Chemical Thinning Studies on Peaches in Utah

Ramzi Mustafa Khalidy

Utah State University

CHEMICAL THINNING STUDIES ON PEACHES IN UTAH

by

Ramzi Mustafa Khalidy

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Horticulture

UTAH STATE AGRICULTURAL COLLEGE
Logan, Utah

1955

ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to Dr. R. A. Norton for his help in the direction of the thesis and for his patient and constructive editing of the manuscript. I am also grateful for the valuable suggestions of Drs. L. H. Pollard, R. W. Ames, and H. B. Peterson, members of the guidance committee. My sincere thanks are due to Professor Gene Oberly, Mr. O. C. Kirk, Professor R. K. Gerber for their technical assistance; Professor B. H. Crandall and Dr. D. K. Salunkhe for helping me with the statistical analyses; Mrs. E. W. Norton for typing the manuscript; and last, but not least, to both my parents, Dr. and Mrs. Mustafa Khalidy, whose moral and financial support made this study possible.

Ramzi Mustafa Khalidy

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Investigations on chemical thinning of peaches by use of blossom and post blossom sprays have been in progress since the last decade mainly in the United States, Canada, and some European countries. Horticulturists (5, 10, 12, 33, 45) are attempting to find new means to minimize the expense of hand thinning. The high cost of the hand thinning operation has caused many growers to underestimate the importance of this practice, and as a result their orchards have fallen into the biennial bearing habit. In addition, the fruit from unthinned orchards was not acceptable on the market since it was small in size, lacked color, and often was infected with insects and diseases because of its hanging in close clusters on the trees.

Results of chemical thinning tests to date have indicated that this practice can readily fit into the grower's spray program. In some areas specific chemicals and concentrations have been recommended after extensive studies on many varieties. In Utah very little work has been carried on to determine which chemicals and concentrations are best for thinning peaches under our climatic conditions. It is hoped that this study will serve as a beginning for future investigations on chemical thinning of peaches for the state of Utah.

REVIEW OF LITERATURE

Definition of plant regulators

Throughout this text, for the sake of consistency, the name "plant regulator" shall be used to indicate the synthetic plant hormones. The definition of a plant regulator was proposed by Van Overbeek, Tukey, Went and Muir (48) at the request of K. V. Thimann, President, American Society of Plant Physiology. Their definition is as follows: "Organic compounds, other than nutrients, which in small amounts promote, inhibit, or otherwise modify any physiological process in plants." Larsen (25), a member of this committee, was not in agreement with the use of the term "plant regulator" and offered the term "growth substance" to be used instead. This Norwegian worker did not believe that the term "plant regulator" complied with the true biological meaning of a regulator which is: "A substance by which living organisms maintain the harmony and balance of their various physiological processes in spite of the action of external factors."

Abbreviations of chemicals cited

Dinitro compounds.

Elgetol	20% sodium dinitro cresylate
Krenite	20% sodium dinitro cresylate
DN-289 (DNOSBP)	2 sec - butyl 1-4,6 - dinitrophenol
DN-1	40% dinitro-ortho-cyclohexyl-phenol
DN-2	40% dinitro-ortho-cresol
DN-111	20% dicyclo-hexyl amide salt of dinitro-ortho-cyclohexylphenol
DN Dry Mix No. 1	(DNOCHP), 2 cyclohexyl 1-4, 6-dinitrophenol

DN Slurries	(DNOC), 4,6-dinitro-ortho cresol

Plant regulators.

NAA	Napthalene acetic acid
NaNAA	sodium salt of napthalene acetic acid
App-L-Set	sodium naphthalene acetate
Maleic Hydrazide	1,2-dihydropyridazene-3, 6-dione (MH-40)
Amid-Thin	a-naphthylacetamide
CMU	chlorophenyl 1, 1-dinethyl urea
3-Cl-IPC (L-461 and T515)	Isopropyl N-3 chlorophenyl carbamate
T-516	Isopropyl N (3 methyl) carbamate
T-595	2 chloroethyl N- (3 chlorophenyl) carbamate
T-596	2 (1 chloropropyl) N-(3 chlorophenyl) carbamate
T-640	Allyl N-(3 chlorophenyl) carbamate
CIPA	Parachlorophenoxyacetic acid

The mechanism of thinning with chemicals

Thinning the flowers. Van Overbeek (47) states that the three periods of fruit drops occurring in nature to be (1) both unpollinated and unfertilized blossom drop, (2) June drop, and (3) pre-harvest drop. Both the unpollinated or unfertilized blossom drop and the June drop are the result of the formation of a true abscission layer due to auxin deficiency. Nitsh (35) indicates that all enlargement ceases after the flower opens unless fertilization of the ovule takes place. There is also a drop in auxin content of the flower when it opens, and unless the pollen supplies this deficiency in auxin, the flowers are shed sooner or later.

There are two types of chemicals used in thinning flowers: the dinitro and the plant regulator type. Fisher (16) states that dinitro sprays thin the blossoms in two ways: (1) by the killing of the pollen grain resting on the stigma of the open flower, and (2) by producing a "shock effect" upon the life process of the flowers and young fruit.

Luckwell (27) discusses the thinning of apple flowers with the plant regulator, NAA. This chemical prevents the fertilization of the flowers by causing a state of incompatibility between the pollen tube and the styler tissue, which in turn inhibits pollen tube growth. According to Luckwell, this type of blossom thinning does not increase the physiological drop termed the June drop.

Thinning the developing fruit. The three stages of fruit growth of a peach are (44),

1. A rapid development of the fruit due mainly to increase in seed parts. This stage is similar in time and extent of growth for all varieties.
2. A period of active growth of the embryo, with the seed formation and the hardening of the stone. During this period--which lasts from five to 40 days, depending on the variety--the growth of the nucellus, integument, and pericarp are arrested.
3. A period of rapid growth of the flesh to maturity.

Abortion of the developing fruit is a result of the pericarp starting to grow while the embryo is still in a period of rapid growth (33). As a result, the embryo does not reach full size and the nucellus and integuments collapse, causing the fruit to ripen rapidly and to drop. Murneek also found that NAA, when used to thin apples, caused a collapse of the seed, endosperm, and nucellus of the fruit which subsequently dropped. This last effect seems to be the one that actually results in abscission of a large number of the young fruits.

According to Van Overbeek (47) the pre-harvest drop of fruit is a result of exaggerated cell elongation, caused by a high auxin content in the fruit and a slow rate of cell elongation.

Trullinger (43), citing the work of the Missouri Experiment Station, points out that the use of NAA causes a temporary retardation in the respiration rate of cells along the abscission zone of the pedicel, and also a strong and prolonged inhibition of embryo development.

Abbott (3), reporting on investigations at Long Ashton, has shown that NAA applied as a post-blossom spray caused seed abortion and retarded formation of the abscission layer.

Advantages and disadvantages of chemical thinning

Advantages. Experimental evidence both in Canada (15, 16) and the United States (6, 32) has shown that chemical thinning over a period of several successive years has induced annual bearing where biennial bearing had been prevalent.

Davidson and Fisher (10, 16) show that blossom thinning with chemicals permits the remaining blossoms to utilize all available nutrients earlier in the season, while hand thinning is completed too late to be of great benefit to the developing fruit. Chemical thinning, according to these workers, cuts down on the expense of hand thinning.

A vital advantage of chemical thinning was reported by Batjer (6). According to this worker it produced a larger crop and also it increased the shoot growth and bud formation for the succeeding year. This was also found to be true in Canada (16).

In Canada (16) and the United States (20) it has been found that chemical thinning has cut down the expense of hand thinning appreciably.

Disadvantages. Perhaps the most important disadvantage of chemical thinning is that in many areas it is usually practiced before all danger of spring frosts has passed, thus risking total loss of crop from a subsequent frost. Furthermore, it is extremely difficult to obtain the desired degree of thinning with chemicals, especially as blossom sprays under the variable conditions occurring each spring (5, 10).

In addition, the material itself may lack one or more of the qualities desired of a good thinning agent (17). The material used in thinning should guarantee (1) sufficient thinning, (2) uniform thinning, (3) no foliage damage, and (4) thinning of the fruit late enough to avoid further loss due to frost.

Luckwell (27) reports that the expected increase in fruit size did not always follow thinning with NAA; in many cases the sprayed branches resulted in smaller fruit. The plant regulator 3-Cl-IPC inhibited fruit growth on Halehaven, according to Marth and Prince (30). However, these workers found that the same treatment caused larger fruit on Afterglow, Hiley, Laterose, Raritan Rose, and Triogem, thus demonstrating that chemical thinning may be both advantageous and disadvantageous, depending on the variety.

Marth and his co-workers (29, 30) showed that fruit treated with 3-chloro-IPC was softer at harvest than fruit from unsprayed trees. It was also noticed that the application of the plant regulator 2,4,5,T resulted in softer fruit when used as a pre-harvest drop spray on 18 varieties. The earlier varieties were more sensitive and some had distorted fruit.

Further disadvantage of some chemicals is that their use may be accompanied by various degrees of leaf and fruit injury. Marth and

Prince (30) found that 200 ppm of chloro-IPC caused leaf injury on the sprayed trees. At the higher concentrations of 600 ppm of chloro-IPC Burkholder (9) noted "flagging" and low vigor of Elberta trees throughout the season.

At Long Ashton, England, NAA applied at full bloom often caused foliage damage, which offset the benefit of its use as a thinning agent (3). Batjer (6), in Washington, noticed a "flagged" appearance of the foliage of peaches for three to four weeks after the application of NAA at concentrations above 20 ppm. When 30 ppm or higher were used, the "flagging" condition was followed by severe foliage yellowing and occasional killing of terminal shoot tips. Similar shoot tip injury from NAA at six to 12 ounces (15-30 ppm) was reported by Southwick and Weeks (39).

Thinning stone fruits

Mechanical methods. It is common knowledge (31) that hand thinning is expensive, and that costs may be reduced by the use of the rubber hose method, fan-belt method, or high pressure water sprays to remove surplus flowers. The pole method has been used in thinning young fruits for years.

It is well known that some type of thinning is necessary since the average sized peach tree usually sets much more fruit than it can mature to a desirable commercial size (21). Nature may thin some buds by severe winter temperatures and additional blossoms by spring frosts, but the remaining fruit may require even further thinning. Thinning prevents the breaking of limbs due to the weight of a heavy crop and reduces the ravages of worms and rot between the close-hanging fruit (2).

Dorsey and McMum (11) have studied three methods of thinning:

(a) Thinning by distance (arbitrary spacing of five to 10 inches between fruits). This may be inadequate since spacing cannot be kept uniform between the fruits because of differences in tree size and varietal clustering.

(b) Leaf to fruit ratio (thinning to a fruit-leaf ratio of 1 to 40 or 1 to 50). This method is not practical commercially, but could be used if the ratio of leaves to fruit were estimated rather than counted.

(c) Thinning as to total load of fruit (regulating the thinning practices according to the total yield and size desired). This method is practical under dry conditions.

If a grower has a clear understanding of these three methods, he can supplement and interchange for best results.

Dorsey and McMum (11) and Ashton and his co-workers (4) have shown that heavy pruning and application of nitrogenous fertilizers do not increase the size of the fruit on a tree that is heavily loaded with fruit.

Chemical thinning.

Physical factors affecting the degree of thinning. Batjer and Rogers (7) propose one reason for failure to secure satisfactory thinning as being caused by favorable weather conditions at bloom time which, in turn, induce a heavy set of fruit regardless of chemical thinning.

Batjer (5) gives a list of physical factors to consider before spraying at full bloom as follows:

1. time of the spray application (usually around 95 percent full bloom).
2. material used (concentration and the susceptibility of the

variety to a particular chemical).

3. spray application method (high pressure and air blast type equipment are best).
4. vigor of tree (the weaker the tree, the more the reduction in set).
5. pollination (adequate pollination weather causes higher set).
6. weather during the bloom opening period (cool and rainy or windy weather produces weaker fruit which is easier to thin).
7. minimum temperatures following the spray application (it is thought that dinitro sprays reduce the blossoms' resistance to low temperatures).
8. prolonged rains after spraying (rain for long stretches results in greater set reduction while short rains after the spray has dried have no particular effect).
9. weather conditions before and after the spraying operation (the effect of weather and temperature during blooming period and rain following the spray application are summarized in Table 1).

Table 1. Effect of weather and temperature during the blooming period

Weather during bloom period	Temperature	Rain following spray	Thinning result
a. Good	High	No	Underthinning
b. Good	Low	No	Moderate
c. Good	High	Yes	Moderate
d. Good	Low	Yes	Moderate to heavy
e. Poor	High	No	Moderate to heavy
f. Poor	Low	No	Heavy
g. Poor	High	Yes	Heavy
h. Poor	Low	Yes	Very heavy

Thinning with dinitro compounds.

General. Fisher and his co-workers (15) urge caution in the use of dinitro sprays on peaches since the peach tree is very susceptible to dinitro injury in damp weather.

Concentration. Usually the same concentrations of the dinitro compounds can be used for both the peach and apple (8, 19). However, Batjer (6) has found that in many cases higher concentrations have proved more effective on peaches. Results with dinitro sprays have been unpredictable, which makes it difficult to recommend definite concentrations for any one variety.

Batjer and Rogers (7) found the concentration of one to two pints of dinitro spray per 100 gallons effective in thinning apples. With peaches one and $1\frac{1}{2}$ pints of the same material caused some reduction in fruit set, while the two and three pint concentrations were generally more effective.

Timing with the dinitro sprays. One of the reasons for not receiving satisfactory thinning is due to the spray being applied too late, i.e., at the full bloom stage or later (7). The best time to apply the spray is when 75 - 90 percent of the flowers are open.

Best results with peach thinning at full bloom have been achieved when a rather constant and uninterrupted opening of blossoms occurs over a period of three to five days (6). In some cases Elgetol sprayed four days after full bloom has given better results than when applied at full bloom, and in others delayed spraying was of no benefit. Elgetol is difficult to administer to an orchard of many varieties in which there is more than one period of full bloom.

In Canada, Bradt (8) reports that the thinning effect was less apparent on trees sprayed when 100 percent of the blossoms were open than on trees that had fewer blossoms open. When, as in some seasons, the bloom period is extended over a long period, and there is no one time when 90 to 95 percent of the blossoms are open, it is necessary to apply two sprays a few days apart rather than a single application.

Batjer (6) gives as one reason for the importance of accurate timing on peaches the fact that the peach blossoms have a very short and thick stem compared to the long, slender, highly exposed stems of the plum, pear and apple flowers. This stem structure, and the small leaf area of the peach tree at blossom time, does not favor the "shock" effect in thinning the flowers. The flowers must be thinned by stopping the process of fertilization.

Edgerton and Hoffman (12) have proclaimed that the fruit buds on the trees thinned with dinitro sprays were more cold-hardy than those thinned with the plant regulators, while the latter were still more hardy than buds on the untreated trees.

Elgetol or Krenite, the commercial names for sodium dinitro cresylate (20 percent), are perhaps the most widely used of the dinitro chemicals. Nevertheless, experimental results with this chemical are extremely variable as may be seen by the discussion to follow.

Extensive tests by Havis (18) exemplify the importance of timing and concentration. He reports:

1. underthinning with Elgetol at $\frac{1}{2}$, 1 and $1\frac{1}{2}$ pints per 100 gallons before bloom and $\frac{1}{2}$ and 1 pint at full bloom;
2. moderate thinning with $1\frac{1}{2}$ pints at full bloom and 1 pint four days later; and
3. overthinning when $1\frac{1}{2}$ pints were used four days after bloom instead of 1 pint as in (2).

Davidson (10) indicates that there is a varietal difference as to degree of thinning with the dinitro sprays. The Halehaven, Early

Elberta and Early Halehaven are the most difficult to thin, whereas Red Haven and Elberta thin more easily.

Fisher and his co-workers (15) noted that 1.5 pints per 100 gallons (Imperial measure) at 50 percent blossom opening, and as a double application, did not reduce set when good weather existed during bloom. Furthermore, while a 20-pint concentration thinned the fruit moderately in dry weather, it completely killed the fruit and defoliated the trees when rain followed.

Three years of inconsistent results with Elgetol in Missouri caused Hibbard and Murneek (19) to recommend the use of plant regulators for thinning since the timing with the latter was not so critical. Similar difficulties with Elgetol for peaches have been reported in New York (21, 41) and in Canada (8).

In New York, Southwick, Edgerton, and Hoffman (40) have shown that thinning with Elgetol and Krenite at 95 percent of full bloom induced larger yields and larger fruit size, and that Krenite was more effective in reducing the set on peaches than was Elgetol.

Trullinger (43), summarizing the data from experiment stations throughout the country, concluded that Elgetol seems to be impractical for thinning peaches.

DN 289 (Elgetol 318) (DNOSBP). This material has shown considerable promise as a thinning agent when used at half the concentration of Elgetol-20 (6, 7). Moreover, the chemical is easier to handle and cheaper than Elgetol 20, and is less injurious to orchard legume cover crops.

Davidson (10) recommends a concentration of 1/2 to 3/4 pints per 100 gallons of DN-289 for Halehaven and three-fourths of these amounts for Elberta and Valiant. In New York (41) DN-289 at 0.5 pints was more effective than both 0.5 pints of DN-1 and one pint of Elgetol-20.

In Canada this chemical has given variable results with different varieties, and Bradt (8) recommends the use of 0.5 pints to 1.5 pints (Imperial measure) concentration, depending on the variety. On Early Halehaven, 1.25 pints of DN-289 slightly overthinned the crop in 1948, did not show any thinning in 1949, and gave the right amount of thinning in 1953. However, DN-289 proved to be better than DN-1 in thinning peach blossoms. Since timing of the spray is important, DN-289 should be applied when 90 to 95 percent of the blossoms are open.

Burkholder (9) indicates that although both DN-289 and DN-1 are erratic in their action, DN-289 is preferable. When used on the heavy setting varieties such as Halehaven and Jubilee, DN-289 must be applied in two sprays of 0.75 pints per 100 gallons concentration. The first spray should be applied when the pistils are just protruding from the expanding bud, and the second spray at full bloom. For Elberta variety 0.5 pints concentration is recommended.

Edgerton and Hoffman (12) gave the following concentrations of DN-289 as most effective: on Golden Jubilee 15 ppm, on Raritan Rose 20 ppm, on Halehaven 30 ppm, and 40 ppm on Redhaven. They concluded that these concentrations may not show the same results from one year to another and from one locality to another, as the conditions affecting tree growth and fruit set differ.

<u>DN-1</u>. Southwick and his co-workers (40) compared Elgetol-20, Krenite, DN-1, DN-2, DN-111, a water soluble powder containing 40 percent of ammonium dinitro-ortho-cresylate, App-L-Set, and methyl naphaleneacetate. All were applied at 95 percent of open blossoms. DN-1 proved

to be the most consistent of all materials tested in reducing fruit set. The optimum concentration was from 3 to 3.5 ounces of soluble toxicant per 100 gallons. This concentration overthinned young Elberta trees and older trees that had a reduced number of live flower buds per foot of shoot growth. On the heavy setting varieties such as Veteran and Halehaven, higher concentrations of 4.5 to 5 ounces or slightly more were required.

Batjer (6) reports that when used at the same concentration, DN-1 and Elgetol-20 produced the same amount of thinning.

Southwick, Hoffman and Edgerton (41) indicate that at 95 percent bloom, DN-289 at 0.5 pints was more effective than DN-1 at 0.5 pounds. Elgetol-20 at one pint and DN-1 produced the same fruit size although Elgetol was slightly more effective in reducing set.

In Canada (8) DN-1 at a concentration of 0.75 to 1.0 pounds did not show any reduction in set because the concentration was thought to be low.

DN Dry Mix No. 1. Davidson (10) obtained a good reduction in set with DN Dry Mix No. 1 at 90 to 95 percent bloom, and recommends 12 oz. to one pound per 100 gallons for Halehaven, Early Halehaven, and Early Elberta. This rate is also suggested for Red Haven while the concentration for Elberta and Jubilee should be reduced to eight to 10 ounces (9).

Ammonium dinitro cresylate. Hoffman and Van Doren (21) secured a similar amount of set reduction by use of 0.5 pound and 0.75 pound concentrations of ammonium dinitro cresylate spray at 95 percent bloom. A five percent dust of ammonium dinitro cresylate produced a slight, but not significant, decrease in set as compared with the spray. On the other hand, other New York workers (40) tested this material in a later test and received excessive thinning at the 0.5 pound rate.

DNOC and DNOCHP. Davidson (10) indicates that the wettable powders of DNOC and DNOCHP are safer to use on peaches in that they thin sufficiently without removing an excess of blossoms. The DNOCHP sprays proved to be more consistent than the DNOC sprays. His recommendations for use are 12 ounces to one pound of DNOCHP, and one to 1.5 pints of the DNOC slurry.

DN-2 and DN-111. Southwick and his co-workers (40) mention that there was a reduction in set and increase in fruit size when DN-2 and DN-111 were used on peaches with 95 percent of blossoms open. No comparison of these materials with Elgetol or Krenite could be found.

Thinning with plant regulators. Plant regulator sprays are gaining in use over the dinitro compounds for thinning peaches (32). The first use of plant regulators on peaches thinning was when NAA was used five to six weeks after full bloom with the intention of reducing the June drop (3). NAA caused a fruitlet drop and demonstrated its effectiveness as a thinning agent when used after full bloom as the chemical is taken into the plant through the leaves and not the fruit (3). Batjer (6) found that NAA was more effective in thinning young fruits 30 days after full bloom because the tree had more leaf surface which allowed for greater absorption.

The reasons for preferring the use of plant regulator sprays may be summarized as follows (18, 19, 32):

a. Timing of the spray is less critical. The spray may be delayed until the danger of frost is greatly reduced.

b. The spray is applied late enough to have imperfect and unfertilized flowers drop naturally, giving the grower the chance to determine the amount of additional thinning desired.

c. The materials are compatible with other spray materials.

d. The leaves at spraying time are more mature and less subject to foliage damage.

A drawback in the use of plant regulators is that some chemicals may cause a softening of the peach (38). Van Overbeek (47) showed that the softening of the peach is due to the enzymatic dissolution of the middle lamella upon receiving the plant regulator.

Maleic hydrazide. Extensive tests by Langer (23) in Michigan have shown that maleic hydrazide can be used at 500 ppm and higher concentrations in thinning of several peach varieties. Maleic hydrazide has a longer effective period at blossom time than the dinitros. A varietal difference and selectivity in thinning showed up in these trials.

In Canada, Bradt (8) indicates that 500 ppm of maleic hydrazide showed no thinning effect on any of the Oriole, Early Halehaven, and Veteran peach varieties.

When using maleic hydrazide at 650 ppm to 2,000 ppm, Langer (24) achieved good results with the higher concentrations applied either at the early blossom stages (75 percent) or at 30 days after full bloom. The treatments at early blossom stage gave the best results.

Limited trials in Utah (28) showed that when 100 ppm of NAA and 5,000 ppm of maleic hydrazide were used on peaches at the pink stage, they produced a reduction in set, as well as foliage injury and bud inhibition. But when 500 and 750 ppm of maleic hydrazide were used on Elberta at full bloom, there was good thinning results.

Goodrite p.e.p.s. and Zimate.[1] Southwick, Hoffman, and Edgerton (41) applied two pounds of Goodrite p.e.p.s. plus 0.25 pounds Zimate with cyclohexylamine per 100 gallons to peaches 18 days after full bloom and did not secure any results in set reduction.

Naphthalene acetic acid and its derivatives, NaNAA and Amid-Thin. Murneek (33) was one of the first to discover that NAA can successfully thin young peach fruits 30 days after full bloom if used at 30 to 40 ppm on the light setting varieties, and at 40 to 60 ppm on the heavy setting varieties. If used at lower than these concentrations, the treatment will result in initiating flower production and foster the formation and growth of the fruit, as well as prevent its abscission. Good thinning results were achieved in Washington with NAA as a post-bloom spray at 15 ppm on Golden Jubilee and 30 ppm on Raritan Rose and Halehaven (6). Luce (26) observed that NAA, as a post blossom spray on Elberta, thinned the crop more than did Elgetol, especially on weak limbs and young trees.

Abbott (3) is of the opinion that the effect and concentration of NAA are logarithmically related, within limits, and he believes that NAA so far has proven to be the most promising thinning agent. However, at Long Ashton, no increase in fruit size followed the application of NAA, which was thought to be the result of treating individual branches rather than whole trees. In the United States (7, 43) NAA has shown variable results, and is not recommended for use on a commercial scale.

In Missouri (19) it was concluded from three-years trials that NAA at 40 to 60 ppm 35 days after full bloom resulted in satisfactory reduction in set; while trials in Ohio (20) indicated that the most effective

1. The chemical names of Goodrite p.e.p.s. and Zimate were not given by the authors and could not be found in other references.

concentration of NAA is at 20 ppm.

Bradt (8) indicates that App-L-Set, a commercial product containing sodium naphthaleneacetate at 30 ppm, 30 days after full bloom, caused some reduction in set and considerable twig injury. When applied in Ohio (20) at the same date on Halehaven, a reduction in set at 30 and 40 ppm was apparent but no significant increase in fruit size showed. However, there was a significant increase in the weight of the treated fruits. Only the 20 ppm was recommended for use as the higher concentrations have caused tip burning and crooked shoots.

Edgerton and Hoffman (12), Bradt (8), and Burkholder (9) have demonstrated that NaNAA causes a slight crook on many of the terminal shoots at approximately the position of the growing point. Short internodes developed in the vicinity of the crook with a reduced fruit bud set over an area of about two inches. There was some wilting or "flagging" of the foliage. The "flagging" was temporary with the low concentrations, but at 40 ppm on the Halehaven and Red Haven, and 30 ppm on Golden Jubilee, there was a permanent dwarfing of the foliage.

Murneek and Hibbard (34) showed that NaNAA five days after full bloom at five to 40 ppm, resulted in an increase in set, while the same concentration at 75 to 100 percent of full bloom caused some reduction in set.

The only available report on the use of Amid-Thin for peach thinning came from Ohio (20) where 80 ppm was recommended.

Although definite recommendations for NAA and Na-Amide have been given on apples (39), peach growers should use them on a small scale only. Effective concentrations for peaches in New York vary from six to 12 ounces per 100 gallons, depending on the variety. Na-Amide is safer to apply on peaches than NAA, and is used at 1.5 pints, but this concentration may fail to thin the heavy setting varieties.

Chloro-IPC and its derivatives. A new type of plant regulator receiving increased attention for peach thinning is the carbamate group. Results with these materials, both positive and negative, are summarized briefly below.

Marth and Prince (30) report that a 200 ppm solution of 3-Cl-IPC applied 30 days after full bloom caused severe thinning on Afterglow and Hiley varieties. On Laterose, Raritan Rose, and Triogem this chemical at 500 ppm applied 42 days after full bloom caused half the fruitlets to abscise. However, Halehaven was not thinned sufficiently and it was the only variety in their tests which did not have larger fruit than the untreated trees. Leaf injury was visible on all treated branches and the sprayed fruit matured earlier and was softer than the unsprayed fruit.

Burkholder (9) found from extensive trials that 200 ppm of Cl-IPC reduced set, but additional hand thinning was necessary. The 300 ppm concentration did not thin Halehaven but overthinned Elberta. All sprays were applied 30 days after full bloom. Where brush thinning was followed by hand thinning the fruit was larger than was the case when Cl-IPC applications were followed by hand thinning. Hand thinning of trees sprayed previously with Cl-IPC was easier than on the unsprayed trees. The Red Haven variety received two successive sprays of 200 and 300 ppm of chloro-IPC and did not show enough thinning. The 600 ppm concentration overthinned Golden Jubilee and Elberta with a severe flagging and a dying appearance of all Elberta trees.

Havis (17) reports that while 100 ppm of 3-Cl-IPC overthinned Elberta, 400 ppm showed the same results on Red Haven. There was no difference in results if the sprays were applied at 30 or 40 days after full bloom. These treatments did not affect color nor the date of fruit ripening.

In Canada (8) good thinning with no injury has been obtained with 200 and 500 ppm of 3-Cl-IPC applied 35 days after full bloom to the Oriole and Veteran peach varieties. Recent results in the United States (2, 8) indicate that 3-Cl-IPC shows best thinning results when applied 30 days after full bloom.

New preparations of Cl-IPC claimed to be safe for use on peaches are under test. Horsfall and Moor (22) have summarized their results with some of these materials in Table 2.

Table 2. The effect of carbamate sprays on fruit thinning of Halehaven, Ambergem, and Elberta peaches in Virginia in 1954

Variety	Code Number[1]	PPM	Percent Drop	Thinning Effect
Halehaven (35 days after full bloom)	L 461	100	54.8	Underthinned
		200	62.6	Satisfactory
		300	66.0	Satisfactory
	T 515	300	78.5	Heavily overthinned
		500	89.8	Heavily overthinned
	Hand thinned		52.0	Underthinned
Ambergem (30 days)	Hand thinned		68.8	Satisfactory
	L 461	100	77.2	Overthinned
		200	84.8	Overthinned
		300	88.3	Overthinned
	T 516	400	79.4	Heavily overthinned
		600	84.0	Heavily overthinned
		800	92.5	Heavily overthinned
	T 595	600	61.0*	Satisfactory
	T 596	200	58.4*	Satisfactory
		500	64.4*	Satisfactory in tops, lower half of tree overthinned
		800	69.3*	Satisfactory in tops, lower half of tree overthinned
	T 640	600	66.0	Satisfactory
Elberta (35 days)	Hand thinned		52.8	Underthinned
	L 461	50	40.1	Underthinned
		100	47.8	Underthinned
		200	47.2	Underthinned

*Not significantly different from hand thinning at the 1 percent level.

1. The chemical names of these materials are given on page 3.

Injury was apparent and temporary on the trees sprayed with 400 ppm. It was thought that the different results achieved with Cl-IPC are due to its volatile nature.

Chemical thinning of stone fruits other than peaches

Apricots. Batjer and Rogers (7) suggest that the same concentrations of Elgetol and DN-289 used on peaches are effective on apricots. The Tilton variety sets a heavier crop than the Wenatchee Moorpark and thus it requires higher concentrations. The Tilton variety was thinned satisfactorily with three pints of Elgetol, and better results were secured on the same variety when DN-289 was used at only 0.75 pints. On Wenatchee Moorpark the same concentrations of Elgetol and DN-289 caused similar results. The timing of blossom sprays on apricots seems to be more critical than with peaches; sprays delayed until full bloom or slightly later resulted in little or no thinning. The thinning effect on Wenatchee Moorpark is governed by weather conditions during and after the blossoming period, while thinning of Royal and Tilton is not as greatly affected by the weather conditions. The problem with Wenatchee Moorpark is solved by either lowering the concentrations or delaying the spray.

Fisher and his co-workers (15) have shown that dinitro sprays are reasonably effective in reducing fruit set and promoting annual bearing of apricots in Canada. When these workers used 15 pints per 100 gallon in the concentrate sprayer, there was less thinning than the 1.5 pints per 100 gallons used in the dilute sprayer; both concentrations can be used on apricots.

Prunes and plums. Batjer (6) indicates that two pints of Elgetol or one pint of DN-289 per 100 gallons have given similar thinning results on prunes. Plums also have been thinned satisfactorily with the dinitros.

The correct timing of the sprays with regard to the stage of flower development has not been determined exactly, but is thought to be around 90 percent of full bloom.

Batjer and Rogers (7) state that dinitro compounds thin many of the Japanese plums with slightly lower concentrations than are used on apricots and peaches. The heavy setting varieties Beauty and Duarte require one to 1.5 pints of Elgetol.

Cherries. Limited work with cherries (7) indicates that any effective concentration of the dinitros caused serious foliage injury.

METHODS AND MATERIALS

The experiments were conducted at the Howell Field Station for Horticultural Research of the Utah State Agricultural College, located at Pleasant View, Utah.

Ninety-one peach trees were selected for the experiment during March 1954. Forty-five trees were of the Elberta variety, hereafter designated as the "Elberta block," and the remaining 46 trees were of the varieties Red Haven, Golden East, Triogem, and Johnston Elberta, hereafter designated as the "variety block."

The Elberta block was planted in 1945 in the northeast corner of the station property. The trees selected for the experiment were border trees surrounding pruning and fertilizer experiments which had been in existence since planting the orchard. The afore mentioned block was under permanent sod culture, and irrigated on the contour from one side of the tree only.

The variety block of 46 trees was located in the southeast corner of the station property, and was planted in 1950. This block was clean cultivated. Twelve trees of each variety were selected for the experiment (two trees per treatment), except in the case of the Red Haven variety where only 10 trees of this variety were found to be of acceptable vigor and uniformity. Since Red Haven is considered a heavy setting variety, the 200 ppm Cl-IPC treatment was omitted. The varieties ranged in maturity from early (Red Haven) to midseason (Triogem and Golden East) and late (Johnston Elberta). All trees selected were pruned in March 1954 by the thinning out method (4).

The wind in the area usually blows from two directions, the east and the west, but predominantly from the west.

The trees to receive the various treatments were chosen by complete randomization throughout the experimental blocks. The blossoms were in the pink stage on April 18, 1954, and were counted on two branches of each tree such that there were approximately 100 blossoms from the end of the branch to a marking tag on the limb.

Five chemicals were used in the experiment and applied at two intervals: (1) full bloom, and (2) post bloom. The spray treatments and concentrations are shown in Table 3.

The Krenite, a standard blossom thinning material for apples, was used after recommendations by Batjer and Rogers (7). Maleic hydrazide, supplied by United States Rubber Company, was sprayed at a concentration of 500 ppm, based on the investigations of Mani (28). Both Amid-Thin and Cl-IPC (ACP-L-461)[1] were supplied by the American Chemical Paint Company. The latter chemical was specially prepared to be used without injury to peach foliage (22, 42). Amid-Thin was prepared according to company recommendations, while the two concentrations of Cl-IPC were derived from the work of Langer (24) and Havis (17). The concentrations of NAA, a common post bloom material tested extensively on apples, was based on the results of Batjer and Hoffman (6).

When spraying the Elberta block with Krenite, heavy winds started blowing. To protect the neighboring trees from the drift, a canvas barrier was erected (Figure 1) and the spraying pressure reduced to about 25 pounds. The maleic hydrazide treatment was delayed to the next morning because of the wind.

1. ACP-L-461 is an experimental product containing 50 percent chloro-IPC.

Because of 12 days of almost continuous rain or snow, the Cl-IPC, Amid-Thin and NAA treatments had to be delayed until 42 days after full bloom. On this date (June 1, 1954) Cl-IPC was applied. The spraying pressure was reduced somewhat from 200 pounds because of wind, and Amid-Thin and NAA applications were delayed until the next morning.

After the June drop, hand thinning was practiced throughout except on the counted branches which had no supplementary hand thinning. Harvest started with the early varieties on August 11, and was completed on September 8. At harvest the fruits from each counted branch were weighed and graded into four size categories based on their horizontal diameters, and the number of fruit in each group was recorded. A total of 7,072 fruits were individually measured and graded in this manner. From the number of counted fruits on each branch the final fruit set was calculated according to the following formula:

$$\frac{\text{Number of harvested fruit from counted branches} \quad \times 100}{\text{Number of blossom buds counted on the same branch}}$$

The data collected from the experiment were statistically analyzed by analysis of variance (37). In the variety block one tree from the Triogem variety was struck by the tractor, and three trees (one Johnston Elberta, one Golden East, and one Red Haven) failed to blossom normally. Missing values for these trees were calculated according to Snedecor's method (37).

Table 3. Treatments applied to Elberta and variety blocks

		Application			
				Temp. in ° F.	
Treatment	Concentration	Date	State	Max.	Min.
		Elberta Block			
Krenite	150 ppm (2.5 pints/100 gal.)	4/20	F.B.*	71	41
Maleic Hydrazide	500 ppm 390 gms. MH-40/ 100 gal.	4/21	1 day after F.B.	61	33
Cl-IPC	400 ppm 314 cc. ACP-L-461/ 100 gal.	6/1	42 days after F.B.	68	41
Amid-Thin	50 ppm 2 pts./100 gal.	6/2	43 days after F.B.	63	31
No Thinning					
		Variety Block			
Krenite	150 ppm 2.5 pints/100 gal.	4/20	F.B.	71	41
Cl-IPC	400 ppm, 314 cc. ACP-L-461/100 gal.	6/1	42 days after F.B.	68	41
Cl-IPC**	200 ppm, 152 cc. ACP-L-461/100 gal.	6/1	42 days after F.B.	68	41
Amid-Thin	50 ppm, 2 pints/ 100 gallons	6/2	43 days after F.B.	63	31
NAA	20 ppm, 8.44 grams 95% acid NAA/100 gal.		43 days after F.B.	63	31
No Thinning					

* F.B.: Full bloom (95 percent blossoms open).

** Cl-IPC at 200 ppm was applied on Triogem, Golden East, and Johnston Elberta only.

Figure 1. Canvas wall erected to protect the non-treated trees in the Elberta block from the Krenite drift.

RESULTS

Effect of thinning treatments on size of developing fruit two months after bloom

When the hand thinning operation had been completed (June 25, 1954), samples of thinned fruit from the various treatments were compared in order to determine whether chemical treatments had begun to show any effect on fruit size. However, no visible difference in size of any variety was apparent at that stage (Figure 2).

Effect of chemical thinning agents on the set, size and maturity of the Elberta peach

As may be seen in Table 4, there was no difference in the date of maturity of the Elberta fruit receiving the different sprays. However, the trees sprayed with Krenite and Cl-IPC at 400 ppm were harvested for two days, compared to three days for all other treatments. Chloro-IPC at 400 ppm produced a highly significant reduction in set on the Elberta from 40.1 percent on the non-thinned trees to 26.5 percent on the Chloro-IPC thinned trees (Figure 3). The Krenite, maleic hydrazide and Amid-Thin treatments did not show any appreciable thinning effect. All chemical treatments produced an increase in average size and weight per fruit, though this was not quite significant. Also, in all treatments there was less unmarketable fruit (less than $2\frac{1}{4}$ inches) than when no chemical thinning agent was used.

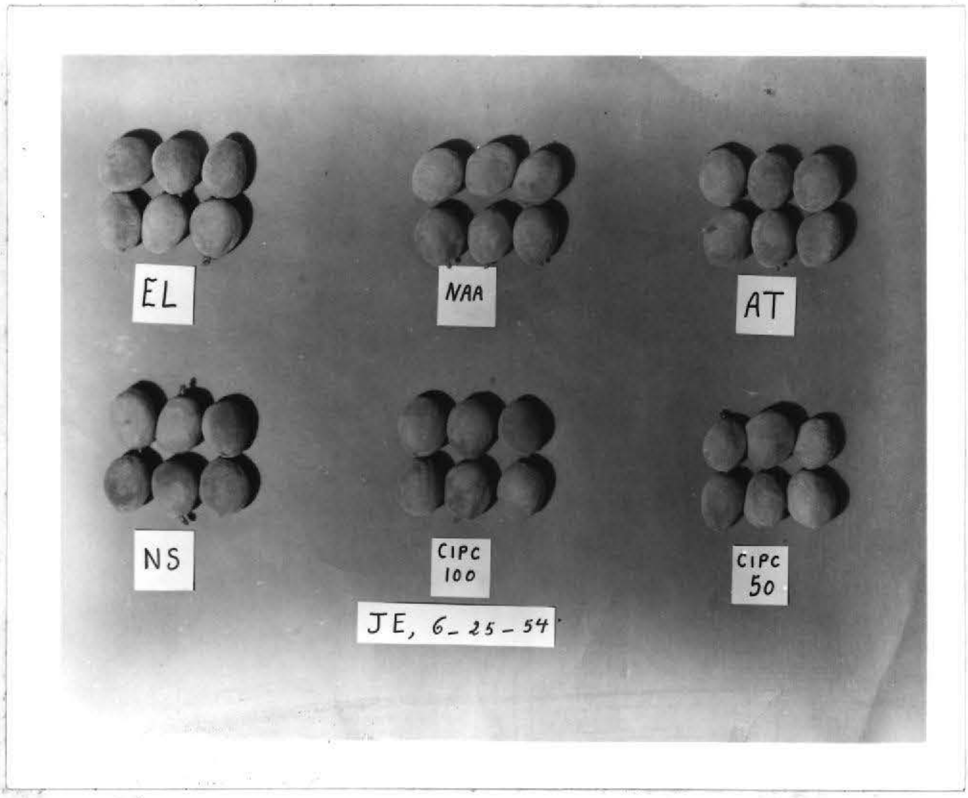

Figure 2. Developing fruits of Johnston Elberta (June 25, 1954) treated with various chemical thinning agents.

EL	-	Elgetol 150 ppm
NAA	-	Naphthaleneacetic acid 20 ppm
AT	-	Amid-Thin 50 ppm
CIPC 50	-	chloro-IPC 200 ppm
CIPC 100	-	chloro-IPC 400 ppm
NS	-	no thinning

Table 4. Effect of chemical thinning agents on the set, size, and maturity of the Elberta peach

Treatment and Concentration	Date Sprayed	Date Harvested August	Final Set %	Fruit Size (% in each group) 2.25"	2.25-2.50"	2.50-2.75"	2.75"	Average Fruit Size	Weight per Fruit	Thinning Effect
Krenite 150 ppm	4/20	6 to 7	36.4	15.7	59.1	22.3	2.8	2.41	0.240	Under-thinning
Maleic Hydrazide 500 ppm	4/21	6 to 8	34.8	11.4	62.5	24.9	1.2	2.42	0.248	Under-thinning
Chloro-IPC 400 ppm	6/1	6 to 7	26.5	15.5	56.2	26.3	1.7	2.41	0.230	Moderate thinning
Amid-Thin 50 ppm	6/2	6 to 8	36.5	17.9	57.2	23.4	1.4	2.40	0.258	Under-thinning
No thinning		6 to 8	40.1	25.0	59.6	15.3	0.1	2.36	0.224	No thinning
L.S.D. 5%			8.3					0.07		
L.S.D. 1%			11.1					0.10		

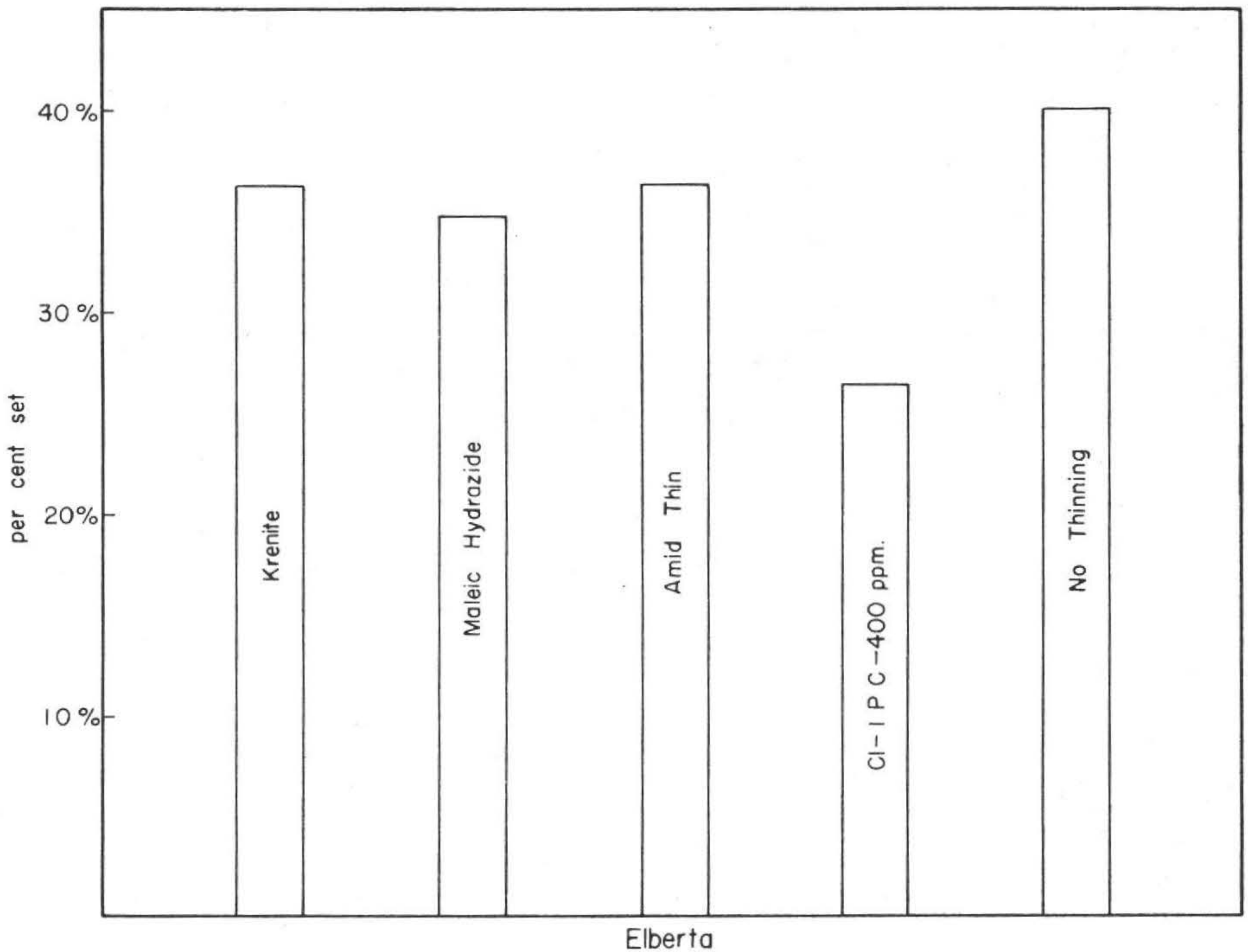

Fig. 3. Effect of chemical thinning treatments on per cent set of Elberta.

Preliminary trials on the effect of chemical thinning agents on the Red Haven, Golden East, Triogem and Johnston Elberta varieties

Red Haven: It is shown from Table 5 that there may have been a difference in the dates of maturity as a result of the different thinning treatments. The trees sprayed with Cl-IPC at 400 ppm yielded the earliest fruit, with the trees receiving the Krenite and NAA ripening next. Amid-Thin treated fruit ripened last and two days after the non-treated fruits. It appeared that none of the treatments produced a consistent degree of thinning on Red Haven. The trees receiving the NAA spray, however, have shown a higher percent of reduction in set -- 34.1 percent compared to 54.8 percent on non-thinned trees (Table 6 and Figure 4). No significant average size difference in this variety is evident from the data in Table 7. However, it is interesting to note that in every case a considerable higher percent of small, generally unmarketable fruit was obtained when no thinning treatment was applied. The percentage of marketable (i.e., $2\frac{1}{4}$ inches or larger) fruit on all treated trees was higher than on the non-treated trees.

Tricgem: Both treatments of Cl-IPC, the 200 and 400 ppm, have caused the Triogem variety to ripen fruit first and at about the same date. The NAA-treated fruit ripened next, followed by the non-thinned and Krenite treatments (Table 5). Krenite and both concentrations of Cl-IPC caused a marked thinning of Triogem (Table 6 and Figure 4). In the Cl-IPC 400 treatment fruit set was reduced by more than half of the non-thinned treatment. There was some reduction in set produced

Table 5. Effect of chemical thinning treatments on the date of harvesting of certain peach varieties.

Variety	Krenite	Amid-Thin	Cl-IPC 400 ppm	Cl-IPC 200 ppm	NAA	No. Treatment
			August			
Red Haven	12-25	19-25	11-22		12-25	17-25
Triogem	19-25	24-25	11-24	12-24	17-25	19-25
Golden East	27	23-30	23-30	24-30	24-30	23-30
			September			
Johnston Elberta	6	6	6	6	6	6

Table 6. Effect of chemical thinning treatments on percent set of various peach varieties (average of four branch counts).

Treatment	Red Haven	Triogem	Golden East	Johnston Elberta
Krenite	42.4	29.5	8.9	31.5
Amid-Thin	47.9	35.5	25.1	50.0
Cl-IPC 400 ppm	42.0	24.4	22.7	52.0
Cl-IPC 200 ppm		31.9	23.6	24.3*
NAA	34.1	35.2	25.3*	40.1
No thinning	54.8*	49.3**	44.5	50.5

* One tree failed to blossom normally and was excluded from the experiment.

** One tree struck by tractor and therefore excluded from experiment.

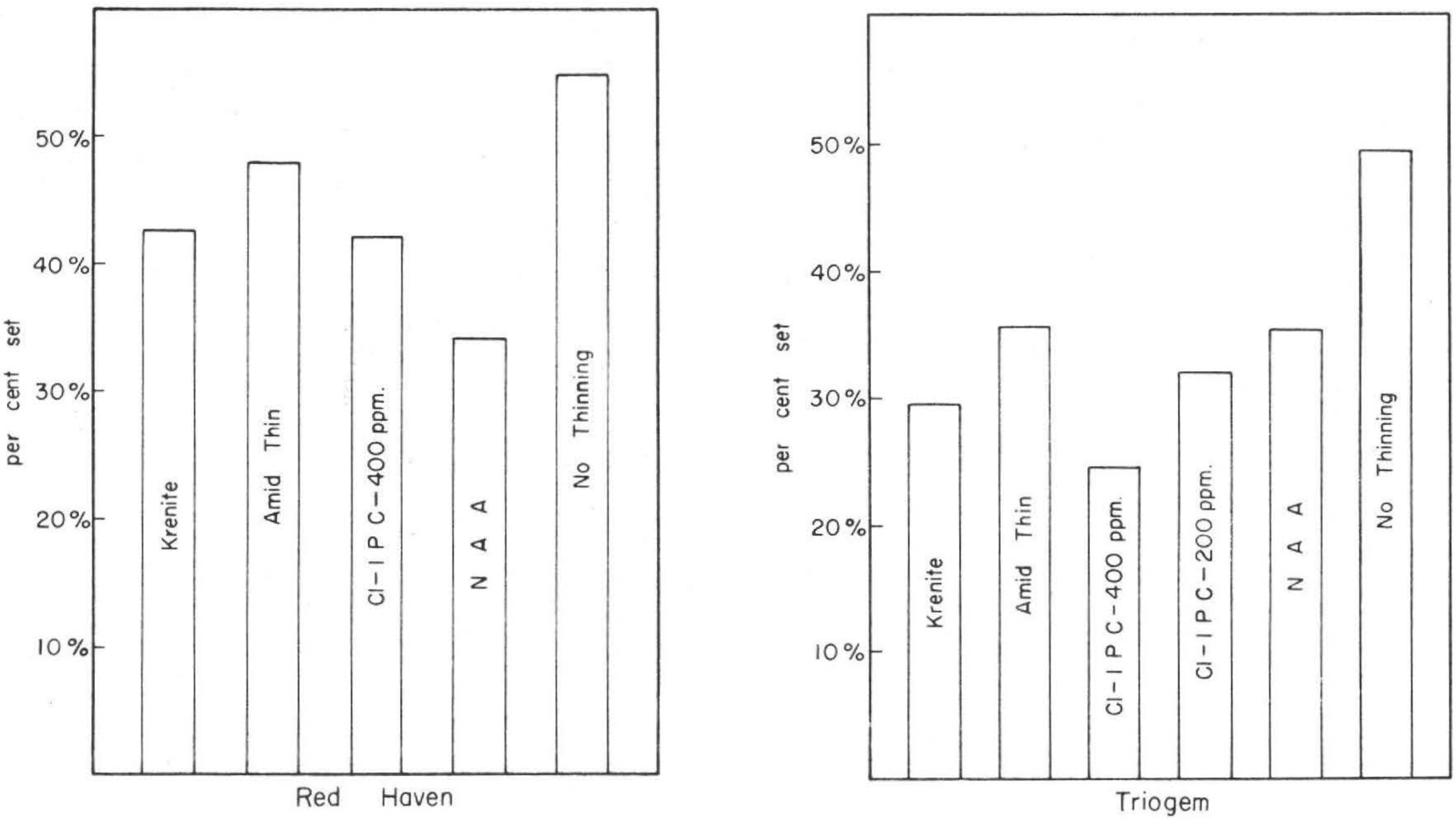

Fig. 4. Effect of chemical thinning treatments on per cent set of Red Haven and Triogem.

by Amid-Thin and NAA: That is, from 49.3% to 35.5 and 35.2 respectively. The sprays Amid-Thin and 400 ppm of Cl-IPC produced the highest percent of unmarketable fruit, as well as the smallest average fruit size (Table 7). This does not correspond with the set data in Table 6, and may not indicate a trend since one tree in the control was missing. The NAA treatment produced the largest fruit and consequently the smallest amount of unmarketable fruit. Neither Krenite nor Cl-IPC at 200 ppm caused any increase in fruit size on Triogem, nor increased the number of marketable fruit.

Golden East: There was no influence of treatment on maturity of this variety, as is indicated in Table 5, except that in the Krenite treatment all fruit was harvested the same day. All of the spray treatments on Golden East produced from moderate to heavy thinning (Table 6 and Figure 5). The Krenite treatment caused marked overthinning. Amid-Thin, Cl-IPC at 200 and 400 ppm, and NAA all reduced the set by about 50 percent of that on the check trees. There was an apparent increase in size caused by all thinning sprays on Golden East (Table 7). Krenite and NAA showed to have caused the largest fruit of all treatments, as well as the smallest number of unmarketable fruit. The non-thinned trees had about 80 percent unmarketable fruit.

Johnston Elberta: No apparent treatment differences in maturity were evident, as shown in Table 5. The only treatments that showed some thinning on Johnston Elberta were Cl-IPC at 200 ppm and Krenite (Table 6 and Figure 5). Chloro-IPC at 400 ppm produced a slight increase in set while Amid-Thin did not show any thinning effect. NAA indicated a very slight tendency towards a reduction in set. Johnston

Table 7. Effect of chemical thinning treatments on fruit size of various peach varieties

Treatment	% of Fruit in Various Size Categories < 2.25	2.25-2.50"	2.50-2.75"	> 2.75"	Ave. Size in Inches
			Red Haven		
Krenite	57.3	25.2	13.6	3.9	2.29
NAA	53.3	25.1	20.9	0.6	2.30
Amid-Thin	60.5	23.6	11.6	4.3	2.28
Cl-IPC-400 ppm	52.7	34.1	13.2	0.0	2.28
No thinning*	78.1	12.5	4.7	4.7	2.22
			Triogem		
Krenite	38.1	42.4	19.4	0.0	2.33
Cl-IPC-400	56.3	32.1	10.7	0.7	2.26
Cl-IPC-200	39.8	47.8	12.3	0.0	2.31
NAA	13.5	54.1	22.3	10.0	2.45
Amid-Thin	57.1	22.7	19.5	0.6	2.29
No thinning**	32.4	42.1	25.5	0.0	2.36
			Golden East		
Krenite	11.4	25.0	34.1	29.5	2.58
Cl-IPC-400	50.4	35.3	14.3	0.0	2.29
Cl-IPC-200	46.0	34.0	12.0	8.0	2.34
NAA*	18.0	40.0	36.0	6.0	2.46
Amid-Thin	39.6	32.4	25.2	2.7	2.36
No thinning	78.1	13.1	3.8	4.9	2.22
			Johnston Elberta		
Krenite	8.3	78.0	13.6	0.0	2.39
NAA	34.0	60.6	5.4	0.0	2.31
Amid-Thin	16.0	77.0	7.0	0.0	2.36
Cl-IPC-400	55.6	43.1	1.3	0.0	2.24
Cl-IPC-200*	25.5	68.4	6.1	0.0	2.33
No thinning	53.1	43.8	3.1	0.0	2.25

* One tree in treatment failed to blossom normally and was excluded from experiment.

** One tree in treatment struck by tractor and excluded from experiment.

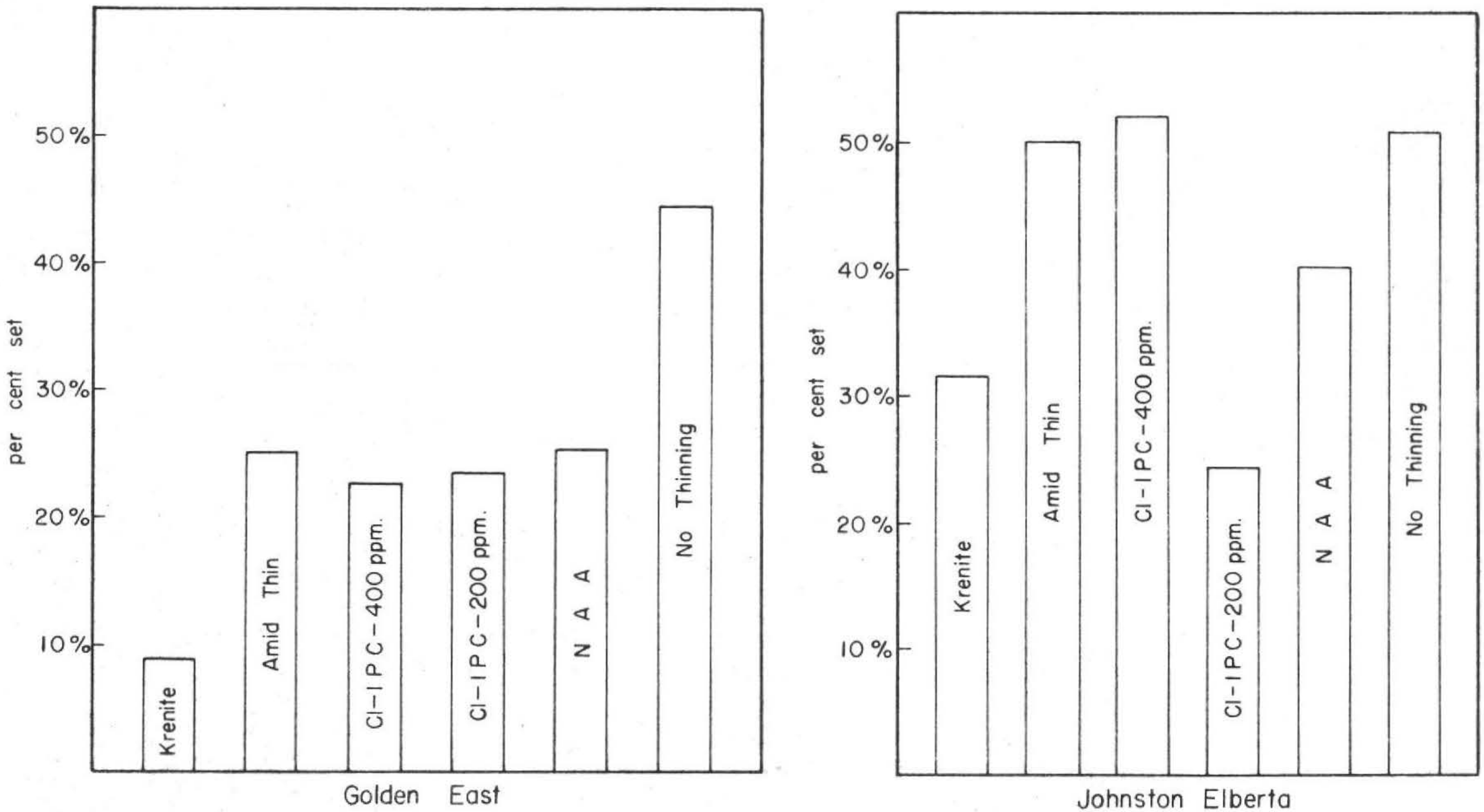

Fig. 5. Effect of chemical thinning treatments on per cent set of Golden East and Johnston Elberta.

Elberta trees thinned with Krenite produced less than 10 percent unmarketable fruit, while Amid-Thin sprayed trees had around 15 percent compared to more than 50 percent on the non-thinned trees and those sprayed with Cl-IPC at 400 ppm (Table 7). These treatments showed that there was an increase in the average size of those fruits that had the lower percentage of set. Chloro-IPC at 200 ppm and NAA caused some increase in average size, as well as a lower percent of unmarketable fruit compared to the non-thinned trees.

It is apparent from the data in Table 5 that the earlier ripening varieties have a longer picking period than the late ripening varieties.

DISCUSSION

Krenite

It is apparent from Table 5 that there is no marked decrease in fruit set of Elberta and Red Haven peaches when thinned with Krenite. This might be due to the favorable weather for heavy set during blossoming period. If so, it concurs with the findings of Batjer and Rogers (5, 7). There may be another factor--the concentration used. Hoffman (12) indicated that concentrations differ for the different varieties, localities, and from one year to another. Krenite produced some thinning on Johnston Elberta and Triogem, and overthinned Golden East. The overthinning of Golden East can be partly explained to the abnormality in one of the trees in this treatment. This tree had a final set of 40 fruits; four of these fruits were on the counted part that had 245 blossoms. The foliage on this tree was more sparse than on normal trees. It can also be noticed from Table 6 that Krenite produced some thinning effect which was reflected in an increase in fruit size.

Maleic hydrazide

Maleic hydrazide was used only on the Elberta variety. This chemical reduced the crop by five percent more than the check trees, which is considerably less than desired. Possible explanations of this result could be related to the vigor of the trees, as well as the low concentration of maleic hydrazide used as compared with concentration (750 ppm) used by Mani (28). Langer (23), in Michigan, reported that the effect of maleic hydrazide depends on vigor of tree and stage of fruit development. The average size of fruit in this treatment was large and highly marketable.

Amid-Thin

No reduction in fruit set occurred when Amid-Thin was used on the Elberta, Red Haven, and Johnston Elberta, which could be due to the later-than-normal application of Amid-Thin. The observations (17) show that applications earlier than 43 days were more effective. Secondly, it may be due to the lower concentration--50 ppm. Hill (20) recommended the use of 80 ppm on Halehaven. The effective thinning of Golden East and Triogem may be explained as a varietal response to the concentration applied. Amid-Thin sprays produced larger fruit as compared with the check trees except on the Triogem variety.

Chloro-IPC, 200 ppm and 400 ppm

The only significant reduction in set was achieved with Cl-IPC at 400 ppm on the Elberta trees. Reports on Cl-IPC by Prince, Burkholder and Havis (9, 17, 30) indicate a reduction in set and injury to the foliage. No such injury was noticed in this experiment, which complies with the findings of Bradt (8) and Horsfall and Moore (22). This may be due to the special preparation of ACP-L-461 which is claimed by the manufacturer, as well as other workers, to be safe for use on peach foliage (22, 42). Hardly any thinning followed applications of Cl-IPC on Red Haven, while on Golden East and Triogem good reduction in set was distinctly apparent. However, a slight increase in set was caused by 400 ppm of Cl-IPC on Johnston Elberta, while the 200 ppm concentration of the same chemical on the same variety decreased the set. (Hibbard and Murneek (19) found an increase in set when using NaNAA.) The 200 ppm concentration has satisfactorily reduced the set on all trees of Golden East, Johnston Elberta, and Triogem. But on Johnston Elberta, Golden

East, and Triogem the fruitlets thinned with the 200 ppm produced larger fruits than those thinned with the 400 ppm, although the latter concentration caused higher reduction in set on both Golden East and Triogem. There is an indication that Cl-IPC may cause an inhibition on the fruit size of some varieties.

NAA

Comparatively speaking, NAA has shown some thinning effect on Red Haven and Triogem, and better results on Golden East, with little thinning on Johnston Elberta. This decrease in set has produced a logarithmic proportional increase in the size of fruits from the sprayed trees.

SUMMARY AND CONCLUSIONS

Summary

This experiment was planned to investigate the possibilities of chemical thinning with various dinitro compounds and plant regulators on the peach varieties--Red Haven, Golden East, Triogem, Johnston Elberta, and Elberta. Krenite and maleic hydrazide were applied at full bloom, while naphthalene acetic acid, Amid-Thin, and Chloro-IPC were used at 42-43 days after full bloom. The effectiveness in reduction of fruit set was calculated on the basis of fruit harvested from previously counted blossom buds. The size of the fruit was measured by grading it into various size categories from which the average size was then calculated.

Krenite at 150 ppm showed a variety of results from almost no thinning on Elberta to heavy thinning on Golden East, and some thinning on Red Haven, Johnston Elberta, and Triogem. It is felt that if higher concentrations are used in a fine mist spray a satisfactory reduction in set may be achieved. There was an increase in size of fruit on all varieties except the Triogem.

Maleic hydrazide at 500 ppm sprayed one day after full bloom exhibited a very slight reduction in set, as well as an increase in fruit size.

Amid-Thin at 50 ppm did not show a reduction in set on Elberta, Red Haven, and Johnston Elberta when sprayed 43 days after full bloom. However, there was a reduction on Golden East and Triogem. The average fruit size was slightly larger on all varieties harvested except for the Triogem.

Chloro-IPC at 400 ppm has demonstrated significant results when sprayed 42 days after full bloom on the Elberta variety only. On Johnston Elberta this chemical caused a slight increase in set. However, there was some reduction on Red Haven and satisfactory thinning of both Golden East and Triogem. The 200 ppm treatment of Chloro-IPC showed good results in all the trials on Golden East, Johnston Elberta, and Triogem. The 200 ppm treatment resulted in larger fruit than the 400 ppm treatment on Triogem, Johnston Elberta, and Golden East, although on the latter two the higher concentration caused a lower set than at the lower rate. It seems that Cl-IPC at 400 ppm inhibits fruit growth of some varieties.

NAA at 20 ppm, sprayed 43 days after full bloom, reduced the set efficiently on Red Haven, Golden East, and Triogem. There was some apparent thinning of Johnston Elberta. The average fruit size was increased proportionately with the degree of thinning secured.

Conclusions

The results of these experiments, and investigations in other areas, indicate that plant regulators applied as post blossom sprays (30-42 days after full bloom) are more satisfactory for peach thinning than the dinitros under Utah conditions, where spring frosts are common. NAA and its derivatives can be used at 30 ppm for the light bearing varieties and 60 ppm for the heavy bearing varieties. ACP-L-461 (Chloro-IPC) may be efficient in reducing set at 200-400 ppm, depending on the bearing nature of the variety. However, before using this material commercially, further trials of Cl-IPC are needed to determine whether it causes any inhibition in fruit size.

LITERATURE CITED

(1) Anonymous. Amid-Thin. Technical Service Data Sheet H-49. Ambler, Penn.: Amer. Chem. Paint Co. no date.

(2) ________ Chemical thinner for peaches. Agr. Res. 2:11. 1953.

(3) Abbott, D. L. Recent applications of growth substances in fruit growing. Ann. Appl. Biol. 41:215-220. 1954.

(4) Ashton, C. D., S. W. Edgecombe, R. K. Gerber, and O. Kirk. How to prune peach trees in Utah. Utah State Agr. Coll. Ext. Bul. 199. no date.

(5) Batjer, L. P. Factors affecting results with dinitro sprays. Proc. Wash. State Hort. Assn. 48:158-161. 1952.

(6) Batjer, L. P., and M. B. Hoffman. Fruit thinning with chemical sprays. U. S. Dept. of Agr. Circ. 867:31-44. 1951.

(7) Batjer, L. P., and B. L. Rogers. Chemical thinning of stone fruits. Proc. Wash. State Hort. Assn. 47:115-119. 1951.

(8) Bradt, O. A. Chemical thinning of peaches. Hort. Expt. Sta. and Products Lab. Ontario Dept. of Agr. p. 19-25. 1951-1952.

(9) Burkholder, C. L. Chemical thinning of peaches. Mimeo. Purdue University. 1954.

(10) Davidson, J. H. Experiences in thinning apples and peaches with sprays. Amer. Fruit Grower 69:16. 1949.

(11) Dorsey, M. J., and R. L. McMum. Tree conditioning the peach crop. Ill. Agr. Exp. Sta. Bul. 507:358-389. 1944.

(12) Edgerton, L. J., and M. B. Hoffman. Effects of thinning peaches with bloom and post-bloom sprays on the cold hardiness of fruit buds. Proc. Amer. Soc. Hort. Sci. 60:155-159. 1952.

(13) Farley, A. J. Factors that influence the effectiveness of thinning. Proc. Amer. Soc. Hort. Sci. 20:145-151. 1923.

(14) Fisher, D. V. Time of blossom bud induction in apricots. Proc. Amer. Soc. Hort. Sci. 58:19-22. 1951.

(15) Fisher, D. V., A. W. Watt, S. W. Porritt, and E. D. Edge. Chemical fruit thinning with concentrate spray machines. Proc. Amer. Soc. Hort. Sci. 61:144-148. 1953.

(16) Fisher, D. V. Spray thinning in British Columbia. Amer. Fruit Grower 73:32. 1953.

(17) Havis, L. Spray thinning peaches with 3-Cl-IPC. Amer. Fruit Grower 74:38-40. 1954.

(18) _______ Studies in peach thinning. Proc. Amer. Soc. Hort. Sci. 49:55-58. 1947.

(19) Hibbard, A. D., and A. E. Murneek. Thinning peaches with hormone sprays. Proc. Amer. Soc. Hort. Sci. 56:65-69. 1950.

(20) Hill, R. G. Chemical thinning of peaches. Proc. Ohio State Hort. Soc. p. 128-137. 1954.

(21) Hoffman, M. B., and A. Van Doren. Some results in thinning peaches with a blossom removal spray. Proc. Amer. Soc. Hort. Sci. 46:173-177. 1945.

(22) Horsfall, F., and R. C. Moore. The effect of carbamate sprays on fruit thinning of Halehaven, Ambergem, and Elberta peach in Virginia in 1954. Mimeo. Va. Poly. Inst. 1954.

(23) Langer, C. A. Effects of maleic hydrazide on the thinning of peaches during three successive years. Mich. Agr. Exp. Sta. Bul. 35:209-213. 1952.

(24) _______ Effect of certain chemicals on the thinning of peach blossoms and young fruit. Abst. Amer. Soc. Hort. Sci. Madison, Wis., 1953.

(25) Larsen, P. Nomenclature of chemical plant regulators. A criticism. Plant Phys. 21(4):400. 1954.

(26) Luce, B. Bill Luce's Corner. The Good Fruit Grower 5(7):2. 1954.

(27) Luckwell, L. C. Studies on fruit development in relation to plant hormones. Jour. Hort. Sci. 28:25-40. 1953.

(28) Mani, A. A. A study of the influence of some plant growth regulating chemicals on delaying the blossoming of Elberta peach tree to reduce damage from spring frost. Thesis. Utah State Agr. Coll. 1953.

(29) Marth, P. C., L. Havis, and V. E. Prince. Effect of growth regulating substances on development and ripening of peaches. Proc. Amer. Soc. Hort. Sci. 55:152-158. 1950.

(30) Marth, P. C., and V. E. Prince. Effect of 3-chloro-isopropyl-N-phenyl carbamate on abscission of young fruits of peach. Sci. 117: 497-498. 1953.

(31) Meister, R. T. Is thinning worth the trouble? Amer. Fruit Grower 72:11. 1952.

(32) Mitchell, A. E. Chemical fruit thinning. Amer. Fruit Grower 72: 26. 1952.

(33) Murneek, A. E. Plant growth regulators during fertilization and post-fertilization periods. Proc. Amer. Soc. Hort. Sci. 59:207-217. 1952.

(34) Murneek, A. E., and A. D. Hibbard. Investigations on thinning of peaches by means of caustic and hormone sprays. Proc. Amer. Soc. Hort. Sci. 50:206-208. 1947.

(35) Nitsh, J. P. The role of plant hormones in fruit development. Thesis. Calif. Inst. of Tech. 1950.

(36) Shoene, D. L., and O. L. Hoffman. Maleic hydrazide, a unique growth regulator. Sci. 109:588-590. 1949.

(37) Snedecor, G. W. Statistical methods. The Iowa State Coll. Press, Ames, Iowa. 1948.

(38) Southwick, F. W. Effect of some growth regulating substances on the rate of softening, respiration and soluble solids content of peaches and apples. Proc. Amer. Soc. Hort. Sci. 47:84-90. 1946.

(39) Southwick, F. W., and W. D. Weeks. Chemical thinning of apples and peaches. Mass. Agr. Ext. Serv. Circ. 189:1-4. 1954.

(40) Southwick, F. W., L. J. Edgerton, and M. B. Hoffman. Studies in thinning peaches with blossom removal sprays. Proc. Amer. Soc. Hort. Sci. 49:26-32. 1947.

(41) Southwick, F. W., M. B. Hoffman, and J. E. Edgerton. Further experiences with the chemical thinning of apples and peaches. Proc. Amer. Soc. Hort. Sci. 51:41-47. 1948.

(42) Tafuro, A. J. Correspondence. Agr. Chem. Div., Research Dept., Amer. Chem. Paint Co., Ambler, Penn., 1955.

(43) Trullinger, R. W. Chemical thinning of fruits. Report on Agr. Exp. Stations 1952. p. 88-89. 1953.

(44) Tukey, H. B. Growth of peach embryo in relation to growth of fruit and season of ripening. Proc. Amer. Soc. Hort. Sci. 30: 209-218. 1933.

(45) _______ Plant regulators in agriculture. New York, N. Y.: John Wiley and Sons, Inc., 1954.

(46) Tukey, L. D. The why and how of apple thinning. Science for the farmer. Penn. Agr. Exp. Sta. 1(3):11-12. 1954.

(47) Van Overbeek, J. Agricultural applications of growth regulators and their physiological basis. Ann. Rev. Plant Phys. 3:87-108. 1952.

(48) Van Overbeek, J., H. B. Tukey, F. W. Went, and R. M. Muir. Nomenclature of chemical plant regulators. Plant Phys. 29(3): 307-308. 1954.