water pH at the highest B concentrations (Spraybor in all three waters; Greenleaf Boron in WCW and TWW; and Albion Liquid Boron in TWW). Five products (Solubor, Solubor DF, Borosol, Liquibor, N-Boron) caused pH to increase at all tested B concentrations.

The additives in some of the B products qualitatively explain the differential pH effects. The acidifier incorporated into Spraybor was effective at partially neutralizing the pH increase caused by polyborate hydrolysis. The possible presence of residual processing acid in Greenleaf Boron makes it a less alkaline product than the polyborate-only products, as does the presence of amino acids in Albion Liquid Boron. Hydrolysis of amino compounds and urea and consequent release of ammonium likely accounts for the high pH values generated by the boric acid-based N-Boron and Borosol-10. The small amount of sodium polyborate in the boric acid-dominated Liquibor appears to increase and maintain solution pH in the range characteristic of the polyborate-only products.

Conclusions

Of 10 tested products formulated for use in B nutritional sprays, only the boric acid-based B-17 and MorBor-17 did not increase solution pH over background levels in natural waters; rather, they reduced pH. For many spray waters, using these products as the B source for tank-mixes would eliminate the requirement for adding an acidifier to counterbalance B product-induced alkalinity. In waters that are naturally alkaline and highly pH-buffered, the acidity generated by boric acid-based products alone may be insufficient to reduce final solution pH to values low enough to preclude alkaline hydrolysis. Addition of an exogenous acidifier may still be required in such waters. It is possible that adding boric acid-based products to poorly buffered naturally acid waters could reduce pH to values low enough to influence the chemistry of acid-sensitive tank-mixed compounds, thereby requiring addition of an acid-neutralizing agent. Diazinon is an example of a pesticide that degrades rapidly in low pH solutions (Bailey et al., 1996).

All of the remaining products caused pH to increase, sometimes substantially, at the B spray concentrations likely to be used in agricultural settings, typically less than 1 lb/100 gal (1.2 $g \cdot L^{-1}$). Tank-mixing of these latter B products with alkalinity-sensitive crop protection chemicals and growth regulators therefore would require addition of an acidifier to reduce solution pH to an acceptable level. Less acidifier may be required for Spraybor because it produced a smaller pH increase than did the other sodium polyborate-based products. The difference in pH performance between the six most alkaline B products was small enough to be of little practical significance; hence, other properties, such as organic certification, handling characteristics, and cost may distinguish which of these product is best suited for a particular spray application.

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Canopy Development and Spray Deposition in Highbush Blueberry

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Additional index words. captan, sprayer, *Vaccinium corymbosum*, fungicide, insecticide

Summary. **Most highbush blueberrie (*Vaccinium corymbosum* L.) in Michigan are treated annually with fungicides and insecticides with several types of sprayers. The goal of this study was to determine how sprayer type, pruning severity, and canopy development interact to affec spray deposition patterns. Deposition was measured as the percentage of th surface area of card targets that was covered following applications of black dye. Light measurements indicated that the canopy of blueberr bushes, regardless of pruning treatment, closed by the middle of June, and light levels within the canopy changed little from then until fruit harvest in August. A standard airblas sprayer that pushed spray up and**

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white kromcoat cards were clipped to each target. Targets were placed in four positions within bushes: 1) bottom [0.6 to 1.0 m (2 to 3 ft) height in center of canopy], 2) top of canopy, 3) west side at height of 1.0 to 1.5 m (3 to 5 ft), and 4) east side at the same height. Targets were clipped to branches in a random orientation in the same two bushes used for the light measurements. After the dye solution was sprayed and the cards had dried, the cards were placed in plastic bags, and later read with computer imaging software (Optimas Imaging Corp., Edmonds, Wash.) that measured the percentage of the surface area that was covered with dye. Sixteen measurements were made per target (two per surface on four cards). The mean of 16 measurements was calculated for each target. Coverage usually varied greatly depending on the orientation of surfaces relative to the sprayer. A coefficient of variation was calculated for the 16 measurements per target to illustrate the uniformity of coverage.

This system was used to study the spray deposition patterns of two sprayers on 13 May, 29 May, 3 July, and 11 July 1996. An Agtec (Ag-Chem, Minnetonka, Minn.) three-point hitch airblast sprayer (Fig. 1) was tested at a spray volume of 187 $L \cdot ha^{-1}$ (20 gal/acre). The airblast sprayer was driven every other row middle at 1.5 $m \cdot s^{-1}$, (3.4 miles/h) and had an estimated field capacity of 3.2 $ha \cdot h^{-1}$ (7.9 acre/h). The target bushes were in rows three and four of the five row-wide pruning plots, and the airblast sprayer was driven between rows two and three, and back between rows four and five. Average coverage was calculated between the two target bushes for the top and bottom of the bushes, and for the sides nearest to and farthest from the sprayer pass.

Deposition patterns of an above-row sprayer (Fig. 2) were also studied on the same days. The above-row sprayer was constructed by agricultural engineers at Michigan State University, and was similar to the Proptec machine marketed by Ledebuhr Industries (Bath, Mich.). The sprayer boom covered four rows (two nozzle/fans units per row), and delivered a spray volume of 94 $L \cdot ha^{-1}$ (10 gal/acre). The above-row sprayer was driven every fourth row middle at 1.5 $m \cdot s^{-1}$ giving a field capacity of 6.7 $ha \cdot h^{-1}$ (16.5 acres/h). The nozzle/fan assemblies were positioned about 1 m apart along the boom, and were oriented facing downward at roughly 10 o'clock and 2 o'clock positions about 1 m (3.3 ft) above the plants. The front fan was angled about 20 degrees forward toward the center of the row, while the back fan was angled 20 degrees rearward towards the center of the row. During the deposition tests, the above-row sprayer was driven between rows three and four of the pruning plots, and the target bushes were the same as those used for the airblast sprayer (rows three and four).

A third study was conducted to compare deposition patterns when the airblast sprayer was driven down each row middle or every other middle. Targets were placed in the same positions in the same bushes for each run. Flow rates were changed when every row middle was sprayed so that the spray volume was the same [187 $L \cdot ha^{-1}$ (20 gal/acre)]. Comparisons were made on 13 May (budbreak) and 14 June (full bloom).

Data were analyzed by SAS computer software (SAS Institute, Cary,

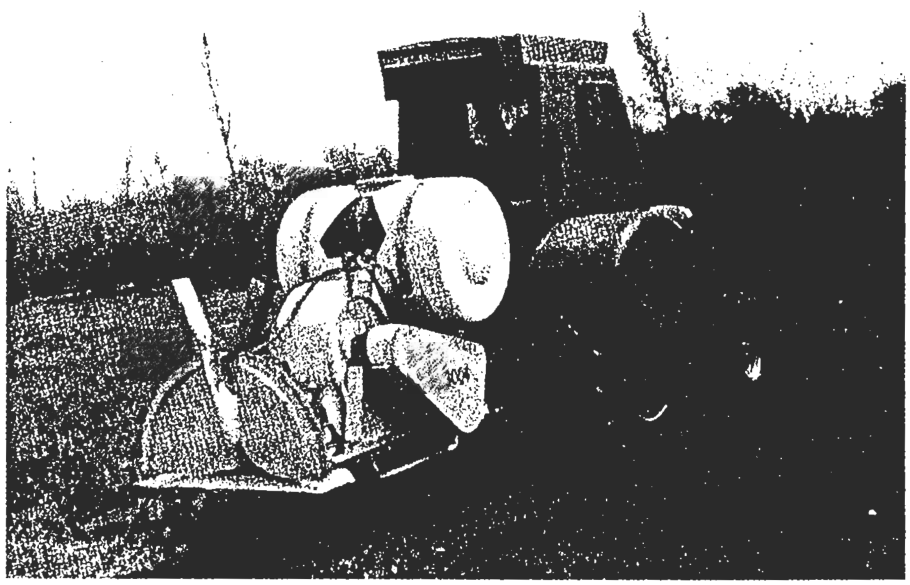

Fig. 1. Conventional airblast sprayer used in spray deposition studies.

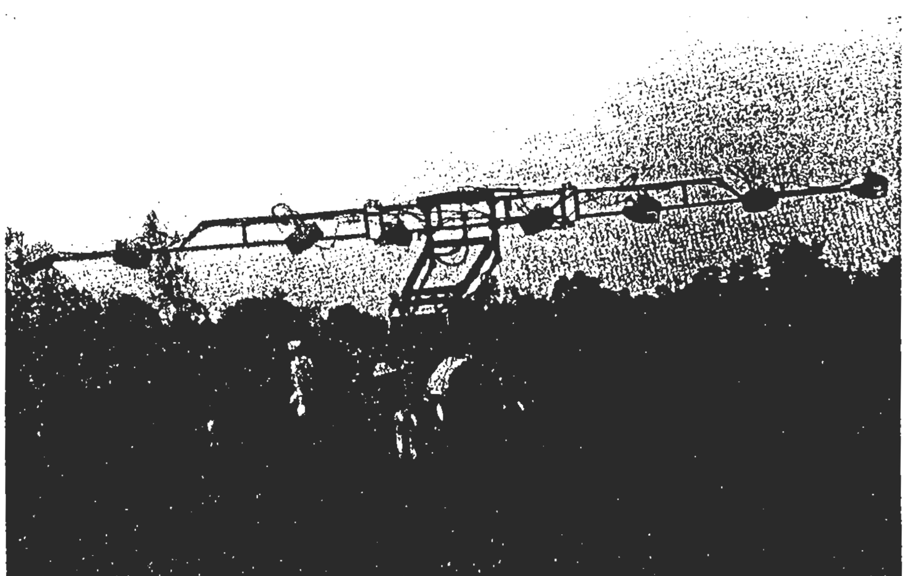

Fig. 2. Above-row sprayer used in spray deposition studies.

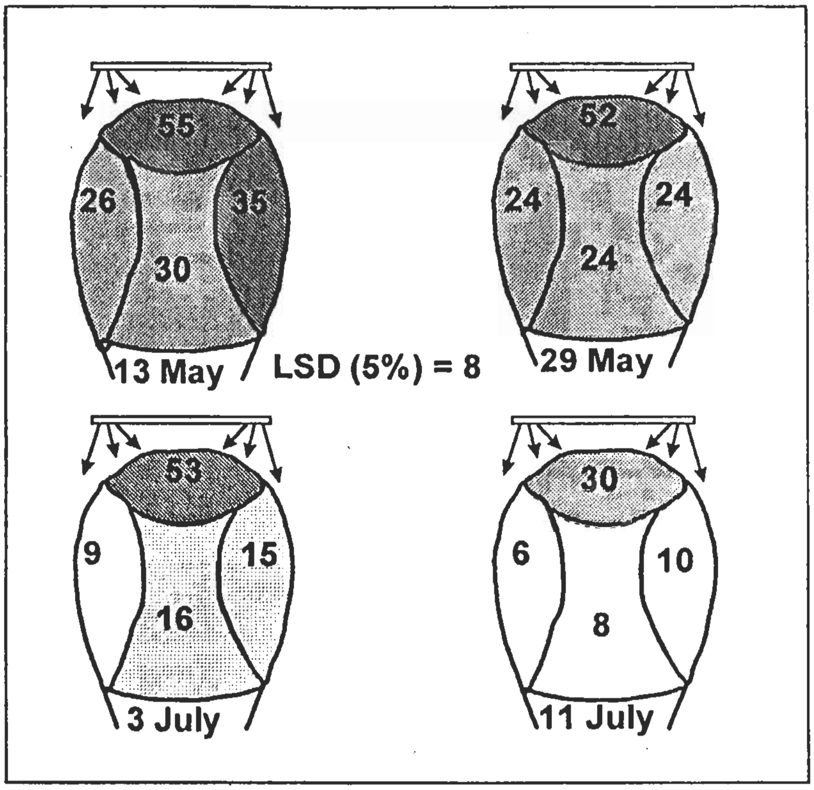

Fig. 4. Spray coverage (percent of surface area of card targets) in different positions in 'Jersey' blueberry canopies following treatment with an above-row sprayer on four dates between 13 May (pink bud) and 11 July (green fruit). Data are means across three pruning treatments. LSD value refers to comparisons between dates and positions.

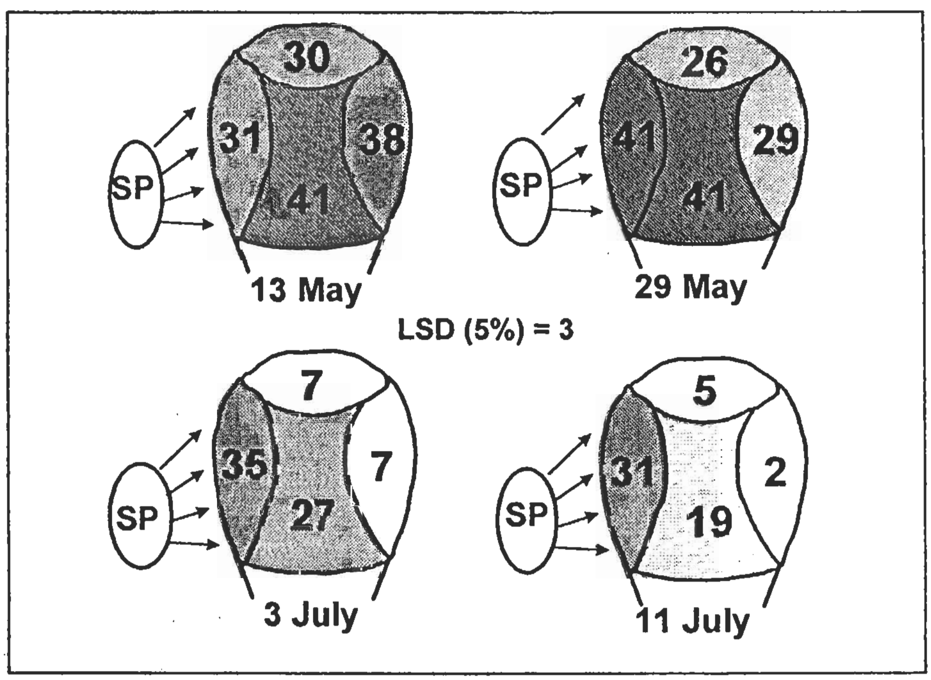

Fig. 5. Spray coverage (percent of surface area of card targets) in different positions in 'Jersey' blueberry canopies following treatment with an airblast sprayer (SP) on four dates between 13 May (pink bud) and 11 July (green fruit). Data are means across three pruning treatments. LSD value refers to comparisons between dates and positions.

11 July, coverage was poor on the sides and in the bottom of the bush, while that in the top of the bush remained high (Fig. 4). Driving the airblast sprayer down alternate row middles resulted in thorough coverage throughout the bush on 13 May and 29 May (Fig. 5). On 3 July and 11 July, coverage was poor on the top and the side farthest from the sprayer, while coverage on the side facing the sprayer remained high (Fig. 5).

The airblast sprayer operated in every row middle resulted in thorough coverage in all parts of the bush, whether sprayed on 13 May or 14 June (Fig. 6). In contrast, alternate row middle spraying with the same sprayer resulted in thorough coverage on 13 May, but poor coverage on the far side of the bush when sprayed at full bloom (14 June) (Fig. 6). Whereas driving airblast sprayers between every row provides excellent coverage, acreage can only be treated at half the speed of alternate row middle spraying. Also, every row middle spraying may not be practical for large bushes close to harvest because berries on overhanging canes may be knocked to the ground or bruised.

The impact of pruning severity on spray coverage with the two sprayers is illustrated in Fig. 7. In general, more severe pruning increased coverage in the areas of the canopy receiving lower overall coverage (e.g., bottom and sides with the above-row sprayer, and the top and far side with the airblast sprayer). Pruning tended to have less effect in positions where overall coverage was high (e.g., top of bush with the above-row sprayer, and bottom and near side with the airblast sprayer).

Spray coverage varied considerably between the 16 measurements on each target. Typically, readings varied from 10% to 90% coverage within a target, presumably due to the orientation of the surfaces relative to the spray source. The uniformity of coverage was assessed by comparing the coefficients of variation (CV) of the 16 measurements within each 4-card target (Table 3). The CVs were lowest with both sprayers early in the season. Targets closest to the spray source (top for the above-row sprayer, near side for the airblast sprayer) had lower CVs than targets in other canopy positions. Pruning reduced the CVs for the above-row sprayer, but not for the airblast sprayer.

The relationships between the

Table 3. Effect of time of application, position in the canopy, and pruning severity on the coefficients of variation among the 16 measurements of percent coverage on card targets.

Parameter	Coefficient of variation	
	Airblast sprayer	Above-row sprayer
Time		
13 May	70 a[z]	77 a
29 May	70 a	76 a
3 July	101 b	94 b
11 July	104 b	94
Significance	***	***
Position		
Top	89 b	63 a
Bottom	96 c	99 c
Near/east	76 a	88 b
Far/west	82 a	92 b
Significance	**	***
Pruning		
Light	87	96 c
Moderate	84	77 a
Heavy	86	84 b
Significance	ns	**

[z]Means in columns separated by LSD ($P = 0.05$).

ns,**,***Nonsignificant or significant F test at $P \leq 0.001$ or 0.01, respectively.

The above-row sprayer provided excellent coverage in the top of the bush, but coverage in the bottom and on the sides was poor late in the season. The airblast sprayer resulted in high coverage in the bottom of the bush and on the side facing the sprayer, but coverage was poor later in the season on the side opposite the sprayer and in the top of the bush. Operating the airblast sprayer between each row rather than alternate row middles, increased coverage and uniformity, but also increased treatment time and may result in more fruit damage.

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Effects of Spinosad and Acephate on Western Flower Thrips Inside and Outside a Greenhouse

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Additional index words. natural enemies, transvaal daisy, *Frankliniella occidentalis*, spinosad, biological control, *Gerbera jamesonii*

Summary. Greenhouse studies were conducted from 1996 to 1998 to determine the efficacy of spinosad, and acephate, against western flower thrips (*Frankliniella occidentalis* Pergande) on transvaal daisy (*Gerbera jamesonii* H. Bolus ex. Hook f). In addition, the number of natural enemies inside and outside the greenhouse was determined. Studies were arranged in a randomized complete-block design with four blocks and four treatments per block. Three rates of spinosad, 50, 100, and 200 $mg \cdot L^{-1}$ (ppm), and one rate of acephate, 600 $mg \cdot L^{-1}$ were used in all three studies. Plants were artificially inoculated at bloom with 10 adult western flower thrips. The number of live and dead thrips was counted from each plant. In all three studies, both spinosad and acephate controlled thrips. However, there was more variation in the average number of live thrips for acephate than spinosad across years. In all treatments fewer live thrips and more natural enemies were found on plants outside the greenhouse than inside the greenhouse. This suggests that placing plants outdoors allows the natural enemies of thrips to colonize plants and provide supplemental control.

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