EFFICACY OF APPLICATION METHOD FOR DEPOSITING FUNGICIDE IN A POTATO CANOPY

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INTRODUCTION

Fungicides are generally applied one of three ways to control fungal diseases of potatoes; air, ground, or by chemigation. In the Columbia Basin of Oregon and Washington, air applied materials is the most common, followed by application through the center pivot system, very little acreage is treated with a ground applicator.

All application methods seemed to work adequately for applying materials until 1993, the first year of a major outbreak of late blight on potatoes in the Columbia Basin caused by the fungus Phytophthora infestans. Unknown at that time was the fact that the strains present were predominately resistant to Ridomil products, the one time mainstay for controlling this disease. Had the weather not become hot and dry, a substantial loss in potatoes could have occurred due to poor late blight control in some fields. Based on what seemed to be a poor performance of materials, a study was initiated to compare the efficacy of the methods to apply fungicides to potatoes in hopes that information would be generated to help better control this disease in the future. This paper reports some of the information obtained during that two year study.

MATERIALS AND METHODS

In 1994 and 1995 a randomized complete block design with three replications was established at a potato research facility in the Southern Columbia Basin of Washington. In 1994 there were four treatments; air (using 7.5 gallons water/acre), ground (using 30 gallons of water/acre at 46 PSI, conventional boom), chemigation (using .23 inches of water through a lateral move system), and control (untreated). Ridomil Bravo pre-packs (Bravo = chlorothalanil) were rotated with Bravo (chlorothalanil) alone for five weeks. A full labeled rate of Bravo was always applied. Each replication in each block measured 72' X 760'. In 1995, an additional chemigation treatment was included where fungicides were applied using .11 inches of water.

During both years leaf samples from 5 plants were taken from three canopy locations (upper, middle, and lower) from each replication prior to the first treatment, and 2 and 5 days following. Samples were always from leaves exposed to the fungicide. Sub-samples of each were placed in zip-lock plastic bags and in small vials (5 five mm discs from 5 leaves), and immediately placed on ice (1994) or in vials containing acetone (1995).

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Samples were taken each subsequent week following application, and 2 and 5 days later. Samples were also collected up to 12 days following the last application. Samples in vials were analyzed for residue of chlorothalonil using acetone extraction and gas chromatography. Values obtained were determined based on the amount of chlorothalonil/cm2 of leaf area. By this method, the average amount of chlorothalonil per canopy area in each treatment could be determined.

Leaf samples in bags were exposed to the fungus causing late blight in the laboratory. By this method spores of the fungus were sprayed on the leaf surface and the amount of disease that resulted was visually rated based on a severity index of the disease. Average severity by canopy and treatment could be determined. It was expected that the more chemical present the less severe the disease would be on the individual leaves.

RESULTS

The amount of chlorothalonil deposited, regardless of year, was greater when applied by the ground applicator, next was air, least was applied by chemigation, regardless of water amount used during application (Figure 1). As what would be expected, the amount of fungicide in the canopy, when all treatments were collectively compared, was always higher in the upper canopy, least in the lower canopy. Figure 2 shows the amount deposited the day of the first application in 1995. Figure 3 shows the average amount the day of application following 5 applications. The amount of fungicide in the canopy in figure 3 would be influenced by previously applied materials. A breakdown of the canopy amounts by application method indicated a stair step decrease in the amount of chlorothalonil deposited the further downward in the canopy, particularly associated with air and ground treatments (Figure 4). Through time, the amounts in each canopy location decreased, however the amount found was always greater when applied by ground, followed by air (Figures 5 & 6).

Little material remained in the canopy following chemigation as brief as 2 days following treatment. Five days following applications the amount in the upper canopy was equal to that in the other canopy locations. However, the amount in the lower canopy locations had not decreased as much as had occurred in the upper canopy, presumable due to the fungicide being washed downward (Figure 6).

Figures 7 & 8 describe what occurs in a potato canopy through multiple applications of fungicide following a 7 day repeated schedule. At day 0, the day of application, peaks representative of increase levels of fungicide could always be seen from the ground applied treatment, less often with air applied, and was nearly non-existent in the chemigation treatment. Levels always decreased by day 5.

Leaf samples collected from each treatment and exposed to the late blight fungus showed protection when treated with the chlorothalonil. The highest level of protection was obtained from leaves treated by ground (Figure 9).

DISCUSSION

Ground applied chlorothalonil was consistently found at higher levels, at all canopy locations, than any other treatment. Air application was next, and chemigation applied levels, while uniform in the canopy, were clearly less than the other two methods, even when reduced water levels were used in 1995. Levels of material decreased substantially with time, particularly in the upper canopy, presumably moving and thereby helping to maintain levels at the mid and lower canopy locations. Higher amounts of the fungicide provided a higher level of protection from the late blight fungus in the laboratory. This study may provide a partial answer to the lower than expected late blight control obtained in 1993.

In 1993 weather was wet and cool, conditions that late blight favors. The disease was first found in the Columbia Basin in mid-late June and applications of fungicides were initiated. Not until after the season was the fungal population identified to have been primarily resistant to Ridomil. Some fields were exposed to fungal spores prior to fungicide treatments, while in other fields, fungicides were applied at varying lengths of time prior to exposure. Where the fungus had already infected prior to fungicide treatment, areas in some fields were destroyed. The fields that received applications of protectant fungicides prior to exposure showed different levels of control. Clearly, protectant fungicides have to be in place before exposure, but this work (and that by Dennis Johnson et al) showed that lower canopy locations may not be adequately protected until fungicides have had a chance to wash down in the canopy, a process that may take repeated fungicide applications. The fungus could have infected those poorly protected areas during that time.

Starting applications early (6-8") is only the beginning to help ensure the best possible control. This work, and the level of control seen in 1995, clearly indicated that improvements are needed in the way fungicides are applied in the Columbia Basin. While all methods of applying fungicides controlled late blight to some degree, factors such as skips and poor applications caused significant amounts of disease in fields that would have otherwise been better protected in 1995. Application of fungicides should always be applied when conditions favor good applications, i.e., no wind. However, applications of fungicides in a consistent manner, following a 7 day schedule, and beginning early in the growing season, are the most important criteria (indicated by figures 2, 7 and 8). If chemigation is used, a minimum amount of water during application should be used. If .1 inch or more water is being applied, too much fungicide is being washed off to ensure good protection for an entire week. This method did deposit equal levels of the fungicide throughout the canopy during this study, but at low levels. Work continues (in cooperation with Dennis Johnson) on the use of even less water during chemigation. Fungicide injector pump plugging must be prevented, or if it occurs, the pivot must be backed up to make sure of complete coverage.

Air application of materials will continue to be an important component of controlling late blight in the Columbia Basin. In one other study similar to that reported here, air applied chlorothalonil was as good as that of ground applied methods. To ensure good applications, care must be taken to ensure no skips occur in the field. This can be done by using permanent field flags or flaggers to follow each pass.

Likewise, new systems, such as GPS (ground positioning satellite) will also be helpful. Use of air application in areas where the plane cannot maintain proper distance to the canopy, such as around houses, trees, power lines, etc. is unwise. Likewise, using planes in fields with highly irregular topography will make it difficult for the pilot to maintain the proper distance to the canopy.

The amount of water used during application is probably important and will be tested in 1996 (in cooperation with Ag Northwest in Hermiston). Higher water rates (10 gallons) is probably better than 3 gallons. Again, more importantly, is consistent and continual use. Results from another test this past summer suggested that air applied material needed to be used at least twice, over a two week period, to ensure the material had an opportunity to be redeposited throughout the canopy, prior to late blight exposure.

Acknowledgments

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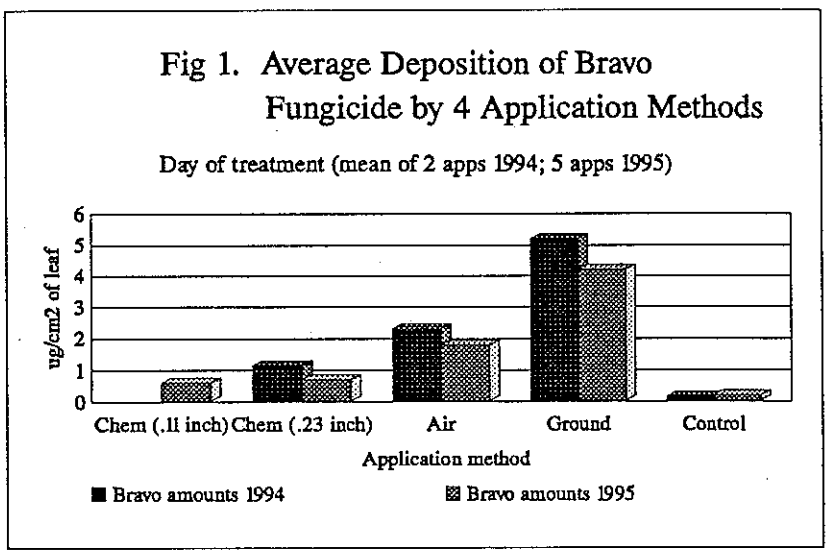

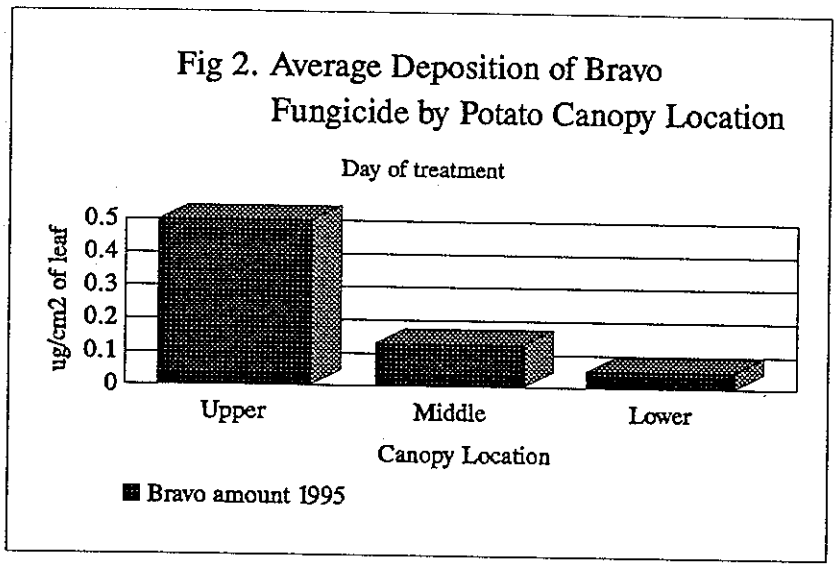
Fig 2. Average Deposition of Bravo Fungicide by Potato Canopy Location
Day of treatment
ug/cm2 of leaf
0.5
0.4
0.3
0.2
0.1
0
Upper
Middle
Lower
Canopy Location
Bravo amount 1995

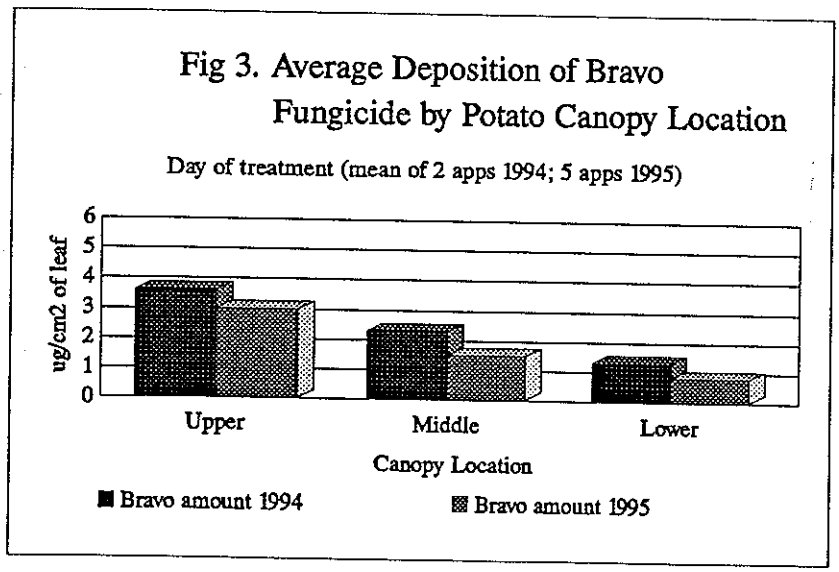
Fig 3. Average Deposition of Bravo Fungicide by Potato Canopy Location
Day of treatment (mean of 2 apps 1994; 5 apps 1995)
ug/cm2 of leaf
6
5
4
3
2
1
0
Upper
Middle
Lower
Canopy Location
Bravo amount 1994
Bravo amount 1995

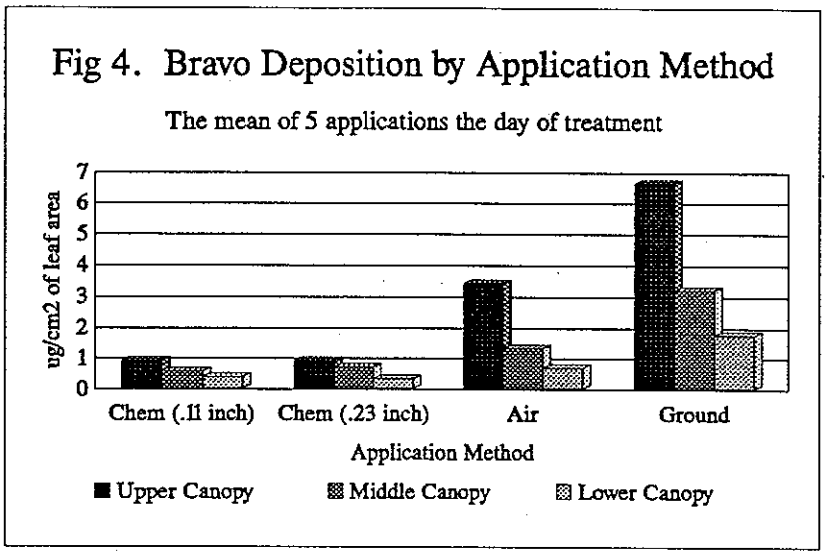
Fig 4. Bravo Deposition by Application Method
The mean of 5 applications the day of treatment
ug/cm2 of leaf area
7
6
5
4
3
2
1
0
Chem (.11 inch)
Chem (.23 inch)
Air
Ground
Application Method
Upper Canopy
Middle Canopy
Lower Canopy

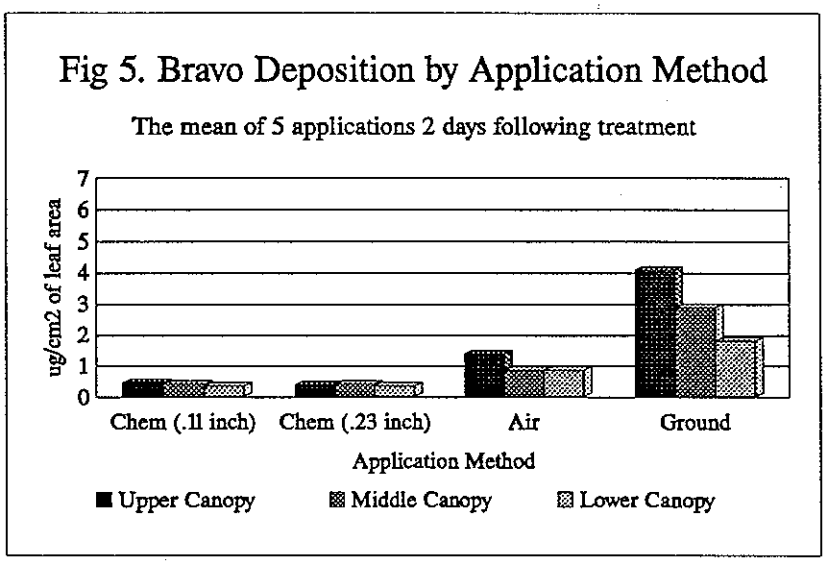
Fig 5. Bravo Deposition by Application Method
The mean of 5 applications 2 days following treatment
ug/cm2 of leaf area
7
6
5
4
3
2
1
0
Chem (.11 inch)
Chem (.23 inch)
Air
Ground
Application Method
Upper Canopy
Middle Canopy
Lower Canopy

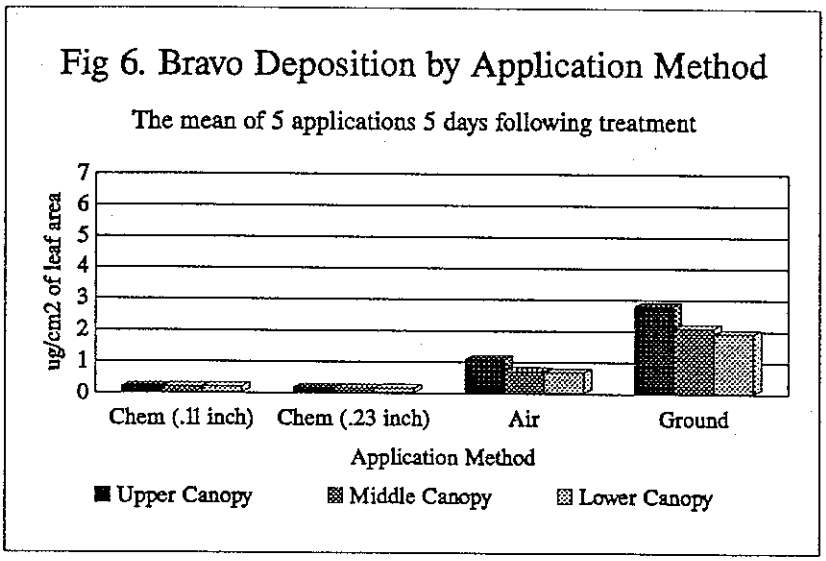
Fig 6. Bravo Deposition by Application Method
The mean of 5 applications 5 days following treatment
ug/cm2 of leaf area
7
6
5
4
3
2
1
0
Chem (.11 inch)
Chem (.23 inch)
Air
Ground
Application Method
Upper Canopy
Middle Canopy
Lower Canopy

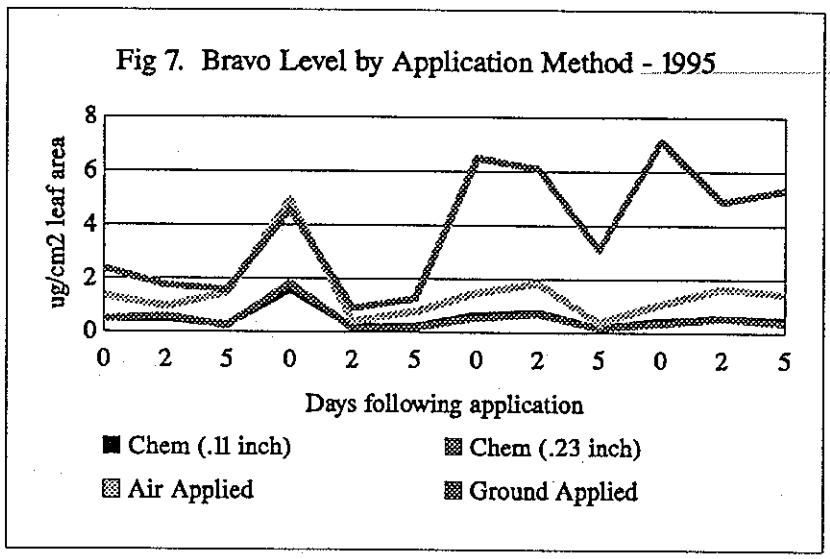
Fig 7. Bravo Level by Application Method - 1995
ug/cm2 leaf area
8
6
4
2
0
0 2 5 0 2 5 0 2 5 0 2 5
Days following application
Chem (.11 inch)
Chem (.23 inch)
Air Applied
Ground Applied

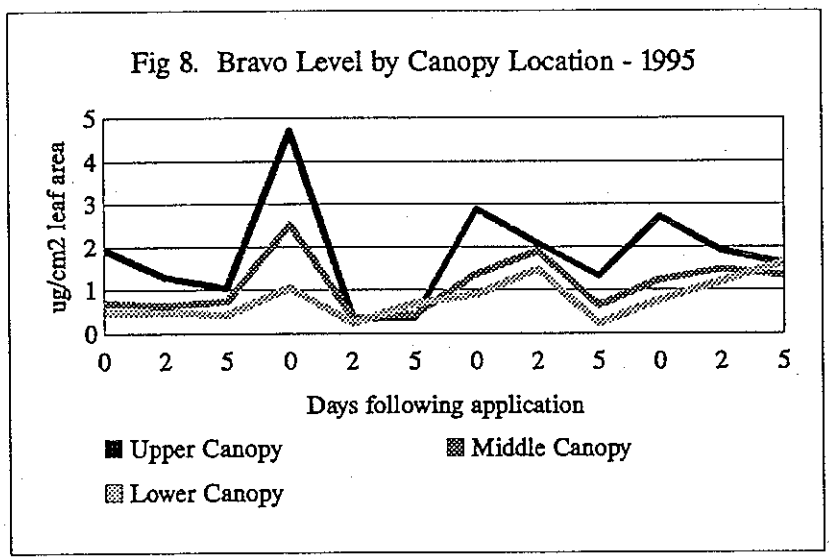
Fig 8. Bravo Level by Canopy Location - 1995
ug/cm2 leaf area
5
4
3
2
1
0
0 2 5 0 2 5 0 2 5 0 2 5
Days following application
Upper Canopy
Middle Canopy
Lower Canopy

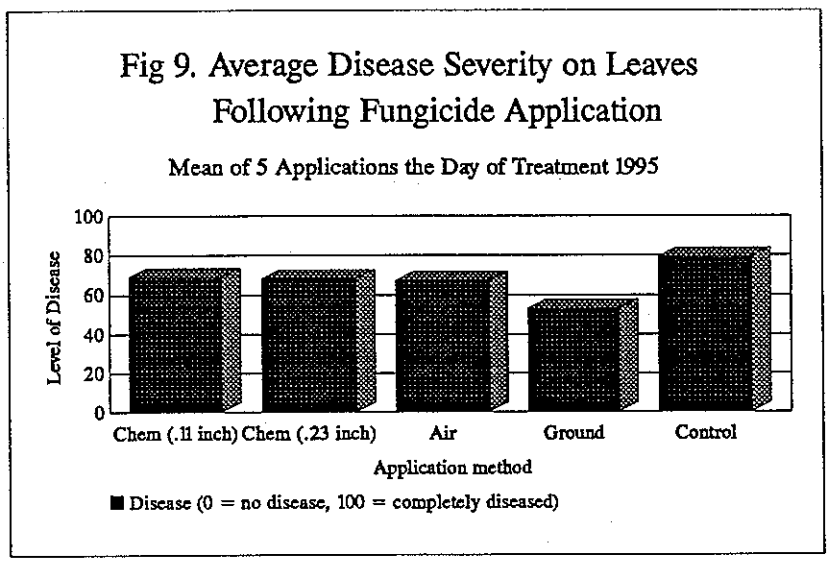
Fig 9. Average Disease Severity on Leaves Following Fungicide Application
Mean of 5 Applications the Day of Treatment 1995
Level of Disease
100
80
60
40
20
0
Chem (.11 inch)
Chem (.23 inch)
Air
Ground
Control
Application method
Disease (0 = no disease, 100 = completely diseased)