Effect of Liquid Volume, Spray Pressure, and Nozzle Arrangement on Coverage of Plant Foliage and Control of Snap Bean Rust with Chlorothalonil

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ABSTRACT

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Chlorothalonil (2.5 kg a.i./ha) solutions were sprayed on snap beans (*Phaseolus vulgaris*) on a 7- to 10-day schedule to control bean rust (*Uromyces appendiculatus* var. *appendiculatus*). Solution application rates were 190, 375, and 560 L/ha at 345 and 690 kPa nozzle pressure, using one, two, and three nozzles per row. Foliage coverage was evaluated using fluorescent tracer particles applied similarly. Mean percentage of surface area covered on both top and bottom sides of the leaves increased with increases in application rate, nozzle pressure, or number of nozzles per row. Rust control, however, was not influenced by these factors. Plots treated with chlorothalonil had less bean rust and produced greater pod yields than untreated plots.

Rust caused by 33 identified races of *Uromyces appendiculatus* (Pers.) Unger var. *appendiculatus* (9) is the major foliar disease affecting snap beans (*Phaseolus vulgaris* L.) in Tennessee. Historically, occasional outbreaks were reported in the state, but the disease reached epidemic proportions in 1972 and has since been an annual problem. Most commercial snap bean cultivars are susceptible to rust but some rust-resistant cultivars are available (2). Rust control by foliar application of fungicide is essential for commercial production of high-quality snap beans. Maneb (Manzate D 80W and Dithane M-22) and chlorothalonil (Bravo 75W) were found to be the most effective fungicides for controlling rust in Tennessee (1).

Conditions favoring urediniospore germination and rust development are humidities of 95% or more (8) and temperatures of 18–21 C (6). Climatic conditions in Tennessee in late July, August, and September are often ideal, especially when heavy dew and fog occurs. In years characterized by generally low humidity, rust has been less severe.

Commercial snap bean growers in Tennessee have traditionally applied foliar pesticides in the form of dusts. Because the effective fungicides have not been formulated as dusts, spraying has become necessary. Studies in Ohio (7) and Tennessee (5) showed that applying pesticides as sprays was much more efficient than dusting, but optimum levels of spraying parameters necessary for obtaining rust control have been largely speculative. A study conducted at the University of Tennessee Plateau Experiment Station near Crossville in 1979 and 1980 to identify optimum liquid application parameters for controlling rust in snap beans is reported.

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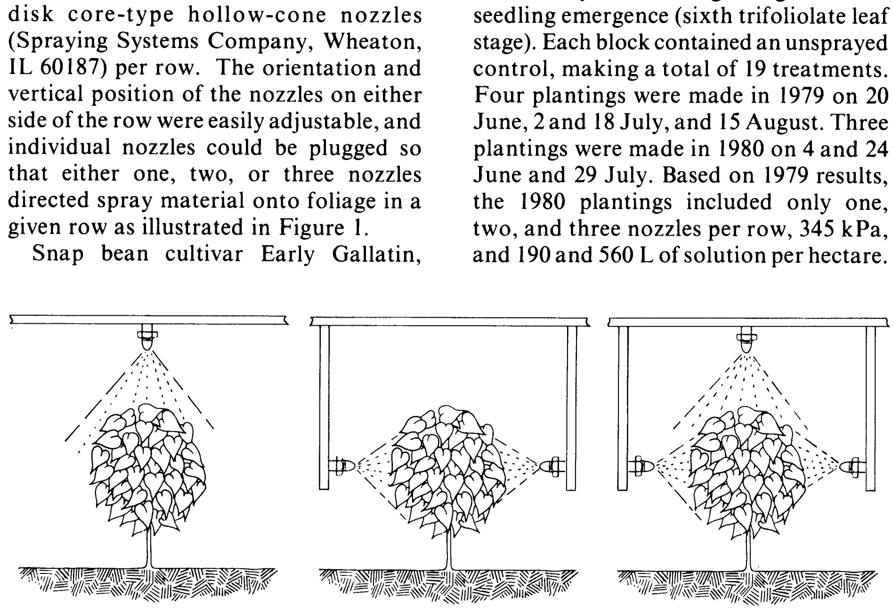
MATERIALS AND METHODS

A medium-volume two-row hydraulic sprayer was constructed and employed for applying treatment formulations. The sprayer boom was outfitted with three disk core-type hollow-cone nozzles (Spraying Systems Company, Wheaton, IL 60187) per row. The orientation and vertical position of the nozzles on either side of the row were easily adjustable, and individual nozzles could be plugged so that either one, two, or three nozzles directed spray material onto foliage in a given row as illustrated in Figure 1.

Snap bean cultivar Early Gallatin, which is highly susceptible to rust, was planted in 1-m rows. Each plot (experimental unit) consisted of four rows, each 6 m long. Cultural practices were typical for snap beans grown in the Cumberland Plateau area. A stand of 15–20 plants per meter of row was established in a conventionally prepared seedbed. Dinoseb (Premerge 3) and EPTC (Eptam 7E) were used for weed control. Pentachloronitrobenzene (Terrachlor 10G) was in-furrow applied for control of *Rhizoctonia solani* Kühn root rot. One application of carbaryl (Sevin 50-W) at a rate of 1.1 kg a.i./ha was made when plants were in full bloom to control insects, principally Mexican bean beetle (*Epilachna varivestis* Mulsant).

Treatments were arranged in a randomized complete block experimental design with a factorial arrangement of treatment combinations with five replicates. Treatment combinations consisted of spraying with 190, 375, or 560 L of chlorothalonil solution per hectare at 345 or 690 kPa (6.89 kPa = 1 lb/in.^{2}) nozzle pressure, using one, two, or three nozzles per row.

Spray solutions were formulated so that chlorothalonil was applied at a rate of 2.5 kg a.i./ha. Plots were sprayed on a 7- to 10-day schedule beginning 3 wk after seedling emergence (sixth trifoliolate leaf stage). Each block contained an unsprayed control, making a total of 19 treatments. Four plantings were made in 1979 on 20 June, 2 and 18 July, and 15 August. Three plantings were made in 1980 on 4 and 24 June and 29 July. Based on 1979 results, the 1980 plantings included only one, two, and three nozzles per row, 345 kPa, and 190 and 560 L of solution per hectare.



(a) (b) (c)

Fig. 1. Application of spray formulation using **(A)** one, **(B)** two, or **(C)** three nozzles per crop row.

Table 1. Effect of fungicide application parameters on leaf surface coverage percentages, rust ratings, and pod yields of Early Gallatin snap beans in 1979

Spray parameter	Leaf surface coverage (%) Top	Bottom	Rust rating[x]	Pod yield (t/ha)
Liters of solution/ha				
190	63 a[y]	29 a	1.4 a	4.2 a
375	75 b	43 b	1.4 a	4.4 a
560	77 b	44 b	1.4 a	4.2 a
Sprayer pressure (kPa)[z]				
345	70 a	37 a	1.4 a	4.2 a
690	75 b	40 b	1.5 a	4.4 a
No. of nozzles/row				
1	63 a	18 a	1.5 a	4.2 a
2	78 b	50 b	1.4 a	4.5 a
3	81 b	59 c	1.3 a	4.2 a
Sprayed mean	...	...	1.4 a	4.3 a
Unsprayed control	...	...	3.0 b	3.6 b

[x]Rust rating based upon percentage of leaf surface with pustules: 1 = 0–5%, 2 = 25%, 3 = 50%, 4 = 75%, and 5 = 99%.

[y]For a given parameter within a column, numbers followed by the same letter are not significantly different ($P = 0.05$) as indicated by Duncan's multiple range tests.

[z]6.89 kPa = 1 lb/in.^{2}

A 1-m segment selected at random from each of the middle two rows of each experimental unit was harvested by hand to determine pod yields. Immediately before harvest, rust control afforded by each treatment was rated by visual examination of 10 randomly selected trifoliolate leaves. With a subjective scheme similar to that described by Hilty and Mullins (3), a rating scale based on percentage of leaf surface with pustules was used to depict the severity of rust infection on each leaf: 1 = 0–5%, 2 = 25%, 3 = 50%, 4 = 75%, and 5 = 99%.

Using the technique described by Himel (4), a suspension containing fluorescent (Zn-Cd sulfide) particles was applied when one planting was in the bloom stage to evaluate the extent of foliage coverage achieved by the various spray parameter combinations. The particles are highly insoluble and not fungitoxic (C. Himel, *personal communication*). Twelve trifoliolate leaves were selected randomly from the treated rows in each of the 18 treatment combinations. These trifoliolates were examined visually under ultraviolet light (BLE Spectroline model B-100, Black Light Eastern, Westbury, NY 11590), where the percentages of surface area on both the top and bottom sides of the leaves were estimated.

RESULTS AND DISCUSSION

Effects of the various spray parameters on thoroughness of snap bean foliage coverage show that as the application rate was increased from 190 to 560 L/ha, mean percentages of surface area covered on both the top and bottom sides of the leaves increased (Table 1). These increases in surface coverage, however, were not proportional to the increases in application rates. Significantly ($P = 0.05$) better coverage of both sides of the leaf was achieved with 375 L/ha than with 190 L/ha, but increasing the application rate to 560 L/ha did not significantly ($P = 0.05$) improve coverage further. Note that even at the higher application rates, only about 60% of the total leaf surface had deposited spray material. This implies that little or no protection was offered against urediniospore germination on 40% of the plant leaf surface for any given application. Thus, using a protectant fungicide at regular intervals appears essential for controlling urediniospore germination and preventing bean rust from developing.

The effect of nozzle pressure on degree of coverage shows that increasing the spray pressure from 345 to 690 kPa increased coverage percentages of both top and bottom leaf surfaces (Table 1). These increases, however, were modest in a practical sense, although they were sufficiently large to be declared statistically significant ($P = 0.05$).

The number and arrangement of nozzles also affected foliage coverage (Table 1). In general, increasing the number of nozzles per row increased coverage of leaf surface on both the top and bottom sides. Note that when a single nozzle was used directly over the row, less than 20% of the surface area on the bottom sides of the leaves received deposits of spray. Adding nozzles to direct the spray onto the plant from the sides markedly increased coverage on the underneath portion of the leaf. About 70% of the total surface (both top and bottom sides) had deposits of spray when three nozzles were used per row compared with only 40% coverage obtained with one nozzle per row.

None of the sprayer operating parameters considered had a significant effect on rust control (Table 1), but the collective group of plots sprayed regularly with the chlorothalonil solution had significantly ($P = 0.05$) less rust than check plots receiving no fungicide treatment. Bean rust ratings were not obscured by other foliar diseases. A trend toward better rust control as the number of nozzles per row was increased was indicated by the magnitudes of the rust rating numbers. This trend could be anticipated because of the more thorough foliage coverage obtained with multiple nozzles per row.

Pod yields were well below those normally expected in Tennessee and were attributable to drought conditions (Table 1). Although none of the sprayer operating parameters significantly affected crop yields, the mean yield of sprayed plots was significantly ($P = 0.05$) higher than the average yield of the unsprayed plots.

Climatic conditions did not favor rust development in 1980 because the year was generally very dry. Consequently, little snap bean rust was observed, even on untreated plots, but plots sprayed regularly with chlorothalonil solution again had significantly ($P = 0.05$) less rust than untreated plots.

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