through the drip system at rates comparable to those applied uniformly. The extent of movement was determined by rate of application. At the rate of 90 kg of P_2O_5/ha., the movement of P was 25 cm laterally and 30 cm in depth, compared with 10 cm laterally and 10 cm in depth for the 15 kg of P_2O_5/ha. rate. The drip system has a much greater effective application rate because it applies phosphorus on a very small surface area, creating greater movement. For example, at 7,200 emitters per ha., a uniform application rate of 15 kg of P_2O_5/ha. applied through the drip system would give an application rate equivalent to 66,000 kg of P_2O_5/ha., assuming the P was applied within a 1 cm radius of the emitter. For an 8 cm radius, which is comparable to the amount of horizontal movement of inorganic P observed in the field and laboratory for the same rate, the effective rate of application is 1,000 kg of P_2O_5/ha. This is comparable to the movement caused when high rates of P_2O_5 are applied on the soil surface.

Furthermore, calculations of the volume of soil to which increased P levels have been attained from a uniform broadcast application are of the same order of magnitude as the volume of soil to which elevated P levels are observed when it is applied through a drip system. Consequently, it is logical that the chemistry of P reactions in a given soil would dictate that the volume of soil in which increased levels of P are measurable should be similar no matter how the P is applied.

Glycerophosphate applied through an emitter moved approximately 5 to 10 cm farther (fig. 1) in the horizontal plane than did orthophosphate, according to field measurements. The organic phosphate moved farther than the inorganic phosphate because of the delay in release of the orthophosphate ion from the organic moiety which requires an enzymatic hydrolysis. Although organic phosphate moved slightly farther than inorganic phosphate, the plant uptake of P was not greatly affected by 5 cm of increased movement as indicated in the discussion on plant uptake.

A laboratory experiment was designed to evaluate the extent of phosphorus movement when applied to soils in a way duplicating drip irrigation placement. In a laboratory experiment orthophosphoric acid containing radioactive P (^{32}P) was slowly dripped onto the soil surface at one spot in the center of a box filled with Yolo loam soil. The ^{32}P was used to distinguish the applied P from the soil P which may have dissolved as a result of the acid application, and to unmistakably determine the extent of inorganic P movement under these conditions. The rate of P application was equivalent to 30 kg of P_2O_5/ha. and at the same emitter density (72 per plot) as in the field studies. The same procedure was used to apply calcium glycerophosphate. The glycerophosphate did not contain ^{32}P.

After two days, the soil was sampled on a 5 cm grid in both the horizontal and vertical plane, using the point of application as the zero point. The P and radioactive P content was measured in bicarbonate extracts of the soil samples. The movement of orthophosphoric acid was ascertained from the distribution of ^{32}P. The movement of glycerophosphate was ascertained from the increase in bicarbonate soluble P above the background level. Glycerophosphate moved approximately 5 cm farther both horizontally and vertically than inorganic phosphate (fig. 2)—movement similar to that observed in the field.

Both phosphoric acid and glycerophosphate apparently move far enough below emitters at small application rates to be a satisfactory means of placing P in the root zone of drip irrigated crops. However, the problem of inorganic phosphate precipitation clogging drip lines is of great concern and can only be prevented by careful adjustment of the pH of the irrigation water receiving the inorganic phosphate. Glycerophosphoric acid and its soluble salts cause no such concern since the phosphate ion is only hydrolyzed enzymatically in the soil; this also allows sufficient movement in the soil for the P to be placed in the root zone. Furthermore, in other types of irrigation systems where concentrated applications cannot be achieved (as with drip irrigation), the movement of the organic phosphate can be utilized to achieve the desired P placement.

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WALNUT

Walnut blight, caused by the bacterial organism *Xanthomonas juglandis*, is a disease of worldwide importance on walnuts. In northern California, blight may occur on a number of commercial varieties of English walnuts, although late-blooming varieties generally escape infection by leafing out after most of the spring rains are over.

Buds, catkins, leaves, shoots, and nuts of current season's growth are all susceptible to infection. On leaves, the parenchyma tissues, midrib, lateral veins or the rachis and petiole may all be involved; dark brown to black irregular-shaped spots on young leaflets cause malformed older leaves.

Nut infection accounts for a major part of the economic loss. Rain during pollination commonly results in blossom-end infection of young nutlets. The first sign of blight appears on the stigma in the form of a rapidly enlarging black spot which might subsequently involve the entire fruit. Occasionally infection enters the young nutlet, causing a breakdown of the internal tissues with only limited ex-

TABLE 1. EFFECTIVENESS OF MATERIALS AGAINST BLIGHT ON ASHLEY WALNUTS, SACRAMENTO VALLEY, 1974.

Material*	Rate/ 100 gal.	Mean % infected nuts†
Copper-Count-N	3 gal.	18 a
Bordeaux mixture	8:5:100	18 a
PQ8	2 pt.	31 b
Untreated check	—	32 b

* Sprayed by air-blast sprayer at the rate of 100 gal./acre on April 16 and May 2, 1974.

† Three hundred nuts per replicate were evaluated on May 23, 1974 (1200 nuts/treatment). Values followed by a common letter are not significantly different at the 0.05 level, according to Duncan's multiple range test.

Experiments indicate that the number and timing of treatments for optimum control of walnut blight vary with the season, rainfall being the governing factor. There was no evidence that any one control chemical was superior to another.

BLIGHT CONTROL

W. H. OLSON • W. J. MOLLER • L. B. FITCH • R. B. JETER

ternal evidence of the disease. Many affected young nuts drop from the tree. Lesions produced by infection of partly grown nuts appear first as water-soaked spots. These spots darken and enlarge rapidly, resulting in black sunken areas on the walnut hull. Attack by walnut blight before the shell hardens usually results in shriveled kernels. If nuts are attacked after the shell hardens, the kernel may not shrivel but is often discolored.

It is generally assumed that pollen from partially infected catkins is contaminated with blight bacteria. Segments of affected catkins turn black and shrivel. On infected green shoots, black and elongated lesions develop near the tip. In some cases this infection may result in girdling and twig death. Lesions that do not girdle the shoot may develop into elongated sunken cankers which, along with diseased buds, provide a source of blight bacteria for the following year. Water, particularly rain droplets falling on holdover sources, spreads the bacteria to current season's growth. Windblown contaminated pollen might also contribute to spread of the disease.

Although blight bacteria can cause damage at any time during the growing season, the major period of risk is in spring—between the period of initial growth and two weeks after full bloom. Frequent and prolonged rains during this period result in serious blight outbreaks. Infections occurring after nuts are about three-fourths grown are generally of little economic importance.

The present studies were conducted during 1974 and 1975 in Ashley walnut orchards in the northern Sacramento Valley. Three trials compared the efficacy of various materials, and differing rates of bordeaux mixture, in the control of walnut blight. Two other trials were conducted to determine the influence of spray timing on blight control.

TABLE 2. EFFECTIVENESS OF MATERIALS AGAINST WALNUT BLIGHT ON ASHLEY WALNUTS, SACRAMENTO VALLEY, 1975.

Material*	Rate/ 100 gal.	Mean % infected nuts†
Copper-Count-N	2.5 gal.	6.1 a
Kocide 101	8 lb. (+ 1 pt. 80% summer oil emuls.)	6.1 a
Bordeaux mixture	8:5:100 (+ 1/2 gal. 60% summer oil emuls.)	6.3 a
COCS	12 lb.	8.1 a
Untreated check	—	21.5 b

* Sprayed by air-blast sprayer at the rate of 100 gal./acre on March 30, April 19 and May 7, 1975.
† Three hundred nuts per replicate were evaluated on May 29, 1975 (1500 nuts/treatment). Values followed by a common letter are not significantly different at the 0.05 level, according to Duncan's multiple range test.

Materials tested

In 1974, one trial was established using four treatments replicated four times in a randomized complete block design, with individual plots of 5 X 5 trees. Bordeaux mixture at 8:5:100 was compared with two fixed copper formulations—Copper-Count-N and PQ8 (copper-8-quinolinolate), both applied according to label directions—and an untreated check. All materials were applied at the semi-concentrate rate of 100 gallons per acre by air-blast sprayer and were timed to coincide with various stages of plant growth during the main walnut blight susceptible period. Unfortunately, the earliest (pre-bloom) spray had to be omitted due to orchard flooding. The second and third sprays went on at 30 to 40 percent pistillate bloom and 50 percent post-pistillate bloom, respectively.

In 1975, two trials were established, each with five treatments and five replicates in a randomized complete block design. Individual plots were 4 X 4 trees and materials were applied at the rate of 100 gallons per acre by air-blast sprayer. Blight chemicals tested in *the first trial* included Copper-Count-N, Kocide 101, COCS (copper oxychloride sulphate) and bordeaux mixture. These materials were used at the manufacturer's minimum recommended rate per acre, along with an 80 percent summer oil emulsion when specified. The bordeaux mixture was 8:5:100, combined with 0.5 gallon of an 80 percent summer oil emulsion. In *the second trial*, various rates of bordeaux mixture were evaluated—4:2.5:100, 8:5:100, 12:7.5:100 and 16:10:100. Again, in these two trials, three applications were timed to coincide with various stages of plant growth during the spring blight susceptible period: 1) catkins expanding and beginning to shed pollen, 2) 30 to 40 percent pistillate bloom, 3) 50 to 60 percent post-pistillate bloom.

TABLE 3. EFFECTIVENESS OF DIFFERENT RATES OF BORDEAUX MIXTURE AGAINST WALNUT BLIGHT ON ASHLEY WALNUTS, SACRAMENTO VALLEY, 1975.

Material*	Rate/ acre	Mean % infected nuts†
Bordeaux mixture	12:7.5:100	0.2 a
Bordeaux mixture	16:10:100	0.5 a
Bordeaux mixture	4:2.5:100	0.7 a
Bordeaux mixture	8:5:100	0.8 a
Untreated check	—	8.2 b

* Sprayed by air-blast sprayer at rates of 100 gal./acre on March 30, April 18 and May 8, 1975.
† Three hundred nuts per replicate were evaluated on May 30, 1975 (1500 nuts/treatment). Values followed by a common letter are not significantly different at the 0.05 level, according to Duncan's multiple range test.

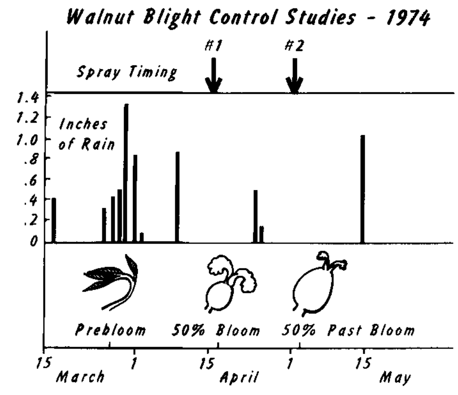

Fig. 1

In both years, treatment plots were evaluated for blight infection approximately three weeks after the final spray application. One-hundred nuts were randomly picked from 4 to 6 feet above ground level on each of three trees located in the center of each plot. The 300 nuts collected from each plot were then inspected for visible blight infection.

Results

Table 1 shows the results of the 1974 trial. Although blight control was poor, due to the aforementioned spring flooding of this orchard, both Copper-Count-N and bordeaux mixture were significantly more effective than the experimental material PQ8 or the untreated check. These two chemicals almost halved the amount of disease. PQ8 gave no control of walnut blight and was comparable to the untreated check in percent blighted nuts.

Table 2 shows the results of the material comparison trial conducted in 1975. All materials tested were significantly better than the untreated check which had approximately three times the amount of blight found in any of the treatments. Differences in efficacy were slight and there was no significant difference between the materials at the 0.05 level of probability. Results of the bordeaux rate trial, conducted in 1975, are presented in table 3. In this trial the incidence of walnut blight was low: the untreated check had only 8.2 percent of the nuts blighted. All rates tested brought the percent blight down to 0.8 percent or lower and there was no significant difference between any of them.

Spray timing evaluated

Two spray timing trials were also conducted, one in 1974 and the other in 1975.

In 1974, an 8:5:100 bordeaux mixture was applied by air-blast sprayer at the rate of 100 gallons per acre to trees replicated four times in a randomized complete block design; individual plots were 5 X 5 trees. Comparisons were made between two variables, apart from the untreated check. These were: 1) a single spray applied at 50 percent pistillate bloom; and 2) two sprays, the first applied at 50 percent pistillate bloom and the second at 50 percent post-pistillate bloom. Statistically significant differences were observed between each treatment. Two sprays reduced blight by 16 percent, while the single spray reduced blight by 11 percent over the untreated check.

In 1975, a spray timing trial, with 10 replicates of three different spray schedules and an untreated check, was established in a randomized complete block design. The standard chemical treatment in this case was Kocide 101 which was applied by handgun to single tree plots at the rate of 2 pounds/100 gallons + 1 pint of 80 percent summer oil emulsion per 100 gallons. This is approximately equivalent to a dilute air-blast application of 8 pounds Kocide and 1/2 gallon 80 percent summer oil emulsion per acre. The three schedules included: 1) one spray, applied during the catkin elongation period; 2) two sprays, applied first at catkin elongation, then at 30 to 40 percent pistillate bloom; and 3) three sprays, applied respectively, at catkin elongation, 30 to 40 percent pistillate bloom and two weeks later (during early post-bloom). The primary objectives were to evaluate the blight susceptibility of these various stages of nut development and determine optimal spray timing. Although there was no statistically significant difference in blight control between any treatments at the 0.05 level of probability, spray schedules that included a bloom spray did have a lower incidence of blight. In this trial, infection ranged from 2.1 percent where all three sprays were applied, to 4.6 percent where only the catkin spray was applied.

Discussion

Based on the data reported here, there was no evidence that any one walnut blight material was superior to another, nor was there any evidence that higher rates of bordeaux were superior to lower rates. The authors cautiously assert that this may not be true in other years.

Rainfall records for 1974 and 1975 (figs. 1 and 2) give clues to the variable results obtained in some of these trials. In 1974, approximately four inches of rain fell during the pre-bloom and early-bloom stages before the first spray was applied. This quantity of rainfall resulted in significant disease and probably explains the high percent blight found in the bordeaux and Copper-Count-N treatments in the 1974 trial. This also serves to underline that protective sprays must be applied *before* significant rainfall to obtain blight control. In the 1974 timing trial, it was found that each additional spray helped to reduce the presence of blighted nuts in the orchard. Consequently, a bloom and post-bloom spray resulted in 16 percent blight, a bloom spray only resulted in 21 percent, and no sprays resulted in 32 percent. Again, rainfall records can be used to explain these results: shortly after the post-bloom spray an inch of rain fell, then after the bloom spray 0.7 inches of rain fell. As mentioned earlier, there were

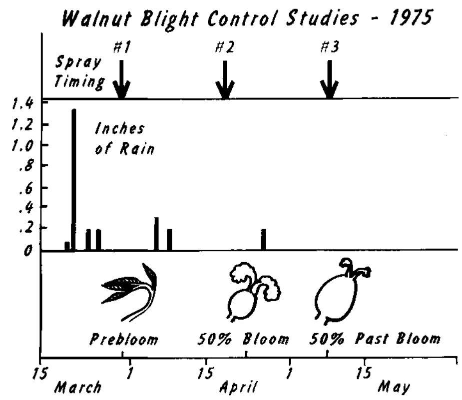

Fig. 2

approximately four inches of rain during the pre-bloom and early-bloom stages. Results from this trial indicate that both the bloom and post-bloom sprays were important in reducing blight and that a pre-bloom or early-bloom spray would also have been beneficial.

In 1975, none of the spray timing schedules significantly reduced the percent blight over the untreated check. However, where a bloom spray was included, blighted nuts were reduced by approximately 2 percent over the untreated check and pre-bloom application, which had 4.5 and 4.6 percent blight, respectively. This low percentage of infection in the untreated check can also be related to rainfall during the blight-sensitive period. During the period from pre-bloom through post-bloom there was only 0.7 inches of rain. The pre-bloom spray showed no benefit over the untreated check, even though 0.5 inches of rain fell one week after application. Perhaps, under these light rainfall conditions, this application was made well before nutlets were exposed to blight infection. The inference that the bloom spray was the most beneficial may be because 0.2 inches of rain fell shortly after its application.

Summary

These experiments indicate that both the number and timing of treatments for optimum walnut blight control will vary with the season. In years when there is only a relatively small amount of rainfall during the infection period (as in 1975) few sprays will be needed. But if the rainfall is heavy and prolonged during the infection period (as in 1974) several treatments will be needed. Protective sprays applied at a particular stage of nut development will be helpful in reducing blight infection only if appreciable rainfall follows. However, because it is impossible to predict the weather during the critical period of infection, applications should be applied to cover the major period of susceptibility. On early varieties, a pre-bloom spray should be used to help keep the bacterial inoculum at a minimum before the highly susceptible pistillate flowers are exposed. In addition, a pre-bloom spray might help to eliminate catkin infection and subsequent spread of the disease through infected pollen. A bloom spray should be applied to protect the pistillate flowers. Due to rapid growth of fertilized nuts after pollination a third spray should be applied at post-bloom. If rains threaten, additional sprays would be beneficial as the nuts continue to enlarge, but in most years in the Sacramento Valley this will be unnecessary. The nut enlargement period usually ends around the first of June on early-maturing varieties. Success in control of walnut blight depends on proper timing and thoroughness of coverage. In devising a blight spray schedule remember that copper sprays are only protective agents; their continuous presence on susceptible parts of the plant is absolutely essential during the critical spring period.

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Reducing Set in Ruby Seedless Grapes with Gibberellin

FRED JENSEN • FRED SWANSON • GEORGE LEAVITT

Ruby Seedless is a red seedless variety used as a table grape and for the freezer. The clusters are well filled to compact. In some vineyards, looser clusters would be desirable to reduce bunch rot and to facilitate packing. Gibberellin sprays reduce set in Thompson Seedless and several wine varieties, so trials were established with Ruby Seedless to determine the possible benefits.

In 1973, we sprayed vines at three stages of development: 1) pre-bloom shoots 15 to 18 inches long; 2) bloom, 30 percent caps off; and 3) bloom, 60 percent caps off. The concentrations of gibberellin tested were 2 1/2, 5, and 10 ppm. Although a replicated trial was established for detailed sampling, the effects of the sprays were obvious and precluded the necessity of further evaluation. All of the pre-bloom treatments resulted in straggly clusters and excessive numbers of shot berries. The 5 and 10 ppm concentrations during bloom also produced straggly clusters with shot berries. Only the 2 1/2 ppm concentration approached the desired loosening but even this low dosage appeared to be excessive. The late bloom spray was more favorable than the early bloom spray.

Based on our 1973 experience, we established a trial in 1974 using gibberellin rates of only 1 and 2 ppm to compare to no treatment. Vines were treated only in the late bloom stage on May 17, when 70 percent of the caps had fallen from the flowers. About 150 gallons of spray were applied per acre to insure good coverage of the clusters and leaves. Each treatment was replicated 15 times.

Just before the grower's harvest, we sampled for soluble solids and berry weight determination by taking 50 berries from each replication. The character of the clusters was rated visually by three observers. Clusters in the desired range, well filled to loose, were assigned numbers of 3 and 4. An average cluster index number below 3 was excessively compact, and above 4, excessively straggly.

Our data in the table show that the most favorable results were obtained with a 1 ppm spray. This treatment produced loose clusters without increasing shot berries. This treatment had no effect on the soluble solids or berry weight. Two ppm produced excessively straggly clusters but did not increase the numbers of shot berries.

The low rate of gibberellin treatment required shows that the Ruby Seedless variety is very sensitive to gibberellin. In contrast, Thompson Seedless table grapes require a 10 ppm concentration for berry thinning.

This is a report of work in progress only. The chemicals and uses contained in this article are experimental and should not be considered a recommendation for use.

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EFFECT OF BLOOM-TIME GIBBERELLIN TREATMENT ON RUBY SEEDLESS GRAPES

Treatment gibberellin conc.	Berry weight grams	Soluble solids °Brix	Looseness index†
1. 0 ppm	3.35 a*	15.2 a	2.87 a
2. 1 ppm	3.33 a	15.5 ab	3.80 b
3. 2 ppm	3.42 a	15.7 b	4.43 c

* Mean separation by Duncan's multiple range test, 5% level.

† Favorable range of well-filled to loose clusters in the range of 3 to 4.