THE EFFECT OF VARIOUS FOLIAR SPRAYS ON THE SIZE AND COMPOSITION OF THE FRUIT AND ON THE RATE OF RESPIRATION OF THE LEAVES OF THE RED CHERRY (*PRUNUS CERASUS L.*)

By

VERNON JACOB FISHER

A THESIS

Submitted to the School of Graduate Studies of Michigan

State College of Agriculture and Applied Science

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

1950

TABLE OF CONTENTS

INTRODUCTION

A survey of red cherry acreage in Michigan (25), conducted during the winter of 1948-49, revealed that the number of bearing trees is increasing rapidly. Within ten years the tonnage of red cherries in the state may well be expected to increase ten percent over present production, and the increase may be as great as twenty percent.

With this potential increase in production, and with world production of food rapidly recovering from the effects of World War II, the red cherry industry is faced with the necessity for producing a high quality product and advertising it vigorously in order to maintain a profitable outlet for the entire crop. Practices should be followed in the growing and processing of cherries which will benefit the industry most, for individuals will prosper as the industry prospers.

In recent years red cherry processors have become increasingly conscious of great variations in the quality of the processed product. This interest in quality has no doubt stemmed in part from a consideration of the future status of the industry. It was immediately apparent that the quality of the finished product was closely correlated with the quality of the raw product received from the growers. In fact it is felt that the cherry crop is becoming more variable in quality. Whether this variation has always existed without making any particular difference, or whether the variation is something new are unanswered questions. Accordingly it was considered advisable to make a study of orchard practices with the purpose of gaining information which might enable growers to supply processors with the high quality product they must have if they are to maintain a healthy red cherry industry in the State of Michigan. It was for this purpose that the work reported in this thesis was undertaken.

This thesis covers only the initial stages of a study which is continuing at the Michigan Agricultural Experiment Station. Specifically, the work reported here is concerned primarily with the effect of two different fungicides and of an oil-wax emulsion which has recently come into limited use in cherry orchards, on the physiology of the leaves and on the composition of the fruit. This particular phase was selected for the first part of the study because observations had indicated a correlation between foliar sprays and quality of fruit, and the physiological effects of these sprays was not as well understood as other practices, such as the use of commercial fertilizers, barnyard manure, and cover crops.

REVIEW OF LITERATURE

The fact that the size of fruits varies with spray treatment has been known as least since 1921. In that year Fisher (11) reported that alkaline sprays dwarfed the fruit of sweet cherry trees, and suggested that this may have been brought about through an increase in transpiration resulting from injury to the cuticle of the leaves.

Dutton and Wells (10) reported dwarfing of red cherry fruits from the use of Bordeaux mixture, compared to lime-sulphur. Results reported by Rasmussen (38) were similar, but he found that Bordeaux of a strength weaker than 4-6-100 did not give a detectable decrease in size. He also reported no decrease from the use of Bordow.[1]

Groves et al (15) found that Bordeaux as well as several proprietary copper fungicides, including Bordow, decreased the size of fruit of red cherry in comparison to fruit from trees which received no spray treatment. The decrease with Bordow and most of the other proprietary coppers was not as great as was obtained with Bordeaux. They found no effect on size from the use of either of two organic materials, Fermate[2] and Japanese Beetle Spray (tetramethyl thiuram disulfide). Langer and Fisher (23) obtained larger red cherry fruit from trees receiving Fermate than from trees receiving Bordow.

---

1. Bordow is a proprietary copper material manufactured by the Dow Chemical Company of Midland, Michigan.

2. Fermate (ferric dimethyldithiocarbamate) is an organic material manufactured by E. I. Du Pont de Nemours and Company of Wilmington, Delaware.

Miller et al (26) obtained an increase in the size of red cherry fruit when they applied an oil-wax emulsion with the fungicidal mixture to act as a spreader. The material used was D-82, one member of a series of emulsions sold under the trade name of Dowax.[1] The increases obtained were, 7, 15, and 35 percent when one, two, and three applications, respectively, were made.

Further work using five formulations of Dowax emulsions was reported by Neal et al (30). All of the emulsions increased the size of cherry fruits in comparison with fruit from untreated trees. The increase was greater in orchards which were in sod than in those which were cultivated. It was also greater where the set of fruit was heavy than where trees were bearing a light crop. Dowax 222 was applied by these same workers to Grimes apple trees one month before harvest, and its use doubled the number of bushels of apples attaining a minimum size of $2\frac{1}{2}$ inches in diameter.

In commenting on the economic aspects of using Dowax 222 for the sole purpose of increasing tonnage yields of cherries Neal et al (31) set ten percent as a reasonable value for the increase in size of fruit to be expected from one application, although they

1. These emulsions were formulated by members of the Section of Agricultural Chemistry of the Michigan Experiment Station. They were designed as transpiration - reducing sprays for use primarily in off-setting the shock of transplanting. The emulsions are protected by a U. S. Patent (27) assigned to the Michigan State Board of Agriculture. A liscense to manufacture them has been granted to the Dow Chemical Company. This material was used on a limited scale commercially in 1947 and 1948 for the purpose of increasing the size of cherry fruit. The Dow Chemical Company did not sell the material commerically in 1949.

emphasized the fact that great variation in response had been obtained up to that time. They felt that prediction of the response to be obtained would be very difficult.

Langer (22) experimented with Dowax 222 applications to red cherry, pears, and apples and obtained increases with all three fruits. Langer and Fisher (25) in a preliminary report on part of the data presented in this thesis, reported increases of from 3.7 percent to 17.3 percent from the use of one and two applications of Dowax 222 to Montmorency cherry trees.

Schuster and Stephenson (39) applied Dowax 222 to sweet cherries for three seasons and obtained increases of as much as 20 percent. The increase was greater where irrigation was used than where it was not, and was also greater in a season when temperature was high and humidity low during harvest than when converse conditions obtained.

So far as has come to the attention of this writer the earliest report of a variation in solids content of cherries with different spray treatments was that made by Rassmussen (38) in 1939. He reported that Bordeaux and Bordow increased the percentage total solids content of fruit as compared to lime-sulphur and resulted in a darker color of fruit as well.

Groves <u>et al</u> (15) found an increase in soluble solids content of cherry juice from the use of both Bordeaux and Bordow on the basis of total amount in a give number of fruit as well as on the basis of percentage. A decrease in solids was obtained by them from the use of Fermate and Japanese Beetle Spray in one season. This effect was not found when these organic materials were used in another season in split schedules, lime-sulphur being used for the petal-fall spray.

Concerning the effect of Dowax emulsions on the fruit of red cherry, Langer and Fisher (23) found that the use of Dowax 222 lowered the soluble solids and total solids content of fresh cherries on the percentage basis. They stated that a reduction in the absolute amount of solids per cherry was indicated. Dowax 222 also resulted in a decrease in the drained weight of canned cherries. Fermate had much the same effect in comparison with Bordow as did Dowax when incorporated with either fungicide.

Physiological effects of foliar sprays have been the subject of a large amount of study. These studies have dealt mostly with photosynthesis and transpiration, although respiration has also been studied to a considerable extent.

Oils have probably been studied from the standpoint of physiological effects more than any other type of foliar spray, and the usual result has been a reduction in the apparent rate of photosynthesis. Hoffman (20) reported that two and three applications of spray oils materially reduced carbon dioxide intake by apple leaves. Overholser _et al_ (34) have given further evidence that oil sprays reduce carbon dioxide intake, but they reported no reduction from the use of light mineral oils. Overholser and Overley (33) reported no reduction from applications of a combination of calcium arsenate and mineral oil. In commenting on reduction of photosynthesis by oil sprays Ginsburg (14) suggested that the mechansim may be a reduction in light intensity.

Oberle _et al_ (32) found that pertoleum oils reduced respiration, and that the reduction was less severe when dinitrophenolic materials were used with the oils.

In recent years considerable effort has been made to determine whether hormone stop-drop sprays have any direct effect on the physiology of leaves and fruit. Early studies with these materials indicated that there was no direct effect on maturity of fruit (7, 16). More recently, however, Allen and Davey (2) and Gerhardt and Allmendinger (13) have found that a-napthaleneacetic acid may accelerate ripening. Truab (42) found that citrus fruits ripened earlier when treated with high concentrations of a-napthaleneacetic acid, indolebutyric acid. Low concentrations, on the other hand, retarded ripening. Smock and Gross (41) found that various forms of a-napthalenacetic acid increased respiration of fruit during a short period of three to five days, this period occurring about two weeks after application.

The literature on physiological effects of fungicidal and insecticidal materials other than oils is voluminous, so a complete coverage will not be given.

Agnew and Childers (1) found that both magnetic spray, a sulphur suspension, and lime-sulphur reduced apparent photosynthesis of apple leaves, lime-sulphur having the greater effect.

Hoffman (18) reported that some spray materials practically stopped the assimilation of carbon dioxide by apple leaves, treated leaves having assimilated as little as five percent as much as untreated leaves. Using lime-sulphur at the rate of 2½ gallons per hundred on bearing trees in the orchard, carbon dioxide assimilation was reduced to about 25 to 75 percent of the rate before treatment.

Murphy (29) found that applications of bordeaux and lime-sulphur reduced photosynthetic activity. The largest reduction obtained was from 10.83 grams of sugar accumulated per square meter of leaf surface for the control to 5.77 grams after three applications of lime-sulphur. He also reported that three applications of Capro K, a proprietary copper fungicide, decreased photosynthesis about 17 percent.

Christopher _et al_ (6) studied the effect of lime alone and in combination with other materials and found no effect on the rate of apparent photosynthesis.

Fossum and Laurie (12) obtained a reduction in apparent photosynthesis from the use of several proprietary materials. Similar results were obtained by Laurie and Witt (24).

Pieniazek and Christopher (36) found that Fermate and lauryl pyridium chloride reduced apparent photosynthesis.

Shutak and Christopher (40) studied respiration of tomato leaves when sprayed with Bordeaux and found little effect from the material. Pickett (35), working with peach leaves using the Wahrburg manometric technique, found that foliar sprays affected the rate of respiration of young leaves far more than mid-stem and basal leaves. He found that lead arsenate and zinc sulphate decreased respiration less than did lead arsenate alone. Dichlorodiphenyltricholoroethane increased respiration markedly in young leaves but had a depressing effect on mature leaves. Benzenehexachloride stimulated respiration, especially in young leaves.

Physiological studies with Dowax emulsions have been quite limited up to this date. Results of two investigations with wax-type materials are of interest. Smock and Gross (41) found that apple fruit dipped in 0.5 percent carbowax had a lower respiration rate than untreated fruit. When a-napthaleneacetic acid was applied with carbowax as a carrier, the carbowax prevented the increase in respiration which was obtained when a-napthaleneacetic acid was used alone in one year, but it did not reduce the stimulatory effect the next year. Lanolin showed the opposite effect in that it increased the rate of respiration. It did not offset the effect of the hormone when used as a carrier.

Barr (5) has reported on work with Dowax emulsions on leaf physiology. In analyzing leaf punches of maize, he used the accumulation of sugars as a measure of photosynthesis, and obtained a decrease in the rate of photosynthesis. The accumulation of sugars in sprayed leaves was 62.10 percent as great as in unsprayed leaves on the day following the application. He found that twenty days after the application the accumulation of sugars was about 18 percent greater than at the time of the earlier analysis, and suggested that reduced efficiency of the spray film in retarding photosynthesis could have resulted from a change in the permeability of the wax coating or from cracking or shrinking of the spray film, or from both of these factors. From his reference to "wax and oil emulsions developed for the prevention of desiccation of shrubs and trees in transplanting" it is assumed that the material he used was "Dowax 82", or one of the other early emulsions of the Dowax series.

Further work was done on leaf physiology with these emulsions by Comar and Barr (8). They found that one of the commercial emulsions in a concentration of 12.5 percent or higher at 110°F caused very severe injury to leaves of sunflower because of destruction of chlorophyll. Concentrations of 4 percent caused some injury.

Neal et al (30) analyzed cherry leaves for reducing sugars and found that application of 10 percent Dowax 222 retarded photosynthesis temporarily.

Reduction in transpiration by potted cherry trees when treated with Dowax 222 was found by Neal et al (30). At a concentration of one percent this emulsion was as high as 60 percent efficient in reducing transpiration just after application. Efficiency dropped very rapidly, however, until the effect was practically nil after about five days.

METHODS AND MATERIALS

<u>Field trials</u> — Use was made of four privately owned orchards, designated Orchards I, II, III, and IV, in conducting field trials. Experiments conducted in 1948, (in Orchards I, II, and III,) included determination of size, soluble solids, total solids, drained weight of canned fruit and titratable acid content. (Orchards I, II, and III were used.) Field work in 1949 consisted of measuring the solids content of cherries from Orchards III and IV.

Trees of all orchards were mature, large and vigorous. All orchards were managed under a system of clean cultivation during spring and summer, followed by a fall cover crop. The soils of Orchards I, II, and III were sandy loams. Each was underlain by a heavy zone of accumulation at a depth of $3\frac{1}{2}$ to 4 feet below the surface. The surface soil of Orchard IV was considerably heavier than that of the other three. Excellent insect and disease control was obtained in all orchards throughout the experiments. Orchards I and II were located in the southwestern cherry producing region of Michigan, at Fennville in Allegan County and Gobles in Van Buren County, respectively. Orchards III and IV were located at Kewadin in Antrim County and Traverse City in Grand Traverse County, respectively.

Orchard I comprised a single block of trees, all of which received fungicidal cover sprays of Bordow. In 1948 Orchards II and III were each divided into a Bordow block and a Fermate block. Each block of these three orchards was divided into three plots of two or three rows each, the rows containing from 20 to 30 trees each.

Plot 1 of each block received no Dowax, plot 2 received one application of Dowax 222, and plot 3 received two applications. When one application of Dowax was made it was included with the second cover spray, applied when the pits had reached full size and fruit had just begun to color. When two applications were made Dowax was included with the second and third cover sprays, the third being applied seven to ten days after the second or when fruit showed about 25 percent red color. Spray treatment in Orchard II was somewhat irregular in that the first application of Dowax was made with the first cover spray on May 28, and the second with the second cover spray on June 14.

One end of each block in Orchards II and III received a high rate of nitrogen fertilization (ten and eight pounds ammonium nitrate per tree, respectively), while the other end received a lower rate (six and five pounds, respectively). Orchard I was fertilized uniformly throughout at two pounds ammonium sulphate per tree.

Trees of Orchard I were on Mahaleb roots, and were spaced twenty feet apart on the square. The trees were larger than in the other orchards. The orchard was 16 years old. The cover crop the previous fall was Sudan grass. The set of fruit in 1948 was light, resulting from a large amount of rain and cool weather during blossoming. The orchard received four cover sprays.

Trees of Orchard II were on Mazzard roots, and were spaced fifteen feet apart on the triangle. The orchard was 39 years old. The cover crop the previous fall was rye grass, which received 200 pounds of an 0-20-20 fertilizer per acre. The set of fruit was about 90 per cent. The orchard received three cover sprays.

Trees of Orchard III were on Mahaleb roots and were spaced 18 by 20 feet. The orchard was 21 years old. The cover crop the previous fall was chewing fescue. The set of fruit was about 90 percent. The orchard received four cover sprays.

In all orchards picking was done by plots in order of apparent maturity. The picking was spread out so that all plots were in as nearly the same stage of maturity as was practicable under the circumstances. Since transient labor was used in picking it was not possible to spread the picking out as much as was desirable.

Spray materials --The fungicides used were Bordow, Fermate, and Dithane. Bordow was mixed for all experiments at the rate of four pound Bordow, three pounds hydrated lime, and two pounds lead arsenate per hundred gallons of material. Fermate was used at the concentration of two pounds Fermate and two pounds lead arsenate per hundred gallons. Dithane (Disodium ethylene bisdithiocarbamate), an organic material manufactured by Rohm and Haas Company, Philadelphia, Pennsylvania, was mixed at the rate of one quart Dithane, one-half pound monohydrated zinc sulphate, one-quarter pound hydrated lime, and three pounds lead arsenate per hundred gallons. Dowax 222 was used in all experiments at the rate of one percent by volume.

Size determination — Size determination in field experiments was made for three to five trees from each plot. These trees were selected on the basis of uniformity in size and vigor and freedom from observable winter injury and disease infection. Three samples of 100 cherries each were picked from spurs only, taking the entire spur cluster. Spurs were picked at random from the entire tree so as to secure a fair representation of the total crop. Each sample was weighed to the nearest gram on a portable Toledo balance. Volume was then determined by water displacement in a 500 ml. graduated cylinder. Total yield per tree in pounds was determined as the trees were picked.

Size was determined for Orchards I and III only once, that being done just ahead of the pickers. Size of fruit in Orchard II was determined twice, once on July 14 for all plots and once as the trees were picked.

In an attempt to determine whether Dowax 222 had its effect on size of fruit because of its being applied to the fruit or the leaves a single tree was selected for work in 1948, on which six pairs of branches were selected and tagged. These paired branches were selected so that one could be treated and the other left untreated as a control, in such a way that treated and control were as nearly alike as possible. Both members of each pair were in as nearly as possible the same location with regard to exposure to sunlight, and were attached to the same scaffold limb in order that their supply of nutrients from the tree would be as nearly equal as possible. The two branches were also as nearly the same size as possible, being about three feet in length and having similar patterns of branching and about the same ratio of leaf area to number of fruit. Treatments were made by spraying with a hand atomizer or by dipping in a beaker. Controls were treated with distilled water by the same methods. Size of fruit was determined by measuring the smallest diameter with a calipers. Two measurements were made.

The first was made on June 25, two days after treatment, and the second was made on July 8. The delay in making the first readings was unavoidable, and not preferable.

In 1949 similar experiments were conducted except that smaller branches were selected, being about $1\frac{1}{2}$ to 2 feet in length and bearing from ten to fifteen cherries each. By selecting smaller branches greater uniformity was secured. All treatments were made by dipping. Size was measured as volume by water displacement in a ten ml. graduate cylinder on June 19 and 24, and in a 50 ml. graduated cylinder on June 30, July 5, and July 13. Controls were treated with distilled water.

Solids Content -- Soluble solids content was determined by reading the refractive index of the expressed juice of a sample made up of at least ten cherries from each field trial plot. These samples were taken from a random sample picked from several trees in each plot. Readings were repeated until at least three closely agreeing values were obtained for each treatment. Refractive indices were converted to percentage sucrose by the use of the International Scale of 1936 (4). This technique was used by Allinger *et al* (3) and was found satisfactory also for various varieties of watermelon by Porter *et al* (37). It has been used in a large amount of experimental work in recent years, and is commonly used by cherry processors in checking quality of the raw product. Porter *et al* found that the correlation between refractive index and total sugar content was not perfect, but that it was close enough to make refractive index a reliable indication of solids content. It can obviously be accurate as used to date only in so far as the total soluble solids of the experimental solution approach a pure sucrose solution. Since about 80 percent of the sugar of red cherries is in the form of invert sugar and the correction factor for converting refractive indices of sucrose solutions to those of invert sugar solutions is 1.022, the values as reported here are probably somewhat low.

Total solids content was determined by drying a composite sample of from 80 to 200 grams in an oven at 100 to 105° C for 24 hours. In 1948 the pits were not removed from the dried flesh, but they were removed and weighed separately in 1949. All weights were accurate to the nearest 0.1 gram.

Drained Weight of Canned Cherries — Cherries from the 1948 experimental plots were kept separate and their identity maintained through the various processing plants. The number ten cans from each treatment were set aside for drained-weight measurements. All of them were canned in water without change in the routine of the plant where the processing was done. The drained weight measurements were made by the standard method consisting of opening the cans, emptying the contents of each can separately on a screen strainer, allowing them to drain in an inclined position for two minutes, and weighing the drained fruit.

Titratable Acid — A composite sample of fruit from each plot of Orchard II was picked on June 19, 1948 and taken to the laboratory where a known weight of about ten grams of juice was titrated against 0.1 NaOH, using phenolphthalein indicator. These determinations were made in three replications.

<u>Uptake of Water</u> -- In commercial practice an attempt is made to soak cherries before pitting. The temperature used depends on the temperature of the availabele water, and the cost of refrigeration or of obtaining water at a low temperature. The length of time cherries are allowed to soak depends largely on the condition of the fruit, the amount of space available, the schedule of arrival of fruit from the orchards, and the capacity of processing facilities. In general processors prefer to soak cherries for at least four hours at a temperature of 50 to 65^{o} F. The reason usually offered for this soaking is that the cherries absorb water and become firm, so that they pit cleaner and with less rupturing.

In order to determine the effect of the application of Dowax 222 on the uptake of water in soaking a single tree at the College Horticultural Farm, at East Lansing, was given one application of Dowax 222. This application was independent of the fungicidal program, being made soon after the second cover spray was applied. An adjacent tree which received no Dowax was used as a control. Uptake of water was determined by weighing samples of cherries, soaking them in running water for varying lenghts of time, and then reweighing them. In order that weights could be taken before and after soaking under comparable conditions, the samples were first immersed in water, immediately drained and the adhering surface water removed by moving them around on a dry piece of cheese cloth. This same drying procedure was used after soaking. Samples contained from 200 to 500 grams, treated and corresponding control always being of about equal weight. Treated and control were handled alike throughout the experimental periods. Soaking was done in glass jars about a foot tall. Tap water was run continuously over the samples by attaching rubber tubing to a glass Y so that water from the same tap was used in soaking a given treated sample and the corresponding control. The soaking period was from 5 to 28 hours, and the temperature was 57 to 63° F. Loss of weight before soaking and its effect on the uptake of water compared to that of samples which were started soaking soon after picking was measured by permitting some samples to remain in quart berry boxes in the laboratory at a temperature of about 70 to 80° F for 11 to 27 hours before soaking was begun. Weights were taken at the beginning of this storage period, and before and after soaking. Stems of most samples were removed, as is done in the most frequent commercial procedure. Four samples had the stems left intact to determine the relative magnitude of water passage through the skins and through the puncture made in separating the stems.

Ease of Pitting — The response of cherries in the pitting process was studied by visual observation in commercial processing plants and by measuring the amount of pressure required to break the skins and to pit the cherries using a hand type cherry pitter. Observations were made of the cleanness with which the flesh was removed from the pits, the failure of pits to be removed from the cherries, rupturing of cherries, and failure of cherries to clear the pitters. These observations were made on cherries from Orchards I, II, and III in 1948 in which field trials were made, as reported above.

Pressure tests were made on cherries from the same trees used as a source of Dowax-treated and untreated fruit for determining the uptake of water. In one series of tests the distance through which a blunt-pointed glass rod had to be dropped to pierce the skins was measured, and expressed in centimeters. This rod weighed 6.91 grams. It was 4 mm. in diameter, drawn to a point 1 mm. in diameter, and fire polished. To be sure that each cherry was struck at the same angle by the rod it was inserted in a 6 mm. glass tube held in a burette clamp, and then released. Cherries were placed singly in a depression cut into a cork placed directly under the rod. Cherries were so placed that they were always struck squarely on the cheek. Measurements were made both with and without soaking, as well as after storage at low temperature.

In another series of tests with similar cherries a hand type cherry pitter was used. The pitter was attached to a frame provided with a system of pullies, cord, and weights so that adding weights to one hander tended to pull the pitting plunger downward and other hanger acted as a counter-balance. The force was applied directly to the plunger, the handle having been disengaged. Here again cherries were placed in the pitter so that they were struck on the cheek. The skin was considered broken only if the plunger broke entirely through the skin, and unbroken for anything less, even though one, two, or all three points of the plunger may have pierced the skin.

<u>Respiration Experiments</u> — Respiration was measured by two methods. Evolution of carbon dioxide by leaves was measured, using an apparatus of essentially the same design as that described by Heinicke and Hoffman (17); and absorption of oxygen by leaf punches was measured, using a commercial Warburg manometric apparatus.

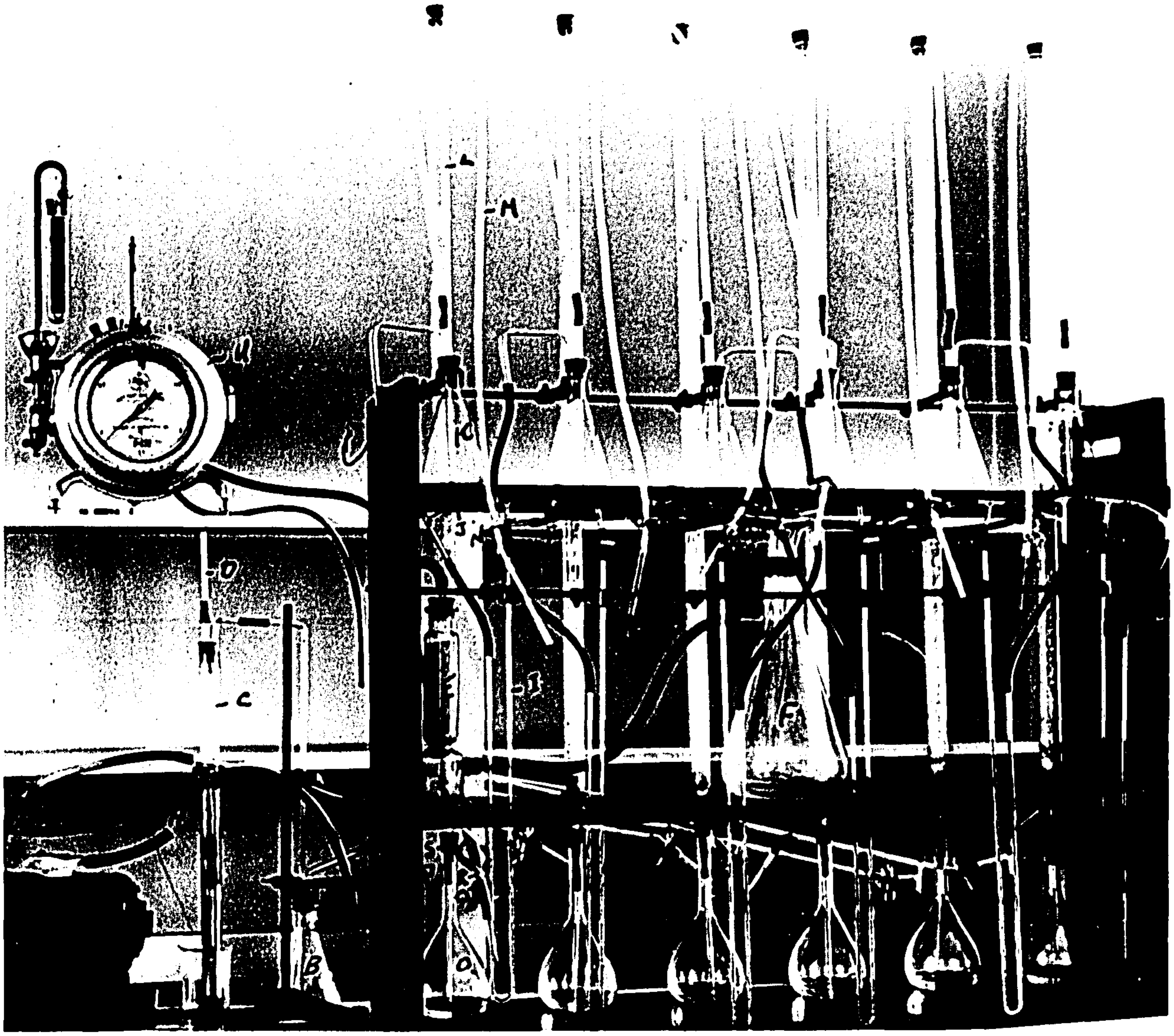

Figure 1. Carbon dioxide absorption apparatus. A, vacumn line from pump; B, suction flask; C, mercury valve; D, inlet to mercury valve; E, drying tower; F, central connecting flask; G, inlets from units; H, needle valve; I, water manometer; J, hose containing capillary tube; K, phenolphtahlein trap; L, absorption tower; M, water inlet; N, screw clamp; O, 1 l. volumetric flask; P, flexible joint; Q, point for connection of gas meter; R, T, leading to by-pass; S, pinch clamp; T, tube to storage chamber; U, wet test gas meter.

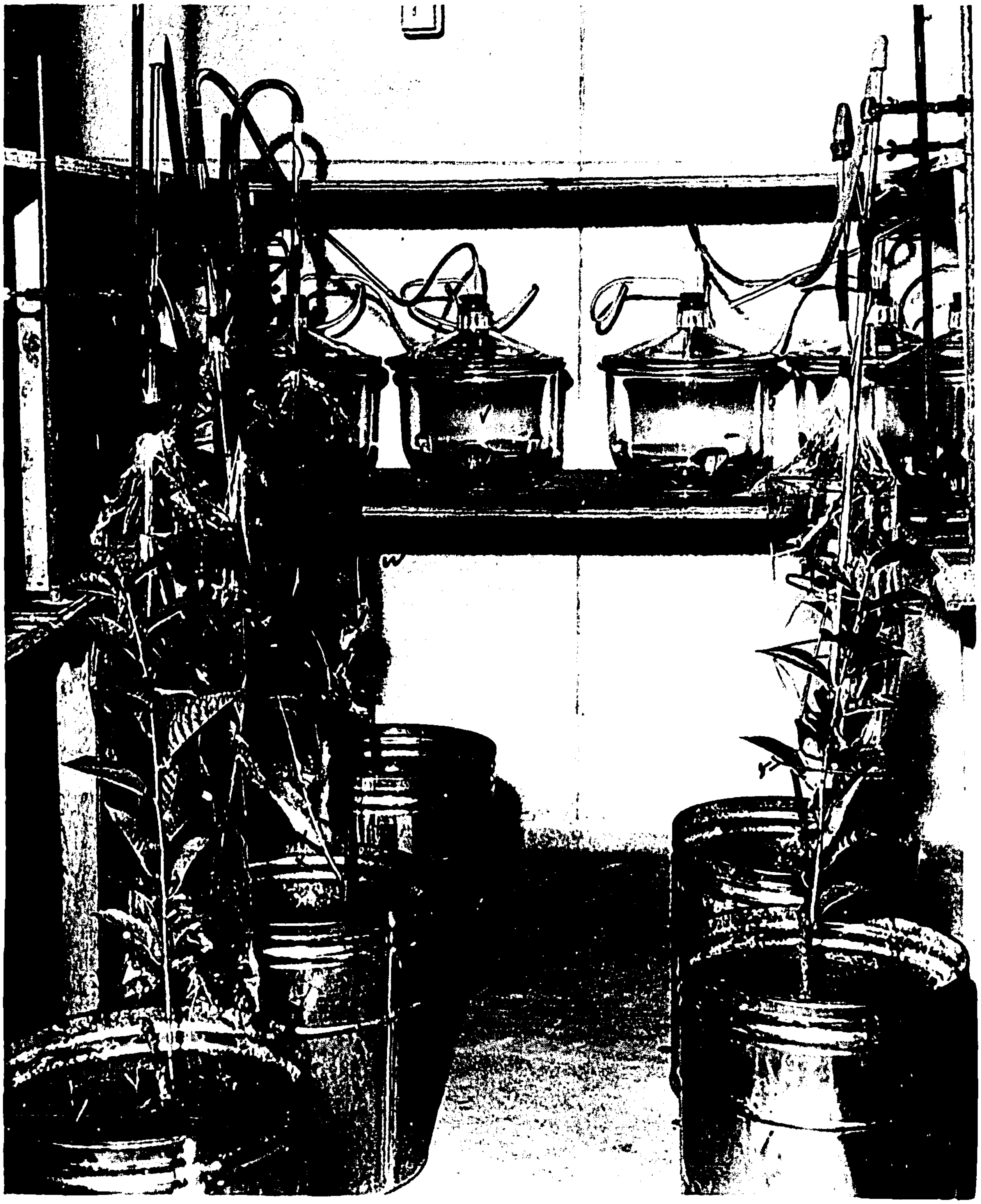

Figure 2. Interior of storage chamber. V, disccator; W, envelop; X, Paper clip; Y, wire frame.

The measurement of carbon dioxide evolved consisted essentially of drawing air from around the leaves of a potted cherry tree through an absorption tower containing standardized alkali which removed the carbon dioxide from the air stream and converted it into soluble carbonate. The carbonate was then percipitated and a sample of the unneutralized alkali was titrated against standardized acid. The amount of alkali which was neutralized was then determined by difference. The carbon dioxide equivalent was then calculated. The rate of flow of air was measured, so that results could be expressed as mg. carbon dioxide absorbed per liter of air. This carbon dioxide represented that contained in the air and that added to the stream by respiration of the cherry tree. A blank was operated with each run to establish the carbondioxide content per liter of the air which entered the envelopes; that added by respiration was then determined by difference. Leaf area was measured, and respiration rate was expressed as mg. carbon dioxide evolved per unit of leaf area.

The carbon dioxide absorption apparatus is pictured in Figs. 1 and 2. Lettered parts of these two figures are explained in the following text. A Cenco Hyvac pump operated by a one-eighth horse-power motor drew air through tube A from a suction flask (B), which was in turn connected to a mercury valve (C) and to a drying tower (E). The drying tower led to a central five-liter suction flask (F) which was provided with an outlet (G) for each unit. Each of these outlets drew air through a Hoke needle valve (H) connected to a water monometer (I), thence to a phenophthalein trap (K), and thence to the top of the absorption tower (L). When the pump was started suction on the absorption tower first caused the alkali in the 1000 ml. volumetric flasks (O) attached at the bottom to rise into the towers. Once the liquid had risen air was drawn through the system from tubing (T) which passed from the volumetric flasks through the partition between the laboratory and the storage chamber shown in Fig. 2 where the trees were placed during runs. Inside the storage chamber the tubing lead first to desiccators (V) which had no purpose in these experiments, being inserted in the lines for use in studies with small plants or plant parts. From the desiccators air was drawn from celophane envelopes (W) surrounding a branch of a potted cherry tree. These envelopes were not sealed completely so that air was drawn into them from the outside.

The mercury valve (C) was provided for two reasons. First, it served as a safety feature by removing all probability of implosion of glass vessles in case the suction pump had been turned on at any time when all openings to the atmosphere were sealed off. Second, it provided a means whereby suction could be applied gradually to the towers to prevent the water in the manometers from being sucked into the tubing and thence to central flask (F) by a sudden rush of air through one unit when the alkali rose in one tower more quickly than in the others. This hazzard was great since there was a large difference in tension on the two sided of the manometers. The mercury valve consisted of a 30 mm. glass tube sealed at the bottom and filled to a height of about one foot with mercury. This tube was fitted with a two-holed stopper through which it was connected into the vacumn line through flask B, and to an inlet (D) from the atmosphere. This inlet was a glass tube which permitted air to pass readily to the pump when the lower end was raised out of the mercury, but restrained this passage as the tube was lowered into the mercury. As the amount of suction required to draw air through the mercury valve increased the suction on the tube leading to the towers increased. After the alkali had risen in the towers this inlet tube was always depressed far enough that no air entered through it since the full capacity of the pump was needed to maintain a suitable flow of air.

The drying tower (E) served to remove water from the air stream before it passed into the pump. The central flask (F) served to connect the one vacumn line from the pump to the six separate vacumn lines leading to the towers; as a "head" in the system so as to decrease the fluctuation of suction on the towers; and to trap any large amount of liquid being drawn through any of the lines.

The needle valves (H) were used to regulate air flow through the separate units. All valves were adjusted so that flow through all towers was about equal, and a constant amount of alkali was used to avoid changes from one run to another. During the first replication the valves were not adjusted during the runs, and the rate of air flow was measured three or four times during each run. The average of these measurements was accepted as the rate of flow for the run. During the second and third replications the apparatus was attended regularly and valves adjusted to maintain uniform flow, as indicated by the anmometers. Slight variation occurred from time to time as foaming in the towers increased and decreased in nearly constant cycles. This, of course, caused a small variation in the total flow through the system, but since all manometers were kept at about the same position relative to the marks on the manometers accepted as their average reading error from this source was minimized.

Manometers were made by bending four foot lengths of glass tubing into a U shape, connected across the top by glass T's and rubber tubing. The difference in tension on the two arms was increased so that a suitable reading of 10 to 14 cm. was obtained by inserting into rubber hose J a piece of glass tubing with one end drawn out into a capillary. The water levels in the manometers fluctuated constantly, so glass beads were placed in the bottom of them to decrease this fluctuation. Air flow was measured by connecting a wet test gas meter (U) into the units between the absorption towers and the envelopes. This point for unit number one is indicated by the letter Q in Figure 1. The passage of air through the test meter increased the friction enough that the rate of flow was decreased slightly, so it was necessary to readjust the valve before a reading could be taken. The time required for a given number (usually 3) of liters of air to pass was measured with a stop watch, and converted to liters per minute. The manometers were calibrated so that in later stages of the work the rate of flow was read directly from graphs of manometer readings in centimeters plotted against liters of air per minute.

The difficulty in accurately establishing rate of air flow was a serious obstacle. A need was felt for a gas meter permanently connected into each unit.

The phenolphthalein trap (K) was used to indicate carry-over of alkali from the towers. It contained a small amount of distilled water to which three or four drops of phenolphthalein dye were added.

Absorption towers were six feet long, made of 30 m.m. pyrex tubing. The bottom end of each was melted until almost closed, and then a length of 6 m.m. pyrex tubing was fused to it. This provided a shoulder to support the tower in the frame. An extension of this tubing of suitable length to reach to the bottom of the volumetric flask was connected by a piece of rubber tubing (P). This provided the flexible joint necessary to remove the volumetric flask in which the alkali was placed. This flask was inserted onto a stopper which was left permanently on the extension of the absorption tower. There was a second hole in this stopper through which was connected the tubing from the envelope. The air passing through the tower was broken up into small bubbles to hasten the absorption of the carbon dioxide by filling it almost to the top with glass beads and short lengths of glass tubing. These were prevented from falling through the constriction at the bottom by a layer of glass wool.

The absorption tower also had connected into it a length of tubing (M) which could be sealed off by a screw clamp (N). This was used in washing the towers down. The envelopes surrounding the leaves were made of 300 MSAT 86 cellophane, a product of E. I. DuPont de Nemours and Company. The method of closing the lower ends of the envelopes with paper clips is shown at X, and one of the wire frames used to prevent collapse of envelopes is shown at Y. Circulation of air inside the envelopes was good when the pump was running as indicated by the rapid removal of tobacco smoke blown into the envelopes.

Efficient removal of carbon dioxide from the air stream in the absorption towers was indicated by the fact that when two towers were connected in series no appreciable change occurred in the strength of the alkali in the second tower.

Leaf area was measured by tracing the shadow cast by the leaves on paper when a light was placed below them, and measuring the enclosed area with a planimeter. This measurement was made twice for each replication, and daily growth was assumed to be constant.

Trees were placed in the chamber at about 5:00 PM. of each day on which a run was made. The temperature of the chamber was maintained at 70 to 75° F. The runs were started between 6:30 and 8:00 PM., being somewhat later for most of the runs for the secone and third replications than for the first replication. Each run was of three hours duration. Envelopes were placed over the branches just before starting the run. These envelopes were aerated by running a second suction pump for about two minutes, this pump being connected with all units by means of glass T's (R) between the towers and envelopes. After aerating the envelopes these bypasses were sealed off by means of pinch clamps (S). The pump to the towers was then started, the towers having been previously charged by pipetting 50 ml. of 1 N NaOH and 100 ml. of water into each volumetric flask. The inlet of the mercury valve was then depressed and the needle valves manipulated so that air started flowing through all towers at the same time.

At the end of each run the alkali was permitted to flow into the volumetric flasks, and distilled water containing phenolphthalein dye was drawn into the towers through the waster inlets (M), and then allowed to drain into the volumetric flasks below. This washing was repeated until the phenolphthalein did not become colored. The flasks were then removed, and saturated barium chloride was added to precipitate all carbonate. The flasks were then made up to volume, shaken thoroughly, stoppered, and set aside to allow the carbonate to settle overnight. Three replicate samples were then withdrawn and titrated against standardized hydrochloric acid.

Calculations consisted of determining the number of milliequivalents of alkali with which the towers were charged, subtracting the milliequivalents remaining after the run, and multiplying by the equivalent weight of carbon dioxide to determine the number of grams of carbon dioxide absorbed in each tower. These were then divided by the number of liters of air which passed through each tower. The value for the blank was then subtracted from each of the other values to determine the total number of mg. of carbon dioxide given off by each branch. These values were divided by 3, the length of each run in hours, and then by the leaf area in square decimeters. The final answer was mg. carbon dioxide given off per hour per square decimeter of leaf area.

Three replications of respiration studies were made by this method. Each consisted of a standardization period to establish the normal rate of respiration, at the end of which treatments were made, followed by more measurements of respiration to determine the effect of the treatments. One tree was left untreated as a control, since respiration varied from day to day irrespective of treatment. The six units were thus used as follows: No. 1, blank; No. 2, control; No. 3, sprayed with Fermate; No. 4, same as No. 3 except that Dowax 222 was added; No. 5, sprayed with Bordow; and No. 6, same as No. 5 except that Dowax 222 was added. Dates of runs and treatments are shown in Table XVIII. Applications were made with an electric motor-driven atomizer.

Trees used in these experiments were set out in five-gallon berry cans containing a mixture of equal parts sand and the remnants of a compost pile. The trees were one-year-old budded seedlings. They were set in the cans in late April. The whips were cut back to about six inches from the crowns. After growth started all shoots were removed except one on each tree. Just before a tree was placed in an experiment the lower leaves were removed so that all remaining leaves could be enclosed in the envelope. No fertilizer was applied to the soil, and care consisted only of watering and removing weeds. During the experimental periods the trees were watered each night, after runs were made, so that the hydration of tissue would be as nearly uniform as possible when runs were started. Except for the time when the trees were in the chamber for respiration runs they were kept outside at all times. The cans were surrounded by black cloth to protect them from the direct rays of the sun which would have heated the growing medium and roots excessively.

Climatological data were obtained from the records of the U. S. Weather Bureau Station at Lansing, Michigan. These records were taken at the Capitol City Airport, which is about five miles from the Michigan State College campus where this work was done.

Since much recent work on respiration has made use of Warburg equipment it was considered desirable to compare this method with the modified Heinicke and Hoffman method described above. The Warburg method was used by Pickett (35) in work with foliar sprays on peach leaves, by Mitchell et al (23) in studying the effect of several materials on various plant tissues, and by Kelly et al (21) in studying the effect of growth promoting substances on pea and oat tissues. Deys (9) used an adaptation of the Warburg apparatus in studying the effect of bruising on the respiration of tea leaves.

Respiration studies with Warburg equipment was made on leaf punches from three year old potted cherry trees. In order to increase the uniformity of samples one side of leaves was treated, and the other side was left untreated as a corresponding control. Two standardization runs were made to test the accuracy of the method before any treatments were made. Four disks were used in each unit. These disks were 10 m.m. in diameter and were cut out with a cork borer pressed against a large cork. Measurements were started about 30 minutes after the disks were cut.

Five units were used as follows: No. 1, control for No. 2; No. 2, treated with Fermate for four runs and Fermate plus Dowax 222 for three runs; No. 5, control for Nos. 3 and 6; No. 3, treated with Bordow for three runs and Bordow plus Dowax 222 for three runs; No. 6, same as No. 3 except that an additional measurement was made with Bordow. Thus disks for Nos. 1 and 2 came from opposite sides of the same leaf; those for Nos. 3 and 6 came from the same side of the same leaf; and those for No. 5 came from the opposite side of the same leaf from which those for Nos. 3 and 6 were taken.

Spray materials were mixed in the same way as for the previous respiration studies. Applications were made by painting with a fine brush, about 30 minutes before disks were removed.

Respiration runs were made with the water bath at 28° C, and lasted from 60 to 100 minutes. Readings of the manometers were taken every ten minutes, in centimeters. Manometer readings were then plotted against time, and cubic millimeters of oxygen taken up per hour were calculated by use of manometer constants calculated by using hydrogen peroxide in the vessels under such conditions that the amount of oxygen liberated was known. The carbon dioxide evolved was prevented from counteracting the suction created by the absorption of oxygen by absorbing the carbon dioxide in concentrated sodium hydroxide in the central vessels of the Warburg flasks.

After the completion of each run disks were dried to constant weight at 100°C. and final results were expressed as cubic millimeters of oxygen absorbed per gram dry weight per hour.

PRESENTATION OF DATA

Data from experimental work are presented on pages 42 to 64. Such remarks are made here as are necessary for clarification.

Data on size of fruit from the various orchards are given in Tables I to VI. There is little relation between size of trees and size of fruit. Variations in size of fruit and yields are very large between orchards, and within a given orchard and a given treatment. In general it may be said that in a given plot the smaller the trees the lower the total yield and the smaller the fruit. In Orchard I there is an exception in the one-Dowax 222 plot, where the smallest fruit came from the one outstandingly large tree, and the highest yields came from the two smallest trees. There are several exceptions to this rule also in Orchards II and III. These variations in size and productivity are disturbing in view of the elaborate precautions taken in selecting experimental trees. In no case was more than one third of the trees in a given plot selected for size analysis because of the difficulty in finding trees of about the same diameter, volume of foliage, number of scaffold limbs, freedom from visible injury, and so on. It was desired to analyze five trees from each plot, but in some cases it was necessary to make a choice between reducing this number and selecting trees that were highly variable. The choice made was to reduce the number of experimental trees, so that in some plots only two or three trees were considered acceptable.

The higher yields in Orchard III than in Orchard II, undoubtedly resulted from greater volume of foliage due to wider spacing, although many other factors play a part in determining size and yields of fruit. Yields from Orchard I were higher than from Orchard II in spite of their lighter set of fruit and lower rate of fertilizer application, size of trees again being the logical explanation.

The larger size of fruit from Orchard II than from either of the other orchards where similar spray treatment was used is attributed to the high productivity of the soil in Orchard II and the unusually high rate of fertilizer application.

Table VII gives soluble solids and total solids content of cherry samples from the same plots as are covered in Tables I to VI on size of fruit. These data were not as conclusive as desired, especially in consideration of their tremendous importance. A very undesirable feature of the data in Table VII is that the effect of Fermate and of Dowax 222 on the total solids content of cherries is calculated on the basis of the whole fruit. While it is not necessarily a correct assumption that foliar sprays have no effect on size and composition of pits, it seems much more logical that most of the effect of sprays applied in these experiments would be manifest by the fleshy pericarp and very little by the stony pericarp or pit. This is indicated by the work of Tukey (43) who reported that the stony pericarp of Montmorency cherry reaches full size in about 22 days after full bloom. The earliest date on which any Dowax was applied was May 28, when Dowax 222 was included in the first cover spray in Orchard II. This application came very nearly at the time the stony pericarps were reaching full size, but all other applications of Dowax were made well after this stage of growth. In Orchards I and III the first cover sprays, which did not include Dowax, also were made at about the time the stony pericarps were reaching full size. Thus it is difficult to conceive of foliar sprays having an appreciable effect on the pits.

Since data were obtained for total solids only on the basis of the entire fruit, it was impossible to express the effects of the foliar sprays in any other way, except by weighing several samples of pits and establishing an arbitrary figure for pit weight. An endeavor to do this revealed that pit weight was such a variable item that it would be preferable to express total solids as the data were actually obtained, and continue this phase of the work the next year.

The results of investigations in 1949 on the effect of foliar sprays on the solids content of cherries are shown in Tables VIII and IX. The variation in weight of pits is clearly evident from Table VIII, as is the absence of any trend in pit size except for a fairly close relation to size of fruit within a given orchard, regardless of spray treatment.

The low value of 0.44 grams total solids of flesh per cherry from the plot receiving Fermate as the fungicide without inclusion of Dowax in Orchard IV should be disregarded. The low fresh weight of these samples may account entirely for the low value, although the accuracy of such a figure is difficult to conceive in view of the high readings from other plots of the same orchard.

Table X gives drained weights of No. 10 cans of processed cherries from the various plots. Those values marked with an asterisk were not obtained by draining No. 10 cans, as were the others, because the commercial plant in which these cherries were processed was not operating a No. 10 line on the days these lots were run through, and all cherries were put into No. 2 cans. The values for these lots were obtained by draining ten No. 2 cans, taking the average drained weight, and multiplying by the factor 5.25. This factor was derived by dividing the put-in weight for No. 10 cans used for cherries from this orchard (83.5 grams) by the put-in weight for No. 2 cans used (16.1 grams). This method is not entirely reliable since the filling of No. 2 cans is only spot-checked and considerable variation is found. The values are recorded here largely because they agree so closely with those obtained from Orchards I and III, but they should not be taken too literally.

Table XI contains data on titratable acid content of expressed juice of fresh fruit from the various foliar spray plots of Orchard II.

Tables XII and XIII summarize experiments designed to determine whether Dowax 222 had its effect on size when applied to the leaves or when applied to the fruit. In Table XIII all averages given are genuine except for the following: a total of 846 measurements are indicated, not including twelve oversights represented by asterisks. Fourteen of these 846 measurements were not obtained because of early dropping of fruit. A plotted value was inserted for five measurements when fruit dropped between the last two measurements, but in the other nine cases the fruit dropped too much prematurely to use this procedure, and averages of the remaining cherries were substituted for averages of all cherries with which the experiment was begun. Calculated values were substituted for six measurements which were out of line with the measurements made before and after these particular measurements, by calculating daily growth and assuming that it was uniform.

Twelve cherries were measured on each branch, except for branch number five on which all measurements of one cherry were disregarded when this fruit practically stopped growing after the second measurement.

In analyzing the data from the paired-branch experiment of 1949 it was found that cherries varied in volume at the beginning of the experiment from 0.7 to 2.8 ml. Since it was felt unreasonable to compare the growth increment of cherries that had such a wide range of potential growth, two ways of presenting the data were used. In Table XIII where values appear for two different numbers of cherries for a given branch the larger number represents all cherries measured on that branch, and the smaller represents the cherries that were left after dropping data on those cherries that were smaller than 1.0 ml. or larger than 2.0 ml. at the beginning of the experiment. Additional measurements were dropped from the tabulations in order to compare equal numbers of cherries on each pair of branches, and have these cherries of approximately the same volume at the beginning of the experiment.

It should be emphasized here that data in Table XII are expressed as effect on growth over a short period of time rather than on total size reached at a given time. This accounts for the large effects. As an example, the controls in the first pair of branches in Table XII had an average volume of 1.46 c.c. on June 25 and 2.40 c.c. on July 8. In order for them to have attained a size ten percent larger than that actually reached it would have been necessary for them to grow 26 percent faster during the intervening 13 days.

Data on pressure required to break the skin and to pit fresh cherries comprise Tables XIV to XVI. These data could be expressed as energy expended by multiplying distances and the weight of the glass rod used (6.91 grams). However, the same relationships would hold, and the data could be of no greater value if expressed as energy because it would be impossible to produce an exact replica of the particular glass used. This is also true of the cherry pitter used. The decrease in force required to pit the cherries between July 13 and 15 was due largely to a change in technique. On July 13 the counter-weight was allowed to hang free so that the pulley cord was in a state of tension when the pitter started downward. It was found that friction had less effect on the acceleration of the pitter if this counter-weight was supported and the tension removed from the pulley cord before the pitter was started downward and this technique was adopted on July 15.

Table XVII gives data on experiments designed to determine the effect of Dowax 222 when applied to foliage on the uptake of water in the cooling tanks. The temperature of the water in which these cherries were soaked varied from 57 to 63° F., but was the same for the two members of each pair of samples; that is, treated and corresponding control.

Results of respiration studies made by Heinicke-Hoffman method are given in Table XVIII, and are presented graphically in Figs. 3 to 5 pages 65 to 67. Figures in parentheses in the graphs following names of foliar sprays used represent amount of daily growth by leaves in square decimeters. The rate of respiration varies with temperature, hydration of tissue, amount and nature of substrate and respiratory enzymes, supply of oxygen, injury, and the presence of foreign materials such as foliar sprays. Evolution of carbon dioxide is accepted as one of the most reliable measures of respiration rate. It is, however, subject to error from such causes as variation in respiratory ratio, freedom with which gasses can pass through the stomates and cuticle, and the limitations of the method of measurement. Thus the large variations from day to day are not surprising. The decrease in respiration rate from the first to the third replication is attributed largely to aging of the leaves, resulting in a decrease in the supply of readily oxidizable substrate.

Variations from one branch to another, due to changes in nature and supply of substrate and enzymes, would be expected to have been closely correlated with amount of growth of leaves. Since it was not; and since there was much to be desired in the closeness with which respiration rate of most leaf groups was correlated with supply of substrate, as indicated by favorability of sunlight and temperature for the process of photosynthesis during the day time; and since no definite trend was established in the effects on respiration rate of the foliar sprays which were applied, one must conclude that a large part of the variation in results was due to limitations of the method.

Probably the greatest limitation of the method as used was difficulty in accurately measuring rate of air flow. Two others were difficulty in rinsing all the alkali from the towers, and the limited accuracy of titration techniques.

Table XIX gives data obtained from studies of respiration of cherry leaves using the Warburg manometric method. Monometer number three was used to duplicate number six, but was not ready for operation during the first three runs. Manometer number two developed a leak during the second run, and so readings for it had to be discarded for that run.

The results were corrected for errors in calibration by means of standardization runs. Calibration error was so great the actual values reported have little more value than they would have if a purely arbitrary manometer constant had been chosen. However the trends obtained were constant enough to be considered fairly reliable.

The center section of Table XIX, entitled "Percentage, Controls Expressed as 100", is presented in order that results with manometer number three can be considered in analyzing these data. It must be excluded from the bottom section since this manometer was not operated during the two standardization runs.

The center section of Table XIX was derived by dividing the values for number two for each run by the corresponding values for number one, and dividing the separate values for number three and six by the corresponding values for number five.

The bottom section of Table XIX was derived by multiplying all readings for number two in the center section by the factor 100/73, or 1.37, which has the effect of attributing all error during the standardization run of August 22 to erroneous calibration of the manometers; the same method was used for number six except that the average values for both standardization runs were used, the factor being 100/180.5, or 0.554. This action was considered justifiable since all readings for the second run were higher than for the first, and all changes were of about the same magnitude.

TABLE I - Size of Cherries from Trees which Received Bordow with and without Dowax 222, Orchard I[1].

Trunk Circum. (in.)	Yield (lbs.)	Size of 300 Cherry Sample Wt. (g)	Vol. (ml.)
Without Dowax, Harvested July 19			
35	204	1240	1186
29	194	1237	1177
30½	179	1262	1189
41	162	1323	1255
26	106	1227	1160
Dowax 222 added once, Harvested July 20			
30	212	1499	1428
32	174	1365	1295
31	171	1370	1310
38	213	1335	1271
30	244	1436	1368
Dowax 222 added twice, Harvested July 21			
31	232	1365	1311
34½	220	1356	1294
28	229	1405	1345
28	158	1375	1317
26	180	1331	1270

1. Each line represents an individual tree.

TABLE II - Size of Cherries from Trees which Received Various Foliar Sprays, Orchard II, Fertilized with Six Pounds Ammonium Nitrate per Tree[1].

Trunk Circum. (in.)	Yield (lbs.)	Size of 300 Cherry Sample: July 14 Wt.(g)	July 14 Vol.(ml.)	As Picked Wt.(g)	As Picked Vol.(ml.)
		Bordow Treatment			
		Without Dowax, Harvested July 19			
27	191.8	1305	1250	1279	1229
24	128.7	1208	1169	1283	1225
29	187.1	1372	1316	1325	1263
		Dowax 222 added once, Harvested July 21			
24	96.2	*	1381	1433	1363
26	166.8	*	1437	1516	1476
		Dowax 222 added twice, Harvested July 23			
27	116.2	*	1310	1416	1345
27½	163.6	*	1474	1447	1377
24	90.3	*	1468	1605	1519
		Fermate Treatment			
		Without Dowax, Harvested July 19			
25	113.5	1499	1452	1466	1408
25	126.9	1319	1272	1339	1284
27	127.7	1398	1346	1429	1370
25	116.5	1394	1342	1465	1400
		Dowax 222 added once, Harvested July 21			
26	123.2	1511	1460	1477	1424
28	152.1	1482	1428	1420	1360
26	124.8	1549	1494	1533	1475
		Dowax 222 added twice, Harvested July 22			
29	117.0	1598	1548	1596	1537
27	111.0	1452	1410	1501	1433

1. Each line represents an individual tree.

* Indicates data not obtained.

TABLE III - Size of Cherries from Trees which Received Various Foliar Sprays, Orchard II, Fertilized with Ten Pounds Ammonium Nitrate Per Tree[1].

Trunk Circum. (in.)	Yield (lbs.)	Size of 300 Cherry Sample: July 14 Wt.(g)	July 14 Vol.(ml.)	As Picked Wt.(g)	As Picked Vol.(ml.)
		Bordow Treatment			
		Without Dowax, Harvested July 20			
*	182.1	1420	1362	1392	1325
25	113.4	1369	1310	1362	1302
24	91.2	1356	1303	1349	1278
25	142.6	1269	1215	1208	1170
		Dowax 222 added once, Harvested July 22			
26	91.1	1306	1252	1412	1336
24½	113.8	1401	1339	1368	1301
26	121.7	1506	1457	1544	1452
		Dowax 222 added twice, Harvested July 26			
26½	109.2	1462	1410	1525	1458
25	120.0	1347	1302	1345	1281
25	117.7	1547	1490	1547	1517
		Fermate Treatment			
		Without Dowax, Harvested July 20			
24½	132.0	1259	1220	1248	1192
24	92.8	1323	1283	1380	1318
28	150.4	1424	1337	1349	1278
		Dowax 222 added once, Harvested July 22			
28½	121.1	1498	1453	1551	1482
25	127.6	1475	1423	1516	1446
25	97.3	1495	1445	1540	1472
		Dowax 222 added twice, Harvested July 23			
*	142.0	1635	1594	1657	1570
25½	152.8	1400	1354	1502	1450
21	138.6	1489	1448	1522	1466
25½	125.0	1499	1447	1562	1496

1. Each line represents an individual tree.

* Indicates data not obtained.

TABLE IV - Size of Cherries from Trees which Received Various Foliar Sprays, Orchard III[1].

Trunk Circum. (in.)	Yield (lbs.)	Size of 300 Cherry Sample Wt. (g)	Size of 300 Cherry Sample Vol. (ml.)
Bordow Treatment			
Without Dowax, Harvested Aug. 14			
24	185	1109	1065
26	245	1140	1090
25½	246	1201	1158
25½	239	1179	1135
24	187	1105	1071
Dowax 222 added once, Harvested Aug. 14			
27	234	1147	1099
26½	277	1183	1134
26	228	1210	1149
26½	278	1317	1269
27	284	1292	1247
Dowax 222 added twice, Harvested Aug. 14			
26½	402	1273	1228
26½	270	1401	1350
26	271	1348	1297
27	357	1336	1284
26	243	1383	1340
Fermate Treatment			
Without Dowax, Harvested Aug. 13			
26½	259	1330	1278
22½	221	1400	1348
26	254	1391	1336
23½	165	1234	1188
26	312	1362	1313
Dowax 222 added once, Harvested Aug. 13			
27	353	1358	1311
25	222	1535	1482
23½	220	1460	1405
23	215	1474	1416
25	256	1431	1378
Dowax 222 added twice, Harvested Aug. 13			
23	223	1418	1366
26	338	1468	1411
28½	251	1487	1431
25	185	1431	1372
26½	265	1422	1364

1. Each line represents an individual tree.

TABLE V - Summary of Size of Fruit from Trees Receiving Various Foliar Sprays

Treatment[1]	Ave. Trunk Circum. (in.)	Ave. Yield Per Tree (lbs.)	Ave. Wt. 300 Cherries (grams)	Increase from use of Dowax 222[2] (%)	Increase from use of Fermate[3] (%)	Increase from use of Fermate and Dowax 222[4] (%)	Ave. Vol. 300 Cherries (ml.)	Increase from use of Dowax 222[2] (%)	Increase from use of Fermate[3] (%)	Increase from use of Fermate and Dowax 222[4] (%)	Density (g/ml.)
Orchard I											
Bordow (0)	32½	169	1258	-	-	-	1193	-	-	-	1.054
Bordow (1)	32	203	1401	11.4	-	-	1334	11.8	-	-	1.050
Bordow (2)	29½	204	1366	8.6	-	-	1307	9.6	-	-	1.045
Orchard II - 6 lbs. NH_4NO_3 per tree - July 14											
Bordow (0)	26½	169.2	1295	-	-	-	1245	-	-	-	1.040
Bordow (1)	25	131.5	*	*	-	-	1409	13.2	-	-	*
Bordow (2)	26	123.4	*	*	-	-	1417	13.8	-	-	*
Fermate (0)	25½	121.2	1403	-	8.3	-	1353	-	8.7	-	1.038
Fermate (1)	26½	133.4	1514	7.9	*	16.9	1461	8.0	3.7	17.3	1.037
Fermate (2)	28	114.0	1525	8.7	*	17.8	1479	9.3	4.4	18.8	1.031
Orchard II - 6 lbs. NH_4NO_3 per tree - as picked											
Bordow (0)	26½	169.2	1296	-	-	-	1239	-	-	-	1.046
Bordow (1)	25	131.5	1475	13.8	-	-	1420	14.6	-	-	1.039
Bordow (2)	26	123.4	1489	14.9	-	-	1414	14.1	-	-	1.053
Fermate (0)	25½	121.2	1425	-	10.0	-	1366	-	10.3	-	1.043
Fermate (1)	26½	133.4	1477	3.6	0.1	14.0	1420	4.0	0.0	14.6	1.040
Fermate (2)	28	114.0	1549	8.7	4.0	19.5	1435	8.7	5.0	19.9	1.043
Orchard II - 10 lbs. NH_4NO_3 per tree - July 14											
Bordow (0)	24½	132.3	1354	-	-	-	1298	-	-	-	1.043
Bordow (1)	25½	108.9	1404	3.7	-	-	1349	3.9	-	-	1.041
Bordow (2)	25½	115.6	1452	7.2	-	-	1401	7.9	-	-	1.036

TABLE V - Summary of Size of Fruit from Trees
Receiving Various Foliar Sprays (Cont'd.)

Treatment[1]	Ave. Trunk Circum. (in.)	Ave. Yield Per Tree (lbs.)	Ave. Wt. 300 Cherries (grams)	Increase from use of Dowax 222[2] (%)	Increase from use of Fermate[3] (%)	Increase from use of Fermate and Dowax 222[4] (%)	Ave. Vol. 300 Cherries (ml.)	Increase from use of Dowax 222[2] (%)	Increase from use of Fermate[3] (%)	Increase from use of Fermate and Dowax 222[4] (%)	Density (g/ml.)
						Orchard II - 10 lbs. NH_4NO_3 per tree - July 14 (Cont'd.)					
Fermate (0)	25½	125.1	1335	-	-1.4	-	1293	-	-0.4	-	1.032
Fermate (1)	26	115.3	1489	11.5	6.1	10.0	1440	11.4	6.7	10.9	1.034
Fermate (2)	24	139.6	1506	12.8	3.7	11.2	1461	13.0	4.3	12.6	1.024
						Orchard II - 10 lbs. NH_4NO_3 per tree - as picked					
Bordow (0)	24½	132.3	1328	-	-	-	1269	-	-	-	1.047
Bordow (1)	25½	108.9	1441	8.5	-	-	1363	7.4	-	-	1.057
Bordow (2)	25½	115.6	1472	10.8	-	-	1419	11.8	-	-	1.037
Fermate (0)	25½	125.1	1326	-	-0.2	-	1263	-	-0.5	-	1.050
Fermate (1)	26	115.3	1536	15.8	6.6	15.7	1467	16.2	7.6	15.6	1.047
Fermate (2)	24	139.6	1561	17.7	6.0	17.5	1496	18.4	5.4	17.9	1.043
						Orchard III					
Bordow (0)	25	2[illegible]0	1147	-	-	-	1104	-	-	-	1.039
Bordow (1)	26½	260	1230	7.2	-	-	1180	6.9	-	-	1.042
Bordow (2)	26½	309	1348	17.3	-	-	1300	17.8	-	-	1.037
Fermate (0)	25	242	1343	-	17.1	-	1293	-	17.1	-	1.038
Fermate (1)	24½	253	1452	8.0	18.0	26.5	1393	8.1	18.5	26.6	1.039
Fermate (2)	26	252	1445	7.6	7.4	25.8	1389	7.4	6.8	25.8	1.040

1. Numbers in parenthesis indicate the number of cover sprays which Dowax 222 was incorporated.
2. Increase over same fungicide without Dowax 222.
3. Increase of Fermate plots over Bordow plots receiving similar Dowax 222 treatment.
4. Increase of Fermate plots receiving Dowax over Bordow plots receiving no Dowax 222.
* Indicates data not obtained.

TABLE VI - Relation of Treatment to Size and Density of Cherries

Density Grams/Ml.	Ave. Wt. of 300 Cherries (g)	Fungicide	No. of Dowax 222 Applications	Orchard Number	Nitrogen Fertilizer Applied Per Tree	Time of Sampling (days before picking)
1.057	1441	Bordow	1	II	10	0
1.054	1258	"	0	I		
1.053	1489	"	2	II	6	0
1.050	1401	"	0	I		
1.050	1326	Fermate	0	II	10	0
1.047	1536	"	1	II	10	0
1.047	1328	Bordow	0	II	10	0
1.046	1296	"	0	II	6	0
1.045	1366	"	2	I		
1.043	1561	Fermate	2	II	10	0
1.043	1425	"	0	II	6	0
1.043	1549	"	2	II	6	0
1.043	1354	Bordow	0	II	10	6
1.042	1230	"	1	III		
1.041	1404	"	1	II	10	8
1.040	1295	"	0	II	6	5
1.040	1445	Fermate	2	III		
1.040	1477	"	1	II	6	0
1.039	1452	"	2	III		
1.039	1475	Bordow	1	II	6	0
1.039	1447	"	0	III		
1.038	1403	Fermate	0	II	6	0
1.038	1343	"	0	III		
1.037	1514	"	1	II	6	7
1.037	1472	Bordow	2	II	6	7
1.037	1348	"	2	III		
1.036	1452	"	2	II	10	12

TABLE VI - Relation of Treatment to Size and Density of Cherries

Density Grams/Ml.	Ave. Wt. of 300 Cherries (g)	Fungicide	No. of Dowax 222 Applications	Orchard Number	Nitrogen Fertiliser Applied Per Tree	Time of Sampling (days before picking)
1.034	1440	Fermate	1	II	10	8
1.032	1335	"	0	II	10	6
1.031	1525	"	2	II	6	8
1.024	1506	"	2	II	10	9

TABLE VII - Solids Content of Fresh Cherries from Trees which Received Various Foliar Sprays, 1948

Spray Treatment[1]	Soluble Solids[2] (%)	Total Solids (%)	Total Solids: Amount in 300 Cherries[3] (grams)	Decrease in Amount of Solids in 300 Cherries from use of Dowax 222[4] (%)	Decrease in Amount of Solids in 300 Cherries from use of Fermate[5] (%)	Decrease in Amount of Solids in 300 Cherries from use of Fermate and Dowax 222[6] (%)
		Orchard I				
Bordow (0)	13.9	-	-	-	-	-
Bordow (1)	14.3	-	-	-	-	-
Bordow (2)	13.9	-	-	-	-	-
		Orchard II				
Bordow (0)	14.5	15.0	194	-	-	-
Bordow (1)	13.7	13.7	202	-4.1	-	-
Bordow (2)	12.0	11.5	171	11.9	-	-
Fermate (0)	12.3	14.0	200	-	-3.1	-
Fermate (2)	11.0	12.3	182	9.0	9.9	6.2
Fermate (2)	11.3	11.5	178	11.0	-4.1	8.3
		Orchard III				
Bordow (0)	13.7	16.9	194	-	-	-
Bordow (1)	12.0	15.4	189	2.6	-	-
Bordow (2)	11.7	13.8	186	4.1	-	-
Fermate (0)	11.6	13.8	185	-	4.6	-
Fermate (1)	10.6	12.1	176	4.9	6.9	9.3
Fermate (2)	10.4	12.1	175	5.4	5.9	9.8

1. Numbers in parentheses indicate the number of cover sprays with which Dowax 222 was incorporated.
2. Expressed as sucrose.
3. Calculated as product of experimentally determined percentage solids times average fresh weight of samples from Table V.

TABLE VII - Solids Content of Fresh Cherries from Trees which Received Various Foliar Sprays, 1948 (Cont'd.)

4. Decrease from same fungicide without Dowax 222.
5. Decrease of Fermate plots from Bordow plots receiving similar Dowax 222 treatment.
6. Decrease of Fermate plots receiving Dowax 222 from Bordow plots receiving no Dowax 222.

TABLE VIII - Solids Content of Fresh Cherries from Trees which Received Various Foliar Sprays, 1949

Spray Treatment[1]	Soluble Solids[2] (%)	Fresh Wt., Fruit (g)	Dry Wt., Pits (g)	Fresh Wt., Flesh[3] (g)	Dry Wt., Fruit (g)	Dry Wt., Flesh (g)	Total Solids of Flesh (%)	Total Solids of Flesh Per Cherry (g)
				Orchard III[4]				
Bordow (0)	15.2	85.7	5.4	80.3	16.6	11.2	14.0	.45
Bordow (1)	13.5	91.3	5.1	86.2	15.8	10.7	12.4	.43
Bordow (2)	11.7	92.3	5.7	86.6	13.7	8.0	9.2	.32
Fermate (0)	13.2	110.4	6.4	104.0	18.0	11.6	11.1	.46
Fermate (1)	11.8	104.3	5.7	98.5	15.8	10.0	10.2	.40
Dithane (0)	12.6	101.8	5.3	96.5	16.4	11.1	11.5	.45
Dithane (1)	13.2	92.8	5.5	87.3	15.6	10.0	11.5	.40
				Orchard IV[5]				
Bordow (0)	15.6	88.6	4.4	84.2	17.7	13.3	15.8	.63
Bordow (1)	13.7	103.7	4.7	98.9	18.1	13.3	13.5	.54
Fermate (0)	14.5	88.7	4.6	84.0	15.7	11.1	13.2	.44
Fermate (1)	13.6	109.1	4.8	104.2	18.8	14.0	13.2	.53

1. Numbers in parentheses indicate the number of cover sprays with which Dowax 222 was incorporated.
2. Expressed as sucrose.
3. Flesh refers to entire fruit less weight of dried pit in all cases.
4. 25 cherries per sample, average of three replications.
5. 25 cherries per sample, average of two replications.

TABLE IX - Summary of Solids Content of Fresh Cherries from Trees which Received Various Foliar Sprays, 1949

Spray Treatment[1]	Total Solids of Flesh Per Cherry[2] (g)	Decrease from use of: Dowax 222[3] (%)	Decrease from use of: Fermate or Dithane[4] (%)	Decrease from use of: Fermate or Dithane and Dowax 222[5] (%)	Soluble Solids[2] (%)	Decrease from use of: Dowax 222[3] (%)	Decrease from use of: Fermate or Dithane[4] (%)	Decrease from use of: Fermate or Dithane and Dowax 222[5] (%)
Orchard III								
Bordow (0)	.45	-	-	-	15.2	-	-	-
Bordow (1)	.43	4.5	-	-	13.5	11.2	-	-
Bordow (2)	.32	28.4	-	-	11.7	23.0	-	-
Fermate (0)	.46	-	-3.0	-	13.2	-	13.2	-
Fermate (1)	.40	13.1	6.3	10.5	11.8	10.6	12.6	22.4
Dithane (0)	.45	-	0.0	-	12.6	-	22.4	-
Dithane (1)	.40	10.5	6.3	10.5	13.2	-4.8	2.2	13.2
Orchard IV								
Bordow (0)	.63	-	-	-	15.6	-	-	-
Bordow (1)	.54	15.3	-	-	13.7	12.2	-	-
Fermate (1)	.44	-	30.0	-	14.5	-	7.1	-
Fermate (1)	.53	-11.9	1.9	16.9	13.6	6.2	0.7	12.8

1. Numbers in parentheses indicate the number of cover sprays with which Dowax 222 was incorporated.
2. From Table VII.
3. Decrease from same fungicide without Dowax 222.
4. Decrease of Fermate or Dithane plots from Bordow plots receiving similar Dowax 222 treatment.
5. Decrease of Fermate or Dithane plots receiving Dowax 222 from Bordow plots receiving no Dowax 222.

TABLE X - Drained Weight of Canned Cherries from Trees Which Received Various Foliar Sprays

Fungicide	No. of Dowax 222 Applications	Drained wt. Per #10 Can (ozs.)	Decrease in Drained Wt. from use of: Dowax 222[1.] (%)	Fermate[2.] (%)	Fermate and Dowax 222[3.] (%)
		Orchard I			
Bordow	0	74.7	-	-	-
Bordow	1	72.2	3.4	-	-
Bordow	2	68.6	8.2	-	-
		Orchard II			
Bordow	0	75.0[4.]	-	-	-
Bordow	1	69.3[4.]	7.6	-	-
Bordow	2	68.1[4]	9.2	-	-
Fermate	0	73.5[4]	-	2.0	-
Fermate	1	68.0	7.5	1.9	9.3
Fermate	2	66.9	9.0	1.8	10.8
		Orchard III			
Bordow	0	75.1	-	-	-
Bordow	1	72.7	3.2	-	-
Bordow	2	72.0	4.1	-	-
Fermate	0	72.8	-	3.1	-
Fermate	1	71.6	1.6	1.5	4.7
Fermate	2	71.5	1.8	0.7	4.8

1. Decrease from same fungicide without Dowax 222.
2. Decrease of Fermate plots from Bordow plots receiving similar Dowax 222 treatment.
3. Decrease of Fermate plots receiving Dowax 222 from Bordow plots receiving no Dowax 222.
4. Calculated from data obtained with number two cans by formula 1 #10 = $5\frac{1}{4}$ #2.

TABLE XI - Titratable Acid Content of Fresh Cherry Juice from Trees which Received Various Foliar Sprays, Orchard II

Fungicide	No. of Dowax 222 Treatments	Ml. of 0.1 N Acid/Gram	Decrease in Acid Content from use of		
			Dowax 222[1] (%)	Fermate[2] (%)	Fermate and Dowax 222[3] (%)
Bordow	0	2.01	-	-	-
Bordow	1	1.70	15.4	-	-
Bordow	2	1.53	23.9	-	-
Fermate	0	1.42	-	29.4	-
Fermate	1	1.33	6.3	21.8	33.8
Fermate	2	1.15	19.0	24.8	42.8

1. Decrease from same fungicide without Dowax 222.
2. Decrease of Fermate plots from Bordow plots receiving similar Dowax 222 treatment.
3. Decrease of Fermate plots receiving Dowax 222 from Bordow plots receiving no Dowax 222.

TABLE XII - Size of Cherries on Branches to which Dowax 222 was Applied to Either Leaves or Fruit, 1948[1]

Part Treated	No. of Cherries[2]	Average Size on June 25: Diameter in Cm.	Average Size on June 25: Vol. in C.C.	Growth June 25 to July 8[3]: Diam.	Growth June 25 to July 8[3]: Vol.	Percent Increase in Growth from Use of Dowax 222[4]: Diam.	Percent Increase in Growth from Use of Dowax 222[4]: Vol.
Fruit (dipped)	27	1.31	1.21	.40	1.46	33.3	55
Control	34	1.35	1.46	.30	.94		
Fruit (sprayed)	24	1.21	.93	.44	1.46	27.5	16
Control	20	1.32	1.25	.35	1.26		
Leaves (dipped)	25	1.32	1.34	.33	1.03	6.5	0
Control	28	1.29	1.17	.31	1.03		
Leaves (sprayed)	36 (7)	1.23	0.99	.41	1.35	10.8	7
Control	32	1.29	1.16	.37	1.26		
Leaves (lower surfaces sprayed)	27	1.21	.96	.41	1.29	2.5	0
Control	31	1.23	1.00	.40	1.29		
Leaves (upper surfaces sprayed)	30	1.39	1.44	.37	1.45	12.1	21
Control	37 (3)	1.41	1.51	.33	1.20		

1. All treatments were made on June 23.
2. Numbers in parenthesis represent the number of fruit that were dropped between the two measurements, if any.
3. As expressed by increase in diameter.
4. Calculated by converting individual diameter measurements to volumes by the formula $V= 1/6\ \pi\ D^3$.

TABLE XIII - Size of Cherries on Branches to Which Dowax 222 was Applied to Either Leaves or Fruit, 1949.

Branch No.	Part Treated	No. of Treatments	No. of Fruit	June 19	June 24	June 30	July 5	July 13
				(Volume in Ml.)				
1	Leaves	1	8	1.7	2.5	3.3	3.5	3.9
			12	1.6	2.5	3.1	3.3	3.9
2	Control		8	1.7	2.5	3.1	3.5	3.9
			12	1.8	2.5	3.1	3.5	3.8
3	Leaves	1	9	1.6	2.5	3.3	3.5	3.9
			12	1.6	2.6	3.3	3.5	3.9
4	Control		9	1.7	2.5	3.3	3.6	3.9
			12	1.7	2.5	3.3	3.6	3.9
5	Leaves	2	6	1.5	2.0	2.9	3.3	3.8
			11	1.4	2.0	2.8	3.2	3.8
6	Control		6	1.5	2.2	2.9	3.2	3.9
			12	1.6	2.2	2.8	3.1	3.6
7	Leaves	2	12	1.4	2.4	3.1	3.6	3.8
8	Control		12	1.4	2.3	3.1	3.4	3.7
9[1]	Fruit	1	4	1.4	2.5	3.1	3.7	4.0
			6	1.7	2.6	3.3	3.9	4.1
9[2]	Control		4	1.4	2.6	3.4	3.9	4.3
			6	1.7	2.8	3.5	4.0	4.3
10[1]	Fruit	1	6	1.5	2.2	3.0	3.4	3.7
10[2]	Control		6	1.5	2.3	3.1	3.4	3.9
11[1]	Fruit	2	4	1.7	2.6	3.4	3.7	4.4
			6	2.0	2.7	3.4	3.7	4.3
11[2]	Control		4	1.6	2.5	3.3	3.5	4.0
			6	1.9	2.7	3.3	3.6	4.1
12[1]	Fruit	2	3	1.9	2.5	3.2	*	3.8
			6	2.0	2.7	3.2	*	3.8
12[2]	Control		3	2.0	2.7	3.2	*	3.7
			6	2.0	2.8	3.2	*	3.8

1. Even numbered fruit 2. Odd numbered fruit. * Indicates data not obtained.

TABLE XIV - Uptake of Water by Fresh Cherries

No. of Dowax 222 Applications	Time Lapse Before Soaking was Started (Hrs.)	Time Soaked (Hrs.)	Wt. as Picked (g)	Wt. at Start of Soaking (g)	Wt. at End of Soaking (g)	Loss on Standing (%)	Gain on Soaking (%)	Net Loss (%)
			July 28					
0	2	28	395	-	391	-	-1.0	1.0
1	2	28	474	-	477	-	0.6	-0.6
0	12	18	421	412	408	2.1	-1.0	3.1
1	12	18	418	406	407	2.9	0.2	2.6
			August 2					
0	3	7	225	-	227	-	0.9	-0.9
1	3	7	256½	-	258	-	0.6	-0.6
0	11	12	228½	223	224	2.4	0.4	1.8
1	11	12	261	255	254	2.3	-0.4	2.5
0	23	11	228½	217	220	5.0	1.4	3.7
1	23	11	258	248	247	3.9	-0.4	4.3
			August 7					
0	5	6	203½	-	206	-	1.2	-1.2
1	5	6	242	-	242	-	0.0	0.0
0	27	7	203	191	199	5.9	4.2	2.0
1	27	7	203	209	210	3.7	0.5	3.2
0[1]	5	5	205	-	206	-	0.5	-0.5
1[1]	5	5	246	-	245	-	-0.4	0.4
0[1]	27	27	201	194	196	3.5	1.0	2.5
1[1]	27	27	231	224	226	3.0	0.9	2.6

1. Stems attached.

TABLE XV - Pressure Required to Pierce the Skin of Fresh Cherries by Dropping a Glass Rod Against the Cherries, August 7

Unsoaked Cherries Treated[1]
(Distance in Cm.)

	Imature	Mature		Overripe
	7	8	9	9½
	7½	8½	8	9
	6½	9	9	10
	8½	8½	10	9
	8	10	8½	9
		9	9½	10
		9	8½	
		9½		
Average	7½		9	9½

Mature Cherries - Distance in Cm.

	Control	Treated[1]
	Unsoaked	
	9	8½
	9	8½
	9	8
	8	7
	8	8½
	8	9½
	10	8
	9	
Average	9	8½

Soaked 6 Hrs.

	Control		Treated	
	5	4	4	4
	4	4	5	5
	3½	4½	4½	4
	5½	3½	4	7
	3½	4½	4	4
	4	4	4	
	5	4½	3½	
	5	4	3½	
	4	4½	5	
Average		4½		4½

1. One spray treatment of Dowax 222 to foliage.

TABLE XVI - Summary of Data on Pressure Required to Pierce the Skin of Fresh Cherries by Dropping a Glass Rod Against the Cherries

	Receiving One Spray Treatment of Dowax 222 (Distance in Cm.)	Control (Distance in Cm.)
August 2 - when picked	9	$10\frac{1}{2}$
August 2 - after 15 hrs. storage at 50°F	$7\frac{1}{2}$	8
August 2 - after 12 hrs. soaking at 63°F	5	$5\frac{1}{2}$
August 7 - when picked	$8\frac{1}{2}$	9
August 7 - after 6 hrs. soaking at 63°F	$4\frac{1}{2}$	$4\frac{1}{2}$
August 7 - when picked, immature	$7\frac{1}{2}$	-
August 7 - when picked, mature	9	-
August 7 - when picked, overripe	$9\frac{1}{2}$	-

TABLE XVII - Pressure Required to Break the Skin and to Pit Fresh Cherries Using a Hand Type Cherry Pitter

Force (grams)	No. Cherries the Skin of Which Was Broken	No. Cherries the Skin of Which Was not Broken	Force (grams)	No. Cherries Which Were Pitted	No. Cherries Which Were not Pitted
		Untreated - July 13			
70	0	3	2100	Most	Few
80	7	2			
90	5	1			
		Treated[1.] - July 13			
40	6	0	2000	Most	Few
30	3	5			
20	0	5			
		Untreated - July 15			
40	3	7	1000	0	4
50	4	4	1100	5	3
60	3	4	1200	3	0
70	3	0			
		Treated[1.] - July 15			
40	0	5	1000	0	3
50	5	3	1100	3	2
60	3	0	1200	4	0

1. One spray treatment of Dowax 222 to foliage.

TABLE XVIII – Amount of Carbon Dioxide Given off by Cherry Leaves Receiving Various Foliar Sprays

Date		Mean Temp. (°F)	% of Possible Sunshine	Starting Time (pm)	CO_2 Content of Air (mg. per liter)	CO_2 Evolved, mg. per dm^2 per Hour				
						Check	Fermate	Fermate & Dowax	Bordow	Bordow & Dowax
					First Replication					
June	22	70	97	6:44	.542	2.64	2.47	3.02	1.87	3.97
"	23	72	96	6:31	.549	2.67	2.93	3.46	2.84	3.95
"	24	79	80	6:30	.544	3.24	2.75	3.59	2.16	2.91
					Treated June 25, 5 PM					
"	25	75	17	7:07	.562	2.63	1.94	3.03	1.74	2.52
"	26	78	76	6:33	.552	*	1.84	2.59	1.77	1.90
"	29	77	52	6:45	.571	2.44	1.56	2.83	1.67	1.81
"	30	79	98	6:45	.598	2.83	1.22	2.85	1.97	2.28
July	1	82	97	6:2[illegible]	.582	3.12	0.87	2.95	1.64	1.03
Daily growth, dm^2						0.10	0.17	0.08	0.24	0.19
					Second Replication					
July	10	68	97	6:58	.410	0.67	1.01	1.42	1.10	1.20
"	11	66	92	7:54	.384	0.85	0.66	1.20	0.94	0.96
"	13	72	91	7:43	.412	1.10	1.00	0.93	1.26	0.71
					Treated July 13-14, Midnight					
"	14	63	22	7:58	.574	1.47	0.97	1.49	1.61	1.38
"	15	64	86	7:47	.615	1.43	0.86	1.21	1.43	0.65
"	16	71	93	7:40	.593	1.60	1.37	1.28	0.91	0.46
"	22	71	87	7:37	.503	1.01	0.43	0.07	1.14	0.07
Daily growth, dm^2						0.05	0.16	0.08	0.17	0.19

TABLE XVIII - Amount of Carbon Dioxide Given off by Cherry Leaves Receiving Various Foliar Sprays (Cont'd).

Date	Mean Temp. (°F)	% of Possible Sunshine	Starting Time (pm)	CO_2 Content of Air (mg. per liter)	CO_2 Evolved, mg. per dm^2 per Hour				
					Check	Fermate	Fermate & Dowax	Bordow	Bordow & Dowa
				Third Replication					
July 17	74	85	7:38	.586	1.43	0.98	1.72	1.21	1.47
" 18	76	87	7:35	.462	1.45	1.11	2.22	1.94	0.75
				Treated July 20, 10 AM					
July 20	71	79	7:40	.430	0.88	1.35	0.94	0.97	0.54
" 22	71	87	7:46	.472	0.75	*	0.31	1.00	0.05
" 24	76	83	7:48	.398	0.36	0.63	0.49	0.87	0.13
Daily growth, dm^2					0.06	0.05	0.10	0.03	0.03

* Indicates data not obtained.

TABLE XIX - Amount of Oxygen Taken up by Leaf Punches from Cherry Leaves Receiving Various Foliar Sprays, August, 1949[1].

Manometer Number	Date								
	22 (PM)	23 (AM)	23 (PM)	24 (AM)	24 (PM)	25 (AM)	25 (PM)	26 (AM)	26 (PM)
	Cubic Millimeters per Gram Dry Weight per Hour								
1	204.3	227.0	263.0	193.1	179.7	198.4	166.6	208.1	150.6
2	148.4	*	265.6[2]	124.4[2]	175.3[3]	207.2[3]	157.6[2]	163.8[2]	137.9[3]
3	*	*	*	175.5[4]	187.9[5]	188.6[5]	148.8[4]	146.1[4]	126.8[5]
5	94.2	108.2	174.1	143.9	131.7	110.9	106.3	110.2	72.7
6	179.4	190.9	202.6[4]	238.0[4]	110.6[5]	161.9[5]	139.6[4]	131.6[4]	136.7[5]
	Percentage, Controls Expressed as 100								
1	100	100	100	100	100	100	100	100	100
2	73	*	101[2]	64[2]	98[3]	104[3]	95[2]	79[2]	125[3]
5	100	100	100	100	100	100	100	100	100
3	*	*	*	122[4]	143[5]	170[5]	140[4]	174[4]	133[5]
6	185	176	116[4]	165[4]	84[5]	146[5]	131[4]	188[4]	119[5]
	Percentage, Controls Expressed as 100, Manometer Constant Corrected								
1	100	100	100	100	100	100	100	100	100
2	100	*	138[2]	88[2]	134[3]	142[3]	130[2]	108[2]	171[3]
5	100	100	100	100	100	100	100	100	100
6	102	98	64[4]	91[4]	47[5]	81[5]	73[4]	104[4]	66[5]

1. Spray treatments are indicated by footnotes. Where there is no footnote, no treatment was made.
2. Fermate alone.
3. Fermate and Dowax 222.
4. Bordow alone.
5. Bordow and Dowax 222.

* Indicates data not obtained.

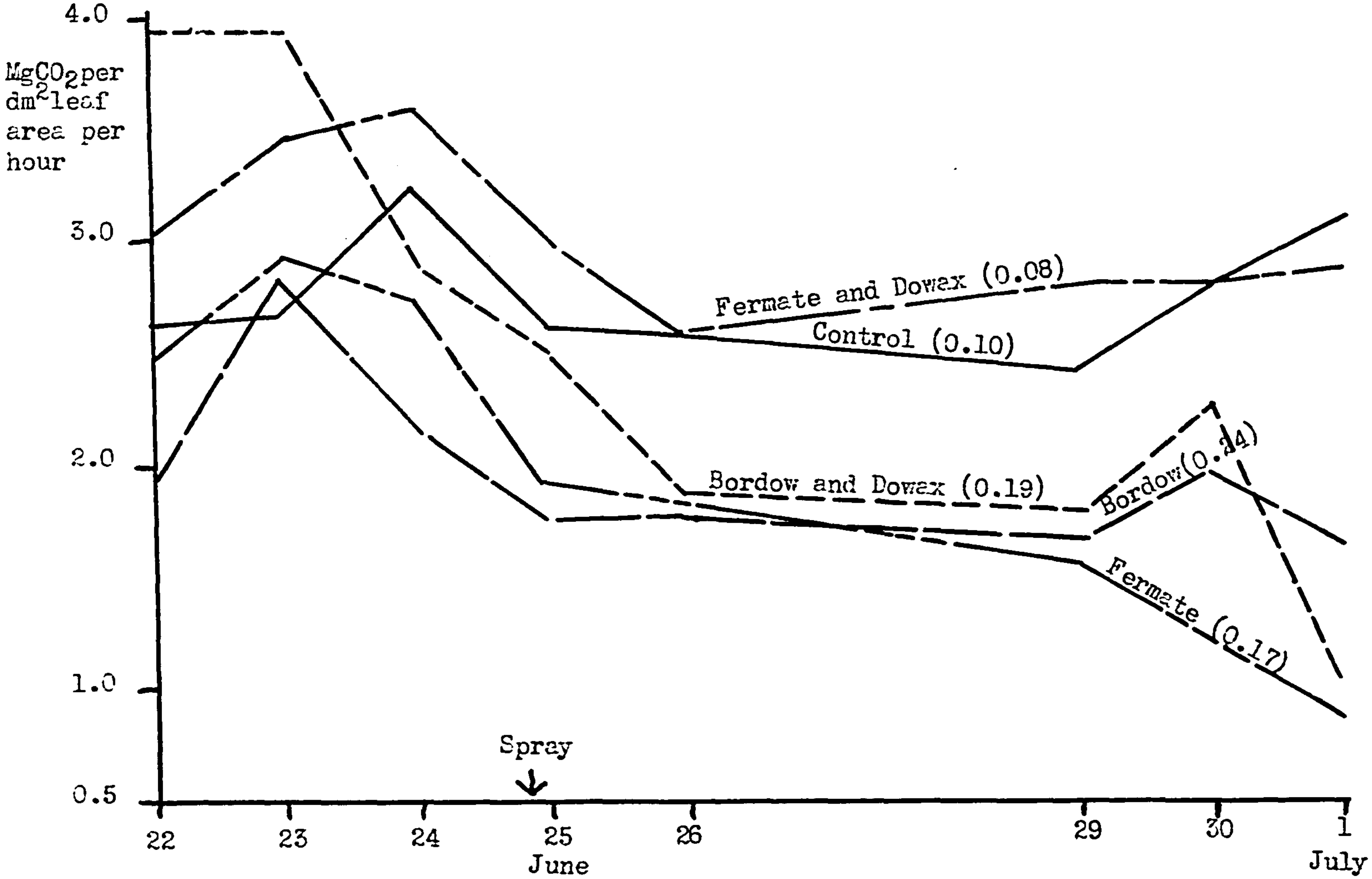

Figure 3. Amount of carbon dioxide given off by cherry leaves, receiving various foliar sprays, first replication.

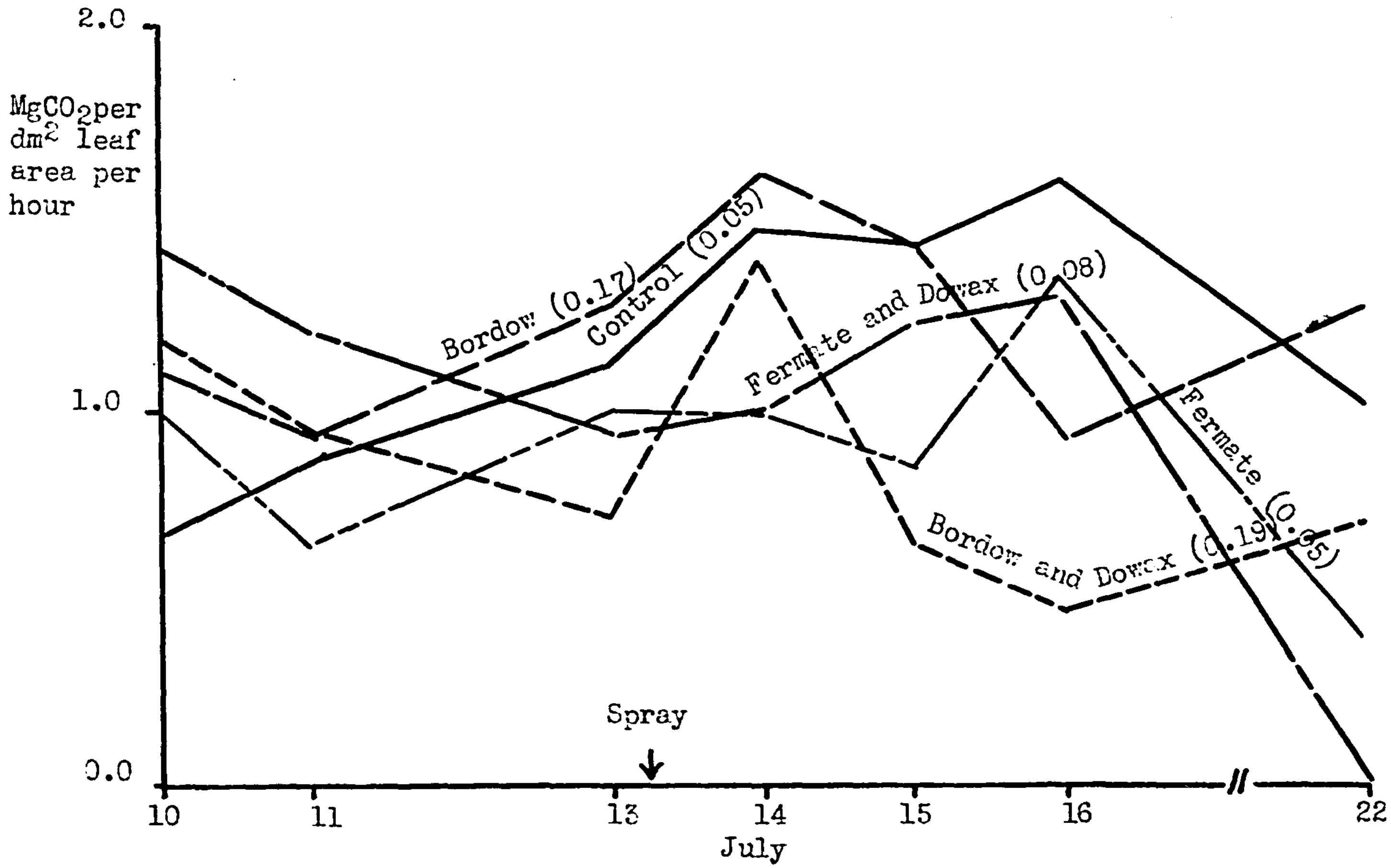

Figure 4. Amount of carbon dioxide given off by cherry leaves, receiving various foliar sprays, second replication.

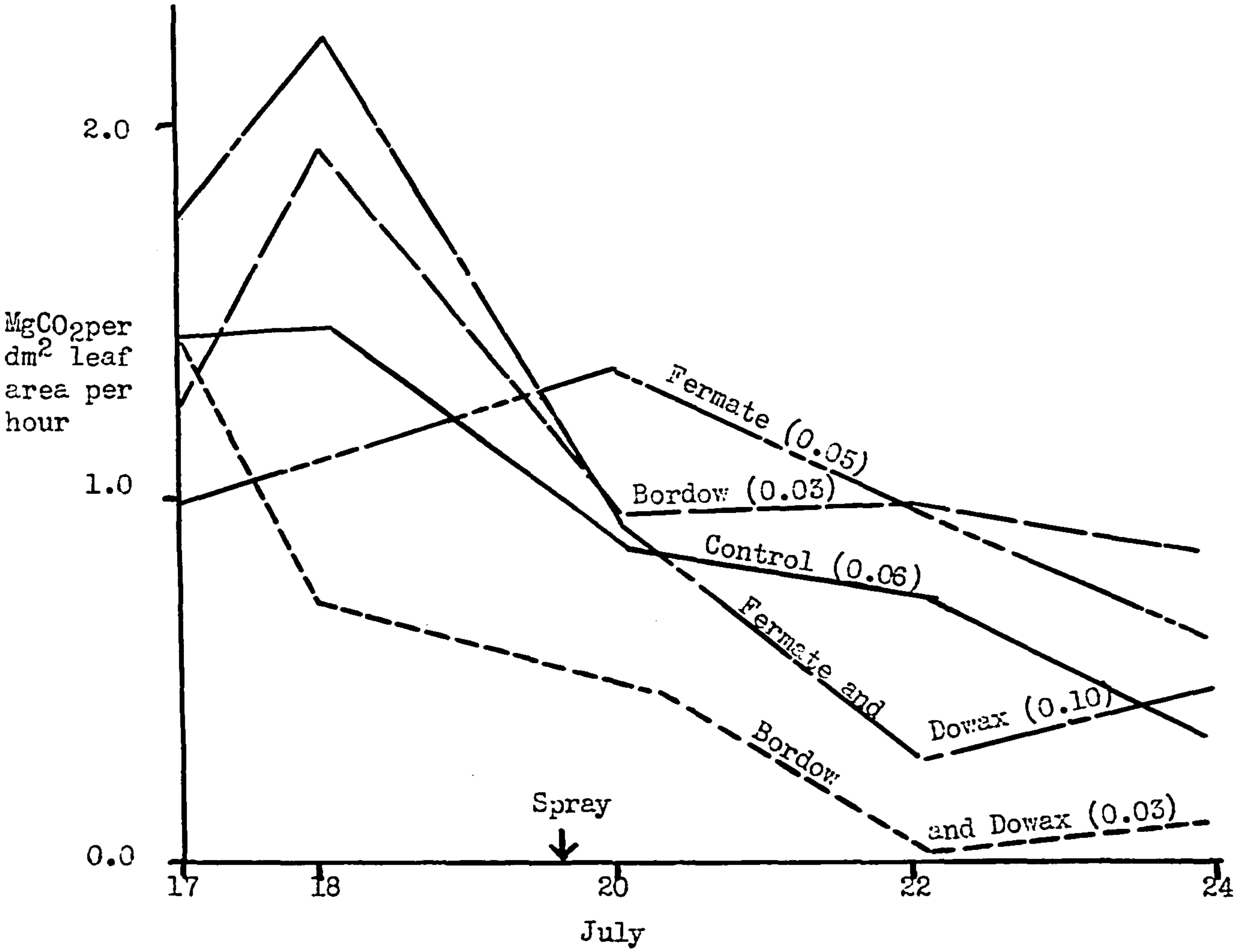

Figure 5. Amount of carbon dioxide given off by cherry leaves, receiving various foliar sprays, third replication.

RESULTS AND DISCUSSION

Inspection of Tables I through V indicates clearly that Dowax 222 caused an increase in the size of cherry fruit over tree receiving no Dowax. This is true for both weight and volume. The averages of increases are as follows: Dowax (one application), 9.1%; Dowax (two applications), 11.4%; Fermate as compared with Bordow with similar Dowax treatment, 6.6%; combination of one Dowax treatment and Fermate as compared with Bordow without Dowax, 16.6%; and combination of two Dowax treatments and Fermate as compared with Bordow without Dowax, 18.4%. Since the magnitude of increase was so variable, the averages of increases given above may not be closely reproducible.

Accepting the fact that both Dowax 222 and Fermate caused an increase in the size of fruit, one naturally wonders what the nature of the increase was. Any change in the relationship of water to solids would be expected to change the density of the cherries, unless the solids had the same density as water.

Table VI shows that the density of cherries analyzed was greater than one gram per milliliter, the approximate density of water. Thus an increase in solids in proportion to water should increase the density.

Other observations that should be made from Table VI are that the four highest densities were from plots which received Bordow as the fungicide and the four lowest were from plots receiving Fermate; that density increased as cherries approached maturity; that density usually decreased when Dowax 222 was included with

RESULTS AND DISCUSSION

Inspection of Tables I through V indicates clearly that Dowax 222 caused an increase in the size of cherry fruit over tree receiving no Dowax. This is true for both weight and volume. The averages of increases are as follows: Dowax (one application), 9.1%; Dowax (two applications), 11.4%; Fermate as compared with Bordow with similar Dowax treatment, 6.6%; combination of one Dowax treatment and Fermate as compared with Bordow without Dowax, 16.6%; and combination of two Dowax treatments and Fermate as compared with Bordow without Dowax, 18.4%. Since the magnitude of increase was so variable, the averages of increases given above may not be closely reproducible.

Accepting the fact that both Dowax 222 and Fermate caused an increase in the size of fruit, one naturally wonders what the nature of the increase was. Any change in the relationship of water to solids would be expected to change the density of the cherries, unless the solids had the same density as water.

Table VI shows that the density of cherries analyzed was greater than one gram per milliliter, the approximate density of water. Thus an increase in solids in proportion to water should increase the density.

Other observations that should be made from Table VI are that the four highest densities were from plots which received Bordow as the fungicide and the four lowest were from plots receiving Fermate; that density increased as cherries approached maturity; that density usually decreased when Dowax 222 was included with the fungicide; that there was little correlation between size of fruit and density; and that density readings were quite consistant within Orchard I and within Orchard III, but were variable within Orchard II and from one orchard to another.

Since Dowax 222 and Fermate decreased the density they must have decreased the proportion of solids to water. Orchard I was expected to have a high solids content because of light nitrogen fertilizer application, light set of fruit, and large size of trees. The poor correlation between size and density from one orchard to another emphasizes the importance of temperature, light, tree vigor, moisture, soil structure, and inherent fertility of the soil in regulating plant growth, and cautions us not to relegate all differences to variations in fertilizer programs and spray schedules.

Further evidence that Fermate and Dowax 222 resulted in a decrease in solids content is given in Table VII. The correlation with density is as close as may reasonably be expected in view of the fact that several persons, times and sets of equipment were involved in collecting data which contributed to the compilation of this table. Here is the first clue as to whether the decreased solids content in proportion to water was due to the retention of more water, a lesser increase in solids than in water, or an actual reduction in the amount of solids produced. As pointed out by Langer and Fisher (23) in analyzing this same data, there is an indication that use of Dowax 222 caused an actual reduction in the absolute amount of solids produced as compared to cherries from trees receiving no Dowax 222. The data are not adequate to warrant a conclusion as to the effect of Fermate on amount of solids per cherry.

Table VIII gives further evidence that Dowax 222 reduced solids content both on percentage and absolute amount bases. The use of Fermate as the fungicide also reduced soluble solids content on the basis of percentage in comparison with Bordow. The data indicate, however, that there was no appreciable change in the amount of solids per cherry brought about by use of any one of the fungicides with respect to the others, independent of Dowax treatment. It appears, however, that there was a reduction in amount of solids attributable to Fermate and Dithane when used in conjunction with Dowax 222. Total solids of both the Fermate and Dithane plots of Orchard III which received one application of Dowax 222 were 6.3 percent lower than the solids of the Bordow plot receiving Dowax 222 once. Fermate and Dithane have either had a stimulating effect on the Dowax 222 which Bordow did not have or had to a lesser degree, or have themselves been stimulated to react in the presence of Dowax 222 as they did not react in its absence.

An effect which is believed to be directly attributable to this distorted relationship between water and solids content of cherries is present in Table X. Here it is noted that the drained weight of canned cherries was reduced both by inclusion of Dowax 222 with the fungicide, and by the use of Fermate as the fungicide in comparison with Bordow. While three of these values were calculated from values obtained by draining number two cans, the put-in weight of which was not accurately checked, the trend is undeniable. This phenomenon is regarded as having a very simple explanation in that the higher the water content of the cherries the greater was the tendency for this water to be liberated from the cherries and drained from the cans during the checking of drained weights.

In cherries receiving Fermate as the fungicide or Dowax 222 in conjunction with either fungicide an insipid taste was detectable. It was desired to ascertain whether this effect was due entirely to dilution or reduction of the sugar, realizing that such a large reduction in total soluble solids could result only from an effect on the sugars. Table XI shows that titratable acid content was affected in much the same way as total soluble solids. In fact the percentage reduction is greater than was obtained for total soluble solids. If taken literally this table indicates a change in tree physiology aside from effects on transpiration and other water relationships.

Data in Table XII indicate that Dowax 222 caused an increase of about 30 percent in the rate of growth of fruit in diameter when the fruit was treated. The leaf treatments show a much smaller increase in diameter-growth. This presents a distorted picture, however, since there is an increasingly large effect on volume as the diameter is increased. If treated fruit were larger than the corresponding controls at the time of the first measurement and each averaged the same amount of increase in diameter, a stimulating effect by treatment would be indicated. By converting the data to the basis of volumes by assuming that the fruit were perfect spheres the greater stimulating effect of Dowax 222 when applied to fruit than when applied to foliage appears to be less certain.

In interpreting these data it is necessary to consider the relation between size of fruit at the time of treatment and amount of growth made. Two leaf treatments showed no effect from treatment; in one of these cases the average volume of controls was smaller than that of treated fruit, and in the other case the controls were 0.04 c.c. larger. The other two leaf treatments showed 7 and 21 percent increase in volume growth from use of Dowax 222, and controls were 0.17 and 0.07 c.c. larger than corresponding treated fruit, respectively. The two fruit treatments gave 55 and 16 percent increase in volume growth from the use of Dowax 222, and controls were 0.25 and 0.30 c.c. larger than corresponding treated fruit, respectively, when first measured.

Small cherries would normally be expected to make more growth during a short period of time than larger ones, other conditions being equal. Individual cherries were not tagged and numbered, so it is impossible to compare the performance of cherries of more nearly equal size at the time of the first measurement.

If the results reported here are taken literally one must conclude that treatment of fruit had more effect than treatment of leaves, that dipping fruit had more effect than spraying them, that treatment of the upper surfaces of leaves had more effect than treatment of the lower surface or both surfaces, and that spraying leaves had more effect than dipping them. The effect on fruit may be explained by a reduction in permeability of the epidermis and cuticle to water by the coating of Dowax 222. Since fruit was thoroughly covered by spraying it seems unlikely that this procedure would have resulted in the formation of a less efficent film than dipping, which is the only logical explanation for the greater effect from dipping than from spraying. Treatment of upper surfaces could have had more effect than treatment of lower surfaces by increasing the absorption of light in comparison to no treatment, but if this were true the effect of treating both surfaces should have had as much effect as treating the upper surfaces only, unless treatment of the lower surface decreased the rate of growth. This could possibly have been brought about by interference with absorption of carbon dioxide through the stomates, since the stomates of cherry leaves are all found in the lower surfaces of the leaves. These explanations are fairly well borne out by the data. In actual percentage increase, treatment of the lower surfaces of leaves showed no effect, but since controls were slightly larger than treated fruit at the time of the first measurement they would have been expected to make less growth than treated fruit. They actually made just as much. While treatment of leaves by spraying seems to have had more effect than treatment by dipping on the basis of amount of growth made, consideration of the difference in initial size of fruit materially lessens the reliability of this observation. At the time of the first measurement, fruit on the branch, the leaves of which were dipped, were larger than the fruit on the control branch. The controls, then, would have been expected to grow more; but they did not, possibly due to Dowax 222 treatment to the other branch. The situation was reversed with the other pair of branches. The cherries on the treated branch would have been expected to grow more under similar treatment, and they did, by seven percent. So it seems unfair to attribute all the difference to Dowax treatment.

Inasmuch as these data are meager and also are subject to several criticisms, it is not possible to draw positive conclusions. Even if borne out by further work the explanations given above must remain theoretical until suitable techniques are developed and information obtained on the effect of spray films on premability of fruit and leaf surfaces to water vapor, carbon dioxide, and oxygen, on the absorption of light rays, and on temperature.

Further investigations were carried out in 1949 in an effort to establish the mode of action of Dowax 222. A part of this work consisted of treating leaves and fruit in a manner somewhat similar to the work conducted the year before. Many refinements were made in the technique, however, one of the most important being the measurement of fruit size in terms of volume instead of diameter. The results are reported in Table XIII, and clearly do not substantiate the previous observations. In measurements of fruit of comparable size at the beginning of the experiment the average amount of growth between June 19 and July 5 for both treated and untreated fruit did not differ by more than 0.1 ml. except in two cases; that is, leaf treatment group number 7 outgrew control group number 8 by an average of 0.2 ml., and control group number 9 outgrew fruit treatment group number 9 by an average of 0.2 ml.

Since each volume measurement was no more accurate than to the nearest 0.1 ml. these data surely indicate that Dowax 222 had no effect on size in these experiments.

The difference in results reported in Tables XII and XIII is subject to several possible explanations. As noted before, the method of measurement was different. In 1948 diameters were measured with a calipers, whereas in 1949 volumes were measured by water displacement in a graduated cylinder. It is difficult to say how nearly either method was to being accurate. Any one diameter was read to about the nearest 0.02 cm., but individual cherries varied. Soft cherries permitted the closing of the calipers more than firm ones. It was difficult to adjust the calipers to the fruit uniformly because of the difference in firmness, and yet it was more accurate to do the adjusting by touch than by sight; the same position was undoubtedly not measured for every cherry every time because of changes in shape; diameter was not a perfect measure of size in that growth was not always uniform in all directions; and the contact of the calipers with the fruit may have affected their growth. However, it may be assumed that all these effects were about equal between treatments. Thus it would seem that all diameter measurements in Table XII are accurate to about the nearest 0.02 cm., since repeated readings on the same cherry almost invariably fell within 0.01 cm. of each other.

In measuring water displacement it was difficult to get the cylinder exactly perpendicular to the ground; it was difficult to obtain uniform background to read the menisci; the menisci were sometimes distorted by the presence of foreign bodies such as dust particles; it was very difficult to keep the cylinder clean; and the volume of stem immersed in the water could not be kept perfectly uniform. The sensitivity of the method also had its limitations. The cylinder could not be read more accurately than to the nearest 0.1 ml. It was necessary to read the cylinder twice for each cherry each time its size was determined. The immersion of the cherries in water could also have had an effect on them. But any differences from these factors should have been relative, or at least the difference between treated and untreated could not have been large. It would appear that any value in Table XIII is accurate to about the nearest 0.1 ml.

There was another difference in the procedure of experiment for these two years. In 1948 much larger branches were treated than in 1949. In the extreme case there were probably three times as many leaves on some branches in 1948 as there were on the branches used in 1949.

It is also possible that different stages of growth could have accounted for different results in the two years. Treatments were made on June 19 and June 23. These are quite close in the calendar year, and by observation the fruit were in about the same stage of growth, being slightly more advanced in 1949. The difference in stage of growth is of more significance than casual consideration may indicate in light of the findings of Tukey (43). He found that there is very little increase in volume until the pits are hardened, and then the period of final swell displays practically a linear relationship between increase in volume and time. It is not likely that any cherry involved in either year concerned here had failed to reach the final swell stage at the time treatments were made.

The matter of cherries taking up water in the soaking or cooling tanks is controversial. One of the arguments advanced against the use of Dowax 222 on red cherries was the decrease it caused in the absorption of water in the soaking tanks, with resulting difficulty in pitting, particularly from the standpoint of the failure of the flesh to be completely removed from the pits. This was supposed to have resulted in more rupturing of cherries in the pitters.

Several tests were made in 1948 to determine the effect of Dowax 222 on the uptake of water during soaking. These results, shown in Table XIV, show that there was seldom a net increase in weight of cherries after soaking at 57 to 63°F, regardless of Dowax treatment. This was especially true when cherries were allowed to sit at room temperature (80 to 90°F) for several hours before soaking was started, as is almost invariably the case in commercial practice.

Dowax 222 decreased the rate at which water was lost on standing. However it also reduced the rate at which this lost weight was recovered. When little or no weight was lost treated cherries in general weighed very slightly less than untreated cherries after soaking. Leaving the stems attached materially reduced the rate of water loss on standing by untreated cherries; it had the same effect on treated cherries but to a lesser degree. It also impaired the recovery during soaking by untreated cherries, but had little effect on treated ones. The net effect of Dowax was a slightly greater net loss or a slightly smaller net gain.

Feeling that the difference in uptake of water by cherries from trees which had received Dowax was so little different from those from untreated trees, it was considered desirable to make further studies of the reaction of cherries to the pitting process. From observations in commercial processing plants no difference could be detected in the cleanness with which the flesh was removed from the pits from different treatments. There was a large difference in this measure of pitting efficiency as the mats through which the pits were plunged by hand pitters became worn, irrespective of spray treatment.

In order to determine whether Dowax 222 had any effect on the firmness of flesh and on toughness and elasticity of skins the distance through which a small, blunt pointed glass rod had to be dropped in order to pierce the skins was measured, and reported in Table XVI. It was noted that as fruit matured the amount of pressure required increased. This was attributed to a softening of the cells of the flesh, so that there was more "give" before the skin was broken. When picked at the same time cherries from Dowax-treated trees required slightly less pressure to break the skins than cherries from control trees. This was another indication that Dowax 222 delayed maturity of fruit. Also noted in Table XVI is the fact that the amount of pressure required to break the skins was very greatly reduced by soaking at 57 to 63°F. This is another indication that it is not uptake of water that makes cherries pit easier, since this would surely have caused cherries to be more turgid and would have resulted in less "give" when the rod was dropped.

With this much evidence against easier pitting because of uptake of water, it would seem that the change must have been due to a change in temperature. However dry storage for 15 hours at 50°F reduced the force required to break the skins only about one third as much as soaking for 12 hours at 57 to 63°F. No difference was detected between the effect of soaking or cold storage on Dowax-treated and untreated fruit. It must be assumed, then, that soaking had an effect aside from the lowering of temperature, and probably aside from the effect on water content of the cherries. This was probably in the form of reducing the toughness of the skins.

Further evidence that Dowax 222 treatment reduced the amount of force required to break the skins of cherries is presented in Table XVII. A difference in the amount of force required to force the pits out of the cherries is not clearly indicated, however. The difference between treated and untreated could again be attributed to lack of maturity, to an effect on the toughness of skins, or to an effect on the flesh.

Respiration studies were conducted for the purpose of ascertaining whether or not this process could account for the effects which the various foliar sprays had been found to have on the composition of fruit. The data obtained by the Heinicke-Hoffman method are quite inconclusive, for reasons discussed under "Presentation of Data". No treatment drastically changed the rate of respiration from that of the control for all replications, as shown by Table XVIII and Figures 3 to 5, pages 65 to 67. In the first replication all treatments reduced the rate of respiration as compared to the control. The reduction from Fermate and Dowax 222 combined was very slight, and that by Bordow and Dowax combined was by far the greatest. In the second and third replications the rates of respiration for all leaf groups was so slow that no distinct differences were indicated. There was a slight reduction by all treatments in the second replication, that by Fermate and Dowax combined being the greatest. In the third replication respiration rate was increased by both fungicides when used alone; and decreased by both in combination with Dowax.

In Table XIX it will be noted that the amount of oxygen taken up by leaf punches that had been treated with Fermate (manometer number two) were greater than that taken up by the corresponding control (manometer number one). This was true both when Dowax 222 was included with the Fermate and when it was not. The opposite was true of Bordow, as seen by comparing the results obtained with manometer number five (the control) and number six (treated).

The increase in respiration by use of Fermate, as measured by the uptake of oxygen, is indicated by the fact that 138, 88, 134 142, 130, 108, and 171 percent as much oxygen was taken up during seven runs by treated disks as was taken up by untreated disks. These figures average 130 percent, so that the average increase obtained was 30 percent. Of these values three of the highest, 134, 142, and 171, were obtained when Dowax 222 was included with the Fermate. This is an average of 149 percent, compared to 116 percent when Dowax was not included. This indicates that Dowax 222 increased respiration as well as did Fermate, or that it had a stimulating effect on the Fermate.

The decrease in respiration by use of Bordow is indicated by the fact that only 64, 91, 47, 81, 73, 104, and 66 percent as much oxygen was taken up during seven runs by treated disks as was taken up by untreated disks. These figures average 75 percent, showing a decrease of 25 percent in the rate of respiration. Of these values 47, 81, and 66 were obtained when Dowax 222 was included with the Bordow. The average is 68 percent, compared with 83 percent when Dowax was excluded. Thus Dowax 222 either decreased respiration or stimulated the Bordow to have more effect than when used alone.

Since both fungicides had the same effect alone as when combined with Dowax 222 but the amount of effect was greater when it was included, it appears that Dowax 222 increased the effectiveness of the fungicide in modifying respiration rather than having a direct effect. However results obtained with manometer number three do not substantiate this finding. This manometer was not operated during the standardization runs, hence no statement can be made from results obtained with it concerning the effect of Bordow as compared to no treatment. Values obtained, with no correction for callibration error, were 122, 140, and 174 for Bordow alone and 143, 170, and 133 for Bordow combined with Dowax 222. Here inclusion of Dowax increased the uptake of oxygen from 145 percent of that of the control to 149 percent. Bearing this in mind, as well as the large variation from day to day, it seems doubtful if the above statement concerning the effect of Dowax 222 on respiration should be accepted at this time.

The stimulating effect of Fermate and the retarding effect of Bordow on respiration under the conditions of this experiment are quite acceptable, according to the limited amount of data presented. Comparisons of solids content in this thesis are made only between various treatments, and not between treated and untreated. If such a comparison were made the increase in respiration by Fermate would be expected to cause the actual amount of solids produced per cherry to be lower than for untreated cherries. Conversely, the decrease in respiration by Bordow would be expected to increase the actual amount of solids per cherry as compared to untreated fruit. Groves _et al_ (15) found this to be the case. They found that in 1941, 100 cherries from unsprayed trees contained an average of 59.4 grams soluble solids; the same number of fruit from trees receiving Bordow contained 61.1 grams; and those from trees receiving Fermate contained 56.4 grams.

In tables VII to IX of this thesis a decrease in actual amount of solids per cherry from the use of Fermate seems somewhat doubtful. This is not in keeping with the findings of Grove _et al_ or the prediction made above on the basis of its effect on respiration.

The discrepancy between these results and those reported by Grove _et al_ have a possible explanation in the effect of Fermate on other physiological processes. Fermate is reported to have a stimulating effect on growth of leaves. It was a common observation during these experiments that foliage was more dense, greener, and apparently more healthy when Fermate was used than when any of the other fungicides were used. Fermate was used in all these experiments at the rate of two pounds per hundred gallons of material, whereas Grove _et al_ used only half this strength. Thus the stimulatory effect obtained by them would not have been as great.

The discrepancy between the predicted decrease in amount of solids by use of Fermate and the failure of Fermate to actually reduce the amount of solids, as reported in Tables VII to IX, has a possible explanation also in other physiological effects. Respiration does not alone determine solids content. Its opposing process, photosynthesis, is responsible along with elaboration of food material for the building up of solids in the plant. The solids content of fruit is also effected by the translocation of food material into the fruit. The effects of Fermate as found are thus easily reconcilable to the facts.

Dowax 222 has been shown to decrease the actual amount of solids per cherry when combined with either fungicide. An increase in respiration was indicated for Dowax when combined with Fermate but was doubtful when combined with Bordow. Since Bar (5) reported a decrease in photosynthesis in maize from application of Dowax and Neal et al (30) obtained similar results with potted cherry trees, this seems to be a logical explanation for the decreased solids content of cherries resulting from its use.

It appears from results of research reported in this thesis that increases in size of red cherry fruit may be expected from the use of Fermate for the control of Cherry Leaf Spot, compared to the size which may be expected if the fungicide used is Bordow. Entirely satisfactory control of the disease was obtained by the use of either fungicide during the seasons of 1948 and 1949. It also appears certain that larger fruit can be expected by inclusion of Dowax 222 with the fungicidal mixture.

The increases in size obtained by use of these materials appear to be attributable entirely to an increase in the water content of the fruit. The actual solids content of each cherry has not been found to increase; in fact an actual reduction may result. This means that more tonnage of cherries may be picked from orchards, but less calorie value may go into each container of processed cherries unless, the put-in weight is increased.

Growers are subject to decreased profits from two sources in spraying. These are the cost of spraying, which is essential for disease control; and reduced yields, resulting from the dwarfing effect of the fungicides which have been most commonly used in the past. His moral right to alleviate the latter condition by the use of fungicides which will not dwarf fruit, or by the application of a material such as Dowax 222 for the specific purpose of off-setting the dwarfing effect of fungicides, carries little weight in a free-enterprise system.

But in a larger sense practices used by cherry growers should be decided neither on a moral basis nor by shortsighted application of economic principles. There are few if any instances of better relationships between producers and processors in Michigan than is exemplified by the cherry industry; there is undoubtedly no instance in which the congeniality of this relationship is more essential. The decisions can be made best by the team, and in this way the maximum volume of red cherries may be profitably grown, processed, and sold. If the expected increase in production becomes a reality, as it surely will, more attention will undoubtedly have to be paid to maintaining and increasing quality. Foliar sprays is presented as one factor affecting quality.

Application of Dowax 222 might seem to be a means of preventing or decreasing the incidence of cracking of Stayman apples, which occurred in alarming proportions in the Shenandoah-Cumberland region of the United States in 1948 and 1949. However, the author is of the opinion that such an attempt will not be successful. Horticultural fruits were endowed by nature with scanty pericarps, to serve only in the dissemination of seeds. Man has, through plant breeding adapted them to better serve his needs. Furthermore, he has forced these fruits to the possible limit of their capacity, through improved cultural practices. It seems possible that Stayman apples have been induced to crowd water, sugars, acids, pectins, and so on, into their cells in such large amounts during favorable seasons for growth that the cell walls have broken under the strain. A material such as Dowax 222 would be expected to reduce the readiness with which water could diffuse out of the cells through the epidermis, thereby aggravating the situation more than it would be alleviated by possible increase pliability of the epidermis, or by possible reinforcement of the epidermis and cuticle as a shell counteracting the pressure of the expanding cells of the pericarp.

SUMMARY

Studies were made during 1948 and 1949 of the effect of foliar sprays on the fruit and leaves of red cherry (Prunus cerasus L. variety Montmorency). The spray materials used in most of the work were the two fungicides, Fermate and Bordow, and a transpiration-reducing emulsion, Dowax 222. The effect of these two fungicides was determined when applied alone and in combination with Dowax 222 in most of the experiments.

Effects were studies on size, total solids content, soluble solids content, titratable acid content, drained weight, uptake of water on soaking, and ease of pitting of fruit, and on respiration of leaves. Size was determined in block experiments in commercial orchards by weighing fruit and measuring water displacement, and in experiments on small branches of mature trees by measuring fruit diameter with a calipers and volume by water displacement. Total solids were determined by drying whole fruits to constant weight in the oven, and soluble solids by determining the refractive indices of expressed juice. Titratable acid content was measured by titrating samples of expressed juice with standardized hydrochloric acid. Drained weight of canned fruit was measured by the standard test, using No. 10 cans. The uptake of water on soaking was determined by weighing samples before and after soaking, the soaking being done in glass jars in the laboratory by allowing tap water to run constantly over the fruit. Ease and efficiency of pitting was determined by observation in commercial processing plants and by the use of pressure tests. The rate of respiration of leaves was determined on potted

cherry trees by measuring the amount of carbon dioxide given off by the leaves, using a modification of the Heinicke-Hoffman apparatus, and by measuring the amount of oxygen taken up by leaf punches, using a Warburg apparatus.

The fruit from trees which had been sprayed with Bordow were smaller in size than thos treated with Fermate, and were higher in total solids, soluble solids, titratable acid, and drained weight of fruit. In these respects inclusion of Dowax 222 had much the same effect as the use of Fermate in comparison to Bordow. Dowax 222 decreased the actual amount of solids produced per cherry. It also slightly reduced the uptake of water on soaking, and reduced the amount of pressure required to pierce the skins, evidently because of a delay in maturity. A possible explanation of the effect of these materials on solids content was found in their effects on the rate of respiration of leaves, Fermate causing an increase and Bordow a decrease. Dowax 222 did not have a consistent effect on respiration.

ACKNOWLEDGEMENTS

The author wishes to express his deep appreciation to H. B. Tukey and C. L. Hamner for guidance in conducting the research reported herein, and in the preparation of this thesis, and to the other members of the staff of the Department of Horticulture of Michigan State College for suggestions and criticisms; to C. A. Langer of the same department and J. H. Davidson of the Dow Chemical Company for assistance in conducting the field experiments; to G. C. DaCosta, graduate student in the Department of Botany, for technical assistance in conducting the Wahrburg experiments; to the Dow Chemical Company and the Horace G. Rackham Foundation for financial assistance; to Jake Baas, Thomas Wade, William J. McLacklin and Neil Morrison, cooperating growers, and Cherry Growers, Inc. and Michigan Fruit Canners, Inc., cooperating processors, for use of their facilities; and to A. H. Eichmeier of the U. S. Weather Bureau for climatological data contained in Table XVIII.

LITERATURE CITED

1. Agnew, E.L., and Childers, N. F. The effect of two mild sulphur sprays on the photosynthetic activity of apple leaves. Proc. Amer. Soc. Hort. Sci. 37:379-383. 1939.

2. Allen, F. W., and Davey, A. E. Hormone sprays and their effect upon the keeping quality of Bartlett pears. Cal. Agr. Exp. Sta. Bul. 692. 1945.

3. Albinger, H. W., Bisson, C. S., Roessler, E. B., and MacGillivary, J. H. Measurement of solids in melon juice. Proc. Amer. Soc. Hort. Sci. 38:563-566. 1940.

4. Association of Official Agricultural Chemists. Official and tentative methods of analysis. Assoc. Off. Agr. Chemists, Washington, D. C. (Ref. Table 44.7, p.825). 1945.

5. Barr, C. G. Photosynthesis in maize as influenced by a transpiration-reducing spray. Plant Physiol. 20:86-97. 1945.

6. Christopher, E. P., Pieniazek, S. A., and Jennings, Cedric. Lime as "safener" in lime sulphur and lead arsenate sprays. Proc. Amer. Soc. Hort. Sci. 44:101-104. 1944.

7. ______________________________, A further evaluation of hormone sprays. Proc. Amer. Soc. Hort. Sci. 43:51-52. 1943.

8. Comar, C. L., and Barr, C. G. Evaluation of foliage injury and water loss in connection with use of wax and oil emulsions. Plant Physiol. 19:90-104. 1944.

9. Deys, W. B. Metinger van de intensiteit der ademhaling bij thiebald. Archief. Voor De Theecultuur. 16:1-15. April, 1948.

10. Dutton, W. C., and Wells, H. M. Some physiological effects of Bordeaux. Proc. Amer. Soc. Hort. Sci. 21:277-281. 1923.

11. Fisher, D. F. Effect of alkaline sprays on the size of sweet cherries. Phoytopath. 12:104. 1921.

12. Fossum, M. T., and Laurie, Alex. Further studies on the effects of several spray materials on the apparent photosynthetic rate of greenhouse roses. Proc. Amer. Soc. Hort. Sci. 40:77-78. 1942.

13. Gerhardt, F., and Allmendinger, D. F. The influence of a-napthaleneacetic acid on the ripening of detached fruits. Bot. Gaz. 106:199-207. 1944.

14. Ginsburg, J. M. Summer oil sprays and their effect on apple trees. N. J. Agr. Exp. Sta. Dept. of Ent. 173-176. 1929.

15. Groves, A. B., Miller, H. J., and Taylor, C. F. Tri-state cherry spray investigations. W. Va. Agr. Exp. Sta. Bul. 310. 1943.

16. Haller, M. H. Effect of preharvest drop sprays on the storage quality of apples. Proc. Amer. Soc. Hort. Sci. 42:207-210. 1943.

17. Heinicke, A. J., and Hoffman, M. B. An apparatus for determining the absorption of carbon dioxide by leaves under natural conditions. Scinece 77:55-58. 1933.

18. Hoffman, M. B. The effect of certain spray materials on carbon dioxide assimilation by McIntosh leaves. Proc. Amer. Soc. Hort. Sci. 29:389-393. 1933.

19. ______________ Carbon dioxide assimilation by apple leaves as affectec by lime-sulphur sprays II: field experiments. Proc. Amer. Soc. Hort. Sci. 30:169-175. 1933.

20. ______________ The effect of several summer oils on the carbon dioxide assimilation by apple leaves. Proc. Amer. Soc. Hort. Sci. 32:104-106. 1934.

21. Kelly, Sally, and Avery, G. S., Jr. The effect of 2, 4- Dichlorophenoxyacetic and other physiologically active substances on respiration.
Amer. Jour. Bot. 36:421-425. 1949.

22. Langer, C. A. Effect of wax sprays on the yield of cherries, pears, and apples. Proc. Amer. Soc. Hort. Sci. 51:191-195. 1948.

23. __________ and Fisher, V. J. Relation of wax emulsion and fungicidal sprays to size, color, and composition of fresh and processed Montmorency cherries. Proc. Amer. Soc. Hort. Sci. 54:163-170. 1949.

24. Laurie, Alex, and Witt, D. J. Effect of some spray materials on the apparent photosynthetic rate of greenhouse rose. Proc. Amer. Soc. Hort. Sci. 38:655-657. 1941.

25. Michigan cherry survey. Michigan Cooperative Crop Reporting Service, Lansing, Michigan. 1949.

26. Miller, E. J., Neal, A. L., and Gardner, V. R. Emulsions for horticultural sprays. Mich. Agri. Exp. Sta. Quar. Bul. 27(3). February, 1945.

27. ___________ Method for the protection of plants. United States Patent No. 2,013,063. September 3, 1935.

28. Mitchell, J. E., Burris, R. H., and Riker, A. J. Inhibition of respiration in plant tissues by callus stimulating substances and related chemicals. Am. Jour. of Bot. 36:368-378. 1949.

29. Murphy, L.M. The effect of certain fungicides on the photosynthetic activity of sour cherry leaves. Proc. Amer. Soc. Hort. Sci. 37:375-378. 1939.

30. Neal, A. C., Barr, C. G., Gardner, V. R., Rasmussen, E. J., and Miller, E. J. Influence of oil-wax emulsion sprays on size of Montmorency cherries. Jour. Agr. Res. 77:261-269. 1948.

31. __________ Gardner, V. R., Rasmussen, E. J., and Miller, E. J. Economic value of oil-wax emulsion sprays in cherry orchard practices. Mich. Agr. Exp. Sta. Quar. Bul. 29 (3):220-225. 1947.

32. Oberle, G. P., Pierce, G. W., Chapman, P. J., and Avens, A. W. Some physiological responses of deciduous fruit trees to petroleum oil sprays. Proc. Amer. Soc. Hort. Sci. 45:119-130. 1944.

33. Overholser, E. L. and Overley, F. L. The effect of spraying apple leaves with certain less used materials upon their carbon dioxide intake. Proc. Amer. Soc. Hort. Sci. 32:93-95. 1934.

34. ______________, Allmendinger, D. F., and Overley, F. L. The effect of certain sprays upon the apparent photosynthetic activity of apple trees. Wash. Agr. Exp. Sta. Bul. 447:1-28. 1944.

35. Pickett, B. S. Respiration of peach leaves as influenced by some spray materials. Proc. Amer. Soc. Hort. Sci. 51:196-198. 1948.

36. Pieniazek, S. A., and Christopher, E. P. The effect of some spray materials on the rate of apparent photosynthesis of apple leaves. Proc. Amer. Soc. Hort. Sci. 44:105-106. 1944.

37. Porter, D. R., Bisson, C. S., and Allinger, H. W. Factors affecting the total soluble solids, reducing sugars, and sucrose in watermelons. Hilgardia 13:31-66. 1940.

38. Rasmussen, E. J. The effect of several spray materials on the size, color, and percent solids of the fruit of Montmorency cherry. Proc. Amer. Soc. Hort. Sci. 37:367-370. 1939.

39. Schuster, C. E., and Stephenson, R. E. Effect of oil-wax emulsion on size of cherries. Proc. Ore. Sta. Hort. Soc. 1947.

40. Shutak, V. G., and Christopher, E. P. The influence of Bordeaux spray on the growth and yield of tomato plants. Proc. Amer. Soc. Sci. 36:747-749. 1938.

41. Smock, R. M., and Gross, C. R. The effect of some hormone materials of the respiration and softening rates of apples. Proc. Amer. Soc. Hort. Sci. 49:67-77. 1947.

42. Traub, H. P. Growth substances with particular reference to subtropical plants. Proc. Amer. Soc. Hort. Sci. 35:438-442. 1938.

43. Tukey, H. B. Growth of the embryo, seed, and pericarp of the sour cherry (Prunus cerasus) in relation to season of fruit ripening. Proc. Amer. Soc. Hort. Sci. 31:125-144. 1934.