Application of Antitranspirant and Reduced Rate Fungicide Combinations for Fruit Rot Management in Cranberries

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ABSTRACT

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Studies were conducted over a 3-year period to evaluate the efficacy of reduced rate combinations of chlorothalonil and an antitranspirant (AT), Wilt-Pruf, for control of fruit rot in cranberries. Several reduced rate combinations provided control comparable to that with the fungicide used alone at suggested label rates of 0.76 to 1.34 liters/ha (4 to 7 pt/A) in field trials. In two trials, higher concentrations of the AT (3 to 5%) had a detrimental effect on total and usable yield at higher fungicide rates. The lowest rate of chlorothalonil that can be effectively used in combination with any tested rate of Wilt-Pruf is 0.76 liters/ha (4 pt/A). Using 0 or 0.38 liters/ha (0 or 2 pt/A) with any tested rate of the AT inadequately protected the berries against fruit rot infection. The incorporation of reduced rate combinations may offer the management advantage of lowered environmental risk per fungicide application in certain situations.

Additional keywords: *Coleophoma empetri, Glomerella cingulata, Godronia cassandrae,* integrated pest management, *Phomopsis vaccinii, Phyllosticta vaccinii, Physalospora vaccinii,* spray adjuvants, *Vaccinium macrocarpon*

The American cranberry (*Vaccinium macrocarpon* Aiton) is a low-growing, woody broadleaf, nondeciduous vine (22). Cranberry acreage in Massachusetts is located in proximity to wetlands and is typically surrounded by residential housing. As a consequence, the cranberry industry operates in an ecologically sensitive environment and is subject to considerable scrutiny by adjacent nonfarm neighbors. Cranberry pest management strategies that minimize pesticide use have considerable appeal. Current integrated pest management programs attempt to balance the need for minimizing environmental distress while supporting growers' efforts to maximize yields. Pest management alternatives may include the use of cultural techniques (1,8) as well as the application of reduced rates of pesticides in combination with spray adjuvants (2). As part of their pest management program, cranberry growers may add spray adjuvants to their pesticide applications to improve the efficacy of these materials.

Fruit rot is the most important disease problem in cranberry culture (23). Fruit rot management in cranberries remains challenging due to the number of different fungal species, such as *Phyllosticta vaccinii* Earle (early rot), *Physalospora vaccinii* (Shear) Arx & E. Müller (blotch rot), *Coleophoma empetri* (Rostr.) Petr. (ripe rot), *Godronia cassandrae* Peck (end rot), *Phomopsis vaccinii* Shear in Shear, N. Stevens & H. Bain (viscid rot), and *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk (bitter rot), that have been identified as pathogens (13,19,25). Regional differences exist between production areas regarding losses due to fruit rot. Inoculum pressure is usually low in Wisconsin and the Pacific Northwest. However, fruit rot fungi can cause 30% or higher yield loss on untreated bogs in the Northeast growing region (17). Yield loss due to fruit rot pathogens on commercial Massachusetts bogs receiving three fungicide applications can range from 1 to 15%. Losses may be higher on susceptible cultivars such as Early Black or Franklin (F. L. Caruso, *unpublished data*).

The severity of fruit rot depends greatly on weather (17,23). The presence or absence of fruit rot pathogens is variable from year to year (3,4). Excessive vine growth and poor drainage promote conditions that favor infection by the fruit rot pathogens (2). Infection of the fruit typically occurs during the bloom period (6). Under favorable conditions, the development of visible fruit rot symptoms may occur within 1 week of infection. Thus, fungicides are needed to manage fruit rot pathogens on most commercial cranberry beds in Massachusetts. Traditional spray programs include three fungicide applications. The first spray is applied during early bloom; subsequent applications follow at 10 to 14 day intervals. The selection, frequency, and rate of fungicides used are dependent upon the individual bed and its fruit rot history. Management practices that extend residuals of a fungicide during the main infection period may offer improved fruit rot control.

Antitranspirants (ATs) have been investigated for their potential role in disease management (12). The addition of spray adjuvants to fungicides may permit a reduction in the number of applications or amount of active ingredient applied. However, a balance must be maintained between the extension of fungicidal activity during bloom and the breakdown of the chemical by harvest. Recent studies show that several spray adjuvants when applied in combination with a commercially available fungicide do not substantially increase end-of-season residues of fungicides on the surface of cranberry fruit (20).

Spray adjuvants (i.e., spreaders, stickers, ATs) have been studied for their utility and applicability in cranberry production (4) as well as other production systems (15,18, 21,27). Previous studies have shown that Wilt-Pruf (Wilt-Pruf Products, Inc., Essex, Conn.) inhibited germination of conidia and germ tube growth (9) and was equally effective in controlling foliar diseases as a traditional fungicide (26). Wilt-Pruf was chosen for examination in the present study due to the lack of information on its performance in cranberry disease management. The objective of this study was to determine if the lower range of recommended application rates of chlorothalonil could be effective for control of fruit rot when used in combination with the AT.

MATERIALS AND METHODS

Experiments were conducted during the 1992 through 1994 field seasons at the University of Massachusetts Cranberry Experiment Station in East Wareham, Mass. In 1992, treatments were applied to Howes (late-maturing cultivar) cranberries and, in 1993 and 1994, treatments were applied to Early Black (early-maturing cultivar) cranberries. Various combinations of chlorothalonil (Bravo 720), a broad spectrum protectant fungicide, and the polyterpene-based AT, Wilt-Pruf, were applied to cranberry vines.

Plots, 2.3 m^2 in size, were established in a strip-plot design with five replications. This design is suited for a two factor experiment in which the desired precision for measuring the interaction effect between the two factors is higher than that for

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measuring the main effect of either one of the two factors (11). Initiation of the spray schedules was determined by crop phenology. The first application was applied at 5% bloom; additional sprays followed at 10 to 14 day intervals. Treatments were applied on 26 June, 7 July, and 22 July 1992; 11 June, 23 June, and 7 July 1993; and 13 June, 23 June, and 7 July 1994. Application was made by backpack sprayer with a fan-type spray nozzle (Solo, Inc., Model 475, Newport News, Va.). Spray was emitted at approximately 173 to 207 kPa (25 to 30 lb/in^2). The fungicide and AT were physically mixed in the sprayer (as appropriate for the treatment) and agitated while the spray was dispensed.

Various combinations of the fungicide and the AT were tested over the 3-year period (Table 1). Selection of the initial AT and fungicide concentrations tested in 1992 was based on manufacturer recommendations. Subsequent selection of AT and fungicide concentrations was determined by experimental results and label recommendations. For example, AT-fungicide combinations at the lower fungicide rates (0 to 0.76 liters/ha) were not effective in 1993. Thus, the suggested label rates of chlorothalonil (0.76 to 1.34 liters/ha) in combination with the lower concentrations of the AT were applied in 1994. When mentioned in the text and tables, the combination treatments are identified by a code. Numbers following "A" and "B" refer to the concentration of the AT and the fungicide, respectively.

Plots were harvested during the second or third week of September for cv. Early Black and the first week of October for cv. Howes. A 900-cm^2 area was randomly selected for each replicate and all berries within this area were collected. The fruit was stored at 5°C in paper bags and visually evaluated for field rot within 1 week. To approximate the size of berries collected during commercial harvesting, very small fruit were removed prior to evaluation. The samples were passed through a 5.6-mm sieve (U.S.A. Standard Testing Sieve, No. 3.5, Fisher Scientific Co., Mentor, Ohio) to eliminate nonpollinated, undersized, and aborted fruit. Rotten fruit sorted during the initial evaluation were designated as field-rotted berries. Berries were assessed, counted, and weighed (pooled sample). The field-rotted berries were discarded. The remaining healthy fruit was placed back into cold storage at 5°C in open paper bags. To approximate the duration of commercial cranberry storage, the percentage of the fruit with storage rot was determined 8 weeks postharvest.

Statistical analysis. Percentage of fruit with field rot was determined by dividing the number of berries that were rotted at harvest by the total number of berries collected multiplied by 100. Percentage of storage rot was calculated by dividing the number of berries that rotted in storage by the total number of berries collected multiplied by 100. Percentage of total rot is the sum of all field-rotted fruit plus storage-rotted fruit divided by the total number of berries collected. Total yield, an estimate of crop potential, was calculated based upon the number of berries (rotted and healthy) collected per plot, assuming 1 g per berry (7,10). Usable or marketable yield was determined by the weight of all healthy berries collected from the sample area.

Analysis of variance was carried out for all parameters using the Multivariate General Linear Hypothesis (MGLH) procedure in SYSTAT for the Macintosh (24). The analysis for a strip-plot design divides the sources of variation as follows: horizontal effects (effects of fungicide), vertical effects (effect of AT), and the interactive effects of these two factors (11). F ratios were used to determine the significance of either factor on the measured parameters. Observations concerning treatment differences are drawn in reference to the fungicide standard for each year (A0B5 in 1992, A0B6 in 1993, and A0B7 in 1994).

Regression analyses were performed on yield and fruit rot parameters to calculate slopes, intercepts (y), and correlation coefficients (r). Equations were generated by using PROC GLM (SAS/STAT User Guide, release 6.04 ed., SAS Institute, Cary, N.C.). A line comparison matrix was generated to allow for direct comparison of the slopes for all possible paired combinations.

RESULTS AND DISCUSSION

1992 study. Individual storage-rotted fruit of cv. Howes from plots receiving the 2.5 and 5% solutions of the AT tended to have lower berry weights than fruit from plots receiving the A0B5 treatment (Table 2). Most berries lost to field rot were very small (10 to 25% of average berry weight). The initial rot evaluation removed all small and rotted berries from the sample. Thus, berries that rotted in cold storage tended to be of higher weights than field-rotted fruit. Individual berry weights of healthy fruit were slightly lower in plots receiving the 2.5 and 5% AT solutions than weights of those in plots receiving the high rate of the fungicide alone.

Plots receiving the 5% solution of the AT as well as the A2B4 and A2B5 treatments had more field and total rot than the plots receiving the fungicide standard (A0B5 treatment) and the untreated control (A0B0). Plots receiving the 2.5% AT solution and low fungicide rate combination applications had total rot similar to the fungicide standard. Plots receiving A2B2 and A2B4 treatments had the highest percentage of storage rot (Table 2).

The effect of the AT treatments was significant for all parameters except berry weight of field-rotted fruit. Fungicide was a significant factor in treatment differences for berry weight of healthy fruit, percentage of field rot, and total rot. The interaction of the fungicide and the AT was not significant in any instance.

Total and usable yields (kg per ha) were lower in plots receiving the 5% solution of the AT, irrespective of fungicide concentration, than in those receiving the A0B5 treatment and the untreated control (A0B0). AT was the significant factor leading to yield differences among treatments.

1993 study. Small treatment differences were seen for individual weights of field-rotted berries of the cv. Early Black (Table 3). Berries receiving B2 and B4 treatments at all AT concentrations had higher individual weights of field-rotted berries than those in the A0B6 treatment. Most of the berries lost in the B6 plots were pea-sized (30 to 60% weight of healthy berries). F ratios for fungicide or AT were not significant for weight of storage-rotted or healthy berries.

Plots receiving B0 and B2 treatments with any rate of AT, as well as the A0B4 treatment, had field and total rot higher than those receiving the fungicide standard (A0B6). The effects of the fungicide were significant for percentage of field and total rot. The effect of the AT was not significant for any type of fruit rot. Thus, the fungicide was the important factor contributing to the observed fruit rot control.

Yield estimates (total yield) varied among treatments, and no trend was ob-

Table 1. Concentration combinations of the antitranspirant and chlorothalonil used between 1992 and 1994

Antitranspirant concentration (%)	Code	1992	1993	1994	Fungicide concentration (liters/ha)	(pt/A)	Code	1992	1993	1994
0	A0	*[a]	*	*	0	0	B0	*	*	*
1	A1		*	*	0.38	2	B2	*	*	
2	A2		*	*	0.57	3	B3	*		
2.5	A2	*			0.76	4	B4	*	*	*
3	A3		*	*	0.96	5	B5			*
5	A5	*			1.05	5.5	B5	*		
					1.15	6	B6		*	*
					1.34	7	B7			*

[a] Asterisks indicate the inclusion of a selected concentration for that particular year.

served relative to the fungicide standard (Table 3). Usable yield was lower in plots receiving any AT concentration combination with the B0 and B2 treatments relative to the A0B6 treatment. Plots receiving 2 and 3% AT with the B4 treatment also had lower usable yield. The *F* ratios for the effects of the fungicide were significant for both yield parameters, but not significant for the effects of the AT nor the interaction between the two factors.

Percentage of field rot was negatively related in a simple linear regression model to fungicide concentration (Fig. 1A). The slopes of the lines were similar (P = 0.996). Percentage of field rot decreased as fungicide concentration increased at a similar rate across all AT concentrations. Many of the low rate fungicide combination plots averaged between 90 and 100% fruit loss due to field rot. Usable yield was positively related to fungicide concentration (Fig. 1D). The slopes of the lines were similar ($P = 0.669$). Usable yield increased at a similar rate across all AT concentrations as fungicide concentration increased.

A line comparison matrix (least square means) was used to determine if any pairs of lines differed significantly from each other. Lines representing the various AT concentrations were not significantly different from each other for percentage of field rot loss ($P > 0.509$) or usable yield ($P > 0.369$). The addition of the AT at the tested concentrations neither improved fruit rot control nor increased usable yield. Predicted values calculated from the regression equations were used to draw the lines. *F* ratios for fungicide were highly significant ($P < 0.001$) for percentage of field rot, total rot, and usable yield indicating that the fungicide was the main factor contributing to disease control and the number of healthy berries produced.

No regression relationship existed be-

Table 2. Effect of applying three sprays of an antitranspirant (A) and chlorothalonil (B) at various rate combinations on cv. Howes cranberries, 1992

Antitranspirant (AT) concentration (%)	Fungicide concentration (liters/ha)	Fungicide concentration (pt/A)	Treatment code	Weight per berry (g) Field	Weight per berry (g) Storage	Weight per berry (g) Healthy	Rot (%) Field	Rot (%) Storage	Rot (%) Total	Yield (kg/ha) Total	Yield (kg/ha) Usable
0	0	0	A0/B0	0.24	0.92	1.04	9.8	4.4	14.2	17,709	15,711
2.5	0	0	A2/B0	0.14	0.50	0.95	16.6	8.1	24.7	17,009	12,836
5	0	0	A5/B0	0.16	0.38	0.91	22.2	4.5	26.7	13,565	9,109
0	0.38	2	A0/B2	0.21	0.68	1.04	12.7	6.5	19.2	25,186	21,611
2.5	0.38	2	A2/B2	0.13	0.56	1.01	10.9	12.6	23.5	14,642	12,151
5	0.38	2	A5/B2	0.15	0.41	0.92	25.9	7.0	32.9	9,259	5,965
0	0.57	3	A0/B3	0.10	0.49	1.05	11.2	3.3	14.5	17,437	15,852
2.5	0.57	3	A2/B3	0.11	0.48	0.98	17.4	5.8	23.2	15,608	12,214
5	0.57	3	A5/B3	0.16	0.49	0.90	17.3	7.2	24.5	12,165	8,411
0	0.76	4	A0/B4	0.17	0.62	1.00	14.4	3.6	18.0	17,761	15,065
2.5	0.76	4	A2/B4	0.17	0.29	0.93	22.9	11.8	34.7	19,162	12,857
5	0.76	4	A5/B4	0.13	0.20	0.79	31.7	6.7	38.4	9,150	4,486
0	1.05	5.5	A0/B5	0.15	0.66	0.98	12.4	4.8	17.2	20,990	17,345
2.5	1.05	5.5	A2/B5	0.10	0.39	0.89	24.7	8.3	33.0	14,318	8,884
5	1.05	5.5	A5/B5	0.15	0.31	0.89	31.8	4.2	36.0	9,364	5,579
Significance[a]											
Fungicide				NS	NS	*	*	NS	*	NS	NS
AT				NS	**	**	**	*	**	**	**
Fungicide × AT				NS	NS	NS	NS	NS	NS	NS	NS

[a] Analysis of variance, 5 replications: ** < = 0.01, * < = 0.05. NS = not significant.

Table 3. Effect of applying three sprays of an antitranspirant (A) and chlorothalonil (B) at various rate combinations on cv. Early Black cranberries, 1993

Antitranspirant (AT) concentration (%)	Fungicide concentration (liters/ha)	Fungicide concentration (pt/A)	Treatment code	Weight per berry (g) Field	Weight per berry (g) Storage	Weight per berry (g) Healthy	Rot (%) Field	Rot (%) Storage	Rot (%) Total	Yield (kg/ha) Total	Yield (kg/ha) Usable
0	0	0	A0/B0	0.50	0.60	0.77	90.1	1.2	91.3	13,780	1,617
1	0	0	A1/B0	0.52	0.57	0.79	88.4	1.1	89.6	15,608	1,385
2	0	0	A2/B0	0.46	0.53	0.85	90.2	1.0	91.2	15,498	1,219
3	0	0	A3/B0	0.48	0.65	0.81	83.9	0.7	84.6	17,113	2,853
0	0.38	2	A0/B2	0.55	0.67	0.80	45.7	2.2	48.1	20,880	9,014
1	0.38	2	A1/B2	0.60	0.72	0.83	45.4	4.5	49.9	18,728	8,246
2	0.38	2	A2/B2	0.58	0.70	0.89	50.3	1.9	52.2	14,318	5,991
3	0.38	2	A3/B2	0.61	0.77	0.85	52.7	3.1	55.9	21,205	8,540
0	0.76	4	A0/B4	0.54	0.65	0.79	23.1	3.9	27.0	18,948	11,283
1	0.76	4	A1/B4	0.56	0.74	0.86	17.9	4.3	22.2	20,991	13,851
2	0.76	4	A2/B4	0.57	0.80	0.87	20.0	1.6	21.6	14,960	9,823
3	0.76	4	A3/B4	0.43	0.56	0.80	15.4	2.7	18.1	15,284	9,802
0	1.15	6	A0/B6	0.31	0.37	0.82	9.0	1.3	10.3	18,514	13,934
1	1.15	6	A1/B6	0.36	0.57	0.86	6.9	1.3	8.2	20,024	15,454
2	1.15	6	A2/B6	0.26	0.55	0.83	10.9	1.2	12.1	23,358	17,346
3	1.15	6	A3/B6	0.42	0.66	0.82	9.2	3.4	12.6	21,315	15,422
Significance[a]											
Fungicide				**	NS	NS	**	NS	**	*	**
AT				NS	NS	NS	NS	NS	NS	NS	NS
Fungicide × AT				NS	NS	NS	NS	NS	NS	NS	NS

[a] Analysis of variance, 5 replications: ** < = 0.01, * < = 0.05. NS = not significant.

tween percentage of storage rot and total yield ($P > 0.511$ and $P > 0.102$, respectively) and fungicide concentration (Fig. 1B,C). In addition, F ratios were not significant for these parameters. Neither fungicide nor AT positively or negatively affected percentage of storage rot or total yield in this trial.

1994 study. Several treatments had lower weights of healthy berries than the fungicide standard (A0B7) treatment (Table 4). Lower berry weights occurred in treatments receiving either no AT or the 3% solution across several chlorothalonil concentrations. The effects of the AT treatment and the interaction of the fungicide and the AT were significant for individual weights of healthy berries. This indicates that the AT may have caused the observed decrease in berry weight. No significant effect of either factor was observed for field-rotted or storage-rotted berry weight.

Plots receiving the B0 treatment with any of the tested doses of the AT had higher field rot than plots receiving the fungicide standard. Plots receiving the 3% solution of AT combined with chlorothalonil tended to have more field and total rot (except A3B6). Plots receiving combinations of B4, B5, B6, and B7 with 1 or 2% solutions of the tested AT provided similar (commercially accepted) levels of field, storage, and total rot control relative to the fungicide standard. Plots receiving the B4 treatment with any combination of AT had more field and total rot than plots receiving higher fungicide concentration combinations. The effects of the fungicide treatment were highly significant ($P < 0.001$) for percentage of field, storage, and total rot. The effects of the interaction of the fungicide and the AT were significant only for percentage of field rot.

As in the 1993 study, the percentage of field rot was negatively related in a simple linear regression model to fungicide concentration (Fig. 2A). The slopes of the lines were similar ($P = 0.713$). The percentage of field rot decreased as fungicide concentration increased at a similar rate across all AT concentrations. The lines describing storage rot (Fig. 2B) did not relate to fungicide concentration ($P = 0.427$). The slopes of the lines describing the AT solutions were similar ($P = 0.312$) indicating the AT did not affect storage rot.

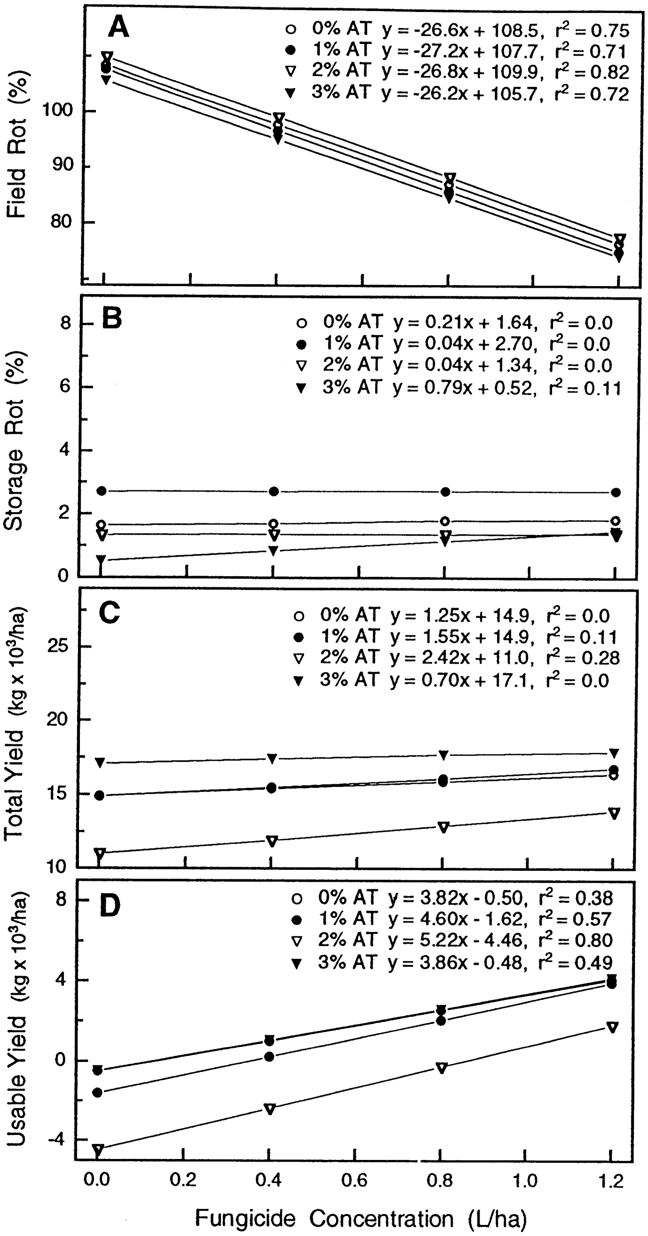

Fig. 1. Regression of predicted **(A)** percentage of field rot, **(B)** storage rot, **(C)** total yield, and **(D)** usable yield at various fungicide concentrations, 1993.

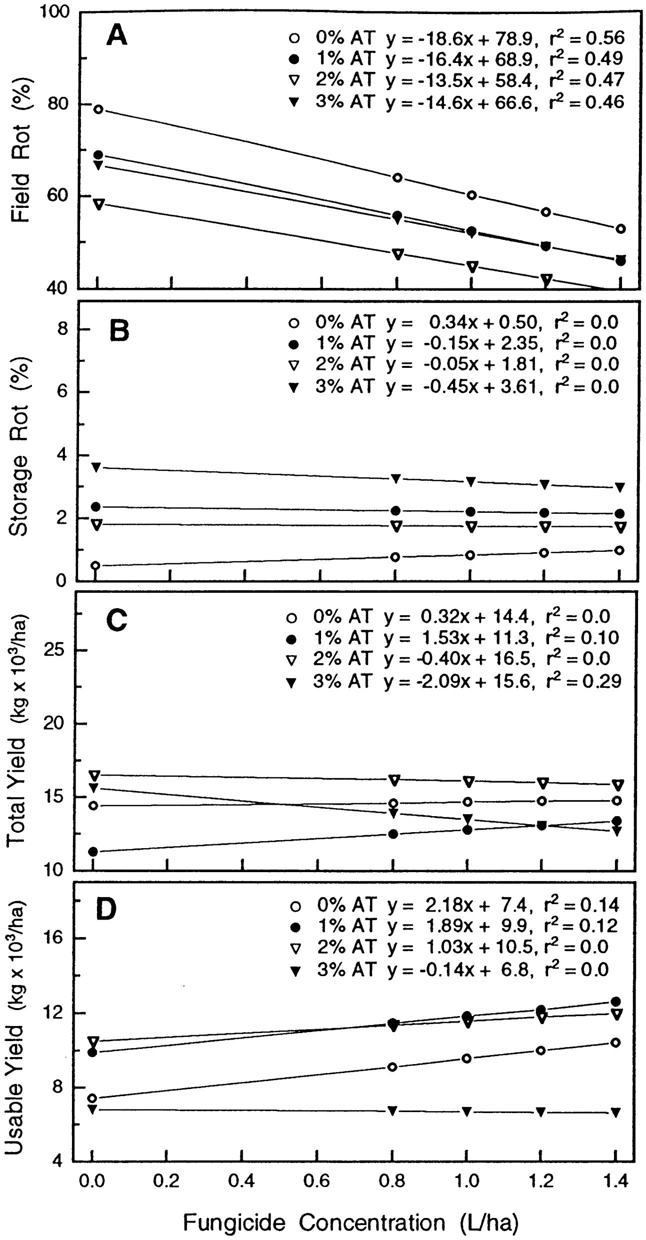

Fig. 2. Regression of predicted **(A)** percentage of field rot, **(B)** storage rot, **(C)** total yield, and **(D)** usable yield at various fungicide concentrations, 1994.

The amount of fruit lost to storage rot was negligible.

Based on the line comparison matrix, the lines representing the various AT concentrations were not significantly different from each other for percentage of field rot, storage rot, and usable yield ($P > 0.446$, $P > 0.236$, and $P > 0.342$, respectively). The addition of the AT did not affect fruit rot control nor the number of healthy berries produced. As in the 1993 study, the predicted values calculated from the regression equations were used to illustrate the general trends.

Total yield was negatively related in a simple linear regression model to fungicide concentration for the 3% AT treatment (Fig. 2C). The slopes of the lines were statistically different ($P = 0.012$). The 3% AT treatment differed from the 0, 1, and 2% AT treatments ($P = 0.006$). The high concentration of the AT was associated with a loss in total yield as the fungicide concentration increased. Plots receiving A3B5, A3B6, and A3B7 treatments had lower yields than those receiving the A0B7 treatment. The effects of the AT treatment and the interaction of the fungicide and the AT were significant for total yield. This indicates that the AT was important for causing the observed effect on total yield.

A positive simple linear relationship between usable yield (Fig. 2D) and fungicide concentration was strong, but not statistically significant ($P = 0.069$). The slopes of the lines representing the AT concentrations were similar ($P = 0.342$) indicating usable yield increased at a similar rate across all AT concentrations. As with total yield, the 3% AT treatment differed from the 0, 1, and 2% AT treatments ($P = 0.001$) for usable yield. The 3% AT treatment was associated with a loss in usable yield as the fungicide concentration increased.

A negative relationship between the use of chlorothalonil and yield components of cranberries grown in Wisconsin has been reported previously (14). No decrease in yield on plots treated with chlorothalonil has been observed in studies done in Massachusetts (3,4,5). Flower or vine injury caused by the fungicide has rarely been documented in Massachusetts (16). Whenever symptoms have been observed, adverse environmental and/or application conditions have usually been associated with the injury. Yield loss to fruit rot can be the most limiting factor in producing a commercially viable crop in Massachusetts (19,25). Thus, the risks of phytotoxicity are generally offset by the benefits provided by the fungicide.

It is not possible to draw conclusions based solely on the 1992 data because fruit rot levels in untreated control plots were not significantly different from those in the A0B5 plots (the standard of comparison for combination treatments). Variability in the data was probably associated with low inoculum present during that year. However, several interesting trends were observed. Reduced fungicide rate combined with the 2.5% rate of the AT had yields and percentage of fruit rot statistically comparable to the B5 rate (1.05 liters/ha or 5.5 pt/A; standard industry practice) of chlorothalonil. No significant detrimental effect on berry weight with the reduced rate combinations was observed with low rates of the AT. High rates of the AT (3 to 5%) were associated with increasing yield loss as fungicide concentration increased in two out of three studies. Occasionally, phytotoxicity has been associated with the use of spray adjuvants (27). Based on the results from the 1992 study, subsequent studies focused on testing efficacy of combinations of fungicide with lower AT concentrations.

The lowest rate of chlorothalonil that can be efficaciously used under these conditions is 0.76 liters/ha, even when combined with several rates of AT. This corroborates data from other research (4) as well as the fungicide label (recommended rate range is 0.76 to 1.34 liters/ha). In 1993, plots receiving B4 treatment with 1, 2, or 3% solutions of the AT averaged over 18% field rot. This level of fruit rot would not be acceptable to commercial cranberry growers. Most growers strive to keep losses due to fruit rot and insect damage below 8% of the crop yield.

Fruit rot levels in these studies are above what would be expected on commercial bogs because fungicide applications have been withheld from this experimental cranberry bed for several years, resulting in high inoculum build-up. Thus, the high percentage of fruit rot that occurred in plots receiving B4 treatments was most likely due to the high inoculum present in the unsprayed experimental cranberry bed. Under typical commercial conditions, this low end rate should pro-

Table 4. Effect of applying three sprays of an antitranspirant (A) and chlorothalonil (B) at various rate combinations on cv. Early Black cranberries, 1994

Antitranspirant (AT) concentration (%)	Fungicide concentration (liters/ha)	(pt/A)	Treatment code	Weight per berry (g) Field	Storage	Healthy	Rot (%) Field	Storage	Total	Yield (kg/ha) Total	Usable
0	0	0	A0/B0	0.71	0.00	0.90	92.4	0.0	92.4	13,241	1,537
1	0	0	A1/B0	0.69	1.33	1.09	84.2	0.6	84.8	10,875	6,069
2	0	0	A2/B0	0.74	1.07	0.96	71.1	0.7	71.8	13,456	4,596
3	0	0	A3/B0	0.72	0.93	0.97	80.7	0.7	81.4	13,131	3,298
0	0.76	4	A0/B4	0.67	0.76	1.10	11.2	1.9	13.1	14,642	14,093
1	0.76	4	A1/B4	0.61	0.79	1.10	5.1	3.5	8.6	16,257	16,543
2	0.76	4	A2/B4	0.67	0.63	1.07	6.1	2.8	8.9	20,128	19,879
3	0.76	4	A3/B4	0.51	0.77	0.91	8.1	5.2	13.3	12,917	10,144
0	0.96	5	A0/B5	0.61	0.72	1.15	3.5	2.1	5.6	19,700	20,919
1	0.96	5	A1/B5	0.45	0.86	1.01	3.2	3.0	6.2	17,223	16,398
2	0.96	5	A2/B5	0.74	0.59	1.04	3.1	2.1	5.2	14,856	14,729
3	0.96	5	A3/B5	0.65	0.52	0.88	11.1	3.7	14.8	6,673	4,902
0	1.15	6	A0/B6	0.66	0.29	1.11	6.2	1.8	8.0	13,780	14,409
1	1.15	6	A1/B6	0.64	1.02	1.09	2.7	1.6	4.3	16,795	16,999
2	1.15	6	A2/B6	0.57	0.76	1.00	5.7	1.8	7.5	13,859	13,393
3	1.15	6	A3/B6	0.64	0.95	1.05	4.1	1.2	5.3	9,474	9,272
0	1.34	7	A0/B7	0.41	0.28	1.03	1.6	1.8	3.4	15,284	15,512
1	1.34	7	A1/B7	0.70	0.50	1.08	3.3	0.7	4.1	18,189	18,813
2	1.34	7	A2/B7	0.60	0.81	1.03	3.9	0.9	4.8	14,642	14,493
3	1.34	7	A3/B7	0.37	0.14	0.90	9.6	0.5	10.1	4,416	3,718
Significance[a]											
Fungicide				NS	NS	NS	**	**	**	NS	*
AT				NS	NS	**	NS	NS	NS	*	**
Fungicide × AT				NS	NS	**	*	NS	NS	*	NS

[a] Analysis of variance, 5 replications: ** < = 0.01, * < = 0.05. NS = not significant.

vide adequate control on beds with low inoculum pressures.

The results of these studies indicate that addition of the AT, Wilt-Pruf, does not significantly contribute to an improvement in fruit rot control in cranberries grown in Massachusetts. However, several reduced rate combinations of chlorothalonil and Wilt-Pruf provided control comparable to that realized with the use of chlorothalonil alone at 1.15 or 1.34 liters/ha (6 or 7 pt/A). Wilt-Pruf and Bravo 720 are cost-equivalent to apply to cranberry bogs, negating any economic advantage to reduced rate combinations with these particular products. In certain situations, the incorporation of reduced rate combinations may offer the management advantage of lowered environmental risk per fungicide application.

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LITERATURE CITED

1. Averill, A. L., Averill, M. M., Kusek, C. C., and DeMoranville, C. J. Flooding in cranberries to minimize insecticide and fungicide inputs. Am. J. Altern. Agric. (In press.)
2. Averill, M. M., ed. Cranberry chart book, 1995 - Management guide for cranberries. Univ. Mass. Coop. Ext. Pub., University of Massachusetts, Amherst.
3. Caruso, F. L. 1993. Fruit rot fungicide studies in Massachusetts, 1992. Cranberries 57(4):5-6.
4. Caruso, F. L. 1994. Fruit rot fungicide studies in Massachusetts, 1993. Cranberries 58(3): 10,31-32.
5. Caruso, F. L., and Kusek, C. C. 1987. Timing Bravo 720 for control of field rot of cranberries, 1986. Fungic. Nematic. Tests 42:47.
6. Caruso, F. L., and Ramsdell, D. C. 1995. Compendium of blueberry and cranberry diseases. American Phytopathological Society, St. Paul, Minn.
7. DeMoranville, C. J. 1992. Cranberry nutrients, phenology, and N-P-K fertilization. Ph.D. diss., University of Massachusetts, Amherst.
8. DeMoranville, C. J., Averill, A. L., and Averill, M. M. 1994. Use of a 'late water' flood for pest control in cranberry production: Impact on pest populations, plant growth, and productivity. HortScience 29(4):248.
9. Elad, Y., Ayish, N., Ziv, O., and Katan, J. 1990. Control of grey mould (*Botrytis cinerea*) with film-forming polymers. Plant Pathol. 39:249-254.
10. Fellers, C. R., and Esselen, W. B. 1955. Cranberries and cranberry products. Univ. of Massachusetts Coop. Ext. Bull. No. 481.
11. Gomez, K. A., and Gomez, A. A. 1984. Statistical Procedures in Agricultural Research. John Wiley & Sons, New York.
12. Han, J.-S. 1990. Use of antitranspirant epidermal coating for plant protection in China. Plant Dis. 74:263-266.
13. Jeffers, S. N. 1991. Seasonal incidence of fungi in symptomless cranberry leaves and fruit treated with fungicides during bloom. Phytopathology 81:636-644.
14. Jeffers, S. N. 1991. Effects of fungicides applied during bloom on yield, yield components, and storage rots of cranberry. Plant Dis. 75:244-250.
15. Kamp, M. 1985. Control of *Erysiphe cichoracearum* on *Zinnia elegans* with a polymer-based antitranspirant. HortScience 20:879-881.
16. Kusek, C. C. 1991. Benefits of bloom fungicide applications can outweigh the risks. Cranberries 55(6):7.
17. Mahr, S. E. R., and Moffitt, L. J. 1994. Biologic and economic assessment of pesticide usage in the cranberry industry. NAPIAP Rep. No. 2-CA-94.
18. Marois, J. J., Bledsoe, A. M., Bostock, R. M., and Gubler, W. D. 1987. Effects of spray adjuvants on development of *Botrytis cinerea* on *Vitis vinifera* berries. Phytopathology 77: 1148-1152.
19. Sandler, H. A. 1993. Pest management in cranberries. Pages 14-21 in: Massachusetts Cranberry Production - An Information Guide. W. F. Clark and H. A. Sandler, eds. Univ. Mass. Coop. Ext. Publ., University of Massachusetts, Amherst.
20. Sandler, H. A., and Kusek, C. C. 1994. Influence of spreaders, stickers, and antitranspirants on chlorothalonil residue levels on cranberry fruit. J. Sm. Fruit Vit. 2(2):31-40.
21. Sisler, H. D. 1986. Control of fungal diseases by compounds acting as antipenetrants. Crop Prot. 5:306-313.
22. Shawa, A. Y., Shanks, C. H., Jr., Bristow, P. R., Shearer, M. N., and Poole, A. P. 1984. Cranberry production in the Pacific Northwest. Pacific Northwest Ext. Publ. No. 247. Washington State Univ., Pullman.
23. Shear, C. L., Stevens, N. E., and Bain, H. F. 1931. Fungus diseases of the cultivated cranberry. USDA Tech. Bull. 258.
24. SYSTAT, Inc. 1992. SYSTAT for the Macintosh User Guides, Version 5.2, SYSTAT, Inc., Evanston, Ill.
25. Weidemann, G. J., and Boone, D. M. 1983. Incidence and pathogenicity of *Phyllosticta vaccinii* and *Botryosphaeria vaccinii* on cranberry. Plant Dis. 67:1090-1093.
26. Ziv, O., and Frederiksen, R. A., 1983. Control of foliar diseases with epidermal coating materials. Plant Dis. 67:212-214.
27. Ziv, O., and Hagiladi, A. 1993. Controlling powdery mildew in euonymus with polymer coatings and bicarbonate solutions. HortScience 28:124-126.