Suppression of Sclerotinia Blight of Peanuts with Dinitrophenol Herbicides

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ABSTRACT

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Dinoseb and Dyanap incorporated into potato dextrose agar at 1 μg/ml significantly reduced mycelial growth of *Sclerotinia minor*, the causal agent of Sclerotinia blight of peanut. Mycelial growth also was reduced on media containing 2,4-DB at 25 μg/ml. Growth of *S. minor* after 192 hr of incubation was not restricted on media containing benefin, vernolate, alachor, or naptalam at 25 μg/ml. Field applications of dinoseb or Dyanap significantly reduced the severity of Sclerotinia blight in peanuts (*Arachis hypogaea*) when applied at postemergence but not when applied only at seedling emergence. Dinoseb reduced disease severity more than Dyanap. Peanut pod yields were greater in plots receiving postemergent treatments of dinoseb or Dyanap than in plots treated at seedling emergence. Peanut crop values was about 23% greater in plots treated at postemergence with dinoseb or Dyanap than in nontreated plots.

Additional key words: Sclerotinia sclerotiorum, soilborne disease, disease control, dinoseb, Dyanap.

Sclerotinia blight of peanut caused by the soilborne fungus *Sclerotinia minor* Jagger (10), was first discovered in Virginia in 1971 (12). This disease has since become widespread in both Virginia and North Carolina and causes severe economic losses to growers (13). All peanut plant parts on or near the soil surface are subject to attack. At present, all peanut cultivars available to growers are susceptible to *S. minor*, and available fungicides provide only limited control.

Several workers have shown that dinitrophenol herbicides reduce the severity of diseases caused by several plant pathogens. In 1956 Chappell and Miller (4) showed that dinoseb and other herbicides were effective against a wide range of peanut plant pathogens. Dinoseb reduced the severity of stem rot of peanuts (caused by *Sclerotium rolfsii* Sacc. [2,5,7]), root rot of pea (caused by *Aphanomyces euteiches* Drechs. [8,14]), root rot of navy bean (caused by *Fusarium solani* [Mart.] Appel & Wr. f. sp. *phaseoli* [Burk.] Snyd. & Hans. [16,17]), and root rot of snapbean (caused by *Pythium irregulare* Buis. [15]). However, the severity of root rot of soybean caused by *Thielaviopsis basicola* (Berk. & Br.) Ferr. was enhanced following application of dinoseb (11). Increases in peanut yield were attributed to weed control and not fungicidal activity of dinoseb against the stem rot pathogen (6).

The purposes of this research were to identify herbicides currently used in peanut production that might possess fungicidal properties against *S. minor* and to determine whether the severity of Sclerotinia blight under field conditions could be reduced by herbicide application.

MATERIALS AND METHODS

The toxicity of commercial grades of herbicides to *S. minor* was measured as the inhibition of mycelial growth on potato dextrose agar (PDA) and on herbicide-amended PDA. The herbicides included dinoseb (2-*sec*-butyl-4,6-dinitrophenol), benefin (*N*-butyl-*N*-ethyl-α,α,α-trifluoro-2,6-dinitro-*p*-toluidine), and vernolate (*S*-propyldipropylthiocarbamate) prepared in water, and alachlor (2-chloro-2′,6′-diethyl-*N*-[methoxymethyl]acetanilide), naptalam (*N*-1-napthylphthalamic acid), Dyanap (a formulation containing one part dinoseb and two parts naptalam), and 2,4-DB (4-[2,4,dichlorophenoxy] butyric acid) prepared in acetone. Desired quantities of these stock solutions of each herbicide were pipetted into flasks containing an appropriate volume of partially cooled PDA. The contents of each flask were stirred during addition of the herbicides, shaken for ~60 sec to insure uniform mixing, and then poured into sterile plastic petri plates (85 × 15 mm). Solidified media were inoculated with 5-mm diameter agar plugs of mycelium taken from the periphery of 3-day-old colonies of *S. minor* grown on PDA. Plates were incubated at room temperature (22 C). Radial colony growth was measured at specified intervals.

A farm with a history of Sclerotinia blight was used for field experiments. The soil type was an Altavista loamy fine sand. Preplant-applied vernolate (1.9 kg/ha) and benefin (1.68 kg/ha) were used in all treatments. Peanuts (cultivar Virginia 72R) were planted in May of 1977 and 1978. A randomized block design with four replications of four-row plots 12.2-m long and spaced 0.9-m between rows was used in all experiments. Dinoseb (1,361 g/3.785 L) was applied at seedling emergence at the rate of 1.68 kg/ha. Dyanap was applied at seedling emergence at the rate of 5.04 kg/ha. Single and multiple postemergent applications of dinoseb or Dyanap at 0.84 kg/ha were made in the middle of the growing season. All herbicides were of commercial grade and were applied with a CO_2 backpack sprayer equipped with 8004 flat spray tips and set to maintain a pressure of 4.3 kg/cm^2 and to deliver 262 L/ha.

Plants were monitored for evidence of *S. minor* infection. Twice each year during the growing season twenty randomly selected plants in each of the two center rows in each plot were scored 1 to 5 on a scale of increasing symptom development and disease indices were calculated. At the end of the growing season, plants in the two center rows of each plot were harvested, dried, and graded by standard procedures to determine pod value.

RESULTS

Effect of herbicides on mycelial growth of *S. minor*. After 48 hr of incubation, mycelial growth on agar amended with alachlor, benefin, naptalam, and vernolate at 25 μg/ml was similar to that on nonamended medium (Table 1). Mycelial growth was greatly restricted on medium containing 2,4-DB at 25 μg/ml and on media amended with dinoseb or Dyanap at 1 μg/ml. Mycelial growth was almost nonexistent on medium amended with dinoseb or Dyanap at 5 μg/ml and on media amended with 2,4-DB at 75 or 100 μg/ml following 96 hr of incubation.

After 144 hr, mycelium covered the surface of petri plates containing media amended with alachlor, benefin, naptalam, or vernolate at 25 μg/ml. After 192 hr of incubation, mycelial growth was abundant on plates containing agar amended with alachlor, benefin, naptalam, or vernolate at 100 μg/ml. After 192 hr, mycelial growth was restricted on agar amended with dinoseb or Dyanap at 1 μg/ml or 2,4-DB at 25 μg/ml. As concentrations of each herbicide were increased, mycelial growth significantly decreased. The results were nearly identical for three isolates of *S. minor*.

TABLE 1. The effect of commercial grades of herbicides at various concentrations on mycelial growth of *Sclerotinia minor* on potato dextrose agar after incubation for various periods at 22 C[a]

Herbicide	Herbicide concentration (μg/ml)[b]	Colony diameter (mm)[c] 48 hr	96 hr	144 hr	192 hr
None	0	37 a	85 a	85 a	85 a
Alachlor	25	36 ab	81 b	85 a	85 a
	75	17 gh	55 f	71 c	75 b
	100	15 i	35 i	47 f	57 d
Benefin	25	24 d	60 d	85 a	85 a
	75	17 gh	39 h	66 d	75 b
	100	15 i	33 j	54 e	67 c
Dinoseb	1	15 i	25 k	33 gh	51 e
	3	11 k	17 mn	25 i	33 h
	5	11 k	15 m	21 j	27 i
Dyanap	1	15 i	33 j	56 e	67 c
	3	13 j	20 l	32 h	43 g
	5	12 j	18 m	25 i	34 h
Naptalam	25	32 c	85 a	85 a	85 a
	75	20 e	73 c	85 a	85 a
	100	16 hi	58 e	72 c	85 a
Vernolate	25	35 b	85 a	85 a	85 a
	75	19 f	80 b	85 a	85 a
	100	17 fg	46 g	76 b	85 a
2,4-DB	25	5 k	17 mn	35 g	47 f
	75	5 k	5 o	17 k	25 i
	100	5 k	5 o	15 l	20 k

[a] Within columns, values followed by a common letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.
[b] Herbicide concentrations calculated on basis of active ingredient.
[c] Values are the means of two tests, each containing four replications with 10 petri plates per replication. A value of 85 mm represents mycelial growth over the entire surface of the agar. A value of 5 mm (size of inoculum plug) represents no growth.

Effect of dinitrophenols on severity of Sclerotinia blight of peanut. Sclerotinia blight was severe at harvest in 1977 and 1978 (Tables 2 and 3). Disease symptoms appeared earlier in 1977 than in 1978. On 1 September 1977, plants treated at postemergence with either dinoseb or Dyanap had a significantly lower disease index than did plants treated at emergence with dinoseb or Dyanap or that were not treated with a herbicide (Table 2). Plants treated with Dyanap had a significantly higher disease index than did those treated with dinoseb. Disease severity was similar in plants given multiple postemergence herbicide applications and those given only a single postemergence application. On 6 October, severity of Sclerotinia blight had increased in all plots. Disease severity was significantly lower in plants given multiple postemergence applications of dinoseb or Dyanap than in those that received the other treatments.

On 28 August 1978, the incidence of Sclerotinia blight was low but disease developed rapidly during the next 2 wk (Table 3). Disease severity was similar in plants not treated with herbicides and in plants treated with dinoseb or Dyanap at emergence. On 19 September 1978, plants treated with Dyanap or dinoseb at postemergence were significantly less severely diseased than were plants treated with these herbicides at emergence. Plants treated with dinoseb at postemergence had significantly less severe disease than did those similarly treated with Dyanap. Multiple postemergence herbicide applications were not superior to single postemergence applications in reducing disease severity.

Effect of dinitrophenols on peanut pod yield. In both years of this study Sclerotinia blight was severe, and pod yields were very low in nontreated plants (in 1977, 2,262 kg/ha and in 1978, 1,730 kg/ha) (Tables 2 and 3). Treatment with dinoseb or Dyanap at emergence had no effect on yields. Yield increases were noted in plants treated with postemergence applications of dinoseb or Dyanap. During the 2-yr study, pod yields of plants that received one postemergence application of dinoseb averaged 490 kg/ha greater than those of nontreated plants. The average yield in plants treated with one postemergence application of dinoseb was 349 kg/ha greater than that in those that received dinoseb only at emergence. The average yield in plants treated with postemergence applications of Dyanap averaged 298 kg/ha greater than that in nontreated plants. Average pod yields were 175 kg/ha greater in plants treated at postemergence with dinoseb than in those similarly treated with Dyanap.

Effect of dinitrophenols on peanut pod value. Peanut pod value in nontreated plots averaged \$958/ha and \$771/ha in 1977 and

TABLE 2. The effect of dinoseb and Dyanap on severity of Sclerotinia blight, peanut pod yield, and crop value in 1977[a]

Treatment: Emergence[b] Herbicide	Rate (kg/ha)	Postemergence[c] Herbicide	Rate (kg/ha)	No. of applications	Disease index[d] 1 Sept.	6 Oct.	Yield (kg/ha)	Value (\$/ha)
None	···	None	···	···	3.3 a	3.4 ab	2,262 cd	958 cd
Dinoseb	1.68	None	···	···	3.1 a	3.5 a	2,346 bcd	1,001 bcd
Dyanap[e]	5.04	None	···	···	3.1 a	3.3 ab	2,105 d	892 d
Dinoseb	1.68	Dinoseb	0.84	1	1.8 c	3.2 b	2,768 a	1,209 a
Dinoseb	1.68	Dinoseb	0.84	2	1.3 d	2.7 c	2,463 abc	1,107 ab
Dinoseb	1.68	Dinoseb	0.84	3	1.6 cd	2.5 c	2,649 ab	1,220 a
Dyanap	5.04	Dyanap	0.84	1	2.6 b	3.4 ab	2,489 abc	1,081 abc
Dyanap	5.04	Dyanap	0.84	2	2.6 b	2.6 c	2,481 abc	1,094 abc

[a] Within columns, values followed by a common letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.
[b] Herbicides applied at first evidence of seedling emergence.
[c] Herbicides applied during middle of growing season (first application, 21 July; second application, 3 August; and third application, 16 August).
[d] Disease index on a scale of increasing severity from 1 to 5.
[e] Dyanap contains 907 g of naptalam and 454 g of dinoseb in 3.785 L.

TABLE 3. The effect of dinoseb and Dyanap on severity of Sclerotinia blight, peanut pod yield, and crop value in 1978[a]

Treatment								
Emergence[b]		Postemergence[c]			Disease index[d]			
Herbicide	Rate (kg/ha)	Herbicide	Rate (kg/ha)	No. of applications	28 Aug.	19 Sept.	Yield (kg/ha)	Value ($/ha)
None	···	None	···	···	1.7 a	3.7 ab	1,730 b	771 b
Dinoseb	1.68	None	···	···	1.6 a	3.6 b	1,927 ab	862 ab
Dyanap[e]	5.04	None	···	···	1.7 a	3.8 a	1,731 b	781 b
Dinoseb	1.68	Dinoseb	0.84	1	1.6 a	2.7 d	2,203 ab	966 ab
Dinoseb	1.68	Dinoseb	0.84	2	1.6 a	2.6 d	2,306 a	1,032 ab
Dinoseb	1.68	Dinoseb	0.84	3	1.5 b	2.5 d	2,427 a	1,094 a
Dyanap	5.04	Dyanap	0.84	1	1.7 a	3.2 c	2,235 ab	992 ab
Dyanap	5.04	Dyanap	0.84	2	1.6 a	3.4 c	1,973 ab	862 ab

[a] Within columns, values followed by a common letter do not differ significantly according to Duncan's multiple range test, $P = 0.05$.
[b] Herbicides applied at first evidence of seedling emergence.
[c] Herbicides applied during middle of growing season (first application, 21 July; second application, 4 August; and third application, 18 August).
[d] Disease index on a scale of increasing severity from 1 to 5.
[e] Dyanap contains 907 g naptalam and 454 g dinoseb in 3.785 L.

1978, respectively (Tables 2 and 3). Value was similar in plots treated with dinoseb or Dyanap at emergence. Increased pod values averaged $240/ha and $143/ha in plots receiving postemergence treatments of dinoseb or Dyanap, respectively, than in nontreated plots. Multiple postemergence herbicide applications increased pod value no more than did single postemergence applications.

Phytotoxic effects of dinitrophenol on peanut plants. Phytotoxicity was not observed in plants treated at emergence with either dinoseb or Dyanap, but did occur on leaflets and stems of plants treated at postemergence with these herbicides.

DISCUSSION

Dinoseb applied preplant or at preemergence suppresses a wide range of plant diseases (2,4,5,7,8,14–16). With the exception of rust in mint (3) most of the plant diseases suppressed with this herbicide are caused by soilborne pathogens that actively attack plant roots. Some pathogens, such as *S. rolfsii*, suppressed with dinoseb attack plant parts in the soil as well as those in contact with the soil surface. *S. minor* is a soilborne pathogen, and the plant parts in contact with the soil are also easily infected by mycelium growing on the soil surface or from other infected plant parts. Once infection sites are established, the fungus grows rapidly on plant tissue.

Altman and Campbell (1) suggested that a decrease in disease after herbicide application could be due to the decreased growth of the plant pathogen. Addition of dinoseb to culture media restricted mycelial growth of a wide range of fungi (2,4,17). Mycelial growth of *S. minor* was greatly restricted on media amended with dinoseb or Dyanap at 1 μg/ml (Table 1). Dinoseb was more effective than Dyanap in reducing mycelial growth. Dyanap contains both dinoseb 454 g/3.785 L) and naptalam (907 g/3.785 L). Naptalam alone, even at high concentrations (100 μg/ml) did not appreciably reduce mycelial growth. Since dinoseb is effective at low concentrations, it is apparently the component in Dyanap that is effective against *S. minor*.

Results of field studies with *S. rolfsii* suggested that dinoseb affected the fungus directly (2). Applications of dinoseb or Dyanap at emergence did not suppress Sclerotinia blight of peanuts. This failure could be due to the inactivity of *S. minor* in the soil at the time of herbicide application. *S. minor* usually becomes active during 15 July to 1 August or about 8–10 wk following preemergence herbicide application.

Postemergence applications of dinoseb or Dyanap made from 15 July to 15 August, when peanut plants grow luxuriantly, suppressed the development of Sclerotinia blight (Tables 2 and 3). Disease symptoms usually were present on treated plants at this time, and mycelium of the fungus was found on the moist soil surface as well as on infected plant tissue. It appears that dinoseb or Dyanap applied at this time might have a direct toxic effect on the mycelium of *S. minor*. With the amount of water (262 L/ha) and pressure (4.3 kg/cm^2) used during herbicide application, the soil surface was usually covered with the herbicide mixture after application. Once the herbicide reached the soil surface its persistence might be lengthened by the shading of the soil surface underneath the plant canopy which would reduce herbicide volatility and photodecomposition (9). Such increased persistence could explain why a single postemergence herbicide application suppressed Sclerotinia blight as effectively as multiple applications.

The use of postemergence applications of dinoseb or Dyanap shows promise in an integrated pest-management program. In fields with histories of Sclerotinia blight, these herbicides would not only control broadleaf weeds but would also aid in suppressing disease development.

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