THE USE OF GIBBERELLIC ACID SPRAYS IN ALTERING FLOWERING AND FRUITING OF THE SOUR CHERRY (PRUNUS CERASUS L. CV MONTMORENCY)

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ABSTRACT

THE USE OF GIBBERELLIC ACID SPRAYS IN ALTERING FLOWERING AND FRUITING OF THE SOUR CHERRY (PRUNUS CERASUS L. CV MONTMORENCY)

By

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Field plots were established in Michigan commercial sour cherry orchards to investigate the potential of gibberellic acid (GA_3) sprays to improve production of low vigor trees and to prevent flowering of young trees.

In the first experiment GA_3 was sprayed on mature sour cherry trees two weeks after full bloom. GA_3 concentrations used were 15 ppm and 30 ppm. Nonsprayed trees were used as controls. Treatments were begun in 1972. They were repeated to give the following timings: 1972 only; 1972 and 1973; 1972 and 1974; and 1972, 1973, and 1974. GA_3 sprays had no effects on yield the year of application.

The percentage of vegetative buds on terminal growth was increased on sprayed trees as evaluated during bloom the year after application. Yields in 1973 were decreased as a result of 1972 GA_3 sprays when compared with nonsprayed trees. Yields in 1974 from trees sprayed in 1972 were greater than from nonsprayed trees. There were no differences between sprayed and nonsprayed trees for combined 1973 and 1974 yields as affected by 1972 GA_3 sprays.

There were no differences in 1975 yields among the 30 ppm timing treatments. Yields in 1975 were increased in plots which had been sprayed with 15 ppm GA_3 in 1972 and 1973 or in 1972, 1973, and 1974. These data suggested that annual applications of 15 ppm GA_3 should result in increased yields after a decrease in yield the year following the year of first application. No differences in fruit firmness or fruit removal force were found between sprayed and nonsprayed trees.

In the second experiment higher concentration of GA_3 were sprayed on young sour cherry trees to try to prevent flowering. In 1973 GA_3 sprays were applied to 2 and 3 year-old sour cherry trees in 4 Michigan orchards two weeks after full bloom. GA_3 concentrations used were 45 ppm and 90 ppm. The percentage of flower buds on 1973 terminal growth as counted during the 1974 bloom season was greatly reduced by all GA_3 sprays when compared with terminal growth on nonsprayed trees. However, there seemed to be no affect on flowering of spurs from the GA_3 sprays.

In 1974 GA_3 was sprayed 2, 3, and 4 weeks after full bloom at 25 ppm, 50 ppm, and 100 ppm in single and repeat applications on trees in 2 Michigan orchards. GA_3 sprayed at 50 ppm or 100 ppm 3 weeks after bloom and again 4 weeks after bloom eliminated most flowers on both terminal growth and spurs as evaluated during the 1975 bloom.

There were no differences in terminal growth, number of nodes on terminal growth, internode length, or leaf nitrogen between sprayed and nonsprayed trees.

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INTRODUCTION

A major problem in sour cherry production is declining yields as a result of low vigor. Gibberellic acid (GA_3) has been found to reduce flower bud initiation on terminal growth. The first part of the work presented in this dissertation involved investigating the use of GA_3 sprays to increase the number of vegetative buds on terminal growth. The year following the GA_3 spray, the vegetative buds should develop into spurs which would bear fruit in subsequent years.

Another problem of the sour cherry industry is flowering and fruiting of trees at an early age - often, the second year in the field. The second part of the work discussed here involved the use of GA_3 sprays to prevent flowering of young sour cherry trees.

LITERATURE REVIEW

Flower buds of the sour cherry are located laterally on one-year terminal growth and on the one-year-old part of short shoots (5 cm or less) known as spurs. Generally there are two to four flowers per bud born in each corymbose inflorescence. The flower buds are pure - that is, they contain only flower parts. Likewise, leaf buds contain only vegetative parts. The terminal bud is always vegetative. As a result, elongation of spurs continues each year from the terminal resulting in relatively straight spurs. Lateral vegetative buds give rise to spurs.

On trees with about 20 cm or less terminal growth, most of the buds formed laterally are flower buds (1,25). The following year these fruit. Since no new vegetative tissue is formed laterally, the year after fruiting the shoots are "blind" (barren of vegetative buds). Shoots in the range of 20 to 45 cm will have some vegetative buds in lateral positions. The longer these shoots are, the higher will be the proportion of vegetative buds. These vegetative buds develop into spurs which will bear fruit for several years. As shoot growth exceeds 45 cm, most lateral buds will be vegetative. Some of these buds likely will develop into lateral branches; others, into spurs.

Flowering and fruiting are necessary for production of the current season's crop. Maintenance of vegetative growth promotes spur formation thereby maintaining or increasing the bearing surface and insuring future crop potential. Thus a balance of vegetative growth and fruiting is desired in a mature sour cherry orchard.

To maintain high yields, trees should not be allowed to become non-vegetative. Weakly vegetative trees will be made more fruitful by any treatment which increases growth without reducing fruiting surface (39).

Gardner (11) proposed that the ultimate upper limit on crop size, with no frost or leaf spot, is set by factors such as soil fertility and moisture supply. He maintained that it is reasonable to encourage heavy cropping by promoting optimum tree development. He recommended that 30 to 60 cm of terminal growth be maintained during the early years of tree life to develop a large fruiting surface. When trees are mature 15 to 30 cm of terminal growth will maintain yields. Similar observations were made by Kenworthy (25).

Many Michigan sour cherry producers observe that plantings are decreasing in productivity as they become older. The "blind" shoots (those without spurs) mentioned previously continue to develop over several years. When this occurs the tree takes on a willowy appearance, fruit is only born laterally on the previous year's terminal growth, and the only leaves are from the terminal vegetative bud. The terminal growth is essentially performing as a spur. In addition to low production, the willowy branches are not stiff enough to allow good shaking action from mechanical harvesters. The fruit either remains on the tree or the tree is injured by excessive shaking in trying to remove the fruit.

The cause of the blind willowy shoots is often attributed to a virus complex. Keitt and Clayton (21) reported that a bud transmissible disease of sour cherry existed in Wisconsin and that the causal agent was a virus. They later reported that this was a disease which formerly was called "physiological yellow leaf" and had been blamed on unfavorable soil and weather conditions (22). A further report (23) included a proposal to call the disease "cherry yellows". Work in New York confirmed these findings (18).

Sour cherry yellows has now been shown to result from a complex of two viruses - necrotic ring spot and prune dwarf (6, 7). Necrotic ring spot is found without prune dwarf but prune dwarf is not found in the absence of necrotic ring spot. It is generally accepted that the tree is infected with ring spot first and is thereby predisposed to prune dwarf.

Symptoms of ring spot are usually found on only a few branches the first year (20). The following year other branches show symptoms though the original area may not. In the years symptoms occur, the tree is considered in the "shock" stage. Later the trees appear normal unless yellows develops. Symptoms during the "shock" stage are most pronounced for the two weeks following petal fall. Leaves may be small and have depressed fine etching. Partial to complete rings may develop. These may become necrotic and fall out giving the leaf a tattered appearance.

Necrotic ring spot affects growth and production. Growth may be reduced 10 to 30% (9,34). Bud take in propagation may be reduced up to 50% when infected scion wood is used (31). There may be a reduction in growth of nursery trees (31). Yield reductions are reported from 20 to 56% (9,30,34). Yield will generally recover to about 90% of normal within one or two years providing yellows does not develop (31).

Symptoms of yellows (4,15,24,26) include a striking green and yellow mottling which appears on the leaves about three to four weeks after petal fall, a much reduced spur system, and long willowy terminals. The last two suggest a set of circumstances quite akin to that described previously. In addition, there is early summer leaf drop.

When the yellows complex is present there may be severe yield reductions (9,26,29,33,42). Since this is primarily the result of a reduction in the number of productive spurs, the yield reduction may occur over several years. Reduction may be greater than 50% (33). Another factor also observed is reduced fruit set resulting from pollination with infected pollen (33).

Necrotic ring spot spreads slowly in orchards less than 4 or 5 years old (8). Prune dwarf generally comes in several years after ring spot and doesn't really spread rapidly until after the trees are about 10 years old (8). Perhaps the most perplexing problem with these diseases is that they are spread by pollen (12,13,14,16,17,41). Because of this, it is almost impossible to keep them out of an orchard (especially if near other infected orchards).

These diseases have a profound effect on the sour cherry industry. Yellows will eventually move into practically all blocks. Control suggested in Michigan is aimed at retarding the movement of the viruses into cherry plantings rather than curing trees (20). Recommended practices are: purchasing virus-free trees, isolating plantings at least 100 feet (preferably 500) from existing blocks, planting solid blocks, and not replanting when a tree dies. Other practices (37) which may prove beneficial include roguing diseased trees and eliminating any factors unfavorable to tree growth.

An increase in growth might be expected to improve the situation. Cain and Parker (5) reported that extra nitrogen stimulated vegetative growth in yellows-infected trees resulting in greater spur production and increased fruiting capacity. Increased yields were noted.

Another approach to the problem is the use of gibberellic acid (GA_3). Hull and Klos (19) found that GA_3 sprays seemed to overcome some of the stunting effects of yellows. Others (3,10,28,35,36) have confirmed this observation.

GA_3 treatment results in an increase in the number of vegetative buds on the terminals. Treatment is most effective if sprays are made two weeks after petal fall. The vegetative buds on the terminals act like those described previously. The year after treatment, they develop into spurs which fruit the next year (two years after treatment). Some will tend to grow into shoots which will also help increase fruiting surface. Yields are reduced the year following the first application, with yields increased in subsequent years (28). The treatment should be repeated every year since spurs will form only the season following treatment and a lapse in the program will deter spur formation (35).

Concentrations in the range of 15 to 25 ppm GA_3 have been found to be effective (35). Parker et al (35) recommended that the GA_3 concentration be adjusted so that 30 to 40% of the lateral buds on the terminals are vegetative. In New York (3,35) the addition of 2 quarts glycerin or 1 pint Tween 20 to 100 gallons of spray with 200 to 300 gallons of spray per acre was suggested. In Michigan (33) adjuvants did not seem to improve performance. Cool and bright conditions during spraying seem conducive to best results (10). On trees which have had yellows for some time, pruning back several years' growth prior to GA_3 application should prove beneficial (35).

In addition to yield increases, Parker _et al_ (35) list other advantages to the GA_3 approach for treating yellows symptoms. Twigs are stronger and less flexible which should reduce wind whip injury and make mechanical harvesting easier and less damaging. Increased numbers of leaves from greater twig growth should help prevent wind damage to the fruit.

In many orchards that have the "blind" willowy shoots there are no symptoms of the viruses involved in the sour cherry yellows virus complex. The condition results from low vigor. The cause may be winter injury, harvester injury, or the viruses described above. In any event, the appearance and performance of the tree are the same.

Higher nitrogen applications to increase vigor should help overcome these problems (2,11,27,38,40). However, nitrogen alone may not be effective in producing the necessary increased terminal growth.

Orchards with a high percentage of spur-born fruit tend to have high yields (2,11,40). Spurs bear fruit for several years. Increasing the number of spur-born fruit usually is accompanied by an increase in fruit born laterally on shoot growth (11,40).

GA_3 should promote spur formation on "low vigor" trees in a manner similar to that described previously for trees suffering from sour cherry yellows. This hypothesis was investigated as the first part of this dissertation.

A similar problem is the flowering and fruiting of young sour cherry trees, sometimes as early as their second year in the field. This takes much of the tree's vitality and reduces terminal growth. The resulting trees are small with very little bearing surface. In many cases, they die. Use of nitrogen does not always prevent early flowering. In some of the early GA_3 investigations with sour cherry yellows, it was noted that higher concentrations resulted in an almost complete absence of flower buds on terminals (3). The second part of this dissertation investigates the possibility of using GA_3 to prevent flowering on young sour cherry trees.

The two parts of the dissertation are prepared in the style for research papers in the _Journal of the American Society for Horticultural Science_.

SECTION I

GIBBERELLIC ACID SPRAYS TO INCREASE
PRODUCTION OF SOUR CHERRY TREES
(PRUNUS CERASUS L. CV. MONTMORENCY)

Abstract. Eight-year-old sour cherry trees were sprayed with 15 or 30 ppm gibberellic acid GA_3 beginning in 1972. Some were resprayed to give the following timings: sprayed 1972; sprayed 1972 and 1973; sprayed 1972 and 1974; and sprayed 1972, 1973 and 1974. The year following treatment there were more vegetative buds on one-year-old wood of sprayed trees that non-sprayed trees. Yield was reduced in 1973 as a result of 1972 treatment. Yield was increased in 1974 as a result of the 1972 sprays. However, the combined 1973 and 1974 yields for sprayed trees were not greater than for nonsprayed trees. Thirty ppm treatments showed no effects on 1975 yields. Trees sprayed each year with 15 ppm had higher yields than nonsprayed trees in 1975. There were no differences in fruit firmness and fruit removal force among treatments.

Flower buds of the sour cherry develop laterally on the current season's terminal growth and on spurs. The following year they flower. On bearing trees, low vigor often results in all the lateral buds on the terminal growth being floral. This generally occurs when the terminal growth is less than about 20 cm long. After the year of bloom, the wood is barren of lateral vegetative growth. If some of the buds on terminal growth are vegetative, the following year they will develop into spurs which will bear fruit for several subsequent years.

Prolonged low vigor or short terminal growth results in a willowy appearance of the tree since no spurs are formed. Fruit will only be born on the previous year's terminal growth. No spurs or lateral branches will develop since no vegetative buds are on the previous year's terminal growth.

Several factors may lead to such a situation. The one most often described as the cause is sour cherry yellows virus complex. This disease is caused by a complex of two viruses - necrotic ring spot and prune dwarf (3,4). Other causes of the low vigor situation may be low nutrient levels, winter injury, or summer defoliation from cherry leafspot.

Several researchers (1,5,6,9,10) have used gibberellic acid (GA_3) sprays to combat the effects of the sour cherry yellow virus complex. Such sprays increase the number of vegetative buds on terminals. The year following treatment these vegetative buds develop into spurs which bear fruit in the following years.

The present work was initiated to determine if GA_3 sprays would be effective in producing similar results in "low vigor" trees. The trees used showed necrotic ring spot symptoms the year before the first treatment. Yellows symptoms were not observed during the treatment period.

MATERIALS AND METHODS

The trees used were in a commercial orchard in the Traverse City, Michigan area. At the outset of the work, they were 8-years old.

Gibberellic acid (GA_3)[1] was sprayed to runoff at 15 or 30 ppm. Approximately 8 liters of dilute GA_3 solution per tree were necessary. The trees were sprayed initially in 1972. Some of the trees were resprayed in 1973 and/or 1974 to give the following timing combinations at each concn: sprayed 1972; sprayed 1972 and 1973; sprayed 1972 and 1974; and sprayed 1972, 1973, and 1974. All trees which had previously been treated, were retreated in 1975. Nonsprayed trees were used as controls. A split-plot design with 3 replications and plots of 5 trees were used.

The trees were harvested mechanically and the fruit from each 5-tree plot was delivered to a water-filled standardized rectangular metal tank (2). The depth of cherries in the tank was measured with a standard probe.[2] Weight of cherries in the tank was then determined by computing volume and coverting to kilograms (1 cm depth = 8.5kg cherries).

Yield data are shown as kg per tree with mean separation by percent of control.

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[1]Pro-Gibb (3.91% liquid formulation). Abbott Laboratories, North Chicago, Illinois.

[2]Tresco, Spring Lake, Michigan

In 1973 and 1974, the flower and vegetative buds on 5 terminal shoots produced the year of treatment (each less than 20 cm long) were counted per tree. The terminal bud which is vegetative was counted each time. Data are expressed as precent vegetative buds.

Fruit firmness and fruit removal force were measured in 1974 and 1975. These data were regarded as measures of fruit maturity. Firmness was measured with a Durometer, type 00[1] (8). Fruit removal force was evaluated using a Hunter Mechanical Force Gauge[2] equipped with a slotted claw (7). A sample of 150 fruit per 5-tree plot was taken 7 days prior to harvest for each of these measurements.

RESULTS AND DISCUSSION

In none of the years of the experiment did GA_3 sprays affect yield the year of treatment. GA_3 sprays on sour cherry have been found to affect bud initiation (6) and thus should have no effect on buds formed the year before treatment.

The percentage of vegetative buds on terminal growth was increased on sprayed trees when compared with non-sprayed trees (Table 1). Previous studies (1,5,6,9,10) had

[1]Shore Instrument and Mfg. Co., Jamaica, NY. 100 units represents 113.5 g resistance.

[2]Hunter Spring Co., Lansdale, PA

Table 1. Effects of gibberellic acid (GA_3) sprays on the percent vegetative buds on sour cherry terminal growth the year following application.[z]

GA_3 Concn (ppm)	% Vegetative Buds[y]	
	1973[x]	1974
0 (Nonsprayed)	19 a	19 a
15	36 b	60 b
30	52 b	44 b

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level. Means followed by the same letter are not significantly different.

[y]% Vegetative Buds = (Number of Vegetative Buds/Total Number of Buds) x 100.

[x]The years shown were the years counts were made during bloom. The GA_3 was applied the previous year in each case. The terminal growth was that produced the year of treatment.

similar findings. There were no differences in the total number of buds (flower + vegetative) in either year between sprayed and nonsprayed trees. Therefore, there was an increased number of vegetative buds present, each with the potential of becoming a spur.

Yield data for 1973 and 1974 as affected by 1972 GA_3 sprays are presented in Table 2. The 1973 yields were lower than 1974 because of cool weather during the 1973 bloom period which hindered bee movement, pollination, and fertilization. The 1973 yields for trees sprayed in 1972 was less than for nonsprayed trees. There were fewer flower buds on the terminals of the sprayed trees in 1973 and thus the yield was less since there were few spurs on these trees.

In 1974 there was an increase in yield from trees sprayed in 1972 (Table 2). It was assumed that the vegetative buds formed in 1972 as a result of the GA_3 spray developed into spurs in 1973 and were bearing fruit in 1974.

There were no differences in combined 1973 and 1974 yields between sprayed and nonsprayed trees (Table 2). The increase in yield in 1974 was approximately equal the decrease in yield in 1973 for trees sprayed in 1972.

Yield in 1974 was increased on trees sprayed in both 1972 and 1973 with 15 ppm GA_3 (Table 3). It was assumed as mentioned above that spurs formed as a result of the

Table 2. Effects of 1972 gibberellic acid (GA_3) sprays on sour cherry yields in 1973 and 1974.[z]

GA_3 Concn (ppm)	1973 Yield		1974 Yield		1973 Yield + 1974 Yield	
	Kg/Tree	% of Nonsprayed	Kg/Tree	% of Nonsprayed	Kg/Tree	% of Nonsprayed
0 (Non-sprayed)	38	100 a	52	100 c	90	100 e
15	29	76 b	65	126 d	94	105 e
30	27	64 b	71	136 d	98	109 e

[z]Mean separation of % of control columns by Duncan's Multiple Range Test, 5% level. Means followed by the same letter are not significantly different.

Table 3. Effects of GA_3 sprays in both 1972 and 1973 on 1974 yield of sour cherry trees.[z]

Ga_3 Concn[y] (ppm)	1974 Yield	
	Kg/Tree	% of Nonsprayed
0 (Nonsprayed)	52	100 a
15	68	131 b
30	56	108 a

[z]Mean separation by Duncan's Multiple Range Test, 5% level. Means followed by the same letter are not significantly different.

[y]The GA_3 concn shown was applied to the same trees in both 1972 and 1973.

1972 sprays were bearing fruit in 1974. The 30 ppm spray in 1973 may have prevented some flower bud initiation on spurs. This could account for yield in 1974 from trees sprayed with 30 ppm in 1972 and 1973 not being as high as yield from trees sprayed with 15 ppm.

Trees sprayed with 15 ppm in 1972 and 1973 or 1972, 1973, and 1974 had the highest yields in 1975 (Table 4). It was assumed that an extensive spur system had developed as a result of the 15 ppm sprays in 1972 and 1973. Since spraying trees with 15 ppm GA_3 in 1974 which had been sprayed in 1972 and 1973 did not decrease yield, it is suggested that annual spraying with 15 ppm should increase yields of sour cherries when compared with nonsprayed trees. These data also suggest that the effects will be greater the more years GA_3 sprays are used.

There were no differences in 1975 yield among the 30 ppm treatments. Perhaps the 30 ppm GA_3 rate was sufficient to prevent some flower bud initiation on spurs. Other observations have shown that 25 ppm GA_3 may somewhat reduce flower bud initiation on spurs (unpublished data). It is suggested that treatment with 30 ppm GA_3 does not provide as consistent results as treatment with 15 ppm.

There were no differences observed in fruit removal force or in fruit firmness in 1974 or 1975. These two measurements were regarded as indications of fruit

Table 4. Effects of 15 ppm GA_3 sprays on 1975 yields of sour cherry trees.[z]

	1975 Yield	
Years Sprayed[y]	Kg/Tree	% of Nonsprayed
Nonsprayed	32	100 ab
1972 only	38	121 a c
1972 and 1973	42	134 cd
1972 and 1974	26	82 b
1972, 1973, and 1974	50	158 d

[z]Mean separation by Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

[y]15 ppm GA_3 was applied to the same trees in the years noted.

maturity. Thus it was concluded that the GA_3 sprays had little effect on fruit maturity.

GA_3 sprays increased the number of vegetative buds produced on terminal growth. Yields were reduced on sprayed trees the year following the initial treatment. The second year following treatment yields for trees sprayed initially were increased. These data were consistent with other findings (1,5,6,9,10).

By the end of the experiment yields were highest for trees sprayed with 15 ppm GA_3 in the first 2 years of the experiment or in the first 3 years of the experiment. It was suggested that annual treatment with 15 ppm GA_3 should result in increased yields compared with nonsprayed trees.

Trees sprayed with 30 ppm GA_3 did not have consistently higher yields than the nonsprayed trees. It was suggested that the 30 ppm GA_3 rate did not provide as consistent results as the 15 ppm. Perhaps the 30 ppm GA_3 sprays prevented some flower bud initiation on spurs.

There were no differences in fruit maturity as a result of GA_3 sprays as measured by fruit removal force and fruit firmness.

Since there were no differences in yields the year of treatment, no effects on fruit maturity the year of treatment, and no effect on the total number of buds on terminal growth, it is suggested that the GA_3 sprays were affecting only bud initiation.

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SECTION II

GIBBERELLIC ACID SPRAYS TO REDUCE FLOWERING OF YOUNG SOUR CHERRIES (PRUNUS CERASUS L. CV. MONTMORENCY)

Abstract. In 1973, 2 and 3 year-old sour cherry trees in 4 Michigan orchards were sprayed with gibberellic acid (GA_3) (45 and 90 ppm) 2 weeks after full bloom. These treatments reduced flowering on terminals in 1974; however, there was little effect on flowering of spurs. In 1974, treatments were continued in 2 orchards. GA_3 (25, 50, and 100 ppm) in single and repeat applications was sprayed at 2, 3, and 4 weeks after full bloom. To reduce flowering to desired levels, 2 applications of at least 50 ppm each were necessary. Leaf nitrogen, shoot length, and intermode length were not affected by GA_3 treatment.

Many factors (drought, low nitrogen, winter injury, leaf spot, nematodes) may reduce a sour cherry tree's vigor in the early "non-bearing" years. Often this occurs the year a tree is planted. The tree usually will flower and fruit the year following the reduction in vigor. The low-vigor situation usually persists and results in a small tree with low production when "bearing age" is reached.

Hull and Klos (3) and Hull and Lewis (4) found that a post-bloom spray of gibberellic acid (GA_3) at concentrations in the range of 100 ppm will greatly reduce bloom the following year. Flower bud initiation does not occur following the GA_3 spray. The vegetative buds which are present grow the year after treatment developing into shoots or spurs.

Since the work mentioned above, other researchers (1,2,6,7) have reported the GA_3 sprays (15-25 ppm) will help overcome effects of the sour cherry yellows virus complex. The number of vegetative buds that develop on terminal growth the year of treatment is increased. The year following treatment these vegetative buds develop into spurs which bear fruit in subsequent seasons.

The present work was initiated to determine if GA_3 sprays at higher concn could be used to eliminate flowering and fruiting on young sour cherry trees.

MATERIALS AND METHODS

Trees used in this work were in Michigan commercial sour cherry orchards. In each case a split-plot design with 5 single-tree replications was used. All sprays were applied dilute to the point of runoff. On 2 and 3 year-old trees, about 3 liters of solution were necessary. On 4 year-old trees, about 4 liters were necessary. Spray timings were as noted in the text and tables.

During bloom the year following treatment the number of flower and vegetative buds on 5 shoots per tree were counted. These shoots were the terminal shoots the year of treatment. Those counted were less than 20 cm long. On such terminal growth, normally most of the lateral buds would be floral (5). Data are presented in the tables as percent flower buds.

To evaluate flowering on spurs the following visual rating scheme was used for each tree:

1 = Little flowering (approx 5% or less of normal)

2 = Some flowering (approx 50% or less of normal)

3 = Normal flowering

Vegetative growth was evaluated by measuring the length of and counting the number of buds on the current season's terminal growth. The most distal and the third most distal terminal shoots on the lowest limb of each tree were used for these measurements.

In 1974 and 1975, leaf samples were collected at location 2. The median leaf on the current season's terminal growth was taken in late July. For each tree these were dried, ground to 20 mesh, and analyzed by the Kjeldahl method.

RESULTS AND DISCUSSION

Treatments were made at 4 locations in 1973. At locations 1 and 2, trees were 2 years old; at locations 3 and 4, 3 years old. All applications were made 2 weeks after full bloom. At the first 3 locations, 3.91% gibberellic acid (GA_3)[1] liquid formulation was used. At location 4, a powder formulation of GA_3[2] was used to mix 50 ppm, 50 ppm + Regulaid, 3 and 100 ppm treatments. The liquid formulation was used for the 90 ppm treatment.

The data in Table 1 and 2 demonstrate that all GA_3 sprays reduced the number of flower buds on 1973 terminal growth as counted in 1974 when compared with nonsprayed trees. Bukovac (unpublished data) had similar findings. However, observations showed that there was little, if any, effect on flower formation on spurs. We hypothesized that flower bud initiation occurs later on spurs than on terminals.

To test this hypothesis, treatments were initiated at two locations in 1974. Trees at location 1 were 3 years old; those at location 2, 4 years old. GA_3 rates were 25 ppm, 50 ppm, and 100 ppm. Timing (relative to full bloom) is noted in the tables. A repeated dosage implies that the given concn was applied each time.

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[1]Pro-Gibb. Abbott Laboratories, North Chicago, Illinois.

[2]Pro-Gibb Plus. Abbott Laboratories, North Chicago, Illinois.

3 Regulaid. Colloidal Products Co., Petaluma, CA.

Table 1. The effects of 1973 GA_3 sprays on flowering of 1973 terminal growth as counted in 1974 at locations 1, 2, and 3.[z]

GA_3 Concn (ppm)	% Flower Buds		
	Location 1	Location 2	Location 3
0 (Nonsprayed)	83 a	55 c	70 e
45	16 b	7 d	24 f
45 + Regulaid	22 b	8 d	21 f
90	19 b	11 d	19 f

[z]Mean separation within columns by Duncan's Multiple Range Test, 1% level. Means followed by the same letter are not significantly different.

[y]% Flower buds = (Number of flower buds/Total number of buds) x 100.

Table 2. The effects of 1973 GA_3 sprays on flowering of 1973 terminal growth as counted in 1974 at location 4.[z]

GA_3 Concn (ppm)	% Flower Buds[y]
0 (Nonsprayed)	81 a
50	26 b
50 + Regulaid	30 b
90 (Liquid formulation)	20 b
100	30 b

[z]Mean separation by Duncan's Multiple Range Test, 1% level. Means followed by the same letter are not significantly different.

[y]% Flower buds = (Number of flower buds/Total number of buds) x 100.

The data in Table 3 represent flowering on 1974 terminal growth for trees at location 1 as counted in 1975. On many trees at location 1, there were not 5 shoots less than 20 cm long; therefore, the shortest 5 present were evaluated. This apparently high vigor could also account for nonsprayed trees having only 48% flower buds on 1974 terminal growth. Applications of GA_3 at 50 ppm or 100 ppm 3 wk and 4 wk or 4 wk after full bloom markedly reduced flowering. There were no effects from GA_3 treatment on the total number of buds (flower buds + vegetative buds).

Applications of GA_3 in 1974 at 50 ppm or 100 ppm, 2wk and 3 wk, 3 wk and 4 wk, or 4 wk after full bloom almost eliminated flowering on spurs as evaluated in 1975 at location 1 (Table 4).

At location 2, GA_3 sprayed 3 wk and 4 wk after bloom at 50 ppm markedly reduced flowering on 1974 terminal growth as counted in 1975 (Table 5). Spraying with 100 ppm 2 wk, 3 wk, and 4 wk after bloom or 3 wk and 4 wk after bloom also markedly reduced flowering on 1974 terminal growth as counted in 1975 (Table 5).

At location 2, GA_3 sprays in 1974 at 50 ppm 2 wk, 3 wk, and 4 wk or 3 wk and 4 wk after bloom reduced flowering on spurs as evaluated in 1975. These same two timings at 100 ppm GA_3 in addition to the 4 wk only timing at 100 ppm GA_3 reduced flowering on spurs (Table 6).

Table 3. Effect of 1974 GA_3 sprays on percent flower buds[y] on 1974 terminal growth as counted in 1975 at location 1.[z]

Timing (after full bloom)	GA_3 Concn 25 ppm	50 ppm	100 ppm
2 wk	23 a	15 e	22 h
2 wk + 3 wk	13 ab	9 efg	19 h
3 wk	19 ab	13 ef	21 h
3 wk + 4 wk	11 b	6 g	10 i
4 wk	19 ab	8 fg	7 i

[z]Mean separation within columns by Duncan's Multiple Range Test, 1% level. Means followed by the same letter are not significantly different.

[y]Percent flower buds for nonsprayed trees was 48.

Table 4. Effect of 1974 GA_3 sprays on rating of spur flowering in 1975[y] at location 1.[z]

	GA_3 Concn		
Timing (after full bloom)	25 ppm	50 ppm	100 ppm
2 wk	3.0 a	3.0 c	3.0 e
2 wk + 3 wk	2.2 b	1.4 d	1.0 f
3 wk	3.0 a	3.0 c	2.8 e
3 wk + 4 wk	2.0 b	1.0 d	1.0 f
4 wk	2.8 a	1.4 d	1.0 f

[z]Mean separation within columns by Duncan's Multiple Range Test, 1% level. Means followed by the same letter are not significantly different.

[y]Rating scheme - see text. Rating on nonsprayed trees was 3.0.

Table 5. Effect of 1975 GA_3 sprays on percent flower buds[y] on 1974 terminal growth as counted in 1975 at location 2.[z]

	GA_3 Concn		
Timing (after full bloom)	25 ppm	50 ppm	100 ppm
2 wk	83 a	70 c	48 g
2 wk + 3 wk	54 b	51 d	23 hi
2 wk + 3 wk + 4 wk	26 b	25 de	10 j
3 wk	58 b	32 de	28 h
3 wk + 4 wk	33 b	12 f	7 j
4 wk	52 b	35 de	17 i

[z]Mean separation within columns by Duncan's Multiple Range Test, 1% level. Means followed by the same letter are not significantly different.

[y]Percent flower buds on nonsprayed trees was 82.

Table 6. Effect of 1974 GA_3 sprays on rating of spur flowering in 1975[y] location 2.[z]

Timing (after full bloom)	GA_3 Concn 25 ppm	50 ppm	100 ppm
2 wk	3.0 a	3.0 c	3.0 e
2 wk + 3 wk	3.0 a	3.0 c	2.6 e
2 wk + 3 wk + 4 wk	2.2 b	1.6 d	1.0 f
3 wk	3.0 a	2.6 c	2.4 e
3 wk + 4 wk	2.6 ab	1.4 d	1.0 f
4 wk	2.8 a	2.6 c	1.6 f

[z]Mean separation within columns by Duncan's Multiple Range Test, 1% level. Means followed by the same letter are not significantly different.

[y]Rating scheme - see text. Rating on nonsprayed trees was 3.0.

Thus it seems that at least 2 sprays are necessary to almost eliminate flowering on both terminal growth and spurs. GA_3 (50 ppm or 100 ppm) applied 3 weeks after bloom and again 4 weeks after bloom perform about equally. These data suggest that flower bud initiation occurs later on spurs than on terminal growth.

In 1974 and 1975 terminal growth at location 2 was evaluated as mentioned previously. Trees were given the same GA_3 sprays in 1975 as in 1974. There were no differences in terminal growth length, number of nodes or internode length among treatments or between sprayed and nonsprayed trees in either year.

There were no treatment effects on leaf nitrogen in either year. All values were within the "normal" range used by the Michigan State University Plant Analysis Laboratory.

The terminal growth and total number of nodes data and leaf nitrogen data suggest that the GA_3 was not increasing vigor when judged by terminal growth. However, there were many more potential growing points with the increased number of vegetative buds as a result of GA_3 sprays. It is suggested that the GA_3 is directly interfering with flower bud initiation rather than altering the vegetative - reproductive competition on terminal growth.

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SUMMARY

Field plots were established in 1972 in a commercial Michigan orchard to test the feasibility of using GA_3 sprays to increase production of low vigor sour cherry trees. There were no effects from GA_3 on yields the year of application. The percentage of vegetative buds was increased by GA_3 sprays (15 ppm or 30 ppm) on terminal growth as evaluated during bloom the year after application. Yields in 1973 were decreased as a result of 1972 GA_3 sprays when compared with nonsprayed trees. Yields in 1974 were greater from trees sprayed in 1972 than from nonsprayed trees. There were no differences between sprayed and nonsprayed trees for combined 1973 and 1974 yields as affected by 1972 GA_3 sprays.

There were no differences in 1975 among 30 ppm treatments. Yields were higher in 1975 from plots which had been sprayed with 15 ppm GA_3 in 1972 and 1973 or in 1972, 1973, and 1974. These data suggested that annual applications of 15 ppm GA_3 should result in increased yields after a decrease in yield the year following the year of first application. No differences in fruit firmness or fruit removal force were found between sprayed and nonsprayed trees.

In the second experiment higher concentrations of GA_3 were sprayed on young sour cherry trees to try to prevent flowering. In 1973, GA_3 sprays were applied to 2 and 3

year-old trees in 4 Michigan orchards two weeks after full bloom. GA_3 concentrations were 45 ppm and 90 ppm. The percentage of flower buds on 1973 terminal growth as counted during the 1974 bloom season was greatly reduced by all GA_3 sprays when compared with terminal growth on nonsprayed trees. There seemed to be no effect on flowering of spurs from the GA_3 sprays.

In 1974, GA_3 was sprayed 2, 3, and 4 weeks after full bloom at 25 ppm, 50 ppm, and 100 ppm in single and repeat applications on trees in 2 Michigan orchards. GA_3 sprayed at 50 ppm or 100 ppm 3 weeks after bloom and again 4 weeks after bloom eliminated most flowers on both terminal growth and spurs as evaluated during the 1975 bloom.

There were no differences in terminal growth, number of nodes on terminal growth, internode length, or leaf nitrogen between sprayed and nonsprayed trees.

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