Trunk Growth Versus Fruit Growth of Apricot as Affected by 2,4-D[1]

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Abstract. Radial trunk growth measured by the Verner dendrometer was reduced markedly due to competition for assimilates and water by greatly stimulated fruit growth resulting from the application of 2,4-D. These responses were accompanied by reduced water tension within the 2,4-D-treated trees, as indicated by less diurnal trunk shrinkage than that which occurred in control trees.

Introduction

The growth regulator 2,4-dichlorophenoxyacetic acid (2,4-D) applied at the initiation of pit hardening in the apricot reduces preharvest fruit drop, increases size, and hastens maturity similarly to 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) (4, 6). Likewise, the phytotoxic effects of these compounds—temporary flagging of the foliage and killing of the shoot tips under certain conditions—are similar.

The higher percentages of water reported in 2,4,5-T-sprayed than in unsprayed fruits (5, 7), as well as current-season's and 1-year-old shoots (15), were found by Marei et al. (15) to be associated with reduced transpiration that persisted for at least 3 weeks after spraying. This indicated that reduction in water tension within the sprayed trees may have occurred, which resulted in the accumulation of water in the fruits and other organs.

Changes in water stress within forest (8, 11, 14) and fruit (17, 22) trees have been shown to bring about diurnal shrinking and swelling of their trunks. Water stress increases as partial dehydration of tissues occurs during the period of transpiration early in the day, while it decreases in late afternoon and at night when transpiration is minimal and rehydration occurs. Schroeder and Wieland (17) showed that transpirational water loss also brought about shrinkage of avocado fruits during the day; as the tree rehydrated at night after cessation of transpiration, the fruits expanded.

The objectives of the work reported here were to determine if reduction in water tension occurred in the trunks of apricot trees after 2,4-D application and to compare patterns of trunk growth of sprayed and unsprayed trees.

Materials and Methods

Six 28-year-old 'Royal' apricot trees, uniform with respect to size, vigor, and crop load, were selected within an acre plot of trees growing in a uniform soil at the Wolfskill Experimental Orchard, Winters. Two dendrometers, calibrated to 5,000ths of an inch (19), were affixed opposite each other (north and south) to the trunk of each tree about 1 foot above the soil. After determining growth rates of the individual trees for several days before 2,4-D was applied, 3 trees were placed in each of 2 groups having identical average growth rates. On April 24, 1967, an aqueous solution of the dimethylamine salt of 2,4-D at a concentration of 50 ppm acid equivalent was applied with a power sprayer to 3 trees to the point of slight drip. The control trees were not sprayed with water because droplets were present from rain the previous night. Pit hardening in the fruits had begun a few days prior to the time of spraying. Fruit thinning as practiced commercially was done a week after spraying.

Fruit growth curves were developed from weekly check diameter measurements with a vernier caliper of 30 tagged fruits per treatment (10 per tree).

Dendrometer readings were made at hourly intervals from 7:00 AM to 7:00 PM for the first 10 days and twice daily (early morning and late afternoon) thereafter until May 20. This procedure provided daily maximum and minimum radii readings which indicated indirectly the comparative water tension within the sprayed and control trees. From May 20 on, readings were made approximately every other day. The dendrometer data represent average readings of 6 instruments per treatment, 2 for each of 3 trees.

Results and Discussion

Spring of 1967 was characterized by relatively cool temperatures and above average precipitation. In fact, 2,4-D application was delayed several days because of persistent rainfall. While April 24, the date of 2,4-D application, marked the end of spring rains, high relative humidity prevailed throughout the day because of cloudiness and little air movement. Consequently, the spray droplets on the leaves and young fruits persisted for several hours. The severity of flagging of the foliage within 2 days indicated that absorption of 2,4-D by the leaves was greater than in previous experiments with this compound when conditions were conducive to rapid evaporation (4, 6). Although the flagged condition of the foliage improved with time, it was noticeable throughout the summer. Spur elongation had ceased sometime before spray application and no deleterious effects were noted. Shoot tips, however, were killed 4–6 inches and only an occasional lateral bud below produced new growth during the summer. Bloom and vegetative growth were normal in 1968.

Fruit growth, as previously reported (4, 6), was stimulated markedly by 2,4-D (Fig. 1A); a difference between treated and control fruits was detected 1 week after treatment. The ultimate average diameter of the sprayed fruits was 16% greater than that of the control and maturity, as judged by color and firmness, was hastened about 7 days. The increase in fruit diameter was the greatest ever obtained with 2,4-D and was accompanied by skin and flesh cracking of 10% of the total fruits. Less than 1% of control fruits cracked.

April 24 marked a peak in trunk radius (Fig. 1C) that was brought about by hydration of the bark and other tissues as a result of preceding rains and accompanying low transpiration. Under clear and relatively warm conditions during the next 8 days, cumulative shrinkage of control trunks occurred. Shrinkage in this case, exceeding the amount of actual growth, which is not uncommon (3, 10, 13), was the result of water loss by transpiration and by evaporation from the bark.

One of 2 phenomena, or both, were probably responsible for the fact that cumulative shrinkage did not occur

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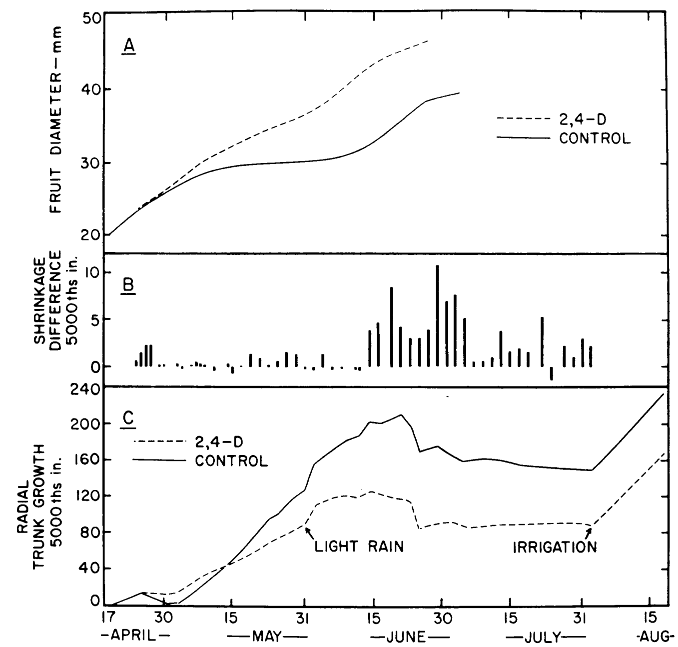

Fig. 1. The effect of 2,4-D on (A) fruit growth in diameter, (B) diurnal trunk shrinkage, and (C) radial trunk growth of the 'Royal' apricot. Bars above the abscissa in B indicate days during which shrinkage of 2,4-D-sprayed trees was less by the amounts shown than that of the control, while those appearing below the abscissa represent days on which shrinkage was greater.

in 2,4-D-treated trunks. Treatment with auxin (a) induces water uptake by excised portions of plants and (b) modifies water distribution within entire plants by suppressing transpiration through reduction in stomatal aperture (2, 9, 21). Marei et al. (15) have reported responses of these types in the apricot following 2,4,5-T application. That increased water uptake or reduced transpiration, or both, took place following 2,4-D application is indicated in Fig. 1B, which shows the difference in diurnal trunk shrinkage between sprayed and unsprayed trees. During the first 4 days diurnal shrinkage of trees sprayed with 2,4-D ranged from 85 to 169% less than that in the control. This period corresponds closely to that reported by Marei et al. (15) of maximum reduction in stomatal aperture following 2,4,5-T application to the apricot. Furthermore, Bradley et al. (1) presented evidence which indicated that histological modifications of apricot leaves brought about by 2,4,5-T application were conducive to reduced transpiration throughout the summer. That 2,4-D may induce similar changes is suggested by the data in Fig. 1B, particularly from about June 14 onward when water in the soil was limiting and severe moisture stress occurred within the trees. During that period diurnal trunk shrinkage of the sprayed trees was markedly less than that of the control, which indicates that transpiration was reduced.

On the other hand, Crane et al. (5) found total sugar concentration (fresh and dry weight bases) in apricot fruits sprayed with 2,4,5-T to be greater than in the control only 11 days after treatment and from then on to maturity. This may be prima facie evidence that similar increase may have occurred in other organs of the trees sprayed with 2,4-D, which resulted in a higher osmotic concentration and subsequent greater water uptake. Regardless of how it was brought about, however, decreased water tension within the trunks of 2,4-D-sprayed trees, as indicated by diurnal shrinkage, occurred generally throughout the experimental period.

After the initial 8-day period of trunk shrinkage in control trees, rate of radial increase paralleled that of sprayed trees until May 9, when the latter began to lag at the expense of increase in rate of fruit growth (Fig. 1A and C). Uriu et al. (18) and Uriu and Crane (unpublished), working with the almond and apricot, respectively, have found rate of trunk growth to be inversely correlated with crop density (number of fruits per cm^2 of cross-sectional trunk area). In this case, the numbers of fruits per cm^2 of cross-sectional area of treated and control trees were similar (between 17 and 18), but weight of fruits of the former was considerably greater than the latter because of the 16% increase in fruit diameter. Thus, reduced trunk growth of the 2,4-D-treated trees was primarily the result of stimulated fruit growth, but possibly also of reduced number of leaves. Kozlowski and Keller (12) and Wardlaw (20) have reviewed recently the extensive literature demonstrating dominance of reproductive over vegetative organs for assimilates.

The shrinkage data in Fig. 1B indicate that severe moisture stress occurred within the trees on June 14 and continued until the soil was irrigated on August 2. Irrigation was not carried out before August 2 because of interference with other management practices in adjacent plots. Crane et al. (5) have shown that from 40–50% of the moisture in mature apricot fruits is accumulated during the final 2–3 weeks of growth. Thus, the diversion of moisture (and assimilates) to the earlier maturing 2,4-D-treated fruits apparently was responsible for the fact that trunk radial increase in the treated trees ceased (June 15) 7 days before cessation occurred in the control (June 22). The difference in cumulative radial trunk growth between treated and control trees on both June 15 and June 22 was significant at the 0.05% level.

Soil moisture depletion and prevailing high temperatures brought about rapid trunk shrinkage from June 21 to 25. From then on until irrigation, shrinkage of control trunks occurred generally but less rapidly, while the radii of 2,4-D-treated trunks remained more or less constant. This response to 2,4-D treatment is similar to that of bean plants treated with various phenoxy growth regulators (16). Water content of the tops was significantly increased and water loss from them was reduced after severance from their roots. Mitchell and Marth (16) suggested that the increased ability to absorb and retain water may have been brought about by increased osmotic concentration of the cell sap due to hydrolysis of carbohydrates. While the data of Marei et al. (15) might indicate this to be the case in apricot trees sprayed with 2,4,5-T or 2,4-D, factors such as reduced number of leaves and reduced transpiration brought about by histological changes in the leaves undoubtedly were involved also.

This experiment was initiated 5–6 weeks after trunk enlargement began and was terminated 6–8 weeks before enlargement ceased. Thus, the radial growths of .046 and .034 inches made by control and 2,4-D-treated trees, respectively, are only fractions of the totals during 1967. Growth would have been greater during the experimental period, however, had not soil moisture been deficient for a period of about 5 weeks. Considering the small increments of growth during the experimental period, the differences between the detailed growth patterns of the sprayed and control trees demonstrate the extreme sensitivity of this type of dendrometer and its usefulness for detecting tree growth response to differential treatment.

The Influence of Calcium on the Development of Lettuce Tipburn[1]

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Abstract. Foliar sprays of $Ca(NO_3)_2$ or $CaCl_2$ completely controlled lettuce tipburn in the variety 'Meikoningen' when directed to susceptible immature leaves. Analysis of treated and untreated plants showed that treatment markedly increased the Ca content of tipburn susceptible leaves and revealed a 5-fold increase in Ca content as one progressed from immature heart leaves to mature basal leaves in untreated plants. Foliar sprays of organic acid salts, particularly oxalate, accelerated the development of tipburn and increased its severity. When Ca and oxalate treatments were alternated, application of Ca at the beginning of the dark period and oxalate in the morning resulted in markedly less tipburn than application of these sprays in the reverse order.

Introduction

A majority of studies dealing with lettuce tipburn have emphasized marked dependence upon environmental factors such as temperature, humidity, moisture, and more recently upon the intensity and duration of light (24). Although much of the older evidence appears contradictory it is generally agreed that tipburn is most severe when both environmental factors, and nutritional factors permit periods of very rapid leaf growth.

A detailed description of tipburn symptomology has been provided by Tibbitts, et al. (25). The visual symptoms of the disorder (marginal necrosis of inner leaves) are preceded by swelling and rupturing of laticifer cells which results in latex release. There are noteworthy similarities, however, between lettuce tipburn and some other physiological disorders, even though laticifers are not always involved. Some of these are brownheart of escarole (15), blackheart of chicory (27), blackheart of celery (8), heartrot of Chinese cabbage (10), and tipburn of cabbage (26). In each case susceptible tissues are the young leaves where rapid cellular division and enlargement occur. Their location on the plant insures a microenvironment of relatively higher humidity than that of the rest of the plant. These disorders are markedly affected by environment and appear to be correlated with rapid growth rates. When analyzed, susceptible tissues have been found to have a very low Ca content, and partial to complete control has sometimes been achieved by timely administration of this element (8, 11, 15, 16, 26, 27).

The need for Ca by young tissues is expected to be greatest during periods of rapid growth. Environmental factors such as temperature, light, humidity, and moisture not only affect growth rates, thus accentuating the requirement for Ca, but also influence the availability and translocation of this relatively immobile element within the plant (4). We therefore felt that the relationship between lettuce tipburn and calcium deserved further attention, in spite of the fact that Jenkins (13) did not influence tipburn development of field grown head lettuce by twice weekly sprays of Ca to outer leaves and that Struckmeyer and Tibbitts (22) have reported tipburn symptoms to resemble more closely those observed in lettuce grown without B than without Ca.

Material and Methods

Experiments were conducted with a small susceptible, bibb type of lettuce, *Lactuca sativa* L., cv. 'Meikoningen'. The symptomatology of the disorder referred to as tipburn was precisely as described by Tibbitts, et al. (25) in work with this same cultivar.

Experiment 1. On January 7 seedlings at the 3 leaf stage were transplanted in the greenhouse to 6-inch styro-

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