experimental materials, OMCC-1763, and GC-2466, were ineffective (6).

During the 1963 season, Dyrene 50W, dodine, zineb, and an emulsifiable copper fungicide (TC-90), and a formulation containing both maneb and zinc ions (Dithane M-45) were tested (6). All of the materials provided excellent control (Table 10). Dyrene 50W, though

Figure 2. Pecan scab lesions on foliage of the Burkett cultivar.

Table 8. Effectiveness of certain protectant fungicides for scab control on Squirrel cultivar pecan trees at Paden, Oklahoma, 1961.

Treatment		Average no. of nuts per pound
Fungicide formulation	Lbs./100 gallons of spray[1]	
Cyprex 65W	½	68
Cyprex 65W	1	76
Parzate C	2	70
Dithane Z 78	2	68
OMCC-1763	2	114
GC-2466	1	132
None (Check)	—	151[2]

[1]Seven applications: 5/10, 5/24, 6/8, 6/22, 7/6, 7/20, and 8/3.
[2]Nuts incompletely filled and non-marketable.

Table 9. Effectiveness of certain protectant fungicides for scab control on Squirrel cultivar pecan trees at Paden, Oklahoma, 1962.

Treatment			Average number of nuts/lb.
Fungicide formulation	Lbs./100 gallons of spray	Application interval (weeks)	
Cyprex 65W	½	2	66
Cyprex 65W	½	3	72
Cyprex 65W	1	2	74[1]
Cyprex 65W	1	3	70
Cyprex 65W	1	4	71
Dithane Z-78	2	2	66
Dithane Z-78	2	3	76
None (Check)	—	—	—[2]

[1]Much stinkbug damage resulted in many lightweight nuts in the treatment.
[2]Nuts not weighed. These trees were inadvertantly sprayed several times with fungicides.

Table 10. Effectiveness of certain protectant fungicides for scab control on Squirrel cultivar pecan trees at Paden, Oklahoma, 1963.

Treatment Fungicide formulation	Rate/100 gallons of spray material[1]	Average no. of nuts per pound[2]
Dithane Z-78	2 lbs.	57
Dithane M-45	2 lbs.	56
Dyrene 50W	2 lbs.	56
Dyrene 50W	4 lbs.	58
Cyprex 65W	½ lb.	52
Cyprex 65W + Plyac	½ lb. + 4 oz.	55
TC-90	¾ gal.	57
None (Check)	------	112[3]

[1]Two-week application interval. Eight applications: 5/1, 5/15, 6/12, 6/26, 7/10, 7/24, 8/7, and 8/21.
[2]Disease-free Squirrel variety nuts usually average between 55 and 60 nuts per pound.
[3]Incompletely filled nuts with blackened, tightly-adhering shucks (non-marketable nuts).

effective, had not yet been approved for use on pecans by FDA and USDA, and could not be added to the list of recommended materials for 1964. Dithane M-45 and TC-90 were retested during the 1964 season to obtain additional data on their effectiveness. Dyrene was later withdrawn from further testing on pecans at the manufacturers request.

During 1964, a new material, Du-Ter 20W, was tested at Paden. Polyram 80WP was also tested as it had provided good control in an exploratory test by Hinrichs at the Pecan Research Station at Sparks, Oklahoma (30). Other materials were included for retesting or as references. All of the fungicides effectively controlled scab under conditions promoting only mild scab development (6) (Table 11). It appeared that Cyprex 65W (65 percent dodine) at ¼ lb/100 gallons of spray (½ lb is suggested) would be effective during "very mild scab" seasons. Dithane M-45 and Polyram 80WP were approved for use on pecans by FDA and USDA and were added to the list of materials suggested for use in Oklahoma.

All of the 1964 materials were retested in 1965, and most of them provided good control including Cyprex at ¼ lb. (7,8) (Table 12). Because TC-90 provided only fair to good control of scab during several years of testing, it was not tested further. In addition, there were problems associated with handling and use of the formulation (a viscous liquid).

Table 11. Effectiveness of certain protectant fungicides for pecan scab control at Paden, Oklahoma, 1964.

Treatment			
Fungicide formulation	Rate/100 gallons of spray material	Application interval (weeks)	Average number of nuts/lb.
Western Cultivar			
Parzate C	2 lb.	2[1]	70
Parzate C + Thylate	1½ lb. + 1 lb.	2	62
Parzate C	1½ lb.	2	62
Dithane Z-78	2 lb.	2	64
Dithane M-45	2 lb.	2	62
TC-90	¾ gal.	3[2]	59
None (Check)	------	--	98[3]
Squirrel Cultivar			
Cyprex 65W	½ lb.	2[1]	54
Polyram 80WP	1½ lb.	2	53
Du-Ter 20W	1 lb.	2	66
Du-Ter 20W	2 lb.	2	54
Cyprex 65W	¼ lb.	3[2]	51
Cyprex 65W	½ lb.	3	51
Cyprex 65W + Plyac Spreader-Sticker	¼ lb. + 6 oz.	3	55
	------	--	79[3]

[1]Application dates: 5/14, 6/4, 6/19, 7/2, 7/20, 8/5, 8/20, and 9/16
[2]Application dates: 5/14, 6/4, 7/20, and 8/20
[3]Incompletely-filled, very poor quality nuts.

During 1966, Brestan 60, triphenyl tin acetate and maneb formulation was tested for the first time in Oklahoma. A new formulation of Du-Ter (47.5 percent TPTH) was tested in place of Du-Ter 20W, at company request, and corresponding lower rates were used. Excellent data were obtained for those materials tested on the Squirrel variety (9,10). Western cultivar trees were heavily damaged by late spring freezes. Many of these trees did not bear and many of the nuts that did form were later damaged by early fall freezes. Because of the absence of a crop on the Brestan 60-sprayed trees, an evaluation of the effectiveness of this material could not be made. The other materials applied to the Western trees appeared to have provided excellent control (9,10) (Table

Table 12. Effectiveness of certain protectant fungicides for pecan scab control at Paden, Oklahoma, 1965.

Treatment		
Fungicide formulation	Rate/100 gallon spray[1]	Average no. of nuts per pound
Squirrel Cultivar		
Cyprex 65W	¼ lb.	59
Cyprex 65W	½ lb.	56
Polyram 80WP	2 lb.	60
Dithane M-45	2 lb.	60
Dithane Z-78	2 lb.	61
TC-90	¾ gal.	77
None (Check)	----	102[2]
Western Cultivar		
Manzate D	2 lb.	70
Parzate C	2 lb.	71
Du-Ter 20W	1½ lb.	72
None (Check)	----	100[2]

[1]Application dates 5/5, 5/19, 6/3, 6/17, 7/3, 7/19, 8/4, 8/19,/ and 9/7
[2]Incompletely filled, very poor quality nuts.

13). Du-Ter (47.5 percent TPTH) was approved for use on pecans by the FDA and USDA during 1966. Because of its effectiveness, it was added to the list of suggested materials for scab control in Oklahoma beginning with the 1967 season.

During 1967, Brestan 60 and Manzate D were retested and a formulation of copper hydroxide, Kocide 101, was tested for the first time in Oklahoma. All of the recommended materials were included as reference compounds. All of the test materials, except Kocide 101, provided good to excellent control (Table 14). A high rate of Brestan 60, for some unexplained reason, did not provide excellent control as did a low rate. Manzate D provided excellent control during the 1965-1967 seasons and it was scheduled for additional testing during the 1968 season.

Kocide 101, because of its poor performance, was withdrawn from further testing. A new fungicide formulation, F-1991, containing benomyl, was given a preliminary screening at Stillwater in the departmental orchard of young Burkett trees. Benomyl attracted a great deal of research interest after it was reported to be a highly effective, wide-spec-

trum, systemic, curative, and protectant fungicide (24). Moderate scab developed on foliage of nonsprayed control (check) trees but no scab disease was evident on foliage of trees sprayed with F-1991 + Surfactant F (8 oz + 4 oz/100 gal equivalent) at 2— and 4— week intervals (11). Control of scab with benomyl applied every 4 weeks prompted an investigation on extended interval applications on mature, bearing trees at Paden.

During 1968, F-1991 and Manzate D were included in the testing program at Paden. F-1991 was applied at 2,4- and 5- week intervals. Previously evaluated fungicide formulations were included as reference materials. The season was very rainy and several times the sprayer could not be pulled through the orchard at scheduled spraying dates. Consequently, valid data could not be obtained. In addition, nut samples were inadequate because many of the trees had a very light crop due to heavy

Table 13. Effectiveness of certain protectant fungicides for pecan scab control at Paden, Oklahoma, 1966.

Treatment		
Fungicide formulation	Rate/100 gallons of spray material	Average number of nuts/lb.
Squirrel Cultivar		
Cyprex 65W	¼ lb.	73
Cyprex 65W	½ lb.	68
Polyram 80W	2 lbs.	62
Dithane M-45	2 lbs.	60
Manzate D	2 lbs.	67
None (Check)	----	216[2]
Western Cultivar		
Brestan 60	½ lb.	63[3]
Brestan 60	¾ lb.	85[3]
Du-Ter	¼ lb.	67[4]
Du-Ter	½ lb.	65[5]
Dithane Z-78	2 lbs.	67
None (Check)	----	159

[1]Spray application dates: 5/18, 6/9, 6/30, 7/30, 8/27, and 9/15.
[2]Very small nuts with tightly-adhering shucks and little or no kernels.
[3]Determined from a single tree. Other trees did not bear. (Late spring frost damage).
[4]Determined from three trees. Other trees did not bear. (Late spring frost damage).
[5]Determined from two trees. Other trees did not bear. (Late spring frost damage).

rains during the pollination period. At Stillwater during the 1968 season, Difolatan and Cyprex were compared at a rate equivalent to 1 pound per 100 gallons. Difolatan did not provide control equivalent to that of Cyprex and was not considered for further testing.

During 1969, Benlate (formerly F-1991), Manzate D and Manzate 200 were tested as experimental fungicides. Benlate was tested at 2- and 4-week application intervals. Polyram 80W and Du-Ter were included as reference suggested fungicides. All tested materials effectively controlled scab (Table 15) (11). Benlate controlled scab when applied every 4 weeks about as well as other materials applied every 2 weeks. This result prompted planning of further testing of Benlate on extended interval schedules during the 1970 season.

Table 14. Effectiveness of certain protectant fungicides for pecan scab control at Paden, Oklahoma, 1967.

Fungicide formulation	Rate of formulation/100 gallons of spray material	Average number of nuts/lb/tree
Squirrel Cultivar		
Manzate	2.0 lbs.	72
Manzate D	2.0 lbs.	79
Du-Ter	3 oz.	84
Du-Ter	4 oz.	79
Cyprex 65W	0.5 lb.	74
Polyram 80W	1.5 lbs.	66
Dithane M-45	2.0 lbs.	78
No (Check)	------	166[2]
Western Cultivar		
Parzate C	2.0 lbs.	89
Dithane Z-78	2.0 lbs.	87
Brestan 60	0.5 lb.	79
Brestan 60	0.75 lb.	102
Kocide 101	2.0 lbs.	100
None (Check)	------	126[2]

[1]Each material was applied to 10 test trees except for Cyprex 65W, Manzate, Dithane Z-78, Brestan 60 and Kocide 101 which were applied to five trees each. All of the materials were applied 10 times: 5/4, 5/18, 6/1, 6/15, 7/1, 7/13, 7/28, 8/11, 8/30, and 9/15,.
[2]Deformed, incompletely-filled, non-marketable nuts.

Table 15. Effectiveness of certain fungicides for pecan scab control at Paden, Oklahoma, 1969.

Fungicide formulation	Rate of formulation/100 gallons of spray mix	Application interval (wks)	Average no. nuts/lb.
Squirrel Cultivar			
Polyram 80W	2 lbs.	2[1]	82[3]
Manzate D	2 lbs.	2	87
Manzate 200	2 lbs.	2	84
None (Check)	----	--	None
Western Cultivar			
Polyram 80W	2 lbs.	2	89
Du-Ter	4 oz.	2	101
Du-Ter	6.4 oz.	2	94
Benlate	6 oz.	2	90
Benlate	6 oz.	4[2]	94
None (Check)	----	--	175[4]

[1]Schedule: 5/5, 5/17, 5/29, 6/9, 6/23, 7/7, 7/21, 8/4, 8/18, 9/11, 9/15.
[2]Schedule: 5/5, 5/29, 6/23, 7/21, 8/18, 9/15.
[3]Nuts were smaller than normal because of very hot and dry conditions during a critical part of the late developmental and filling period.
[4]Nuts deformed, incompletely filled and non-marketable.

Results obtained in other states with Benlate for control of pecan scab have been similar to those of Oklahoma investigations. Excellent control was obtained in Alabama (36), Georgia (44), and Mississippi (28) when this formulation was applied every 3 weeks. Control with a 4-week application interval was also obtained in Georgia (18). Because Manzate D had been shown to be effective during the 1965-1967 and 1969 seasons it was placed on the list of materials suggested for pecan scab control beginning with the 1970 season. Because the active ingredient of Manzate 200 is very similar to that of Manzate D, this formulation was also added to the list.

During 1969 Hinrichs (32) evaluated Cyprex, Dithane Z-78, Du-Ter, and Du-Ter plus Savol (a spray oil) for control of scab on Western cultivar trees at the Department of Horticulture Pecan Research Station at Sparks. Cyprex effectively controlled scab followed by Du-Ter plus Savol, Du-Ter and Dithane Z-78 in that order (Table 16). Du-Ter plus Savol looks rather promising and should be tested further.

During 1970 Benlate was tested for effectiveness when applied every 4 and 5 weeks in comparison with Polyram 80W and Du-Ter applied every 2 weeks. Orchex 795 and Orchex 796, spray oil adjuvants, were added to a Benlate treatment and to Du-Ter treatment, respectively, to determine whether these adjuvants would improve the activity of either material. The adjuvants did not improve the effectiveness of either material. Each Benlate treatment provided control equivalent to that provided by the reference materials (Table 17) (11). The effectiveness of Benlate when applied every 5 weeks was regarded as phenomental and prompted work with longer intervals in the 1971 season.

At Stillwater, a new fungicide, EL-273, reported to be effective for control of apple scab (13), was given a preliminary testing at 4 rates (20, 40, 60 and 80 ppm actual ingredient) on scab-susceptible Burkett trees. EL-273 did not effectively control pecan scab at the tested rates and was withdrawn from further testing by the company.

During 1971 Benlate was tested on Western cultivar trees to determine its effectiveness when sprayed on a long interval schedule. Benlate was applied at 4, 6 and 8 week intervals. Plyac Spreader Sticker was added to Benlate and the mixture was applied at 6 and 8 week intervals. Plyac had been reported to enhance the effectiveness of Benlate for control of apple scab (26). All Benlate treatments effectively controlled pecan scab and the addition of Plyac did not enhance or reduce its effectiveness (Table 18) (12). The effectiveness of Benlate for extended

Table 16. The effect of certain fungicide treatments on control of pecan scab at the Pecan Research Station, Sparks. Oklahoma, 1969. (Modified from Hinrichs (32)).

Fungicide formulation	Rate of formulation/ 100 gallons of spray mix	Number of infected nuts[2] Infection classes[3] 1	2	3	4	5
Western Cultivar						
Du-Ter	0.3 lb.	190	177	130	3	0
Du-Ter + Savol	0.3 lb. + 1 gal.	366	68	66	0	0
Cyprex 65W	0.5 lb.	444	39	17	0	0
Dithane Z-78	3 lbs.	151	67	197	85	0

[1]Savol is a spray oil produced by Thompson-Hayward Chem. Co.
[2]500 nuts evaluated per treatment.
[3]Infection classes: 1=No scab lesions, 2=1—3 scab lesions, 3=4—10 scab lesions, 4=Many lesions (up to half of nut covered), and 5=Shuck completely covered by scab lesions.

Table 17. Effectiveness of certain fungicides for pecan scab control at Paden, Oklahoma, 1970.

Fungicide formulation	Rate of formulation/100 gallons of spray mix	Application interval (weeks)	Average no. nuts/lb/tree
Squirrel Cultivar			
Benlate	6 oz.	4[1]	61
Du-Ter	4 oz.	2[2]	59
Du-Ter + Orchex 796	4 oz. + 5 qt.	2	65
Du-Ter	6.5 oz.	2	58
Polyram 80W	2 lb.	2	60
None (Check)	----	--	0[4]
Benlate	6 oz.	4	61
Benlate	6 oz.	5[3]	59
Benlate + Orchex 795	6 oz. + 5 qt.	5	68[5]
Polyram 80W	2 lb.	2	60
None (Check)	----	--	183[6]

[1]4-week schedule: 5/13, 6/10, 7/8, 8/5, 9/2.
[2]2-week schedule 5/13, ———, 6/10, 6/24, 7/8, 7/22, 8/5, 8/19, 9/2, 9/16.
[3]5-week schedule: 5/13, 6/17, 7/22, 8/26.
[4]Nuts so badly diseased, small, and with such tightly-adhering scucks that nut samples could not be sampled.
[5]A pooled 1 lb. sample (trees bore very poorly).
[6]Nuts deformed, incompletely filled, and non-marketable.

periods is attributed to its systemic activity, probably of a localized nature, in pecan tissues. Fungitoxic activity of Benlate for such extended periods is phenomenal and makes this material very promising for economical control of pecan scab. Further testing was planned for the 1972 season.

During the 1972 season Benlate was evaluated again for its long term effectiveness. Applications were made every 4, 6 and 8 week. A formulation of another fungicide, Topsin M (42), whose actual toxicant formed in water is the same as that formed from the active ingredient of Benlate, was applied every 2 and 4 weeks. Du-Ter, applied every 2 weeks was used as a reference fungicide.

The 1972 season was very dry and many of the test trees did not bear or bore very poorly. As the season progressed, much of the small crop dropped prematurely. Consequently, an adequate research sample could not be obtained from each test tree. However, a very small composite sample was obtained from most of the treatments. The data, there-

Table 18. Effectiveness of certain fungicides for control of pecan scab at Paden, Oklahoma, 1971.

Fungicide formulation	Rate of formulation/100 gallons of spray mix	Application interval (weeks)	Average no. nuts/lb/tree
Squirrel Cultivar			
Cyprex 65W	12.0 oz.	2[1]	74
Cyprex 80W	9.6 oz.	2	77
Du-Ter	8.0 oz.	2	70
None (Check)	----	--	86
Western Cultivar			
Benlate	6 oz.	2	69
Benlate	6 oz.	4[2]	71
Benlate	6 oz.	6[3]	75
Benlate + Plyac Spreader-Sticker	6 oz. + 6 oz.	6	76
Benlate + Plyac Spreader Sticker	6 oz. + 6 oz.	8[4]	80
None (Check)	------	--	107[5]

[1]2-week schedule: 5/4, 5/18, 6/1, 6/15, 6/29, 7/13, 7/27, 8/10, 8/24, 9/7, 9/21.
[2]4-week schedule: 5/4, 6/1, 6/29, 7/27, 8/24.
[3]6-week schedule: 5/4, 6/15, 7/27, 9/7.
[4]8-week schedule: 5/4, 6/29, 8/24.
[5]Nuts deformed, not filled, and non-marketable.

fore, are questionable but are presented in Table 19. No data were obtained for the 6- and 8-week treatments. Both Benlate and Topsin M, when applied every 4 weeks, apparently provided control equivalent to that provided by Du-Ter applied every 2 weeks. Extended interval tests with both materials are being utilized for the 1973 season.

Benlate was approved by the Environmental Protection Agency (EPA) in February, 1973, for use on pecans at rates that would leave only a neglible residue. Experimental use of Benlate on the test trees at Paden was permitted under USDA temporary Permit No. 352-EXP-71G. Because of EPA approval for use on pecans and because of its long term effectiveness, Benlate 50W is suggested to be used on pecans at 6 oz/100 gals applied every 4-5 weeks during wet seasons.

Conclusions and Use Suggestions

Research results from Oklahoma and other pecan states have shown that adhering to the following procedures is effective for control of pecan scab in Oklahoma:

Table 19. Effectiveness of certain fungicides for control of pecan scab at Paden, Oklahoma, 1972.

Treatment formulation Fungicide	(oz/100 gal) Rate	interval (weeks) Application	nuts/lb/tree[1] Average no.
Squirrel Cultivar			
Benlate	6	4	58
Benlate	8	4	57
Benlate	8	6	—[2]
Benlate	8	8	—[2]
Topsin M	8	2	55
Topsin M	8	4	57
Du-Ter	8	2	59
None (Check)	--	--	94[3]

[1]Number determined from a composite sample consisting of 12 oz. to 2 lbs. from 6 trees per fungicide treatment.
[2]No sample available. Trees did not bear.
[3]At the end of a severe scab season, this figure would have been much larger. Limited scab developed during the relatively dry 1972 season.

Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the Oklahoma Agricultural Experiment Station and does not imply its approval to the exclusion of other products that also may be suitable.

1. When planting new orchards in areas where scab is a problem, avoid highly-scab susceptible cultivars such as Halbert, Western, Squirrel, Burkett, etc. unless a fungicide spray program will be followed. Also avoid the use of scion wood from these cultivars for grafting. There are many recommended cultivars available that are scab resistant or tolerant for use in scab areas in Oklahoma (Consult OSU Extension Fact Sheet 6201, "Pecan Varieties for Oklahoma.").

2. In orchards containing scab-susceptible trees allow adequate spacing between trees to allow good air circulation. Clean cultivation and removal of low branches will also aid air circulation. When branch tips from adjoining trees approach each other, remove every other tree. All fallen scab-infected nutshucks, twigs, and leaves should be turned under by shallow disking or destroyed by burning. Destruction of infected plant parts will aid in control of several insects in addition to aiding in controlling several diseases.

3. Thoroughly spray scab-susceptible cultivars and native and seedling trees with a fungicide suggested for scab control at the rates listed on page 4.

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