and 120 pounds of ammonium acetate (4.8) extractable phosphorus (P) and potassium (K), respectively, were adequate for the vegetables grown in the experiments.

When application rates of N, P and K were raised above 130-74-108 (N-P-K) annually, yields of eggplant, onions, squash and spinach declined. This indicates the need for caution in overfertilization.

When P and K were adequate, manure up to 15 tons per acre improved but not significantly yields of some crops. These differences were attributed to increases in exchange capacity and better moisture relations.

ACKNOWLEDGMENTS

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INFLUENCE OF CHEMICAL DEFLOWERING AND DEFRUITING ON THE VEGETATIVE GROWTH AND FRUIT SET OF BELL PEPPERS (*Capsicum annum* L.)

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The results of several greenhouse and field experiments during 1960 and 1961 indicated that the removal by hand of a few initial young flower buds, flowers after anthesis or young developing fruits from pepper plants subsequently increased the average plant height and fruit set to a considerable extent (16, 17, 18). The desirability of testing some chemicals which might be used to remove the initial flowers or young fruits in order to make this procedure applicable to large scale pepper production was evident from the results. Consequently, some plant regulators were tried in field experiments and the results from these experiments are reported in this paper.

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REVIEW OF LITERATURE

Little work has been done during the past years on chemical deflowering or defruiting which is directly associated with the problem in peppers. However, closely allied work on flower and fruit thinning has been reported.

Auchter and Roberts (4) were the first to demonstrate that chemical sprays could be successfully employed to thin apple flowers. From their work the use of toxic substances, such as phenols and cresols, was evolved, to kill some of the blossoms. Burkholder and McCown (7) were the first to find an auxin such as naphthalenacetic acid (NAA) could be effectively used to thin flowers. Subsequent workers have proved that auxin can be effectively used in thinning young fruit as well.

The thinning of flowers and fruits by auxins, as listed by Leopold (11), appears to be the function of three physiological factors: (1) the prevention of natural pollination; (2) abortion of young embryos and the subsequent dropping of fruits; and (3) direct forcing of abscission by altering the auxin gradient at the abscission zone.

In synthetic medium, Addicott (1) obtained a small inhibition of pollen tube growth with indoleacetic acid (IAA) and a greater inhibition of pollen germination. The ability of auxin to cause the abortion of embryos in young fruit was first demonstrated by Swanson, *et al* (19) in Tradescantia fruits. In thinning apples by the use of auxins, Murneek (12) found that the abscissed fruits contained aborted embryos whereas the fruits remaining on the tree contained a large proportion of the normal embryo.

The use of chemicals in inducing male sterility has recently received attention. Sodium 2,3-dichloroiosobutyrate (FW-450) has been of special interest to plant breeders. Hensz and Mohr (10) were able to completely eliminate the opening of staminate flowers in watermelons with concentrations of 0.25 and 0.50 percent FW-450. While working with lettuce, Foster and Murdock (8) did not find any development of anthers following the treatment with FW-450. Pate and Duncan (14) have made extensive studies with FW-450 on cotton and significant results were obtained in inducing male sterility but the gametocide was reported to be phytotoxic at very high concentrations. Recently Scott (15), studying the mechanism and reversal of sodium 2,2-dichloroisopropionate (Dalapan) and FW-450, reported that the exogenous application of these gametocides to cotton plants induced non-dehiscent anthers.

Gibberellic acid (GA), a plant growth substance, has been extensively studied during the last eight years on plant responses (22). According to Biggs (5) GA accelerate abscission over a wide range of concentrations from 10^{-8} to 10^{-3} Molar. The degree of promotion by GA was less than NAA in explants of beans. However, the controlling influence of GA on naturally occurring abscission was not determined. Addicott (3) with excised material reported that gibberellin accelerates abscission markedly when applied close to the abscission zone.

Materials and Methods

Four factorial field experiments were conducted using a randomized block design on Arredonda fine sand at the Horticultural Unit of the University of Florida with peppers of the Yolo Wonder variety. Each experiment included a chemical at five concentrations, including a control of distilled water, applied at three stages of blooming (pre-bloom, bloom and post-bloom). The four chemicals and concentrations tested were:

Chemical	Concentration
Naphthaleneacetic acid (auxin)	0, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} Molar
Trans-cinnamic acid (anti auxin)	0, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} Molar
Gibberellic acid (auxin-enhancing agent)	0, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} Molar

Table 1. Effect of NAA on the Average Number of Abscissed Pepper Flowers.

Growth state at Application	Concentration (Molar) 0	10^{-6}	10^{-5}	10^{-4}	10^{-3}	Average
Pre-bloom	5	8	7	7	9	8
Bloom	5	12	9	17	12	11
Post-bloom	2	8	6	13	15	9
Average	4	10	8	13	12	10

L.S.D.	at 5%	at 1%
Between concentration averages	3	5

Sodium 2,3-dichloroisobutyrate (gametocide) 0, 0.05, 0.15, 0.25 and 0.35 percent

The unit plot size was 6 feet by 34 inches with three plants spaced two feet apart. The field planting of the pepper plants was made on April 11, 1961, with all plots being fertilized initially with a 4-8-8 fertilizer at the rate of 1,200 pounds per acre.

Solutions were sprayed on the plants at the predetermined stages, using a hand atomizer after each of the chemicals was weighed, dissolved and made to volume in distilled water. Sufficient solution was used to completely wet the foliage of each plant.

Records were taken on abscission of flowers, plant height and yield. Fruits were graded as U.S. Fancy, U.S. No. 1 and culls according to U.S. standards (20).

Results

Naphthaleneacetic acid (NAA)

NAA had no effect on height of pepper plants when sprayed at different concentrations. However, as the data indicated in Table 1, NAA did have a marked effect on flower abscission, particularly at higher concentrations (10^{-3} and 10^{-4} Molar). These concentrations resulted in increased abscission of the flowers as compared with the control where no spraying of NAA was made. There was no difference in the number of flowers abscissed when spraying was done at the different stages of blooming.

An interaction between the concentration of NAA and the stage of growth was found with the yield of U.S. Fancy peppers as shown in Table 2. Concentrations of 10^{-5} and 10^{-4} Molar NAA produced a greater yield of U.S. Fancy peppers when sprayed at the bloom stage in comparison to pre-bloom and post bloom stages. Yields of other grades of peppers were not affected by the use of NAA sprays.

Gibberellic acid (*GA*)

It was observed in the field experiment that GA did not have any effect on thinning of flowers or fruits but the effect on the growth of the plants was quite apparent. Although the tallest plants were obtained by spraying with GA at 10^{-2} Molar concentration as shown in Table 3, the leaves of these plants exhibited a chlorotic condition. The increase in the average plant height due to the use of 10^{-2} Molar concentration was significant as compared with the control and the lowest concentration of 10^{-5} Molar. The application of several concentrations of GA to the pepper plants did not affect the yield of fruits, a result similar to that obtained by Ozaki (13).

Table 2. Effect of NAA on the Average Yield in Bushels per Acre of U.S. Fancy Peppers.

Growth state at application	Concentration (Molar) 0	10^{-6}	10^{-5}	10^{-4}	10^{-3}	Average
Pre-bloom	103.3	180.6	111.8	120.7	210.7	146.2
Bloom	141.9	154.8	266.6	296.7	154.8	202.1
Post-bloom	189.2	210.7	133.3	150.5	180.6	172.0
Average	146.2	180.6	172.0	189.2	180.6	173.6
L.S.D.			at 5%		at 1%	
Stage x concentration			119.7		159.9	

Trans-cinnamic acid

The trans-cinnamic acid sprays had a significant effect on the average height of the pepper plants at some concentrations, as shown in Table 4. There was an increase in the height of plants from spraying trans-cinnamic acid at 10^{-7} Molar concentration, then a significant decrease in the average height of the plants as the concentrations were raised from 10^{-7} to 10^{-6} Molar, followed by an increase at the highest concentration. Trans-cinnamic acid had no effect on the yield of fruit of the various grades of peppers.

Sodium 2,3-dichloroisobutyrate (FW-450)

The data obtained on the average height of the plants and the yield of pepper fruits indicated that the various concentrations of FW-450 from 0 to 0.35 percent had no significant effect. However, all treated plants in the field appeared to be more vigorous and some effects on the abscission of flowers and fruits were noted at the 0.35 percent concentration. Consequently, additional concentrations of 0.5 1.0, 1.5 and 2.0 percent FW-450 were tested. It was observed with the concentration of 1.5 and 2.0 percent that the plants were killed. At 1.0 percent concentration, survival of a few leaves with complete abscission of flowers and fruits occurred. However, at 0.5 percent concentration the plants were completely deflowered without any apparent injurious effect to the foliage (Figure 1).

Discussion

Among the several chemicals tested, NAA represents the auxin group. This material showed promise in the removal of flowers from the pepper plants and resulted in higher yields of U.S. Fancy peppers when sprayed at the bloom stage. However, it did not have any effect on increasing the average plant height. The effective concentrations were 10^{-3} and 10^{-4} Molar which have been also successfully used to thin apple flowers (7). Among the manifold roles of auxin which are more important are: inhibition of lateral bud growth; acceleration or inhibition of abscission; stimulation of cambial growth and other meristimatic activity; the inhibition and promotion of non-osmotic water uptake (6). It is postulated that the flower bud might contain an auxin-like substance which inhibits the growth of the pepper plant. By the application of higher concentrations of a synthetic auxin (NAA, for example), the flower abscission is promoted but the inhibition effect is possibly increased; hence, there is no growth response.

On the other hand, the application of GA up

TABLE 3. Effect of GA on the Average Height (Inches) of Pepper Plants.

Growth state at Application	Concentration (Molar) 0	10^{-5}	10^{-4}	10^{-3}	10^{-2}	Average
Pre-bloom	13.6	13.2	13.5	12.0	15.2	13.5
Bloom	12.4	12.7	13.0	14.7	16.7	13.9
Post-bloom	13.3	13.2	14.0	13.6	16.1	14.0
Average	13.1	13.0	13.5	13.4	15.0	13.8
L.S.D.			at 5%		at 1%	
Between concentration averages			1.70		2.34	

Table 4. Effect of Trans-cinnamic Acid on the Average Height (Inches) of Pepper Plants.

Growth state at Application	Concentration (Molar) 0	10^{-7}	10^{-6}	10^{-5}	10^{-4}	Average
Pre-bloom	12.8	12.9	13.2	12.9	14.8	13.2
Bloom	12.6	14.2	11.7	13.0	12.9	12.9
Post-bloom	12.0	14.1	11.7	12.7	12.8	12.6
Average	12.5	13.6	12.2	12.8	13.5	12.7
L.S.D.			at 5%		at 1%	
Between concentration averages			0.57		0.77	

to 10^{-2} Molar concentration had an effect on the growth of the pepper plants but had no effect on the abscission of flowers or fruits, a response similar to that obtained by Biggs (5) and Addicott (3). No information is known which shows a positive response of GA on naturally occurring abscission of flowers and fruits.

Trans-cinnamic acid, representing the anti-auxin group, had an effect on increasing the plant growth but no flower abscission occurred. Trans-cinnamic acid, an antogonist of auxin-action, stimulated stem growth (21) and accelerated leaf-fall in cotton (9). However, the present investigation does suggest that concentrations above 10^{-4} may be tried further since concentrations below 10^{-4} Molar had no effect on abscission and were not injurious to the plants.

The use of a gametocide, FW-450, was encouraging because the concentrations ranging from 0.05 percent to 0.35 percent did not have any injurious effect on the plants and the treated plants seemed to be more vigorous than the untreated plants. The effectiveness of a concentration of 0.5 percent on the pepper plants in causing complete deflowering or defruiting was striking. This suggests that concentrations below 0.5 and above 0.35 percent need to be tested further.

This work was conducted for one season and the experiments were therefore of an exploratory nature. The main purpose of initiating the experiments was to explore the possibilities of finding a suitable chemical for deflowering and defruiting. The results obtained should provide the basis for future work and to stimulate interest in this area.

The use of other chemicals such as Na-monochloroacetate, ammonium thiocynate, 2,3,5-triiobenzoic acid, and some oils and cresols may prove useful additions in future research in this regard (2).

Summary

Four chemicals, namely naphthaleneacetic acid, gibberellic acid, trans-cinnamic acid and sodium 2,3-dichlorisobutyrate, were tested for their potentiality to induce initial abscission of flowers and fruits and subsequently greater growth and fruiting of Yolo Wonder pepper plants. These chemicals were tested at several concentrations and applied at three stages of growth.

Naphthaleneacetic acid had a marked effect on the abscission of flowers and increased the yield of U.S. Fancy pepper fruit but did not

Figure 1.—Effect of sodium, 2,3-dichloroisobutyrate (FW-450) spray at 1.0 and 0.5 percent on deflowering and defruiting of Yolo Wonder pepper plants.

influence the average plant height. Gibberellic acid and trans-cinnamic acid had no effect on abscission and yield of peppers but increased the plant height to a considerable extent. Sodium 2,3-dichloroisobutyrate was quite effective in inducing the abscission but had no marked effect on plant height and yield of peppers. The results, on the whole, suggest the need of further testing of naphthaleneacetic acid, trans-cinnamic acid, sodium 2,3-dicholoroisobutyrate and some additional chemicals in order to assist in the production of moderate size plants prior to blooming and subsequent increased fruit setting.

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SOUTHERN POTATO WIREWORM CONTROL AT HASTINGS, FLORIDA

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Damage to Irish potatoes at Hastings by the southern potato wireworm, *Conoderus falli* Lane, varies from year to year and from field to field, with seasons of severe and widespread damage occurring periodically. The insect is a major pest of Irish potatoes in the Southeastern United States according to Deen and Cuthbert (1955). Dobrovsky (1952) (1953) found that preplanting soil treatments of aldrin, chlordane, dieldrin, and heptachlor gave effective control of the insect in the Hastings area. Later, Norris (1957) reported that wireworm resistance to these insecticides had developed. Reid and Cuthbert (1956) reported that the southern potato wireworm was resistant to these inseticides in South Carolina. Insecticide tests on the wireworm at Hastings since 1958 are reported herein.

LABORATORY TESTS

Laboratory tests were initiated in 1958 when small lots of soil were treated with various insecticides and wireworms added to them. Insecticides were diluted with water, applied to the soil with a small hand atomizer, and then mixed in with a trowel. Insecticide dosage was calculated as actual insecticide per 100 gallons of water per acre mixed to a depth of six inches. Treated soil was placed in four-ounce glass jars and an active fifth-instar wireworm added. Only one wireworm was added per jar as the insect is cannibalistic. Sheets of glass were placed over the jars to prevent wireworm escape and soil desiccation. The jars were checked periodically with the final count of moribund and dead wireworms made after a two-week exposure to the treated soil. Each treatment was replicated five to ten times with untreated soil serving as a check.

The laboratory tests showed that the southern potato wireworm was almost completely resistant to aldrin, chlordane, dieldrin, and heptachlor. Of 32 chemicals tested, the phosphatic insecticides showed the most promise. Wireworms affected by these insecticides exhibited characteristic symptoms which terminated in death. No wireworm in the tests once showing symptoms of poisoning ever recovered. This finding was important as it often eliminated the observation of affected wireworms for long periods until death occurred. The first symptom of wireworm poisoning by a phosphatic insecticide is a marked increase of activity followed by coordination loss and inability of locomotion. Following this stage, the head and posterior segment become fixed in a near-vertical position with the body arced upwards at the ends. The posterior proleg is extended downwards. The wireworm exhibits little movement until death which may take several weeks to occur depending on the insecticide and dosage.

FIELD TESTS

Five insecticides giving excellent wireworm control in laboratory tests at two pounds actual per acre or less were selected for field trials. These were American Cyanamid 18133, diazinon, parathion, Thimet (phorate), and Union Carbide 8305. Di-Syston gave excellent control at four pounds actual and was included in the field trials as it had also shown promise for aphid control.

Potatoes at Hastings are grown on rows about 12 inches high and 40 inches apart which are made up several weeks or more before planting. Summer cover crops of corn, sorghum, grass, or legumes, are incorporated into the rows to produce a high level of organic matter. Wireworm populations developing in these cover crops,

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