Evaluation of the Tree-Row-Volume Concept with Density Adjustments in Relation to Spray Deposits in Apple Orchards

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ABSTRACT

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The tree-row-volume concept (TRV) was evaluated as a method for determining the amount of pesticide or growth regulator to apply per hectare in apple orchards. TRV is based on the assumption that the volume of foliage per hectare in an orchard can be used as a guide for determining the spray-dosage volume per hectare. An adjustment for canopy density was proposed and evaluated. Three pruning levels (light, moderate, and heavy) were established in five orchards of different sizes ranging from 11,720 to 69,520 m^3/ha TRV. TRV and density adjustments resulted in similar deposits on trees over pruning levels within orchard size classes. Deposit was not as consistent among trees in different size classes. Deposit on the smallest trees was signficantly less than on larger trees in other orchard blocks. This may have been due to blow-off of deposit by wind from the sprayer fan. Differences in deposit among trees in other orchards may have resulted from differences in tree structure or from the use of different numbers of nozzles and different disc and core combinations to achieve the proper TRV water volume per hectare. Drift from adjacent rows was shown to contribute significantly to deposit in orchards with small trees. A survey of growers indicated that about 50% were using less fungicide than the TRV rate and 50% were using more.

Additional key words: *Malus domestica*

In the United States, pesticide and growth-regulator recommendations on apples (*Malus domestica* Borkh.) are generally made on the basis of carrier volume (per 378.5 L [100 gal]) or area (per hectare [acre]). These recommendations are based on dilute applications of materials to trees, in a "standard" orchard, which are about 6.1 m (20 ft) high, 7.0 m (23 ft) wide, and 10.7 m (35 ft) between rows (3,6). Most orchards today do not conform to this standard and many pesticides are applied at some level of concentration other than dilute. These changes have caused considerable confusion, which often results in incorrect quantities of pesticides applied.

Byers et al (3) proposed the tree-row-volume concept (TRV) to determine the volume of water necessary to provide pesticide coverage to trees in orchards that differ from the standard. TRV is based on the assumption that each row is a rectangular box and the volume occupied by foliage per hectare is calculated on the basis of this concept. For a standard orchard, the TRV is 39,907 m^3 of foliage per hectare (570,331 ft^3/A). On the basis of dilute application of pesticides to runoff (drip) (3,740 L/ha [400 gal/A]), 1 L of water is required to cover the foliage within 10.67 m^3 (0.7 gal/1,000 ft^3). Thus, using TRV and a standard dosage volume of 1 L/10.67 m^3 for pesticide application, the amount of spray liquid required in any orchard can be determined relative to the standard orchard irrespective of differences in tree size or spacing.

Using the TRV concept, Herrera-Aguirre and Unrath (5) reported reduced variability in thinning spur Delicious with ethephon. They used a standard dosage volume of 1 L/8.62 m^3 of foliage. In subsequent studies, Unrath (*unpublished*) has used 1 L/7.48 m^3 of foliage (1 gal/1,000 ft^3) as the standard dosage volume. Recommendations for thinning spur Delicious in North Carolina are currently based on the TRV concept (8), and the TRV concept is included in spray recommendations from other states (9) as a guide for pesticide application.

This study was undertaken to quantitatively assess uniformity of pesticide deposit when applied according to TRV. An adjustment to TRV for tree density also was investigated.

MATERIALS AND METHODS

Location of studies. Tests were conducted in six orchard blocks at Hillcrest Orchards, Henderson County, NC (Hillcrest), and in an orchard at University Farm No. 2, Raleigh, NC (Unit 2). Orchard descriptions at each location are included in descriptions of individual studies.

Treatment application and determination of deposit. Heavy metal chelated micronutrients were used to determine deposit levels (10). Those used were Sequestrene Zinc (Zn, 14.2%), Sequestrene Manganese (Mn, 12.0%), Sequestrene Copper (Cu, 13.0%), and Sequestrene 330 Fe (Fe, 10%) (Ciba-Geigy Corp., Greensboro, NC 27409). Solutions of 500 μg heavy metal per milliliter were applied for each treatment in all tests. When multiple applications were used, sufficient

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time was allowed after each spray for complete drying. Multiple treatment comparisons within tests were made by determining the deposit of different heavy metals on the same leaf sample.

Treatments at Hillcrest were applied with a Myers model 2A36 airblast sprayer (F. E. Myers & Bros. Co., Ashland, OH 44805). At Unit 2, an FMC model LV400 airblast sprayer (FMC, Jonesboro, AR 72401) was used. In all tests, the sprayer was driven at 54.6 m/min (2 mph). Manifold pressure was 14 kg/cm^2. Appropriate combinations of nozzle numbers and disc and core sizes were selected to deliver the volume of water necessary for each treatment. Sprayer nozzle angles were adjusted to deliver two-thirds of the spray volume to the top one-third of the tree and the other one-third to the bottom two-thirds of the tree.

Because deposition is not uniform within a tree, trees were partitioned into four or six regions for sample collection (10). Trees partitioned into four regions were divided by a vertical plane in the center of the tree and by a horizontal plane at the midpoint of the tree (Fig. 1). Trees partitioned into six regions were divided by two vertical planes into three sections of equal width (right, middle, and left). Each section also was divided into an upper and lower segment at the midpoint of the tree (Fig. 1). All trees were divided into four regions except trees in blocks 4 and 5 at Hillcrest, which were divided into six regions.

After the deposits dried, five three-leaf samples were picked at random from each region. This level of sampling was shown by Travis (10) to provide a reliable estimate of deposit. Leaves that were within 10 cm of one another were selected and picked by their petioles to minimize contact with the leaves' surfaces. Each three-leaf sample was placed in a paper bag, labeled, and refrigerated at 2 C until analyzed.

Deposit determination. Heavy metal deposit on leaves was determined by foliar mineral analysis. Leaf samples were dried at 75 C for 48 hr and ground using a mortar and pestle, then dry weights were determined. Dried leaves were ashed at 500 C for 12 hr, dissolved in HCl, evaporated, and diluted to volume with distilled water. The weight of heavy metal(s) (micrograms per gram of leaf tissue) was determined using an atomic absorption spectrophotometer (model 306, Perkin Elmer, Norwalk, CT 06856).

Regression equations relating leaf dry weight to surface area were used to convert micrograms of metal per gram of leaf tissue to micrograms of metal per square centimeter of leaf surface. Equations were derived for each block from 25 leaves chosen at random. The area of each leaf was measured with an area meter (Li-Cor, model 5000, Lamda Instrument Corp., Lincoln, NE); leaves were dried at 75 C and the dry weight of each leaf was determined.

Table 1. Density ratings for trees in blocks 1–5 at Hillcrest Orchards in 1981[w]

	Tree size (orchard no.)[y]				
Pruning level[x]	**1**	**2**	**3**	**4**	**5**
1	60.43 a[z]	116.80 a	196.56 a	234.65 a	302.12 a
2	55.36 a	92.31 ab	164.40 a	147.26 b	197.35 b
3	27.80 b	62.73 b	144.70 a	118.35 b	167.87 b

[w] Means within columns followed by the same letter are not significantly different according to Duncan's new multiple range test ($P = 0.05$).
[x] Pruning levels: 1 = light or no pruning—maintenance of the drive row, dead and broken branch removal, and selective sprout removal; 2 = moderate—removal of upright growth to reduce shading and size control to maintain tree in its space; and 3 = heavy—limb removal to open the tree and to establish a balanced limb structure.
[y] See Table 3 and text for complete descriptions of orchards.
[z] Average density of cube × number of cubes.

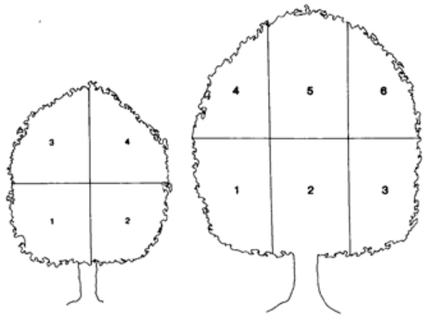

Fig. 1. Diagram of (left) small and (right) large trees illustrating how they were divided into four or six regions in-the-row for sampling deposits.

Tree density ratings. In 1981, tree density was rated in the five blocks at Hillcrest, using a rating system developed by Travis (10). Density values were calculated on the basis of the number of leaves and number and size of branches within a cube. The vertical midpoint of the tree was located and marked and a horizontal plane 61 cm thick was established through the tree. The plane was divided into cubes 61 × 61 × 61 cm and density ratings were made in every other cube. The average density rating of these cubes was multiplied by the number of cubes within the plane to give a density value for each tree (Table 1).

TRV and density adjustments. TRV was calculated as follows: TRV (m^3 foliage/ha) = (10,000 m^2/ha × tree height [m] × limb spread [m])/(cross-row spacing [m]).

To determine the quantity of water necessary to cover the foliage within this volume, TRV was first adjusted for density on a scale ranging from 0.7 to 1.0 (Table 2), the multiplied by 1 L/7.48 m^3. We elected to use 1 L/7.48 m^3 (1 gal/1,000 ft^3) foliage as opposed to 1 L/10.67 m^3 (0.7 gal/1,000 ft^3) foliage as the standard dosage volume because of the second author's experience with growth-regulator application at this rate.

Relationship of deposit to tree size and pruning level. These studies were conducted at Hillcrest during 1981 and 1982. In 1981, 12 trees in each of five orchard blocks of different sized trees were selected (designated as sizes 1, 2, 3, 4, and 5). Block 1 trees were 5-yr-old standard Golden Delicious that had been lightly pruned to a central leader. Block 2 trees were lightly pruned, untrained 14-yr-old Top Red with no central leader. Block 3 trees were upright, lightly pruned, vase-shaped, 12-yr-old Skyspur Delicious. Block 4 trees were moderately pruned and trained, 16-yr-old standard Golden Delicious with a modified central leader. Block 5 trees were unpruned 34-yr-old Stayman. All trees were on seedling rootstock. Within each block, three pruning levels were established: light or no pruning, moderate pruning, and heavy pruning. Light or no pruning involved maintenance of the drive row, dead and broken branch removal, and

Table 2. Canopy density adjustments for tree-row-volume

Density adjustment	Tree canopy description
0.70	Trees extremely open, light penetration throughout entire tree, fewer than 14 scaffold limbs per tree or young tree
0.75	Trees very open, 18–21 scaffolds per tree, light penetration throughout tree, healthy spurs within tree canopy
0.80	Trees well pruned, adequate light in trees for healthy spurs throughout trunk and scaffold limbs, many holes in foliage where light can penetrate
0.85	Trees moderately well pruned, reasonable spur population within canopy, tree thick enough that light cannot penetrate the bottom two-thirds of tree
0.90	Tree pruned minimally, spurs inside canopy weak because of limited light, very few holes where light can penetrate
0.95	Little or no pruning, spurs dead or very weak in canopy, very little light visible through tree
1.00	Tree unpruned, extremely thick, no light penetration through tree canopy, trees more than 6.1 m high

selective sprout removal. Moderate pruning included removal of upright growth to reduce shading and size control to maintain the tree in its space. Heavy pruning involved limb removal to open the tree and to establish a balanced limb structure. Pruning levels were assigned at random to four trees in each block and trees were pruned in March of each year. Moderately and heavily pruned trees were desprouted in May 1981 and June 1982 before the treatment application. The height and width of trees in blocks 1–5 are listed in Table 3.

In 1982, the same trees used in 1981 were used in blocks 2 and 4 and a block of 10-yr-old Starkrimson trees on MM 104 rootstock was also used (designated block 1A). Trees in block 1A were trained to a central leader and had been lightly pruned. Trees in blocks 2 and 4 were lightly pruned to maintain the pruning levels established in 1981. Four trees in block 1A were pruned to approximate the light, moderate, and heavy pruning levels established in other blocks. The height and width of trees in 1A, 2, and 4 are listed in Table 4.

In both tests, the moderately pruned trees were sprayed with the Cu chelate and the lightly pruned trees were sprayed with the Zn chelate. In 1981, well-pruned trees were sprayed with the Fe chelate; in 1982, they were sprayed with the Mn chelate. A 100-leaf sample was taken from each tree in 1981 and 1982 before treatment application to determine base foliar micronutrient levels. In both years, micronutrient levels were generally less than 10% of the total deposit, except Fe, which ranged from 10 to 25% of the deposit. Background nutrient levels were subtracted from the deposit before analysis. Data from the 1981 tests are presented as cumulative percentage of deposit (Figs. 2 and 3).

In 1981, treatments were applied on 22 May. Canopy development was nearly complete at that time. Air temperature was 11.1 C at 0800 hours, increased to 25 C at 1600 hours, and declined to 13.3 C at 1900 hours. Relative humidity was 100% at 0800 hours, rapidly declined to 50% by 1000 hours, and was 32% at 1800 hours. Wind speed ranged from 0 to 14.8 km/hr. The first application was made at 0830 hours and the test was completed by 2000 hours. In 1982, the test was conducted on 18 June. Tree canopies were fully developed and many terminal buds were set. Air temperature was 15.6 C at 0800 hours and ranged from 20 to 21 C from 1300 to 1800 hours. Relative humidity was 100% at 0800 hours, declined to 80% by 1000 hours, and remained at 60–70% from noon until 1800 hours. Wind speed averaged 0–6 km/hr. The test was begun at 1030 hours and completed at 1600 hours.

Contribution of drift to deposit. Two

Table 3. Tree size, pruning level, tree-row-volume (TRV), density adjustment, and amount of water (L/ha) applied in TRV test conducted in 1981

Tree size (block no.)	Pruning level[x]	Mean height (m)	Mean width (m)	TRV (1,000 m³/ha)	Density adjustment[y]	Water (L/ha)[z]
1	1	4.06	3.75	20.80	0.85	2,364
	2	3.36	3.20	14.69	0.80	1,571
	3	3.20	2.68	11.72	0.75	1,175
2	1	5.49	6.34	38.04	0.85	4,323
	2	5.03	6.04	33.20	0.80	3,551
	3	4.51	6.04	29.77	0.75	2,985
3	1	6.34	5.03	49.79	0.85	5,658
	2	5.64	4.72	41.56	0.80	4,445
	3	4.72	4.42	32.57	0.75	3,266
4	1	6.49	7.56	49.06	0.95	6,231
	2	5.79	6.95	43.98	0.85	4,998
	3	5.28	6.71	38.72	0.80	4,141
5	1	7.72	8.24	69.52	1.00	9,294
	2	6.19	7.63	51.62	0.90	6,211
	3	5.73	7.41	46.40	0.85	5,272

[x] Pruning levels: 1 = light or no pruning—maintenance of the drive row, dead and broken branch removal, and selective sprout removal; 2 = moderate—removal of upright growth to reduce shading and size control to maintain tree in its space; and 3 = heavy—limb removal to open the tree and to establish a balanced limb structure.
[y] See Table 2 for description.
[z] Based on 1 L of water to cover 7.48 m³ of foliage.

Table 4. Tree size, pruning level, tree-row-volume (TRV), density adjustment, and amount of water (L/ha) applied in TRV tests conducted in 1982

Tree size (block no.)	Pruning level[x]	Mean height (m)	Mean width (m)	TRV (1,000 m³/ha)	Density adjustment[y]	Water (L/ha)[z]
1A	1	4.88	3.96	24.85	0.85	2,824
	2	4.88	3.96	24.85	0.80	2,658
	3	4.88	3.96	24.85	0.75	2,492
2	1	5.49	6.34	38.04	0.85	4,323
	2	5.03	6.04	33.20	0.80	3,551
	3	4.51	6.04	29.77	0.75	2,985
4	1	6.41	7.93	55.55	0.95	7,055
	2	5.79	6.95	43.98	0.85	4,998
	3	5.28	6.71	38.72	0.80	4,141

[x] Pruning levels: 1 = light or no pruning—maintenance of the drive row, dead and broken branch removal, and selective sprout removal; 2 = moderate—removal of upright growth to reduce shading and size control to maintain tree in its space; and 3 = heavy—limb removal to open the tree and to establish a balanced limb structure.
[y] See Table 2 for description.
[z] Based on 1 L of water to cover 7.48 m³ of foliage.

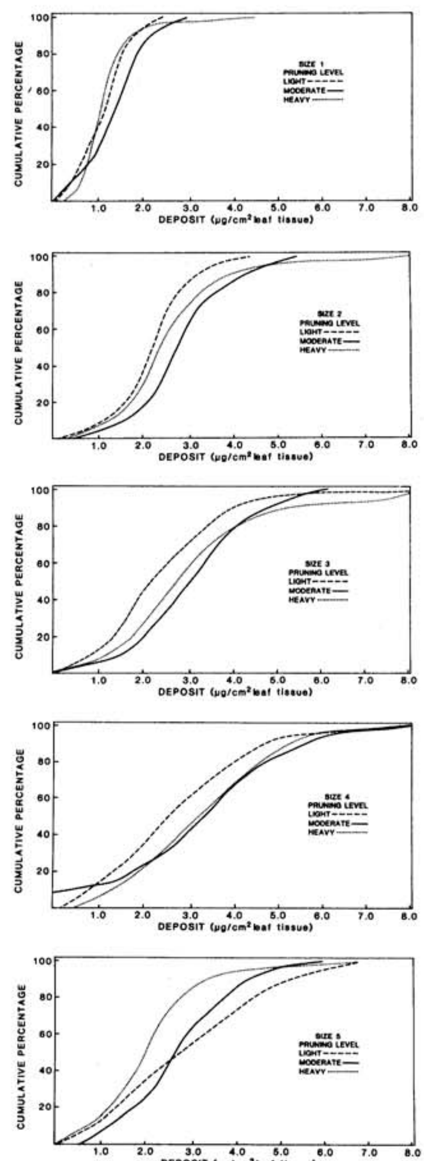

Fig. 2. Cumulative percentage of deposit over three pruning levels for the five orchard blocks (tree sizes) evaluated at Hillcrest Orchards in 1981. See text for complete descriptions of orchards and pruning levels.

studies were conducted to determine the contribution of drift to deposit. One test was conducted in block 1A at Hillcrest. Five rows of moderately pruned trees were selected (designated 1, 2, 3, 4, and 5). Row 1 was a spur-type Golden Delicious; rows 2–5 were Starkrimson Delicious. All trees were pruned to a modified central leader. The TRV of the center row was 19,800 m^3/ha.

A second test was conducted at Unit 2. Three rows (rows 1–3) of 12-yr-old Ryan Red Delicious on M.26 rootstock were selected for this study. The trees were moderately pruned, 2.7 m tall, 3 m wide, and set in rows 5.9 m apart. Their TRV was 13,729 m^3/ha.

At Hillcrest, the center row (row 3) was sprayed with the Cu chelate and samples were taken from four trees selected at random after the residue had dried. Then rows 2 and 4 were sprayed. The foliage was again allowed to dry before the samples were taken from the trees in row 3. Rows 1 and 5 were sprayed, and after drying, trees in row 3 were sampled again.

At Unit 2, the center row (row 2) was sprayed with the Cu chelate, allowed to dry, and four trees selected at random were sampled. Then rows 1 and 3 were sprayed with the Cu chelate and the trees in row 2 sampled again. Before the treatment application, a 100-leaf sample was taken from each tree to determine background micronutrient levels. Background Cu levels were less than 5% total deposit.

The experiment at Hillcrest was conducted on 31 May 1982. The environmental conditions were described before. The experiment at Unit 2 was performed on 23 September 1982. During the period of the treatment application, air temperatures ranged from 10 to 12 C and relative humidity from 56 to 89%. The wind was calm.

TRV rates used by growers. To determine the amount of pesticides growers applied as opposed to the amount calculated by TRV, pesticide use data collected in 1976 in the Integrated Pest and Orchard Management Systems (IPOMS) project in Henderson County, NC (1), were used. Within the IPOMS project, pesticide records were collected from 47 orchard blocks. Growers who used captan 50W, Dikar 76.7W, or metiram 80W in the fourth to seventh cover sprays were selected for study. Each of these materials is recommended in North Carolina at 8.97 kg/ha (8 lb/A) and, therefore, were comparable. The average rate of use per hectare in the fourth to seventh covers was compared with the calculated TRV rates. TRV was computed using 1 L of water per 10.67 m^3 of foliage as the dosage rate. A 20% reduction of the fungicide rate was made if the fungicide was applied at 5× or greater concentration. This adjustment is commonly made when sprays are applied concentrate and accounts for the lack of runoff with concentrate applications (6). Adjustments made for canopy density were based on IPOMS records of canopy structure.

RESULTS

TRV evaluations. The five orchards selected in 1981 and three in 1982 provided a range in TRV from 11,720 m^3/ha (167,496 ft^3/A) to 69,320 m^3/ha (990,687 ft^3/A). Tree pruning and density adjustments created distinct differences in TRV within a size class (Tables 3 and 4). The density measurements made in 1981 reflected these differences but did not significantly differ from one another in all instances (Table 1).

TRV measurements and density adjustments resulted in consistent deposits among pruning levels within orchard size classes (Fig. 2). In 1981, deposit differed between pruning levels only within the largest trees (orchard 5). There was no difference in the level of deposit between sample regions within orchard size except in the unpruned trees in blocks 3 and 4 (P = 0.01) and the moderately pruned trees in block 3 (P = 0.05). In 1982, there were no significant differences within size classes 1 and 3; deposits in moderately pruned trees in class 2 were significantly lower than those of unpruned trees (Table 5).

Deposit was not as consistent among trees in different orchards. In 1981, deposit was less on the smallest trees (size 1) at the three pruning levels (Fig. 3). There were no consistent differences among the other size classes over the pruning levels (Fig. 3). A similar trend was observed in 1982. Deposit on

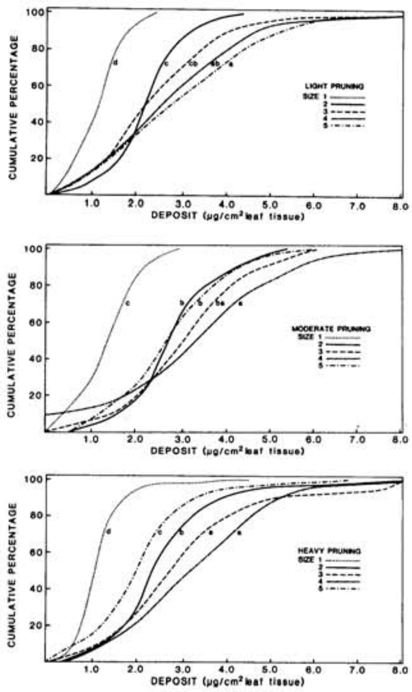

Fig. 3. Cumulative percentage of deposit over five orchard blocks (tree sizes) for the three pruning levels established at Hillcrest Orchards in 1981. Mean deposit (50% cumulative deposit) on tree sizes followed by different letters are significantly different (P = 0.05) according to Duncan's multiple range test. See text for complete description of orchards and pruning levels.

Table 5. Deposit of heavy metal per square centimeter of leaf tissue after application at the calculated tree-row-volume rate to trees of three sizes and three pruning levels in 1982[w]

Tree size[x] (orchard no.)	Pruning level[y] 1	2	3
1	1.32[z] b	1.42 a	1.76 a
2	1.30 b	0.98 b	1.13 b
3	1.88 a	1.63 a	1.76 a

[w] Means within columns followed by the same letter are not significantly different according to Duncan's new multiple range test (P = 0.05).

[x] See Table 3 and text for complete description of orchards.

[y] Pruning levels: 1 = light or no pruning—maintenance of the drive row, dead and broken branch removal, and selective sprout removal; 2 = moderate—removal of upright growth to reduce shading and size control to maintain tree in its space; and 3 = heavy—limb removal to open the tree and to establish a balanced limb structure.

[z] Deposit in micrograms of heavy metal per square centimeter of leaf tissue.

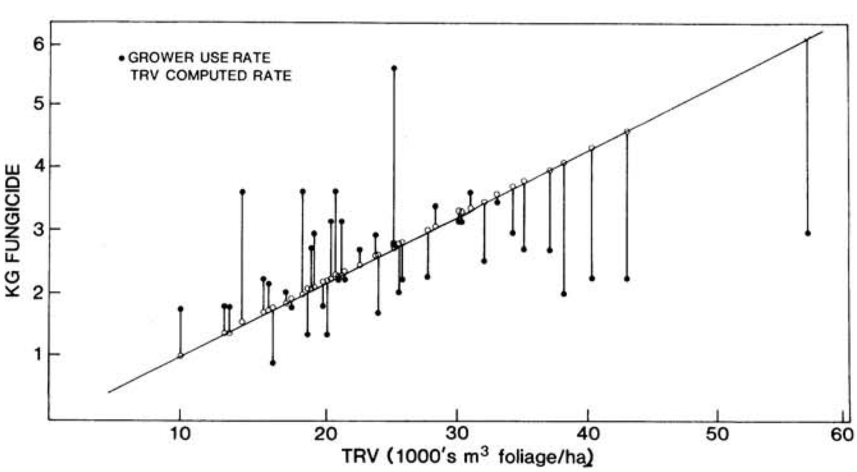

Fig. 4. Comparison of actual grower use rates and those computed by TRV for 40 orchard blocks in the Integrated Pest and Orchard Management Systems project in 1976.

moderate and well-pruned trees of size class 2 was less than on sizes 1 and 3. On unpruned trees; deposit was less on size 3 trees (Table 5).

During the tests conducted in 1981 and 1982, we observed water dripping from many leaves on trees in all orchards and at all pruning levels. Drip was most evident on the outermost leaves of the canopy. On the larger lightly pruned and moderately pruned trees, fewer leaves dripped on the inside of the canopy compared with those on the outside.

Contribution of drift to deposit. At Hillcrest, drift from adjacent rows did not contribute significantly to deposit on leaves in row 3 (center row). Deposit on leaves in row 3 (in μg of Cu/cm^2 of tissue) after the first, second, and third sprays was 2.21, 2.09, and 2.03, respectively. At Unit 2, the deposit in the center row (row 2) was significantly higher after the adjacent rows were sprayed. The deposit on leaves in the center row (in μg of Cu/cm^2 of tissue) was 2.16 after the initial spray and 2.89 after adjacent rows were sprayed.

TRV rates used by growers. Fungicide use patterns were determined for 36 growers. These growers were using 48–233% of the calculated TRV rate. Nineteen growers applied more than the TRV-computed rate, and 17 applied less (Fig. 4). Six growers were within 10% of the TRV rate. Growers with small trees (less than 21,000 m^3/ha [300,121 ft^3/A] TRV) tended to overspray; those with larger trees (28,060 m^3/ha [401,019 $ft^3/acre$] TRV) tended to underspray. From IPOMS harvest records, we were able to determine the incidence of two summer diseases (sooty blotch caused by *Gloeodes pomigena* Colby and flyspeck caused by *Mycrothyriella rubi* Petr.) in 15 of the blocks where growers used more than the calculated TRV amount and in 14 of those that used less. Those using more than the TRV amount averaged 1.26% fruit affected with sooty blotch and flyspeck, and those using less averaged 2%.

DISCUSSION

Growers are confronted with the task of translating pesticide and growth-regulator recommendations for a standard orchard into rates for their own orchard and applying the materials in such a manner to ensure uniform deposits. We believe that TRV, coupled with an adjustment for canopy density, provides a satisfactory guide for determining the rate of material needed per unit area for pesticide, growth-regulator, or foliar nutrient application.

In our tests, consistent deposits were maintained on trees within an orchard size class over three pruning levels. In most instances, the amount of material applied per hectare was reduced by 30–50% in well-pruned trees (as opposed to lightly pruned ones) while maintaining similar deposit levels per square centimeter of leaf tissue. Deposit levels among different sized orchards (orchard blocks) were not as consistent as within a particular orchard. Deposit was consistently lower on the smallest trees (orchard 1) used in the 1981 study than in the other orchards. This may have resulted from shearing of large droplets from leaves by wind from the sprayer fan. This hypothesis is supported by the distribution of deposits on the trees (Fig. 3). On trees in orchard 1, deposit on most leaf samples was less than 2 $\mu g/cm^2$ of leaf tissue, whereas most deposits on samples from trees in other orchards were greater tham 2 $\mu g/cm^2$. Results of the drift tests conducted at Unit 2 indicate that drift may significantly contribute to the level of deposit in orchards with young or small trees.

Differences in tree structure may also account for some of the variation in deposit we observed from orchard to orchard. Ferree and Hall (4) found that deposit varied from 6.5 μg of permethrin per site in pyramid hedgerow trees to 35.5 μg per site in trellised trees. Deposits on slender spindle and interstem hedgerows were intermediate. Alternatively, some of the differences between blocks may have resulted from the use of different nozzle sizes and patterns to adjust for TRV and tree height between orchard blocks. Each disc and core combination produces a different spectrum of droplet sizes that may impinge differently on fruit and foliage (2,7).

Our data indicate that canopy density adjustments to TRV are important to ensure consistency in deposit levels. Within most orchards, 10–20% reductions in TRV were made to account for differences in canopy density. Although the density scale was empirically derived by the second author from many years of observation and data accumulation, higher pesticide deposits within the canopies of well-pruned trees than within those of lightly pruned ones have been well documented (10). Travis (10) found that not only was deposit significantly greater in well-pruned trees than in lightly pruned trees but the deposit was also more uniform.

Many of the growers surveyed in 1976 in the IPOMS project were using more or less fungicide than the rates computed by TRV. There was not a substantial difference in sooty blotch and flyspeck incidence between orchards using more as opposed to less than the TRV rate, but disease incidence was greater in those using less. More than 50% of the growers were using more than the TRV rate and two growers were using more than 200% of the TRV rate. This indicates that many growers could realize substantial pesticide savings by using the TRV approach to determine fungicide use rates.

Deposition of pesticides, growth regulators, nutrients, etc., on apple trees is affected by many environmental (relative humidity, wind speed), physical (sprayer attributes, nozzle properties, etc.), and biological (tree structure, size, spacing) factors (2). TRV does not account for most of these factors but does provide a guide for growers to use in determining the amount of material to use per hectare. There are many aspects of TRV that require further study. We investigated deposit when the canopy was fully developed. The levels of deposit need to be determined for the period from green-tip to full leaf. Furthermore, the effect of tree shape (pruning) on deposit needs investigation. The percent of TRV rate for efficacy of the various chemicals applied to apples needs to be determined. Finally, TRV needs to be evaluated over a number of years and a wide range of orchard conditions. Pathogen inoculum levels and insect populations vary considerably from orchard to orchard. Pesticide rates determined by TRV should provide satisfactory control under all conditions. Similarly, growth-regulator effects may vary considerably depending on environmental conditions and general orchard management. Rates of application should account for these differences based on TRV and other adjustments.

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