hedged and topped trees and the results are open to question as sunlight is known to hasten maturity. In addition, both cacodylic acid and methane arsonic acid are organic arsenicals and not very desirable candidates. N-ethylmaleimide was shown to be a potent inhibitor of the enzyme citrate synthase in grapefruit by Vines (1968b). However, this compound has an exceedingly high mammalian toxicity and is very expensive as well. Consequently, it is also considered to be a poor candidate.

Further field studies are contemplated for sodium 3,5-dinitrosalicylate, cacodylic acid, and alpha-ethyl-alpha-methylsuccinic acid.

The 3rd application was made rather late in the season. However, a decrease in acidity and increase in ratio was produced by Borax, a double strength application of sodium azide, Bismate, and TD-692. These comopnds will be tested again next season.

Preliminary testing.—In the laboratory tests, lead arsenate consistently reduced the uptake of inorganic phosphate and of oxygen in mitochondrial preparations, Table 1, with all 4 substrates. Other compounds tested which produced this same effect with all 4 substrates were sodium azide, N-ethylmaleamic acid, tall oil fatty acid, guanidine acetate, sodium ethyloxalacetate, Chemox PE, 2,4-dichlorophenol, and for all practical purposes DCC. Of these 8 compounds, four were tested in the field, namely sodium azide, N-ethylmaleamic acid, tall oil fatty acid, and 2,4-dichlorophenol. None of them affected grapefruit acidity in the same manner as lead arsenate. Consequently, similarity of results from the laboratory screening technique with those obtained using lead arsenate may not be valid basis for predicting the desired physiological result, namely the reduction of acidity, when using an intact plant. Investigations to find other criteria to correlate laboratory and field trial data are continuing.

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AN ANALYSIS OF APPLICATION COSTS OF AIRBLAST SPRAYING IN FLORIDA CITRUS

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Abstract

Cost of applying spray materials are related to the time efficiency, grove capacity, and hourly labor and machine costs of a spraying operation. Time attributes which describe time efficiency and grove capacity are defined and discussed. Line graphs are presented to show how gallons applied per acre, ground speed, effective width, and intergrove travel time affect time efficiency and grove capacity.

Major labor and machine cost factors for applying sprays are presented with a procedure to estimate their value. Costs are initially calculated on an hourly basis and then converted to an acre basis. Line graphs are presented to show how per-application costs are reduced by decreasing gallons applied per acre, decreasing intergrove travel time, and increasing ground speed and effective width. For many typical operations, per-application costs varied between \$3.00 and \$10.00 per acre.

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Introduction

Costs associated with spraying usually exceed those of any other cultural practice in producing Florida citrus. Application costs are greater than material costs in many dilute sprayings. In the 1960-61 season, Simanton (2) reported the cost per acre of pesticide and application to be approximately $40.00 each. According to Savage (1), total production costs for the same season were about $317.00 per acre. If production costs are to be minimized, an examination of the spray program must have prime consideration.

Costs of materials are easily calculated while application costs involve many factors which are difficult to determine. An accurate cost analysis requires a knowledge of the various operations usually performed in applying the spray. More specifically, this involves the time, equipment, and labor associated with these operations. The objectives of this paper are: (a) to define the major time attributes of a spraying operation, (b) to show how time efficiency and grove capacity are related to the time attributes, (c) to estimate the hourly labor and machine costs of a spraying operation, and (d) to combine the time attributes and hourly costs to arrive at estimated application costs per acre.

Time Efficiency and Grove Capacity

In a daily spraying application, the total time required to accomplish spraying can be accounted for as follows:

(1). T (total time per acre) = S (spraying time per acre) + R (sprayer tank refill time per acre) + D (daily servicing time per acre) + I (intergrove travel time per acre) + N (other nonproductive time per acre).

S (hours/acre) is a function of the ground speed and the effective width sprayed only and can be expressed as:

(2) $S = 8.25/(G.S. \times W)$
where G.S. = ground speed in mph
W = effective width sprayed in feet (for double-side delivery, one drive row spacing; for single-side delivery, ½ drive row spacing).

The value of R can be estimated from the gallons applied per acre (GPA) and the time required for sprayer tank refill. An average of 6 minutes or 0.1 hour per 500-gallon tank is assumed, so that R in hours per acre is:

(3) $R = 0.1 \times GPA/500 = 0.0002 \times GPA$.

Assuming that the average total time per day that is devoted to spraying is 8 hours, and ½ hour is devoted to daily servicing, then (4) $D = 0.5 \times (S + R + N + D)/8 = 0.067\ (S + R + N)$, where D, S, R, and N are expressed in hours per acre.

The value of I in hours per acre can be calculated from the following expression:

(5) I = hours of intergrove travel per day/acres sprayed per day.

Other nonproductive time, N, includes time spent turning at row ends, stopping for minor field repairs, adjustments, etc. It is assumed a constant 20% of the spraying time, S, or

(6) $N = 0.2 \times S$, where S and N are given in hours per acre.

Downtime for major shop repairs is not included but will be considered later in the cost analysis.

Now that the time attributes of spraying have been defined, the time efficiency of the sprayer can be defined as follows:

(7) Time efficiency (t.e.) $= S \times 100/(S + R + D + I + N)$.

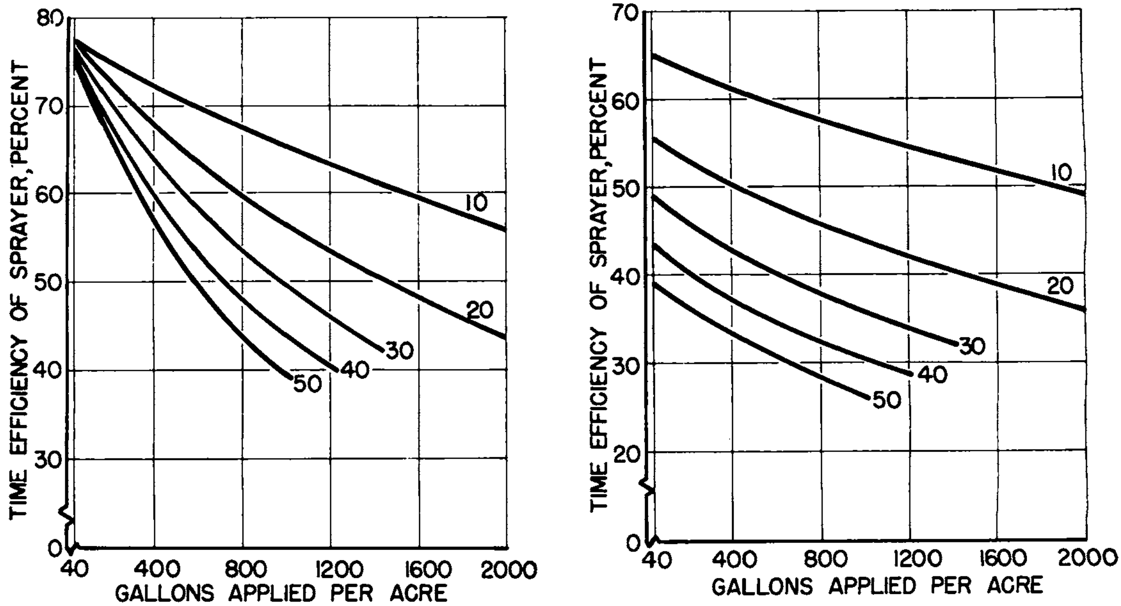
By substituting Equations 2 through 6 into Equation 7, time efficiency can be simplified to Equation 8.

(8) $t.e. = S \times 100/(1.28 \times S + 0.0002134 \times GPA + I)$.

Time efficiency is simply the percent of total time, T, that is productive time, S. The total nonproductive time, which should be minimized, is R + D + I + N. Related to time efficiency is the capacity of the sprayer to cover acreage or grove capacity. It is a function of ground speed, effective width, and time efficiency. Thus,

(9) Grove capacity (acres/hour) $= C \times t.e./100$,
where C = theoretical (no time losses) grove capacity of sprayer in acres per hour $= G.S. \times W/8.25$ (see Equation 2)
t.e. = time efficiency (Equation 8).

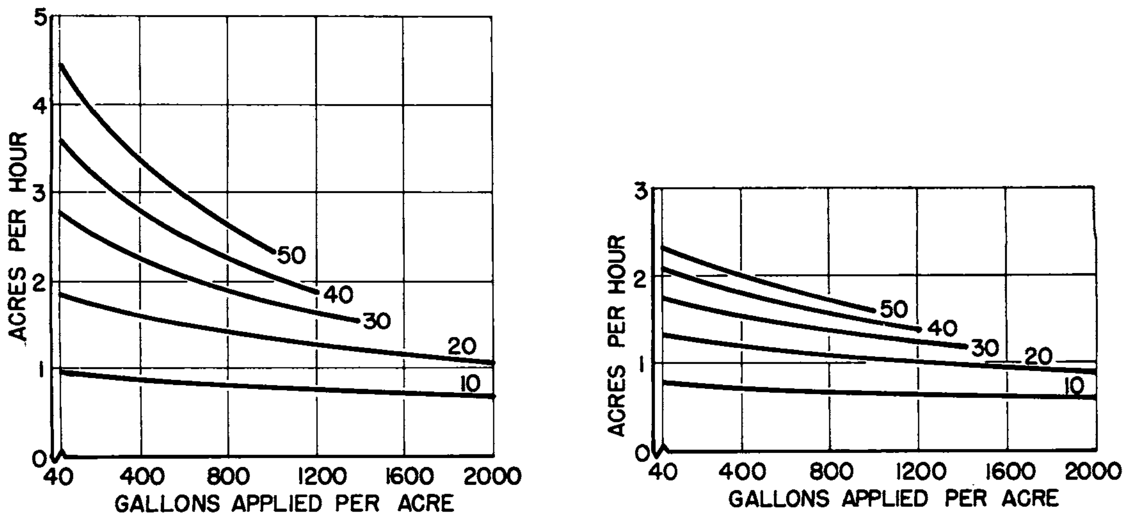
Time efficiencies were calculated with Equation 8 and are plotted in Figure 1. Related grove capacities were calculated with Equation 9 and are plotted in Figure 2. Equation 2 was substituted into Equations 8 and 9 so that the values



a. I=INTERGROVE TRAVEL TIME/AC = 0 HRS

b. I = INTERGROVE TRAVEL TIME/AC = 0.2 HRS

Fig. 1.—Time efficiency of airblast sprayer. Numbers on curves are products of ground speed in mph and effective width in ft.



a. I=INTERGROVE TRAVEL TIME/AC=0 HRS

b. I=INTERGROVE TRAVEL TIME/AC=0.2 HRS

Fig. 2.—Grove capacity of airblast sprayer. Numbers on curves are products of ground speed in mph and effective width in ft.

of efficiency and capacity are presented as functions of gallons per acre and the product of ground speed (mph) and effective width (feet). For example, a double-side delivery sprayer traveling at 1 mph with an effective width (spacing between drive rows) of 20 feet would operate on the 1 x 20 = 20 curve. A single-side delivery sprayer traveling 1 mph between the same drive rows would have an effective width of 10 feet and would operate on the 1 x 10 = 10 curve.

Several basic trends are indicated in the figures. For any given ground speed and effective width, time efficiency and grove capacity increase as the gallons applied per acre decrease (or spray chemical concentration increases). This can be illustrated in Figures 1a and 2a. Suppose the dilute base for a 30 x 30- foot grove setting is 1,200 gallons per acre. If the ground speed of a double-side delivery sprayer is 1 mph, it will operate on the 30 curve at 45% time efficiency (Fig. 1a). Its grove capacity is 1.6 acres per hour (Fig. 2a). However, applying the spray at ⅛ dilute gallonage (150 gallons per acre) increases its time efficiency and grove capacity to 72% and 2.6 acres per hour, respectively. The increase in efficiency is realized because tank refill time per acre is reduced, allowing for more productive or spraying time.

Intergrove travel time, another nonproductive time attribute, also significantly affects time efficiency and grove capacity. For example, enter Figures 1a, 1b, 2a, and 2b on the 40 curve at 600 gallons per acres. For 0 and 0.2 hours of intergrove travel time per acre, time efficiencies are 53% and 35%, respectively; and grove capacities are 2.5 and 1.7 acres per hour. Increased intergrove travel time causes decreases in time efficiency and grove capacity because nonproductive time per acre is increased relative to spraying time.

Changes in ground speed and/or effective width also have significant effects on time efficiency and grove capacity. Compare the performance of sprayers operating on the 20 and 40 curve. This would describe the operation in 20-foot drive rows of either: 1) a double-side delivery sprayer at 1 and 2 mph (changing ground speed) or 2) single and double-side delivery sprayers at 2 mph (changing effective width). At 1,000 gallons per acre, going from the 20 to the 40 curve (doubling ground speed or effective width) reduces time efficiency from 56% to 43% (Fig. 1a, I = 0). In contrast, grove capacity increases from 1.35 to 2.1 acres per hour (Fig. 2a, I = 0) or a 55% increase. If the same comparisons are made at 200 gallons per acre, time efficiency is found to decrease from 72% to 67% while grove capacity increases from 1.75 to 3.25 acres per hour or an 86% increase. This example serves to point out that (a) grove capacity is not increased proportionately to ground speed or effective width and (b) gain in grove capacity with increasing ground speed and/or effective width is maximized as gallons per acre is minimized.

Curves in Figure 2 should be helpful in estimating the acreage that one or more sprayers can cover in a given time. In addition, Figure 2a can be used to estimate the gallons of water per hour used by a sprayer and thus enable one to estimate the number of supply units required to deliver water to one or more sprayers. A sprayer operating on the 40 curve in Figure 2a at 800 gallons per acre has a grove capacity of 1.9 acres per hour. Therefore, 800 x 1.9 = 1,520 gallons used per hour. At 200 gallons per acre, the grove capacity is about 2.5 acres per hour and approximately 200 x 2.5 = 500 gallons used per hour. If a supply unit is capable of hauling three 500-gallon tanks per hour, it could reasonably supply one sprayer at 800 gallons per acre and 3 sprayers at 200 gallons per acre.

Grove capacity and time efficiency have now been considered. They both should be maximized consistent with a satisfactory spray program. This involves many considerations, one of which is cost.

Hourly Costs

The total cost of any piece of equipment must include fixed and operating costs. Fixed costs include depreciation, interest on investment, taxes, insurance, and housing. They are usually calculated for a one-year period as total fixed costs and then evenly distributed as fixed costs per hour. A high percentage of the operating costs are repairs and maintenance, fuel, and labor. Adding the hourly fixed and operating costs yields the total hourly cost of owning and operating a piece of equipment.

Table 1 presents a summary of basic assumptions in a cost analysis, major fixed and operating costs, and a procedure for estimating their values. The table considers all equipment that might be used in a spraying operation with a double-side delivery sprayer with an auxiliary engine. The one-side delivery PTO-powered sprayer will be considered later.

Item 1 is the price paid for the equipment when new. The wear-out life is expressed in years, but is related to the number of hours of use (Item 3) per year. For example, the estimated wear-out life of a sprayer is 3,000 hours. Since its annual use is assumed to be 600 hours, its wear-out life in years is 3,000/600 = 5. Similarly, the wear-out lives for a tractor, water supplying unit, and transport unit are shown. The salvage value, V, is 0.1 of the new purchase price.

Items 5 through 9 are the fixed or ownership costs. Depreciation is assumed linear or straight line. Annual interest on investment, taxes, insurance, and housing are each 1% of the average value $\frac{(P + V)}{2}$ of the equipment over its life. The total fixed cost per hour is shown as Item 11.

Operating costs include Items 12, 13, and 14.

Table 1. Assumptions, major cost attributes, and a procedure for estimating costs in a typical spraying operation (double-side delivery sprayer with auxiliary engine).

Item	Double-side delivery sprayer with auxiliary engine	Equipment type		
		50-hp tractor	Water supply unit	Transport unit
		Assumptions		
1. New purchase price, P	$10,000.00 LPG	$5,800.00 (50 hp diesel)	$4,000.00 gas	$3,500.00
2. Wear-out life, L	5 years	10 years	5 years	8 years
3. Annual hours of use, H	600	1,200	600	500
4. Salvage value, V = .1P	$ 1,000.00	$ 580.00	$ 400.00	$ 350.00
		Fixed costs		
5. Annual depreciation $\frac{(P - V)}{L}$	$ 1,800.00	$ 522.00	$ 720.00	$ 394.00
6. Annual interest on investment $\frac{(P + V)}{2}.06$	$ 330.00	$ 191.40	$ 132.00	$ 115.50
7. Annual taxes $\frac{(P + V)}{2}.01$	$ 55.00	$ 31.90	$ 22.00	$ 19.25
8. Annual insurance $\frac{(P + V)}{2}.01$	$ 55.00	$ 31.90	$ 22.00	$ 19.25
9. Annual housing $\frac{(P + V)}{2}.01$	$ 55.00	$ 31.90	$ 22.00	$ 19.25
10. Total fixed costs (Items 5+6+7+8+9)	$ 2,295.00	$ 808.10	$ 918.00	$ 567.25
11. Total fixed cost/hr. (Item 10 ÷ 3)	$ 3.82	$ 0.67	$ 1.53	$ 1.13

Table 1. (continued)

Item	Double-side delivery sprayer with auxiliary engine	50-hp tractor	Water supply unit	Transport unit
		Assumptions		
	Operating costs			
12. Repairs and maintenance costs per hour (excludes daily servicing)	.0001P = $ 1.00* or .000025P = $ 0.25	.0001P = $ 0.58	.00015P = $ 0.60	.00014P = $ 0.49
13. Fuel costs per operating hour	$ 1.30 or $ 0.24**	$ 0.34+	$ 0.37***	$ 0.75++
14. Labor costs per hour	--	$ 1.50	$ 1.50	$ 1.50
15. Total operating cost/hr. (Items 12+13+14)	$ 2.30 (while spraying) $ 0.49 (while refilling)	$ 2.42	$ 2.47	$ 2.74
16. Total cost/hr. (Items 11+15)	$ 6.12 (while spraying) $ 4.31 (while refilling)	$ 3.09	$ 4.00	$ 3.87

*Repairs and maintenance costs are $1.00/hr. while spraying and $0.25/hr. while refilling.

**While spraying, 100 hp engine 70% loaded (2,250 rpm) uses 100 x .087 = 8.7 gal./hr. at $0.15/gal. is $1.30/hr. While refilling, 100 hp engine is operating at about 800 rpm and 30 hp and is 30% loaded using 30 x .06 = 1.8 gal./hr. at $0.15 = $0.24.

***Three $\frac{\text{trips}}{\text{hr.}}$, 1 mile each way, is $\frac{6\text{ mi.}}{\text{hr.}} \div \frac{4\text{ mi.}}{\text{gal.}} \times \frac{\$0.25}{\text{gal.}}$ = $0.37/hr.

+Two gal./hr. x $0.17/gal. = $0.34/hr.

++Twenty mi./hr. $\div \frac{7\text{ mi.}}{\text{gal.}}$ x $0.25/gal. = $0.75/hr.

Item 12, repairs and maintenance costs per hour, is expressed as a fraction of the new purchase price. The costs are given separately for spraying time and refilling time. This allows costs to be adjusted for different ratios of spraying to refilling time since repair and maintenance costs are higher while spraying. Fuel costs for the sprayer are adjusted in a similar manner. For the other equipment types, the method of calculating the fuel cost is indicated. The water supply unit is assumed to be used a high percentage of the total time. A fuel cost for the transport unit results only when equipment is being towed or hauled between groves.

A labor cost of $1.50/hour is assumed for the tractor and water supply unit. If the transport unit is used, the tractor driver becomes the transport unit driver. Item 15 is an estimate for the operating cost per hour, while Item 16 is the total fixed and operating cost per hour.

Cost calculations on the one-side delivery, PTO-powered sprayer, are made similar to those of the double-side delivery sprayer. For a $5,000.00 sprayer, the fixed and operating costs per hour were estimated as $1.91 and $0.50, respectively. Using the tractor in Table 1, fixed and operating costs per hour were $0.67 and $2.59, respectively. Costs for the water supply unit and transport unit are the same as those presented in Table 1.

Now that the machine and labor costs per hour have been defined, costs can be related to some other meaningful unit such as acre, tree, grove, etc.

Application Costs Pfr Acre

For a particular spraying operation, cost per hour can be converted to cost per any unit if the time spent on that unit is known. Application costs should always be initially based on a unit such as an acre or some other convenient area. From this, cost for other units (per tree, per grove, etc.) can easily be derived.

The time per acre has been discussed in a previous section. If these times are associated with the appropriate cost items, the total cost per acre will result. More specifically, fixed costs and labor cost must be charged for the total time, T (productive plus nonproductive). Repairs and maintenance and fuel costs are only charged for the actual operating time of each piece of equipment.

If the equipment in Table 1 is used in a spraying operation and the number of supply units per sprayer (double-side delivery with auxiliary engine) varies from less than to greater than one, the cost per acre for each application can be expressed as follows

$$(10)\ \frac{\text{Cost}}{\text{acre}} = \overbrace{T\left[\$3.82 + \$0.67 + \$1.13 + \frac{\text{no. of water supply units}}{\text{sprayer}}(\$1.53)\right]}^{\text{total fixed costs}}$$

$$+ \overbrace{\left[S(\$2.30) + (N+R)(\$0.49) + D\left(\frac{\$1.50}{2}\right)\right]}^{\text{sprayer operating costs}}$$

$$+ \overbrace{\left[(S+R+N)(\$2.42) + D\left(\frac{\$1.50}{3}\right)\right]}^{\text{tractor operating cost}}$$

$$+ \overbrace{\frac{\text{no. of supply units}}{\text{sprayer}}\left[(S+R+N+I)(\$2.47) + D(\$1.50)\right]}^{\text{supply unit operating cost}}$$

$$+ \overbrace{\left[I(\$2.74) + D\left(\frac{\$1.50}{3}\right)\right]}^{\text{transport unit operating cost}}.$$

Equation 10 can be simplified as follows with the number of supply units per sprayer expressed as A:

$$(10b)\ \frac{\text{Cost}}{\text{acre}} = S\left[\$12.62 + A\ \$5.04)\right] + GPA\left[\$0.0018 + A\ (\$0.00084)\right] + I\left[\$8.36 + A\ \$4.00)\right]$$

If no transport unit is used for intergrove travel, the cost per acre is expressed as follows:

$$(11)\ \frac{\text{Cost}}{\text{acre}} = S\left[\$11.18 + A\ \$5.04)\right] + GPA\left[\$0.00156 + A\ (\$0.00084)\right] + I\left[\$6.91 + A\ (\$4.00)\right].$$

For the single-side PTO-powered sprayer, per application costs (including transport unit and supply unit) can be expressed as follows:

$$(12)\ \frac{\text{Cost}}{\text{acre}} = S\left[\$8.83 + A\ (\$5.04)\right] + GPA\left[\$0.001472 + A\ \$0.00084)\right] + I\left[\$6.65 + A\ (\$4.00)\right].$$

If the transport unit is not included, then equation 12 becomes:

$$(13)\ \frac{\text{Cost}}{\text{acre}} = S\left[\$7.13 + A\ (\$5.04)\right] + GPA\left[\$0.001188 + A\ (\$0.00084)\right] + I\left[\$5.17 + A\ (\$4.00)\right].$$

Per application costs can be calculated from Equations 10b, 11, 12, and 13. It should be noted that the common terms in these equations are S, GPA, A, and I. Some cost calculations were made with Equations 10b and 11, and are illustrated graphically in Figures 3 and 4. They show that application costs are decreased by: 1) decreasing gallons applied per acre, 2) decreasing intergrove travel time, 3) increasing ground speed, and 4) increasing effective width.

Application costs per acre are decreased by decreasing gallons applied per acre for more than one reason. First, the nonproductive time of the sprayer is reduced. This allows the grove capacity of the sprayer to increase, and thus more acres are covered per unit time. Second, less supply units are needed per sprayer and per sprayed acre. As illustrated in a previous section, a double-side delivery sprayer operating on the 30 curve with I = O has a grove capacity of about 1.9 acres per hour at 800 gallons per acre. (Fig. 2a). It requires 1.9 x 800 = 1,520 gallons per hour. Suppose one supply unit per

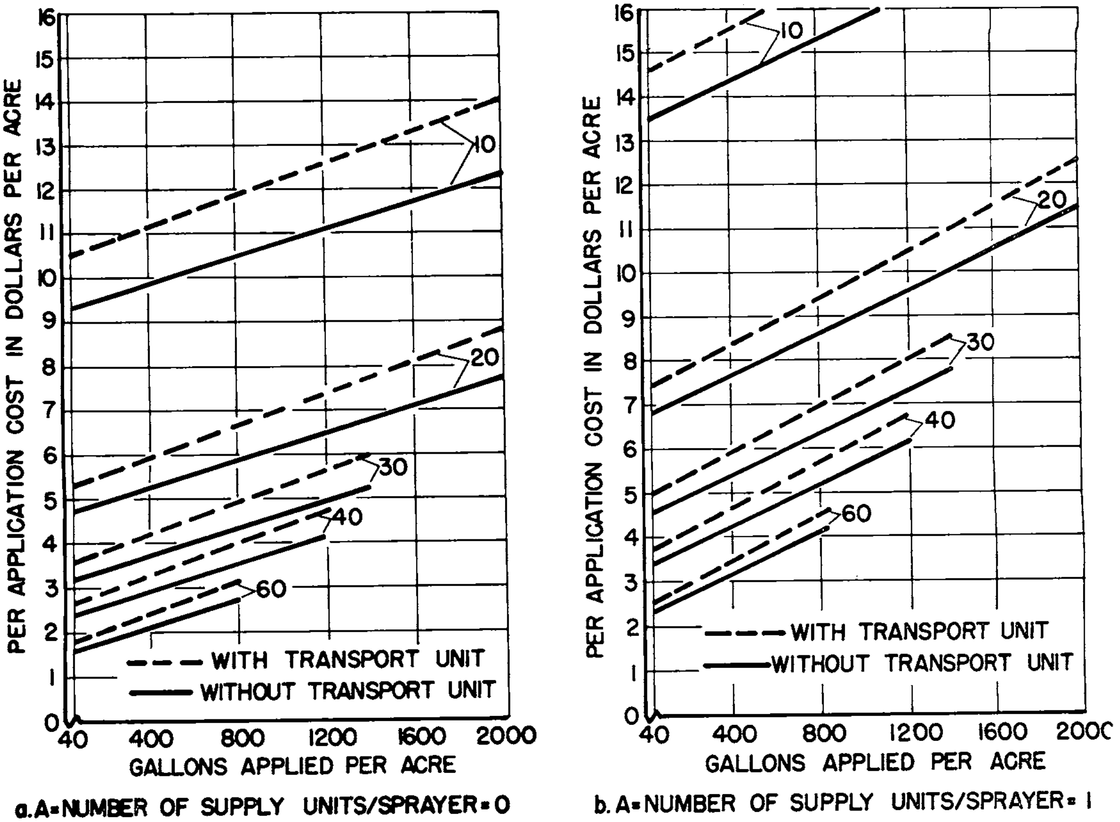


Fig. 3.—Per application costs of airblast spraying (double-side delivery sprayer with auxiliary engine). I = intergrove travel time per acre = 0 hours. Numbers on curves are products of ground speed in mph and effective width in ft.

sprayer (A = 1) is adequate. From Figure 3b, the application cost per acre is about $6.30 (without transport unit). In comparison, at 200 gallons per acre, the grove capacity is about 2.5 acres per hour (a 31% increase). One supply unit could probably serve 3 sprayers with each sprayer requiring 500 gallons per hour. The application cost (Fig. 4a, A = 1/3) is about $4.00 per acre without the transport unit. This represents almost a 36% reduction in application costs.

Intergrove travel time increases application costs. Consider the above sprayer (30 curve, 200 gallons per acre) for A = 1/3. When I increases from 0 to 0.2 (Fig. 4), the application costs per acre increase from $4.00 to $5.50, or 37%, respectively.

An increase in ground speed can decrease cost substantially where little or no change is required in supply units. Suppose a supply unit can effectively deliver 1,500 gallons per hour to 3 double-side delivery sprayers in the same vicinity. At 200 gallons per acre, the total grove capacity of the 3 sprayers on the 20 curve (1 mph in 20-foot drive rows) for I = 0 is 3 x 1.7 = 5.1 acres per hour (Fig. 2a). The supply unit would have to deliver 5.1 x 200 = 1,020 gallons per hour. The cost of application is approximately $5.60/acre (without transport unit). If the ground speed is increased to 1½ mph, then the sprayers would each operate on the 30 curve at 2.5 acres/hour (Fig. 2a). A total of 7.5 acres per hour could be covered requiring 7.5 x 200 = 1,500 gallons per hour. From Figure 4a, the cost per acre is about $3.90. In this case, a 30% decrease in cost is realized by increasing the ground speed from 1 to 1½ mph. It should be noted, however, that application costs may

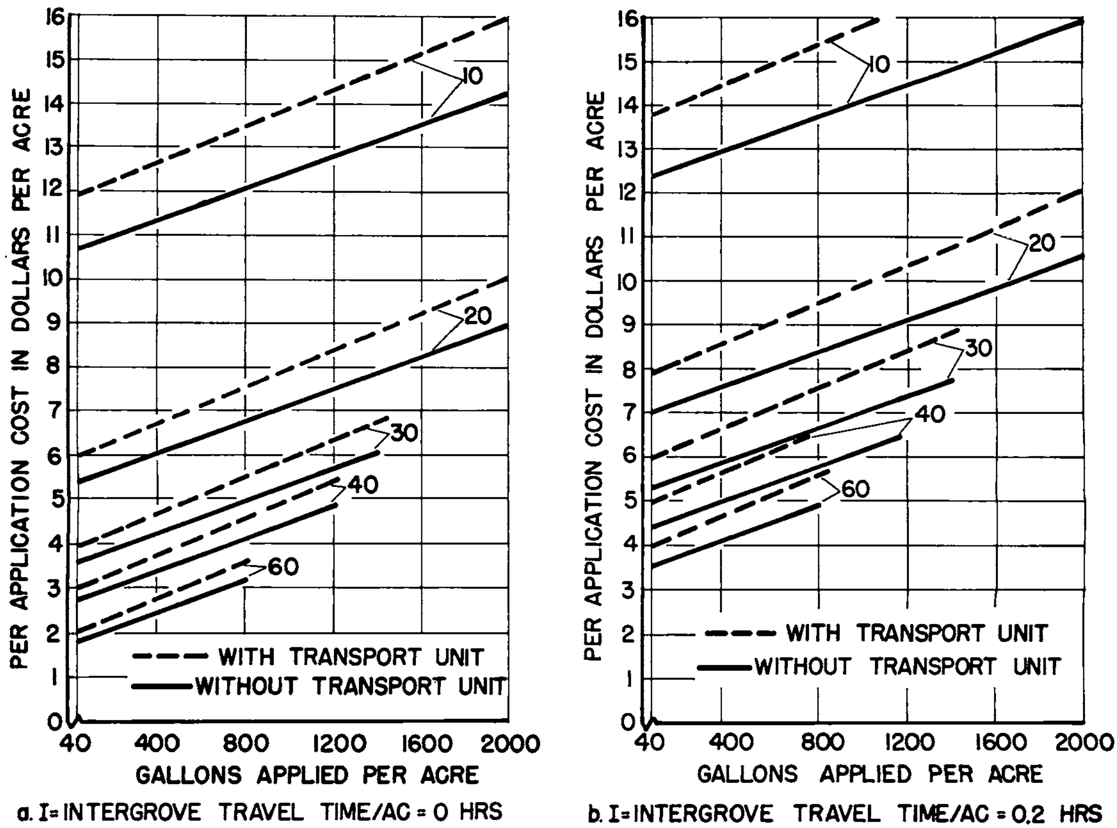


Fig. 4.—Per application costs of airblast spraying (double-side delivery sprayer with auxiliar yengine). A = number of supply units per sprayer = 1/3. Numbers on curves are ground speed in mph and effective width in ft.

not be reduced if additional supply units are needed for a small increase in grove capacity.

Although the above discussion and examples have made use of the double-side delivery sprayer, the same generalizations apply in principle to single-side delivery, PTO-powered sprayers. Application costs of double-side delivery sprayers with auxiliary engines and single-side delivery, PTO-powered sprayers compare favorably. The main advantage of the double-side delivery sprayers is large grove capacity. For the single-side delivery sprayers, the main advantage is smaller capital investment in small acreages.

As has been discussed, reducing the gallons per acre is one of the ways of reducing per-application costs. One of the ultimate aims in reducing gallons per acre is to eliminate the supply unit. What savings can be realized by this step?

In many spray operations, an acceptable minimum rate of application is in the neighborhood of 200 gallons per acre. In most cases, one supply unit can handle 2 to 3 double-side delivery sprayers. From Figure 4a, the cost per application is about $3.00 per acre (I = 0, without transport unit) on the 40 curve. If the supply unit is to be eliminated, then a sprayer should probably be able to operate for ½ day or 4 hours without refill. This is equivalent to about 125 gallons per hour. If such a double-side delivery sprayer operates on the 40 curve, it would cover about 3.6 acres per hour (Fig. 2a). Therefore, its application rate would have to be reduced to 125/3.6 or 35 gallons/acre. The cost per acre for each application is about $2.50 (Fig. 3a, A = 0). The saving is $0.50/acre per application. This saving may not be justified with present technology when one considers the added risks at this low rate of application.

SUMMARY

A good spray program maximizes sprayer time efficiency and minimizes costs consistent with satisfactory control of insects and diseases. From the standpoint of the sprayer, better control is usually associated with increasing gallons applied per acre and decreasing ground speed and effective width. In contrast, timely applications and minimal per-application costs are associated with decreasing gallons applied per acre, increasing ground speed and effective width. Therefore, the optimum results are achieved at some moderate grove capacity of the sprayer. It follows that a good spray program should:

1. Minimize time for intergrove travel and other nonproductive operations.
2. Minimize gallons applied per acre and maximize ground speed and effective width consistent with satisfactory control.

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'MURCOTT' COLLAPSE DUE TO NUTRITIONAL DEFICIENCIES

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ABSTRACT

'Murcott' citrus trees bearing heavy crops often collapse during the time of fruit maturity. In some cases, this disorder is sufficiently severe to kill some of the trees. The trouble apparently is caused by starvation for nitrogen and potassium. This variety responds to much higher rates of these 2 elements than do common varieties of oranges and grapefruit.

INTRODUCTION

Collapse is a common problem of 'Murcott' trees. It occurs on trees with heavy crops and is first noticeable in December and January when the fruit begins to mature. The initial symptom is mottling of the leaves similar to that associated with potassium deficiency. This is followed by partial defoliation and fruit drop. Much of the fruit remaining on the trees may be yellow to green in color and of small size. The longer the fruit remains on the tree, the greater the amount of collapse. In the most severe cases, the trees may die or suffer such damage that removal is necessary. Trees less severely affected usually recover rapidly during the following growing season but fail to set a crop. This paper presents studies and observations made on this problem.

SURVEY

Leaf and fruit samples were taken in 15 groves to establish whether 'Murcott' collapse was related to nutrition of the trees. The samples were taken during the time of fruit maturity from individual trees showing collapse and from adjacent healthy trees with lighter crops. Many of the trees were 8 years old or younger. Results of the leaf analyses indicated that both N and K levels were lower in leaves from trees showing collapse (Table 1). Leaves from affected trees averaged 1.83% N, as compared with 2.37% in those from healthy trees. Potassium was also low in leaves from collapsed trees, averaging 0.25% K; and the most severe cases ranged below 0.20%. These are extremely low levels of K in citrus leaves. Leaves from trees that appeared healthy averaged 0.89% K.

Fruit samples were also taken from a number of groves. Analyses of various part of the fruit indicated significantly higher amounts of N, K, Mg, and Ca in the fruit peel from collapsed trees than from healthy trees. Quality determinations showed that juice from collapsed trees contained 12.6% soluble solids compared

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