# Application of Metham Sodium by Sprinkler Irrigation to Control Lettuce Drop Caused by *Sclerotinia minor*

P. B. ADAMS, Plant Pathologist, Soilborne Diseases Laboratory, Plant Protection Institute, U.S. Department of Agriculture, Beltsville, MD 20705; S. A. JOHNSTON, Plant Pathologist, Department of Plant Pathology, Cook College, New Jersey Agricultural Experiment Station, Rutgers Research and Development Center, Bridgeton 08302; J. KRIKUN, Visiting Scientist, Soilborne Diseases Laboratory, Plant Protection Institute, U.S. Department of Agriculture; and H. E. CARPENTER, Agricultural Engineer, Department of Agricultural Engineering, Cook College

**ABSTRACT**

Adams, P. B., Johnston, S. A., Krikun, J., and Carpenter, H. E. 1983. Application of metham sodium by sprinkler irrigation to control lettuce drop caused by *Sclerotinia minor*. Plant Disease 67:24-26.

In laboratory experiments, metham sodium killed nearly 100% of the sclerotia of *Sclerotinia minor* in soil at rates as low as 25 μg a.i./ml of water. In three field tests, metham sodium applied at 234 L of product per hectare through sprinkler irrigation with 2.4–5.2 cm (1.0–2.1 in.) of water killed 100% of the sclerotia retrieved from plots 1–2 days after application. The incidence of lettuce drop in control plots ranged from 14 to 58%, whereas that in plots treated with metham sodium ranged from 0 to 6%. The amount of metham sodium applied to the fields was 25–33% of the manufacturer's recommended rate and provided 89–91% disease control.

Additional key words: chemigation, fungigation, soilborne pathogens, soil fumigation

Lettuce drop caused by *Sclerotinia minor* Jagger causes 10–30% loss on spring and fall crops in southern New Jersey. About 95% of lettuce drop is caused by *S. minor* (P. B. Adams and S. A. Johnston, *personal observations*) and 5% by *S. sclerotiorum*. Lettuce drop caused by *S. minor* is initiated by direct infection from mycelia from germinated (2) sclerotia. In contrast, infection by *S. sclerotiorum* is primarily caused by ascospores from apothecia produced from sclerotia in the lettuce field or adjacent fields (7). Thus, when all sclerotia in a field are killed by a fumigant, excellent control of lettuce drop caused by *S. minor* is obtained. When the disease is caused by *S. sclerotiorum*, only partial disease control is obtained.

Some growers fumigate their fields with 80% D-D mixture (chlorinated $C_3$ hydrocarbons—including 1,3-dichloropropene and 1,2-dichloropropane—and other related chlorinated hydrocarbons) + 20% methyl isothiocyanate at rates of 187–280 L/ha (20–30 gal/acre). This treatment is usually effective in controlling lettuce drop but is relatively expensive (at least $690/ha). Metham sodium (32.7% sodium methyldithiocarbamate) is a soil fumigant registered for use at 701–935 L/ha ($1,149–1,532/ha) as a soil fumigant. This fumigant is water soluble and can be applied through sprinkler irrigation. To be acceptable to growers, the control measure must be effective and cost about $400/ha or less.

The purpose of this study was to determine the concentration of metham sodium required to kill sclerotia of *S. minor* in soil under laboratory conditions and to assess its efficacy and cost under field conditions. A preliminary report of this work was published (1).

## MATERIALS AND METHODS

In all laboratory experiments, sclerotia of *S. minor* were obtained from 4- to 7-wk-old cultures grown on autoclaved oats at 20 C (2). Sclerotia were collected from the cultures by wet sieving on a 0.35-mm-pore sieve.

Metham sodium was tested in the laboratory for its toxicity to sclerotia of *S. minor* in soil columns by two different methods. In the initial experiments, natural soil (Rumford loamy sand) (pH 5.9, 1.3% organic matter) containing sclerotia was placed in plastic cylinders 3 cm in diameter and 20 cm long. The bottom of each cylinder was plugged with a rubber stopper containing a small hole to allow drainage. The amount of solution added to each soil column (50 ml) was sufficient to allow an excess to drain from the bottom. After 4 days, the soil was removed from the cylinder and mixed. Fifty sclerotia were isolated, surface-sterilized in 0.5% sodium hypochlorite for 5 min, and plated out on a medium (10 sclerotia per plate) to determine viability. The medium was acidified potato-dextrose agar with rose bengal (33 μg/ml). The plates were incubated at 20 C for 2 wk and the number of viable sclerotia determined as evidenced by development of *S. minor* colonies. There were four replicates for each treatment, and each experiment was performed twice.

In other laboratory experiments, plastic cylinders 6.5 cm in diameter and 50 cm long were used and set up as described. In these large soil columns, nylon bags containing sclerotia of *S. minor* were mixed with soil and buried at depths of 5, 20, and 35 cm. Solutions of metham sodium were applied to the soil columns and the excess allowed to drain out the bottom of the cylinders. In these experiments, performed twice, there were three replicates of 50 sclerotia each.

Three field tests at different locations in southern New Jersey were set up to evaluate metham sodium applied at 234 L of product per hectare (25 gal/acre) through sprinkler irrigation to control lettuce drop. In 1980, a four-replicate, randomized complete block test was set up at the Holding farm in which the efficacy of metham sodium was compared with D-D mixture + methyl isothiocyanate at the rate of 178 L of product per hectare (19 gal/acre) and an untreated control. In 1981, the efficacy of metham sodium was compared with an untreated control on the Simoni farm in a three-replicate test and in an unreplicated field test on the Malench farm.

**Holding field test.** Sprinkler irrigation lines were placed 15 m apart with 12 m between sprinklers on each irrigation line. Plots were 12 × 15 m, with the corners of each metham sodium plot corresponding to four adjacent sprinklers. Control (untreated) plots were set up by plugging three consecutive sprinklers on each of two adjacent irrigation lines, and data were collected from the 12 × 15 m

Permanent address of third author: Gilat Experiment Station, Mobile Post, Negev 2, 85-410, Israel.

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S Department of Agriculture nor imply approval of it to the exclusion of other products that may also be suitable. This report does not contain recommendations for the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate state and federal agencies before they can be recommended.

Accepted for publication 14 April 1982.

area in the central portion of this area. On 21 July 1980, in areas between irrigation lines not occupied by control or metham sodium plots, the grower injected D-D mixture + methyl isothiocyanate at the rate of 178 L of product per hectare (19 gal/acre) to a depth of 20 cm utilizing the conventional shank method with a 2-m rig and eight shanks spaced 25 cm apart. Metham sodium was injected into the irrigation line over 4 hr on 23 July 1980 at 234 L of product per hectare (25 gal/acre). A Cheminjector Chemical Metering Pump (Model CV8047-0904, Hydroflo Corp., Dublin, PA 18907) was used to inject the chemical into the irrigation line. Uniformity of the irrigation application was monitored by placing cans within each of the four metham sodium plots.

Soil samples (0–15 cm deep) were collected from each plot (20 subsamples per plot) the day after the application of metham sodium and assayed for number and viability of sclerotia. The field was lightly disked, and beds were formed and planted with lettuce, cv. Mesa 659, on 14 August 1980. At harvest on 22 and 23 October 1980, all plants in each plot were counted and disease incidence determined. Plants were also examined to determine whether drop was caused by *S. minor* or *S. sclerotiorum*. Each plot contained approximately 1,000 lettuce plants. The soil in this field test was Hammonton sandy loam with a pH of 6.5.

**Simoni field test.** The area available for this test was 24 × 69 m, not large enough to set up control plots as in the previous test. Three control (untreated) plots were prepared by laying plastic tarps (3.3 × 7.5 m) at random locations in the field. One irrigation line was placed down the center of the field. Metham sodium was applied to this field on 14 July 1981 at the rate of 234 L of product per hectare (25 gal/acre) through the irrigation line with an injection pump (model L-905, John Blue Co., Huntsville, AL 35807). The plastic tarps were removed from the field the day after the metham sodium application. Soil samples (0–15 cm) were collected from the control and metham sodium plots (20 subsamples per plot) 2 days after treatment and assayed for the number and viability of *S. minor* sclerotia. On 15 August 1981, the field was disked, beds were formed, and Boston lettuce cv. Tania was planted. At harvest on 2 October 1981, all plants in each plot were examined for visible infection by *S. minor*. The soil in this field test was Downer sandy loam with pH of 6.3.

**Malench field test.** In this field test, a portion of a field measuring 20 × 135 m was treated with metham sodium by a single irrigation line down the center of the field. An area of 10 × 135 m was left untreated. Metham sodium was injected into the irrigation line on 21 July 1981 with the same pump that was used on the Simoni field test at the rate of 234 L of product per hectare (25 gal/acre). Soil samples (20 subsamples to a depth of 15 cm) were collected from treated and untreated plots 2 days after application. The soil in this field test was Downer sandy loam with a pH of 6.4. The field was disked and Boston lettuce planted on 20 August 1981. On 3 October 1981, lettuce drop counts were made twice in the treated and untreated areas by examining 400–500 plants each time.

## RESULTS

**Laboratory experiments.** When metham sodium at rates of 0, 1, 10, 100, and 1,000 μg a.i./ml was applied to the small soil columns containing *S. minor*-infested soil, viability of the sclerotia was 92, 90, 55, 1, and 0%, respectively. When metham sodium at 50 μg a.i./ml was applied to large soil columns with sclerotia buried 5, 20, and 35 cm deep, all sclerotia were killed. At 25 μg a.i./ml, nearly 100% kill was achieved at the three depths. In other experiments, approximately 50% kill of the sclerotia was obtained when metham sodium was applied to the soil columns at 11 μg a.i./ml (Fig. 1).

**Holding field test.** The application of metham sodium through the irrigation system varied from 2.3 to 9.1 cm (mean rate, 5.2 cm) as determined by measuring the amount of water in the cans previously placed on plots. It was estimated that metham sodium was applied to this field test in the irrigation water at the rate of 175 μg a.i./ml.

Soil samples collected the day after the application of metham sodium indicated no difference in the number of sclerotia in the various plots (zero to five sclerotia per 100 g of soil). However, viable sclerotia were found only in control plots.

At harvest the average percentage of *S. minor*-infected plants was 19% (14–23%) in the control plots, 7% (6–10%) in the plots with D-D mixture + methyl isothiocyanate, and 2% (1–4%) in the plots with metham sodium (Table 1). Only two *S. sclerotiorum*-infected plants were found in a plot treated with metham sodium. Disease distribution was remarkably uniform, with no significant differences between replicates. For example, the percentage of drop in the four metham sodium plots ranged from 1.0 to 4.2, whereas that in the D-D mixture + methyl isothiocyanate plots ranged from 5.7 to 10.2.

**Simoni field test.** Irrigation rate ranged from 2.3 to 5.1 cm (mean 3.4 cm). It was estimated that the concentration of metham sodium in the irrigation water was 260 μg a.i./ml.

Soil samples collected 2 days after treatment indicated that inoculum density averaged six sclerotia per 100 g of soil and that complete kill of the sclerotia was obtained by the treatment. At harvest there was an average of 43% drop (34–58%) in the control plots and 4% drop (3–6%) in the metham sodium plots. All infections were caused by *S. minor*.

**Malench field test.** Irrigation rate varied from 1.7 to 3.7 cm, with an average of 2.4 cm. It was estimated that the concentration of metham sodium in the irrigation water was 368 μg a.i./ml. Soil samples collected 2 days after application of metham sodium indicated that there were four to five sclerotia per 100 g of soil and that complete kill of the sclerotia was obtained by the treatment. At harvest there was an average of 18% lettuce drop (17–20%) in the untreated area of the field and 2% (0–3%) in the metham sodium area. All of the observed lettuce drop was caused by *S. minor*.

In all three field tests, there was no evidence of phytotoxicity to the lettuce plants as a result of treatments.

## DISCUSSION

Metham sodium has long been recognized as an efficacious pesticide, but it has not always provided consistent

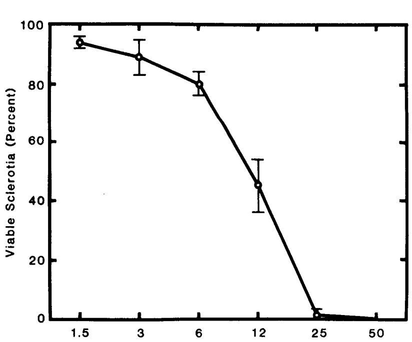


**Fig. 1.** Viability of sclerotia of *Sclerotinia minor* in soil columns 4 days after the application of various concentrations of metham sodium. Vertical bars indicate standard deviation.

**Table 1.** Effect of soil fumigants on control of lettuce drop caused by *Sclerotinia minor*

| Treatment | Rate (L/ha) | Lettuce drop (%) | Disease control (%) | Yield[x] (crates/ha) | Increased profit[y] ($/ha) |
|---|---|---|---|---|---|
| Control (untreated) | ··· | 19 a[z] | 0 | 1,401 | 0 |
| D-D mixture + methyl isothiocyanate | 178 | 7 b | 61 | 1,609 | 229 |
| Metham sodium | 234 | 2 c | 89 | 1,695 | 916 |

[x] Based on a disease-free yield of 1,730 crates (24 heads) per hectare.
[y] Based on the yield minus the yield of the control, multiplied by the 1980 price of $4.42/crate, minus the 1980 cost of the treatment.
[z] Values not followed by the same letter are significantly different ($P = 0.05$) as determined by Duncan's multiple range test.

results (3,4). The most likely reason for these erratic results is that none of the conventional methods of application have given a uniform distribution of the in the soil profile (4). Application of metham sodium during the entire irrigation period provides this uniform distribution (3,4). The depth of the soil treated is dependent upon both the length of the irrigation period and soil type.

In three field tests, application of metham sodium killed all the sclerotia that were retrieved from the plots. Laboratory tests using soil columns indicated that metham sodium had an $LD_{50}$ of approximately 11 $\mu$g/ml (Fig. 1) and at 50 $\mu$g/ml would kill all the sclerotia to a depth of at least 35 cm (13.8 in.). Based on the amount of water applied to the three fields, we estimated that metham sodium was applied at 175–368 $\mu$g a.i./ml.

When applied through the sprinkler irrigation system, metham sodium became an economical method of disease control. It is recommended by the manufacturer to be applied at 700–935 L/ha (75–100 gal/acre), at a 1980 cost in New Jersey of $1,149–1,532/ha ($465–620/acre). In this study, we applied metham sodium at 234 L/ha (25 gal/acre) at a cost of $383/ha ($155/acre) and obtained 89–91% control of lettuce drop caused by *S. minor*. D-D mixture + methyl isothiocyanate is recommended at 280 L/ha, at a cost of $1,086. In this study, it was applied at 178 L/ha at a cost of $690/ha, but it provided only 61% control of lettuce drop. Metham sodium becomes an even more attractive method of disease control when the increased profit is determined for the two chemical treatments (Table 1).

As shown by Krikun et al (6) and Krikun and Frank (5), metham sodium applied by the method and at rates comparable to those described in this paper also controls other soil fungi and the nematode *Pratylenchus thornei*. Preliminary laboratory screening using the method described offers a rapid, reliable technique to determine the susceptibility of fungal propagules to the biocide, especially when used in the soil type in which the field experiments are planned. Using this method of application, effective control of a number of soilborne pathogens—including those that form relatively large resting structures—can be obtained with minimal dosages. This reduces cost and possible and undesirable effects of high fumigation rates.

**ACKNOWLEDGMENTS**

Appreciation is extended to D. B. Holding, D. W. Holding, J. Simoni, and V. B. Malench for their cooperation and use of their lettuce fields. We also express appreciation to L. Evans and C. J. Tate for technical assistance and to D. M. Marini and Stauffer Chemical Co. for the use of their injection pump and supply of metham sodium.

**LITERATURE CITED**

1. Adams, P. B., Krikun, J., Johnston, S. A., and Carpenter, H. E. 1981. Use of metham applied through sprinkler irrigation to control lettuce drop caused by *Sclerotinia minor*. (Abstr.) Phytopathology 71:764.
2. Adams, P. B., and Tate, C. J. 1976. Mycelial germination of sclerotia of *Sclerotinia sclerotiorum* on soil. Plant Dis. Rep. 60:515-518.
3. Gerstl, Z., Mingelgrin, U., Krikun, J., and Yaron, B. 1977. Behavior and effectiveness of Vapam applied to soil in irrigation water. Pages 42-50 in: Proc. French-Israel Symp. Behavior Pestic. Soil. M. Horowitz, ed. Agric. Res. Organ. Bet Dagan Spec. Publ. 82.
4. Gerstl, Z., Mingelgrin, U., and Yaron, B. 1977. Behavior of Vapam and methyl isothiocyanate in soils. Soil Sci. Soc. Am. J. 41:545-548.
5. Krikun, J., and Frank, Z. R. 1982. Metham sodium applied by sprinkler irrigation to control pod rot and Verticillium wilt of peanut. Plant Dis. 66:128-130.
6. Krikun, J., Orion, D., Netzer, D., and Shlevin, E. 1976. An improved method of application of Vapam to control soil pests. Hassadeh 57:369-372. (In Hebrew; English summary)
7. Newton, H. C., and Sequeira, L. 1972. Ascospores as the primary infective propagule of *Sclerotinia sclerotiorum* in Wisconsin. Plant Dis. Rep. 56:798-802.