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An evaluation of the effectiveness of insecticides in controlling aphids, reducing virus disease spread, and increasing yields in gladiolus plantings.

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AN EVALUATION OF THE EFFECTIVENESS OF INSECTICIDES IN CONTROLLING APHIDS, REDUCING VIRUS DISEASE SPREAD, AND INCREASING YIELDS IN GLADIOLUS PLANTINGS.

A Thesis Presented

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INTRODUCTION

Gladiolus production, as that of most commercially grown field crops, is often seriously threatened by diseases and insect pests. For many years thrips were considered the major arthropod pest of gladioli, causing injury to both flowers and corms. However, thrips control has progressed considerably in recent years, so that they no longer pose the threat or dominate the grower's concerns as they did in the past. At present gladiolus growers in many areas of the United States are sustaining serious losses in flower and corm production due to cucumber mosaic virus disease (CMV). This virus is readily transmitted by aphids feeding on healthy plants.

Attempts have been made to control virus disease spread in field crops by trying to control the vector aphids. The results have been generally unsatisfactory or inconclusive. The majority of the work done to date has been done primarily with the standard systemic insecticides such as dimethoate (Cygon[R]), oxydemeton-methyl (Meta-systox R[R]), and phorate (Thimet[R]). Very little work has been done to evaluate the potentials of more recently developed aphicides such as the carbamates, a group of insecticides that has not yet received extensive evaluation. It is possible that some of these

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[R]Trade names.

newer materials may act quite differently and more effectively in supressing or reducing aphid-borne virus disease spread than did previously tested treatments.

The present lack of highly effective control methods should prompt us to pursue virus disease reduction rather than complete control. Some of the newer aphicides may prove to be of value in this regard. The potential, if any, of new materials must be determined through research. This was the primary objective of the present study.

METHODS AND MATERIALS

Replicated small-plot field experiments were conducted during the 1971 and 1972 growing seasons to evaluate insecticide treatments for control of aphids and virus disease in gladiolus. Unanticipated shortcomings in the 1971 experiment led to changes and improvements in 1972. Therefore, the most meaningful results were obtained during the second year.

Location and experimental design. The field tests in both years were conducted in a gladiolus-growing area about one mile north of the Town of West Suffield, Connecticut.

A randomized complete block design was used both years. The rectangular experimental area was oriented north and south, and consisted of seven rows spaced 36 inches apart in 1971 and 39 inches apart during 1972. The five inner rows contained all of the treatment plots; the two outermost rows were planted with gladioli as border rows.

In 1971 there were three replications of 10 different treatments for a total of 30 separate plots. Each plot was five feet long and was planted with 10 corms. At both ends of each plot bordered a two-foot alley. The over-all dimensions of the experimental area were 46 feet long by 22 feet wide. Individual plots (replicates) were identified by plastic stakes numbered and labeled as to treatment.

In 1972 six replicates of 10 different treatments were

used, giving a total of 60 plots. Again the plots were five feet long with two-foot alleys at either end. The over-all dimensions of the experimental area were 82 feet by 22 feet.

Corms and planting. The gladiolus cultiver, Wild Rose, was used in the 1971 tests. Wild Rose was selected because of its notorious reputation for being highly susceptible to cucumber mosaic virus disease.

In 1971 all corms were planted on June fourth. Late planting was desired since it is late plantings that most often become heavily infected with virus disease (Bing and Johnson 1966). A total of 300 Wild Rose corms were used in the experiment. In each of the 30 plots, 10 No. 1, (1¼ inches or more in diameter), randomly chosen corms were planted. Corms were placed in the trench approximately six inches apart in a zig-zag, double-row fashion. All corms were planted with the sprouts or eyes directed upward.

Plots scheduled for granular insecticide treatments received their first application at the time of planting. No fertilizer, fungicidal, or other insecticidal treatments were made at planting. All of the corms were covered with soil by hoe to a depth of approximately six inches.

In 1972 the gladiolus cultivar, Peter Pears, was used in the experiments instead of Wild Rose. The latter was found to be both an inconsistent grower and very susceptible to fungal diseases, thus making critical evaluations

difficult. Peter Pears, being a hardy and consistent producer of both fine spikes and corms, is one of the leading varieties grown commercially in the United States. Therefore, Peter Pears was selected as being ideal for the 1972 experiments.

In 1972 the corms were planted on June 15. A total of 600 corms of Peter Pears were used. Half of these were size No. 1, while the other 300 were of the jumbo size (two inches or more in diameter). In an attempt to reduce corm losses due to fungal diseases, all of the corms used in the experiment were dipped in a 50 per cent wettable powder suspension of the fungicide benomyl (Benlate^{R}) for a period of 15 minutes. The dip was prepared at the rate of four teaspoonfuls of benomyl per gallon of water. Ten corms (five jumbo size and five No. 1 size) were chosen randomly to be planted in each of the 60 treatment plots. The 10 corms selected for each plot were weighed and weights were recorded before planting. The five jumbo size corms were planted first in each plot, followed by the five No. 1 size corms. All of the corms were covered with soil by means of a tractor-powered apparatus for unfiromity of planting depth.

Treatments. A total of eight different insecticides were used during the two years of testing. Of these disulfoton (Di-syston^{R} 2 G and 15 G), oxydemeton-methyl

(Meta-systox R[R] 2 EC), dimethoate (Cygon[R] 2 EC), and acephate (Orthene[R] 75 S) are organic phosphates, while carbofuran (Furadan[R] 4 F and 10 G), aldicarb (Temik[R] 10 G), pirimicarb (Pirimor[R] 50 WP), and oxamyl (duPont 1410 G or Vydate[R] 10 G) are carbamates. All of these insecticides exhibit systemic action. All of the formulations used were obtained "fresh" from the manufacturer, with the exception of dimethoate which was obtained from a local supplier. The insecticides were chosen on the basis of their toxicity, residual activity, systemic action, and recommended or potential use as aphicides.

In the 1971 experiment six different insecticides were used. They were as follows: dimethoate, oxydemeton-methyl, carbofuran, disulfoton, aldicarb, and oxamyl. Of these, carbofuran was used in two different formulations, while oxydemeton-methyl was used by itself and also in combination with Bio-film spreader-sticker made by Colloidal Products Corporation. The final two treatments were a Bio-film control and an untreated control. The dosages used per five-foot plot (replication) were calculated from recommended dosages of actual material to be applied per acre with a row spacing of 36 inches.

In 1971 two granular and three foliar spray applications were made with each of the respective formulations. The first granular treatment was made at planting on June fourth,

while the second was a granular side-dress application made on July 12. Foliar spray applications were made on June 23, July sixth, and August third. The treatments, formulations, and dosages used in 1971 are listed in Table 1.

In 1972 eight different insecticides were used. They were as follows: dimethoate, oxydemeton-methyl, carbofuran, disulfoton, aldicarb, oxamyl, acephate, and pirimicarb. Carbofuran was again used in two different formulations and an untreated control accounted for the final treatment. The two Bio-film treatments used in 1971 were dropped in 1972 in order to test two new materials, acephate and pirimicarb. In 1972 all insecticides were applied at the dosage rate of one pound of actual insecticide per acre. This rate was used for treatment uniformity and ease of comparison.

In 1972, as in the previous year, two granular and three foliar spray treatments were made during the growing season. The first granular treatment was made at planting on June 15, while the second was a side-dress application made on July 20. The foliar spray applications were made on July sixth, July 23, and August 20. The treatments, formulations, and dosages used in 1972 are listed in Table 2.

Insecticide application and equipment. The methods of application and the equipment used for treating with insecticides were the same in both years. Granular applications and foliar spray treatments were the methods of application used in both experiments. These two methods utilize different equipment and treatment procedures, so they will be discussed separately below.

Granular treatments for each replicate were weighed out on an analytical balance to the calculated quantity for a five-foot row. These weighed dosages were sealed in white envelopes, labeled as to the insecticide contained and the plot number to which it was to be applied. The granular insecticides were transported in this manner to the field on the day of application. To treat a plot, the contents of an envelope were emptied into a clean glass jar and mixed with a white quartz sand diluent to increase the volume of material to be applied. This mixture was then shaken evenly into the trench and lightly covered with soil before the corms were planted. Side-dress treatments were applied to the soil in narrow bands approximately four inches from each side of the plants, and the insecticide was carefully worked into the soil by hoe.

The foliar spray treatments required mixing with water to increase the volume of material for uniform application. Wettable and soluable powder formulations were weighed and packaged individually in the same manner as were the

granular treatments.

The emulsifiable concentrate and flowable formulations were measured and diluted in the field just before use. The pre-weighed quantities of wettable and soluable powder formulations were also diluted in the field just prior to use. An aspirator designed to prevent sucking insecticide into the mouth was used in conjunction with a pipette to measure the concentrates. The measured insecticide was then diluted with about 250 milliliters of water.

A plastic one-gallon pump hand-sprayer was used to apply all of the foliar spray treatments. An even application of material was applied as a fine spray covering the foliage completely until the dosage intended for that particular plot was exhausted. To avoid contamination, both the sprayer and the glassware used in preparing the dilutions were washed thoroughly after all the plots for each different insecticide were treated.

The foliar spray applications made later in the season were prepared and applied in the same manner as above, except for the addition of more water to compensate for the increase in foliar area due to plant growth.

Field culture. Field culture methods consisted mainly of weed control and "hilling" the plants for support.

Weed control was obtained by tractor-powered cultivation, rototilling, and manual hoeing. These methods also helped to keep the soil loose, allowing greater water

penetration and better aeration. No herbicides were used during the experiments.

Gladioli, being tall and willowy, are easily blown over by wind or rain unless the corms are planted sufficiently deep (six inches for corms 1¼ inches or more in diameter), and the plants braced or supported during the growing season. The most commonly used method to prevent gladioli from toppling is to "hill" the plants up on both sides with soil. This procedure was performed several times throughout both growing seasons.

The experimental plots received no watering other than natural rainfall, nor did they receive any commercial fertilizer. Soil tests had previously shown the soil to be adequately fertile.

COLLECTION OF DATA

Forms were devised for systematically and accurately recording detailed field observations. Statistical analyses were made to compare and evaluate most of the data.

Aphid observations. The numbers of alatae, apterae, and nymphs observed on individual gladiolus plants were recorded periodically throughout both growing seasons (June through August). In 1971 counts were made on 11 different dates, at three to five day intervals. In 1972 aphid counts were made on 12 separate occasions, at intervals of three to seven days. Averages of the individual observations per plant were computed for each year of testing. These values (seasonal averages) were used in presenting and analysing data. Also in 1972 yellow-pan water traps, 7½ inches in diameter, were placed on the soil between plots to trap winged aphids for species identification (Johnson, Bing, and Smith 1967; Taylor and Palmer 1972).

Virus incidence. Gladiolus plants showing symptoms typical of cucumber mosaic virus disease were recorded as being virus-infected as soon as recognizable symptoms appeared. Characteristic symptoms in gladioli appeared either on the foliage, flowers or both, but were usually most apparent on the floral parts.

Plant growth and flower yield. Plant growth and flower yield data were collected in 1972. Early plant emergence

and plant height data were gathered on July first and July seventh respectively, 17 and 23 days from planting. Flower-head length, number of buds, and plant height measurements were made in late August and early September when each plant was at or just past its floral peak.

Corm weights. In 1972 the 10 corms randomly selected for planting in each plot were weighed prior to planting and were again weighed after the corms had been harvested and cured.

ALUMINUM FOIL EXPERIMENTS

Interest in aphid responses to aluminum foil mulch has been high (Johnson et al. 1967; Adlerz and Everett 1968; Wolfenbarger and Moore 1968; Smith and Webb 1969; George and Kring 1971; Shands and Simpson 1972). Consequently in each year of testing 20 large corms of seven different gladiolus cultivars were used in an aluminum foil experiment separate from the insecticide tests. In 1971 the following cultivars were used: Mountie, Vicki Lin, Blue Mist, Rainier, Peter Pears, Empire Yellow, and King David. In 1972 the cultivars Lemon-Lime, Bluebird, Dewdrop, Vicki Lin, Doubloon, and Carnelian were employed. Ten randomly-selected corms of each cultivar received an aluminum foil mulch treatment, while another 10 corms were planted as an untreated control. Holes were made in the aluminum foil to permit plant emergence. The remainder of the soil in the foil-treated area was covered with aluminum foil which was secured in

place with rocks.

Neither the foil-treated nor the foil control plots received any insecticidal treatments.

In 1971 detailed recordings were made of the number of aphids observed on the plants in the aluminum foil experiment. In 1972 the number of winged aphids caught in yellow-pan water traps were recorded.

LITERATURE REVIEW

Gladiolus

Gladiolus, Latin for small sword, belong to the Family Iridaceae of the Order Liliales. The genus Gladiolus consists of about 250 species, most of which are native to the Mediterranean region and the tropical areas of South Africa. The modern garden gladiolus do not represent any one species. They have been derived by variation and hybridization from several species (Bailey 1949; Griesbach 1972). Bailey (1949) stated that it is, therefore, impossible to give gladioli clear botanical names.

Gladioli are most often grown under outdoor field conditions in full sunlight. In Massachusetts, planting gladiolus corms usually begins in mid-April and may continue through the end of June, although early planting is most desirable (Jenkins et al. 1970). Gladioli do not normally require high levels of fertilization due to the large reserve of nutrients present in the corm. A complete fertilizer such as 5-10-10 should be used when treatments are needed (Magie, Overman, and Waters 1964).

Weed control is often a major problem in gladiolus production (Waters and Raulston 1972). Bing (1970) reviewed the herbicides and dosages that are most frequently used for weed control in gladioli.

Gladioli are susceptible to many bacterial and fungal

diseases that may require control. Excellent accounts of gladiolus diseases and their control were given by Magie et al. (1964) and Magie and Poe (1972).

Aphids

Metcalf, Flint, and Metcalf (1962) stated that aphids are probably the most universal group of plant-feeding insects. The same authors mentioned that there is scarcely a kind of plant, cultivated or wild, that is free from supporting one to several species of aphids. Aphids may injure, kill, or reduce the aesthetic and economic value of plants in the following ways: (1) direct feeding which may result in lower plant vitality, stunted or curtailed growth, and deformed growth; (2) "sooty mold" fungus growth on honey-dew contaminated foliage; (3) the presence of aphids (contamination) on the market product; and (4) the transmission and spread of plant virus diseases (Metcalf et al. 1962; Westcott 1964; Naegele and Jefferson 1964; Matthews 1970).

Aphids have achieved their success both evolutionarily, and as agricultural pests, through parasitic exploitation of plants. They have been able to achieve this success through their reproductive capacity and an elaborate system of polymorphism in their life cycle (Kennedy and Stroyan 1959).

General aspects of aphid biology and ecology have

been reviewed in the literature (Kennedy and Stroyan 1959; Lees 1966; van Emden et al. 1969; Matthews 1970).

Much work has been done on alary polymorphism in aphids. The following factors have been shown to influence wing dimorphism in aphids: crowding; plant nutrition; turgor of the host; temperature; photoperiod; humidity, form, age, and generation of the parent; and endocrine interactions (Johnson and Birks 1960; Hille Ris Lambers 1966; Johnson 1966; Lamb and White 1966; Lees 1966; Lees 1967; Dixon, Burns, and Wangboonkong 1968; van Emden et al. 1969; Shaw 1970; Sutherland 1970; Judge and Schaeffers 1971; Schaeffers and Judge 1971; Sutherland and Mittler 1971; White 1971).

Insecticides are often employed to control injurious populations of aphids on floricultural crops. In general, insecticidal control of aphids has been successful (Douchette 1961; Douchette 1962; Swenson 1963; Jefferson et al. 1964; Gould 1968; Schread 1969; Poe and Marousky 1972).

Virus Diseases of Gladioli

When a virus infects a gladiolus plant it soon becomes a permanent resident of the plant and continues to thrive as long as the plant is propagated vegetatively. The increase in gladiolus production, the growing of corms in many places, and the interstate and international commerce in gladioli offer great opportunities for both transporting virus diseases and increasing their incidence in the crop

(Brierley, Smith, and McWhorter 1953).

Dosdall (1928) gave the first detailed account of a virus disease of gladioli. By 1952 three virus diseases of gladiolus were known and several others were suspected (Dosdall 1928; Smith and Brierley 1944; McWhorter, Boyle, and Dana 1947; Wade 1948; Berkeley 1951; Bridgmon 1951; Brierley 1952; Palm and Young 1952). The viruses most often reported in this crop are as follows: cucumber mosaic, bean yellow mosaic, tobacco ringspot, and tomato ringspot (Berkeley 1953; Brierley et al. 1953; Pinney 1969; Beute, Milholland, and Gooding 1970; Bing 1972).

Surveys in North Carolina in 1968 and 1969 revealed that 20.9 per cent and 27.2 per cent respectively of all field-grown gladioli examined (over 20,000 plants) showed virus symptoms. In 1968 the range of infection was from 0.7 to 98 per cent (Beute et al. 1970).

McWhorter (1957) reported that in a particular area of Oregon more than 98 per cent of the plants in about 3½ acres of gladioli showed conspicuous sumptoms of cucumber mosaic virus (CMV). The infection was so complete that the grower harvested only a few dozen flowers from the entire acreage. We have seen similar losses in gladiolus plantings in Western Massachusetts. Heinis (1954) reported virus symptoms in 21 per cent of the gladiolus plants examined in Oregon.

Pinney and Hildebrandt (1968) found that nearly 67 per

cent of all gladiolus plants examined in Wisconsin showed virus symptoms. Of the 163 varieties examined, not one was found to be free of virus symptoms.

Cucumber mosaic virus is a polyhedral ribonucleic acid (RNA) virus with a diameter of approximately 28 to 30 millimicrons (Finch, Klug, and van Regenmortel 1967; Matthews 1970).

Bridgmon (1951) was the first to report gladiolus as a natural host of CMV in North America. Since then CMV has become one of the major diseases of gladioli in the United States causing considerable losses to both commercial and amateur plantings (Bing 1962; Bing and Johnson 1966; Johnson et al. 1967).

Cucumber mosaic virus is transmitted non-persistently by many species of aphids (Swenson and Nelson 1959; Bing 1962; Coudriet 1962; Castillo and Orlob 1966; Swenson and Marsh 1967; Pinney 1969; Bing 1972).

CMV symptoms are expressed three or more weeks after infection and may vary somewhat (Brierley and Smith 1962). In most cultivars the disease is expressed as white flecks or chlorotic interveinal streaking on the foliage. Severely infected plants of some cultivars are markedly dwarfed and may not flower (Brierley et al. 1953; Bing 1962; Bing and Johnson 1966; Jenkins et al. 1970; Bing 1972). Infected corms may be pitted and have wrinkled husks, while others may remain symptomless (Bing 1962; Bing and Johnson 1966;

Johnson et al. 1967). The most striking and damaging effects of CMV infection occur in the flowers (Pinney 1969). In many cultivars the virus causes a distortion of the flowers and failure to open properly. In cultivars with colored flowers a bleaching, blotching, or breaking of color may occur on the petals (Smith and Brierley 1944; Brierley et al. 1953; McWhorter 1957; Bing and Johnson 1966; Johnson et al. 1967; Pinney and Hildebrandt 1968; Pinney 1969; Bing 1972). This symptom is commonly known as "white break." Other flower symptoms may involve a degradation of color (fading) or a transformation of color to yellow, blue, silver, grey, or purple streaks throughout the floret (Nelson 1948; Bing 1962; Pinney 1969).

Flowers from infected plants are unsatisfactory for commercial sale, ornamental plantings, flower arrangements, and are worthless for exhibition in flower shows (Johnson et al. 1967; Bing 1972). Symptomless corms are often sold unknowingly, thus spreading the virus to new areas (Bing 1972).

Jenkins et al. (1970) and Beute (1970) reported that viral infection of gladioli also increased the susceptibility of the plants to corm rot, root rot, and leaf spot diseases.

Bean yellow mosaic virus may cause a mild mosaic that is usually barely noticeable, and thus does not reduce flower value (Pinney 1969; Bing 1972). Tobacco ringspot virus is not a serious disease of gladioli, but when symptoms are

present they appear as bright chlorotic ringspots on the foliage (Bridgmon and Walker 1952; Brierley 1952; Bing 1972). Tomato ringspot virus disease in gladioli causes severe stunting of the plant without color break in the flowers (Snow 1956; Bozarth and Corbett 1958).

Aphids as Vectors of Gladiolus Viruses

Both Matthews (1970) and Watson and Plumb (1972) published excellent reviews of aphid transmission of plant pathogenic viruses. Earlier reviews have dealt with arthropod transmission of plant viruses (Smith and Brierley 1956; Smith 1958; Maramorosch 1963; Ossiannilsson 1966).

The emphasis throughout this study is on the non-persistent relationship since CMV is transmitted in a stylet-borne, non-persistent manner. Characteristics of a virus that has a persistent or circulative type of relationship with its vector appear in Sylvester (1969) and Watson and Plumb (1972).

Pirone (1969) stated that it was the speed with which the non-persistent viruses can be acquired and transmitted which suggested that the viruses are carried on the aphid's stylets. It has been shown that non-persistent viruses are indeed carried on the tips of aphid stylets (Bradley and Ganong 1955 a,b). Much work has been done to determine exactly where and how the virus is carried on the stylets, but this problem still remains unsolved (Sylvester and

Richardson 1964; Bradley 1966; Hashiba and Misawa 1969b; Pirone 1969).

In the non-persistent relationship both the virus acquisition and inoculation periods are only a few seconds long; therefore transmission is rapid (Sylvester 1969). Optimum acquisition and transmission probes have been reported to be between 10 to 60 seconds duration (Swenson 1952; Bradley and Rideout 1953; Bradley 1954; Zettler 1963; Hashiba and Misawa 1969a; Swenson 1969).

Aphids cannot accumulate non-persistent viruses. They are retained for only a short time by feeding aphids (Swenson, Sohi, and Welton 1964; Normand and Pirone 1967; Swenson 1969; Sylvester 1969). Aphid transmitted non-persistent viruses usually survive in the feeding vector for less than one hour (Watson and Plumb 1972). Swenson (1969) stated that few aphids remain infective after 15 minutes of acquiring a non-persistent virus, and many may loose infectivity within five minutes after leaving the virus source.

Once an aphid has acquired virus during a brief probe, the subsequent activities of the vector are critical if transmission is to occur (Sylvester 1969). If the aphid has the opportunity to rapidly make a series of brief inoculation probes, successive transmissions of the virus are possible (Bing 1962; Bing and Johnson 1966; Sylvester 1969). On the other hand, if the inoculated aphid feeds

for a period in excess of 15 minutes, the probability of inoculating another plant with a subsequent probe are quite low. When a viruliferous aphid does not probe or feed, but simply remains away from a susceptible host, the probability that it will successfully infect any plant fed upon decreases rapidly with time (Sylvester 1969).

Aphids have the habit of probing once or twice on plant tissues before penetrating deeper for feeding (Hashiba and Misawa 1969a). Aphids are believed to probe into plants to select a favorable host or feeding site (Bradley 1964; Matthews 1970). A probe has been defined as the inserting of the stylets into plant tissue for a period of 30 seconds or less, while a feeding was defined as the inserting of the stylets for over two minutes (Hashiba and Misawa 1969a). The same authors reported probing to be more efficient than feeding for acquiring a non-persistent virus.

Various workers have attempted to explain the differences observed in virus transmission efficiency between aphid probing and feeding behavior. Some workers have suggested that loss of virus from feeding aphids results from the continuous scouring and flushing activities associated with stylet penetration and sheath formation during a feeding insertion (McLean and Kinsey 1965; Sylvester 1969). An inhibitory effect of aphid saliva on non-persistent virus has also been reported (Nishi 1963; Nishi 1969).

Kennedy (1950) stated that the behavior of aphids

suggests that they could serve as virtually the sole vector of a virus disease for a crop they do not colonize. The above author stated that this is the case with tomato fern leaf virus disease. Swenson and Nelson (1959) reported virtual absence of aphid colonization on gladioli, and thus concluded that CMV spread would be largely due to migrating aphids.

Host and Environmental Influences on Aphids and Virus Infectivity

The effects of temperature and photoperiod will not be covered here since references were cited earlier in regard to aphid polymorphism and migration. In general, aphids prefer to feed on either young or senescing (aging) foliage, rather than mature foliage (Ibbotson and Kennedy 1950; Kennedy, Ibbotson, and Booth 1950; Kennedy and Booth 1951; Kennedy 1958; Kennedy and Stroyan 1959; Wyatt 1965; Swenson 1969). Leaf age selection by aphids has been interpreted as a response to high levels of nitrogen and low levels of potassium in the phloem associated with both plant growth and senescence (Evans 1938; Kennedy 1958; Branson and Simpson 1966; van Emden 1966; van Emden et al. 1969).

Secondary substances or non-nutrient indicator materials may also be involved in leaf age selection (Kennedy and Booth 1951; Fraenkel 1959; Wensler 1962).

There is evidence that some selection by aphids for

either young or aging leaves occurs as a visual response to yellow before alighting (Kennedy, Booth, and Kershaw 1961; Cartier 1966; Kring 1967; van Emden et al. 1969; Kring 1970b; Kring 1972). Aphids have also been shown to reproduce more rapidly on virus-infected and yellows disease infected plants (Kennedy 1951).

Variable results have been reported in regard to aphid responses to water content of plants (Kennedy, Lamb, and Booth 1958; Wearing and van Emden 1967; van Emden et al. 1969).

In general, plants are most susceptible to virus infection when they are grown under the following conditions: mineral nutrition and water supply such that they do not limit plant growth; moderate to low light intensities; temperatures in the range of 18 to 30 degrees Centrigrade (Bawden and Roberts 1948; Bawden and Kassanis 1950; Kassanis 1952; Tinsley 1953; Matthews 1970).

Vector aphids. Pinney (1969) noted over 65 species of aphids that have been reported as being able to transmit CMV. Twenty-seven have been reported to be found on gladioli. Thus there is a considerable number of aphid species that are potential vectors of CMV in gladioli, and only a small number of species have been tested in transmission tests. Those species starred in Table 20 are known vectors of CMV.

Twelve species of aphids were reported on gladioli in Wisconsin (Pinney 1969). Swenson and Nelson (1959) collected alates of 18 aphid species on gladioli in Oregon.

Their transmission tests also indicated that most aphid species found in gladiolus fields would be capable of transmitting CMV.

It is generally agreed that Myzus persicae (Sulz.) is one of the most efficient vectors of CMV in gladioli. The alatae of Myzus persicae are very active and restless aphids that take to flight readily, thus increasing the probability of their acquiring and transmitting a virus. Myzus persicae is also a relatively non-host-specific species that will alight and probe into many potential host plants without necessarily colonizing them (Kennedy 1950).

Plant Virus Disease Control

Most of the effective virus disease control procedures involve preventative measures that are designed to: (1) reduce the virus sources; (2) limit the spread by vectors; (3) minimize the effects of infection on yield (Matthews 1970). Excellent reviews discussing virus and vector control have been published by Broadbent (1957), Broadbent (1969), Matthews (1970), Bing (1972), and Watson and Plumb (1972).

Insecticidal control of vectors. In regard to controlling virus vectors, Broadbent (1969) stated that the problem of killing aphids is simple as compared with preventing them from spreading viruses. Many workers have reported it difficult to kill aphids quickly enough to prevent them from infecting healthy plants with a stylet-

borne virus (Burt, Heathcote, and Broadbent 1964; Hull and Selman 1965; Bing 1972). Shanks and Chapman (1965) tested several insecticides for speed of toxic action on winged green peach aphids which were placed on tobacco leaves that were treated two hours prior to testing and found that they required 51 to 180 minutes to kill 90 per cent of the test insects. They also reported that the best insecticide treatments required 80 minutes to kill 100 per cent of the aphids.

However, there have been favorable reports of reducing the spread of non-persistent virus by the use of insecticides to control aphid vectors (Broadbent, Burt, and Heathcote 1956; Burt, Broadbent, and Heathcote 1960; Broadbent et al. 1961; Broadbent, Heathcote, and Wright 1962). Simons (1957) reported that it was possible to reduce spread of potato virus Y in peppers by spraying infected border plants and weeds with parathion to control aphid vectors.

Broadbent (1957) stated that there is a need for persistent insecticides that paralyze or kill immediately, or for repellents that will prevent insects from probing or feeding. If the insecticide kills slowly or irritates the insect to become more active, the vector may move and spread the virus to more plants than it normally would infect (Broadbent 1957; Shanks and Chapman 1965). Conversely if the insecticide causes the insect to become lethargic and remain on one plant, the probability of further

virus spread will be reduced (Shanks and Chapman 1965).

Cultural control methods. Various cultural control practices may be of great value in reducing virus spread in gladioli (Bing 1972). One of the major problems in attempting to control virus disease spread is to locate and reduce sources or reservoirs of the virus. Broadbent (1969) stated that this may do nothing to decrease the number of vectors, but it may considerably decrease the proportion that is viruliferous. A major source of CMV in gladioli is infected corms planted along with healthy stock (Bing 1972). CMV does not over-winter in the soil or in plant remains from the previous season, but perennial weeds and volunteer plants may provide excellent reservoirs (Broadbent 1969; Matthews 1970; Tomlinson and Carter 1970).

Plants that are infected should be rogued and destroyed (Cadman and Chambers 1960; Bing 1962; Bing 1972). Forsberg (1962) was able to reduce the virus infection in gladioli from 29.6 per cent to 2.9 per cent by roguing. Roguing must be done early in the season before virus has spread to healthy plants (Broadbent 1969).

Many plants show an increase in virus resistance as they age. Bing and Johnson (1966) reported that, in general, later gladiolus plantings are most seriously affected by CMV. The results of a four year study showed a definite increase from a low of eight per cent CMV infected flowers for early April plantings to 46 per cent for late July

plantings (Bing and Johnson 1966). The same authors stated that there is a good correlation between the spread of CMV in late plantings and the abundance of winged aphids at the time gladiolus plants are in a young, growing, virus susceptible stage.

Simons (1957) stated that the most obvious weak link in the cycle of non-persistent virus transmission, from the standpoint of the vector, appears to be the relatively short time that the aphid remains infective after acquiring a non-persistent virus. Because of this, both increasing the distance from the virus source and the use of border crops may aid in reducing virus spread.

Growing plants under glass, cloth, or plastic for quarantine testing or for the production of virus-free stock is becoming more common (Broadbent 1969). Bing (1972) proposed a certified gladiolus corm program to produce virus-free stock. He stated that gladiolus cormels may have to be grown in cloth houses to exclude vectors and control virus spread. Corms may also be grown and propagated in this protected manner.

Individual plants may be found to be free of virus, in which case propagation may continue from these selected plants. Brierley (1963) reported that CMV infected gladiolus corms often produced virus free cormels, which may be grown and selected for freedom of virus.

Virus free stock propagation has been reported to be

successful with some plants by meristem tip cultures (Broadbent 1969; Matthews 1970; Simonsen and Hildebrandt 1971).

Protection of plants with chemicals other than insecticides. Considerable work has been done in search of virus inhibitors or anti-viral chemicals that can be applied directly to a growing crop to prevent virus infection (Matthews 1951; Simons, Swidler, and Moss 1963; Hirai and Shimomura 1965; Hariharasubramanian 1968; Lockhart and Semancik 1968). The conditions necessary for safe and effective virus control with anti-viral chemicals have been too limiting for practical use in the field.

Oil films sprayed on plant foliage have been reported to inhibit or prevent aphid acquisition and transmission of some non-persistent viruses (Bradley, Wade, and Wood 1962; Loebenstein, Alper, and Deutsch 1964; Allen 1965; Bradley, Moore, and Pond 1966; Loebenstein et al. 1966; Hein 1971). However, phytotoxicity has been noted in gladioli when treated with oil film sprays (A. Bing, personal communication).

Aluminum foil repellency. Many species of aphids are repelled by the light reflected from aluminum foil (Kring 1964; Smith et al. 1964; Wolfenbarger and Moore 1968; Kring 1969; Smith and Webb 1969; Kring 1970a; Kring 1970b). Repellency has been reported to either reduce or delay virus spread and increase yields in some plants (Smith et al.

1964; Johnson et al. 1967; Adlerz and Everett 1968; George and Kring 1971). However, in some instances aluminum foil mulches have reportedly given inadequate protection from aphid-borne virus disease infections (Dickson and Laird 1966; Hakkaart 1967; Rothman 1967; Shands and Simpson 1972).

A number of papers discuss flight behavior and color vision in aphids (Kennedy, Booth, and Kershaw 1961; Kring 1967; Kring 1970b; Kring 1972; Lewis and Siddhorn 1972).

When compared to non-foil controls, aluminum foil sheets placed between rows of gladioli repelled 87 to 97 per cent of the winged aphids and reduced the spread of CMV as much as 67 per cent (Smith et al. 1964; Johnson et al. 1967; Smith and Webb 1969; Bing 1972). Best results were obtained by placing foil on both sides and across the ends of gladiolus rows, covering at least 50 per cent of the planted area. At a distance of over two feet from the aluminum surface aphid repellency is slight; therefore, foil must be placed close to the plants (Bing 1972).

Kring (1969) discussed some of the advantages and disadvantages of using aluminum foil mulch to repell winged aphids. Although there are certain disadvantages, Bing (1972) stated that the use of aluminum foil mulch can be quite effective in propagating virus-free gladiolus stock when used in conjunction with the growing of stock from cormels, plus a continuous roguing program throughout the growing season.

RESULTS

Aphid Observations

Aphid abundance data were gathered and are presented in three catagories: alatae, (winged), apterae, (wingless), and nymphs. The majority of the data were analyzed by one or more of the following statistical treatments: analysis of variance, Duncan's multiple range test, orthogonal and non-orthogonal comparisons (Hills 1966).

The results of the 1971 experiment are considered to be less reliable than those of the 1972 experiment due to both a lower degree of replication and unanticipated difficulties encountered during the 1971 growing season.[1]

1971 experiment. Figure 1 indicates the seasonal abundance of aphids observed on gladioli grown in West Suffield, Connecticut in 1971. Two aphid population peaks were noted. The first peak occured the week of July 18, while the second reached its apex the week of August eighth. Rapid aphid population declines were noted following both peak periods. The majority of the aphids observed on gladioli were found to be alatae, with little or no population build-up or colonization by other aphid forms. However, it was noted that the aphid population observed the week of August 15 was comprised primarily of apterous and

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[1]Difficulties encountered are discussed earlier in this paper in the Methods and Materials section.

nymphal forms, while the number of alatae observed fell off sharply (Figure 1).

Results presented in Table 3 indicated that in 1971 the lowest numbers of alate aphids were observed on gladiolus plants treated with either aldicarb or oxydemeton-methyl. Analysis of variance revealed no statistically significant[2] differences between treatments (Table 9).

The seasonal averages of apterous aphids observed per gladiolus plant appear in Table 4. When apterous aphid data were subjected to analysis of variance a statistically significant difference in apterae numbers was detected between treatments (Table 10). Further statistical analysis by Duncan's multiple range test indicated that plants in bio-film control plots had significantly larger numbers of apterae than plants in either insecticide treated or untreated control plots. However, none of the insecticide treatments were found to be significantly better than the untreated control (Table 11).

Results of nymphal aphid data revealed that no immature aphids were observed throughout the entire growing season on gladiolus plants treated with aldicarb (Table 5). Upon completion of analysis of variance, a statistically

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[2]Unless otherwise stated in the text, all statistical analyses reported in this paper are at the 0.05 confidence level.

significant difference at the 0.01 level was found between treatments (Table 12). Results of Duncan's multiple range test indicated that when compared with the untreated control significantly fewer nymphal aphids were observed on plants treated with any of the following insecticides or combinations: aldicarb, oxydemeton-methyl, disulfoton, and oxydemeton-methyl plus bio-film spreader-sticker. When examined at the 0.01 level none of the treatments were found to differ significantly from the untreated control (Table 13).

1972 experiment. Figure 2 illustrates the seasonal abundance of aphids observed on gladioli grown in West Suffield, Connecticut in 1972. As in the previous year, two aphid population peaks were observed in 1972. The peaks occured during the weeks of July nine and August 13 respectively. Aphid numbers were again observed to drop off rapidly following these peak periods. Seasonal totals indicate that considerably more aphids were observed on gladiolus test plants in 1972 than in 1971. This is understandable since twice as many plants were used in the 1972 experiments. As in 1971, alatae comprised the majority of the aphid population observed on gladioli. Apterae and nymphs were found to dominate only during the week of August 20 (Figure 2).

The lowest average number of alatae in 1972 occured on plants treated with carbofuran 4 F, while the greatest average number of alatae were observed on untreated control plants (Table 6). When the data were subjected to analysis of variance a statistically significant difference in alate aphid numbers was detected between treatments (Table 14). Duncan's multiple range test further indicated that significantly fewer alatae were recorded on plants treated with either carbofuran 4 F or oxydemeton-methyl than on plants in untreated control plots. Carbofuran 4 F was also found to be significantly better than the following chemical treatments: oxamyl, dimethoate, and carbofuran 10 G.

Furthermore, when analyzed by Duncan's multiple range test carbofuran 4 F treated plants were still found to have had significantly fewer alatae than the untreated control at the 0.01 level (Table 15). Single degree of freedom orthogonal comparisons at the 0.01 level indicated that the chemical treatments grouped as a whole had significantly fewer alatae than the untreated control. No significant difference was detected between granular and foliar spray treatments (Table 14).

Results presented in Table 7 show that the lowest number of apterae were found on plants treated with aldicarb. Results of analysis of variance indicated that differences between treatments were approaching statistical significance (Table 16). Subsequent application of Duncan's multiple range test revealed that plants treated with carbofuran 4 F had significantly more apterae than any of the following treatments: aldicarb, disulfoton, oxamyl, oxydemeton-methyl, dimethoate, and untreated control. None of the treatments was found to have had significantly fewer apterae than the untreated control (Table 17). Results of single degree orthogonal comparisons indicated that significantly fewer apterae were observed on plants treated with granular insecticides than on those treated with foliar spray materials (Table 16).

As in 1971, no nymphal aphids were observed in 1972 on plants treated with aldicarb (Table 8). The results of

analysis of variance indicated that a significant difference in nymphal aphid numbers existed between treatments (Table 19). By virtue of Duncan's multiple range test, aldicarb, dimethoate, and disulfoton-treated plants were found to have had significantly fewer nymphal aphids than plants in carbofuran 10 G, acephate, and pirimicarb-treated plots. Once again, none of the treatments was found to be significantly different from the untreated control (Table 18).

Aphid Species

Aphid species collected in yellow-pan water traps placed in gladiolus fields in West Suffield, Connecticut during 1972 are listed in Table 20. A total of 22 species of alate aphids were identified by L. M. Russell at the USDA Entomological Laboratory in Beltsville, Maryland.

The following seven species of alate aphids were collected most frequently in West Suffield, Connecticut gladiolus fields: Aphis fabae Scop., Capitophorus hippophaes (Wlk.), Myzus persicae (Sulz.), Rhopalosiphum maidis (Fitch), Myzocallis punctata (Monell), Macrosiphum venaefuscae (Davis), and Aphis gossypii Glov. During late August both Macrosiphum euphorbiae (Thos.) and Acrythosiphum pisum (Harris) were also commonly observed. A large number of specimens of many of the above mentioned aphid species were collected; however, only a representative number of individuals was sent for identification.

There are no reports in the literature of either Myzocallis punctata or Macrosiphum venaefuscae being collected or reported in gladiolus plantings. The following other aphid species collected in West Suffield, Connecticut also have not been previously collected in gladiolus plantings: Nasonovia ribisnigri (Mosley), Calaphis betulaecolens (Fitch), Pemphigus populitransversus Riley, Therioaphis trifolii (Monell), Tinocallis ulmifolii (Monell), Monellia sp., Myzocallis walshii (Monell), and Myzocallis alnifoliae (Fitch). However, individuals of these species were found only singly or in very limited numbers, making evaluation of their importance as virus vectors questionable. Nevertheless, Nasonovia ribisnigri has been reported as being capable of transmitting cucumber mosaic virus to indicator plants (Pinney 1969).

Aphid Preference: Gladiolus Spike and Floral Tissue Versus Foliage

Data were gathered in 1972 to evaluate possible aphid preference for gladiolus spike and floral regions versus foliar areas of the plant. A total of 293 gladiolus plants in the process of spiking or flowering were sampled. Results revealed that considerable more aphids of all developmental stages were found on spike and floral regions than on foliar surfaces (Table 21). Aphids were frequently observed migrating from foliar to floral areas.

It appears that at the time of flowering, aphids prefer to feed on the young actively growing spike and flower tissues, rather than gladiolus foliage which would be mature at that time.

Virus Incidence

1971 experiment. Results presented in Table 22 show that the lowest percentage of virus-infected plants occured in plots treated with aldicarb, while the highest percentages appeared in untreated control and dimethoate-treated plots. However, results of analysis of variance indicated that no statistically significant differences existed between treatments (Table 24). Further investigation by Duncan's multiple range test also indicated no significant differences in virus incidence (Table 26).

Single degree of freedom orthogonal comparisons failed to detect a statistically significant difference in per cent virus infection between granular insecticide-treated plants and those treated with foliar spray materials (Table 24). Further examination by non-orthogonal[3] comparisons similarly

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[3]Non-orthogonal comparisons are non-independent single degree of freedom class comparisons. They are not considered to be as reliable as orthogonal comparisons since being non-independent they affect each others' results. For this reason the results of non-orthogonal comparisons are not presented in tabular form and should be considered as ambiguous probability statements. However, valuable directional or predictive information may be gained from such comparisons (LeClerg 1957).

indicated no significant difference between granular insecticide-treated and untreated control plots.

1972 experiment. Carbofuran 10 G and acephate-treated plants were found to have the lowest percentage of virus infection, while disease incidence was greatest in untreated control and oxydemeton-methyl-treated plots (Table 23). However, as in 1971, the results of analysis of variance showed no statistically significant differences between treatments (Table 25). Further analysis of the data by Duncan's multiple range test revealed virus incidence in oxydemeton-methyl-treated plots to be significantly higher than that observed in plots which received any of the following treatments: carbofuran 10 G, acephate, carbofuran 4 F, disulfoton, and pirimicarb. Aldicarb and dimethoate were also found to be approaching significance when compared to oxydemeton-methyl. None of the treatments was found to have had a significantly lower virus incidence than the untreated control (Table 27).

Gladiolus Growth and Yields

Plant height. Results presented in Table 28a revealed that gladiolus plants treated with aldicarb had the greatest average height per plant. Results of analysis of variance indicated that a statistically significant difference existed between treatments (Table 20). Further analysis by Duncan's multiple range test revealed that aldicarb-treated

plants were significantly taller than those that received any of the following treatments: untreated control, pirimicarb, dimethoate, oxydemeton-methyl, and carbofuran 10 G. Plants treated with either disulfoton or oxamyl were also found to be significantly taller than pirimicarb-treated plants. Aldicarb was also found to be significantly better than pirimicarb at the 0.01 level (Table 30).

Orthogonal comparison results at the 0.01 level indicated that plants treated with granular insecticides were significantly taller than those that received foliar spray materials (Table 29). A subsequent non-orthogonal comparison suggested that granular insecticide-treated plants were not significantly taller than untreated control plants.

Average heights for gladioli grown in granular-treated foliar spray-treated and untreated control plots are presented in Table 28b. Average heights of untreated control and foliar spray-treated plants were found to be essentially identical. However, gladiolus plants that received granular insecticide treatments averaged 2.16 inches taller than foliar spray-treated plants.

Flowerhead lengths. Results presented in Table 31a revealed that average flowerhead lengths were greatest for gladiolus plants treated with aldicarb. When the data were subjected to analysis of variance a statistically significant

difference was found between treatments at the 0.01 level (Table 32).

Further examination by Duncan's multiple range test indicated that plants treated with aldicarb, oxamyl, or disulfoton had significantly longer flowerheads than plants that received any of the following treatments: pirimicarb, dimethoate, carbofuran 4 F, oxydemeton-methyl, untreated control, and carbofuran 10 G. Aldicarb was additionally found to be significantly better than acephate. Results of Duncan's multiple range test at the 0.01 level revealed that aldicarb-treated plants had significantly longer flowerheads than untreated control plants (Table 33).

Results of single degree orthogonal comparisons at the 0.01 level indicated that plants treated with granular insecticide materials had significantly longer flowerheads than those that received only foliar spray treatments (Table 32). Results of a subsequent non-orthogonal comparison at the 0.01 level indicated that granular insecticide-treated plants also had significantly greater flowerhead lengths than untreated control plants.

Average flowerhead lengths for plants grown in granular-treated, foliar spray-treated, and untreated control plots appear in Table 31b. Average flowerhead lengths were found to differ only slightly between plants in foliar spray-treated and untreated control plots. Granular-treated

plants were found to have had average flowerhead lengths 2.14 inches longer than foliar spray-treated plants and 2.38 inches longer than those of the untreated control (Table 31b).

Bud number. Gladiolus plants treated with aldicarb were found to have averaged the greatest number of buds per spike (Table 34a). Even at the 0.01 level results of analysis of variance indicated that a statistically significant difference existed between treatments (Table 35).

Results of Duncan's multiple range test at the 0.01 level revealed that plants treated with aldicarb had significantly more buds per spike than plants which received any of the following treatments: pirimicarb, oxydemeton-methyl, carbofuran 4 F, dimethoate, and untreated control. Aldicarb was also found to be significantly better at the 0.05 level than either carbofuran 10 G or acephate. Likewise oxamyl and disulfoton-treated plants were also found to have significantly more buds than pirimicarb, oxydemeton-methyl, and carbofuran 4 F-treated gladiolus plants (Table 36).

Results of orthogonal comparisons at the 0.01 level indicated that plants treated with granular insecticides had significantly more buds per spike than those treated with foliar sprays (Table 35). Furthermore, results of non-orthogonal comparisons suggested that granular-treated plants had significantly more buds than untreated control plants.

The average numbers of buds per spike for plants grown in granular-treated, foliar spray-treated, and untreated control plots appear in Table 34b. Essentially no difference in average bud number per spike was detected between foliar spray and untreated control plots. However, a difference of 1.01 buds was noted between granular-treated and untreated control gladiolus plants.

Plant Growth of Healthy Versus Virus-Infected Gladiolus

Average plant heights for healthy and virus-infected plants are presented for each treatment in Table 37. Both healthy and virus-infected plants treated with aldicarb had the greatest average height per plant. Over-all the average height of virus-infected gladiolus plants was approximately 6.54 inches shorter than healthy plants. The loss in plant height for virus-infected plants was determined to be approximately 13.12 per cent (Table 40).

Results presented in Table 38 indicated that healthy aldicarb-treated plants had on the average the longest flowerheads, while flowerhead lengths of virus-infected plants were found to be longest for plants treated with either disulfoton or aldicarb. The average flowerhead lengths of healthy plants was found to have been approximately 3.07 inches longer per spike than virus-infected plants. This figure was found to represent an 11.06 per cent loss in flowerhead length (Table 40).

Healthy aldicarb-treated plants also averaged the greatest number of buds per spike (Table 39). Bud number for virus-infected plants was found to be greatest for aldicarb and acephate-treated plants. Healthy plants were found to have averaged 1.36 more buds per spike than virus-infected plants. This figure represented a 6.20 per cent loss in bud number (Table 40).

Corm Weights

Gladiolus corm weight data are presented in Table 45. When examined after curing the average weight of gladiolus corms planted was found to have doubled during the 1972 growing season. However, no major differences in corm weight gains were detected between insecticidal treatments and the untreated control. Average corm weight increases for the following six treatments were higher than the over-all average: disulfoton, acephate, pirimicarb, untreated control, oxamyl, and carbofuran 10 G (Table 45).

Plant Emergence and Early Season Growth

Plant emergence. More aldicarb-treated plants had emerged from the soil 17 days after planting than plants in other chemically-treated or untreated control plots (Table 41). Results of analysis of variance detected no significant differences between treatments (Table 42). Non-orthogonal comparisons indicated that gladiolus plots treated with granular insecticides at planting had

significantly more plants emerged 17 days later than plots that had not received granular treatments at planting.

Plant height 23 days after planting. Early in the growing season plants in plots designated to be treated with either dimethoate or pirimicarb had the greatest average height per plant (Table 46). Analysis of variance detected no significant differences between treatments (Table 47).

Non-orthogonal comparisons detected no significant difference in early season gladiolus plant heights between plants that received granular insecticide treatment at planting and those plants that remained untreated until a later date.

Aluminum Foil Treatments

1971 experiment. Results of the 1971 test are presented in Table 48. The results of this test were inconclusive.

More aphids were observed on plants treated with aluminum foil than on plants in untreated plots. However, the majority of aphids observed on foil-treated plants were apterae and nymphs, while the greatest number of alatae were observed on untreated foil-free plants. In both control and foil-treated plots aphids were observed to be more abundant on plants of the variety Vicki Lin (Table 48).

Numbers of virus-infected plants were found to be lowest in aluminum foil-treated plots (Table 48). However, it appeared that all of the plants of the variety Blue Mist

recorded as being virus-infected were diseased at the time of planting, since severe virus symptoms were present immediately upon emergence from the soil. If these data are eliminated little difference in virus incidence was observed between aluminum foil-treated and untreated control plots.

1972 experiment. Alate aphids were collected in aluminum foil-treated and untreated control plots by means of yellow-pan water traps. These results are presented in Table 49. They show that throughout the entire growing season only 11 alate aphids were collected in water traps placed in aluminum foil-treated plots. In contrast, a total of 481 alatae were captured in traps located in gladiolus plantings that had not received foil treatment (Table 49).

Results presented in Table 50 revealed that the number of virus-infected plants observed in aluminum foil-treated versus non-foil-treated control plots differed only slightly in 1972.

DISCUSSION

Certain insecticide treatments reduced the number of aphids observed on gladiolus plants. Significantly fewer alate aphids were recorded on plants treated with either carbofuran 4 F or oxydemeton-methyl than on untreated controls (Table 15). Orthogonal comparisons demonstrated that significantly fewer alate were observed on insecticide-treated plants than on untreated controls (Table 14).

In 1971 some chemicals reduced nymphal aphid numbers on gladioli (Table 13). During the two years 1971 and 1972 no nymphs were ever observed on aldicarb-treated plants (Tables 5, 8).

The alate form made up the bulk of the aphid populations found on gladiolus. Practically no aphid build-up was observed (Figures 1, 2). These findings are in agreement with earlier work in Oregon (Swenson and Nelson 1959).

Although some success was attained in reducing aphid numbers with insecticides, none of the treatments was found to significantly reduce virus disease incidence. In both years the untreated controls had the second highest virus incidence, but in neither year were the differences between treatments statistically significant (Tables 22, 23, 26, 27).

A total of 22 different aphid species were collected from gladiolus (Table 20). Ten of these had not previously been reported in gladiolus plantings. Most of the aphids collected from gladiolus in Oregon were found to be capable

of transmitting cucumber mosaic virus disease (Swenson and Nelson 1959). Also aphids have been reported to alight and probe on both host and non-host plants with equal frequency (Kring 1972). It is during these host testing probes that aphids are most successful in transmitting non-persistent virus diseases (Hashiba and Misawa 1969a). Therefore, there are many species of alate aphids that are potential vectors of CMV in gladiolus.

The primary shortcoming of virus disease control through vector control is that successful stylet-borne virus transmission requires only one viruliferous aphid probe of a few seconds duration on a susceptible plant (Shanks and Chapman 1965). This may have been the reason for lack of disease control in treatments where alate aphid numbers were reduced. Apparently the chemicals tested did not prevent aphids from probing, nor did they kill the vectors quickly enough to prevent virus transmission.

Our results confirm earlier reports that CMV cannot be significantly reduced through insecticidal control of vector aphids. However, recommendations are still being made regarding control of vector aphids to reduce non-persistent virus spread (Manning, in "Gentile, Manning, and Thomson" 1973; Miller and Partyka 1974; Sherf and Schultz 1974). It is hoped that our results will end such misleading recommendations.

Aphids were found to prefer gladiolus spikes and

flowers over foliage (Table 21). This was understandable since spike and flower tissues were in actively growing stages after the foliage had matured. This suggests a cultural approach which should be useful in reducing virus spread in gladiolus. First, we suggest that gladiolus spikes be cut for sale as soon as commercially feasible. Second, those flowers not sold (overbloomed, dying and undersized spikes) should be cut and removed from the field. Such a "clean-cutting" procedure would remove both the tissue most susceptible to viral infection and that most acceptable to aphids as probing sites.

Some growers purposely leave spikes in the field to flower to the terminal bud. This is done as part of a roguing program to be "completely sure" that the plant is not virus-infected. Often the last few flowers of what otherwise appeared to be a perfectly healthy plant will show CMV symptoms. The grower may feel that he has caught this inconspicuously infected plant by letting it flower-out in the field. We are suggesting that some of these plants could have been initially virus-free, but became infected during the "inspection" period by viruliferous aphids attracted to the flowers. Even if symptoms do not have time to develop in the fall the plant may still be virus infected. If so, the virus may overwinter in the corm and symptoms may become visible the following season.

Some of the granular insecticide treatments were found

to have significant stimulatory effects on gladiolus growth. A similar phenomenon has been reported for other crops (Chapman and Allen 1948; Cox and Lilly 1952; Apple 1971). Chapman and Allen (1948) noted that the effects of DDT on plants closely resembled that of plant hormones. Only granular treatments applied to the soil exhibited a stimulatory effect on gladiolus plant growth. Possibly soil-borne root-feeding pests may have been controlled, thus resulting in better root systems.

Virus infection reduced gladiolus growth in all three indicator catagories used (Table 40). Plant height was reduced by approximately 13.12 per cent, flowerhead length was down 11.06 per cent, and bud count dropped by 6.20 per cent in virus-infected plants. However, even the virus-infected plants in plots treated with aldicarb, disulfoton, and (to a lesser degree) vydate exhibited superior growth as compared to other virus-infected plants (Tables 37, 38, 39). It appears that even the virus-infected plants benefited from these granular treatments.

Work should be done to determine whether growers might be able to reduce fertilizer applications by using granular treatments of aldicarb, disulfoton or oxamyl. Aldicarb and disulfoton are also of value in thrips control. Neither thrips nor their damage was noticeable on plants treated with aldicarb or disulfoton, as compared with some other treatments.

Plant stimulation by granular insecticides, regardless of whether it is direct or indirect, should be of interest to growers of exhibition gladioli. Increased flowerhead length and greater bud production are of primary concern to exhibitors.

No significant differences in plant emergence and early season growth were observed (Table 42). Therefore, plant stimulation probably occured later at the time of spike formation. However, significantly more granular insecticide-treated plants had emerged 17 days after planting than in plots that had not received granular treatment.

Aluminum foil treatment of gladiolus plots was not successful in reducing CMV spread. Foil treatment reportedly has been successful in protecting cormlet and propagative stocks from virus infection (Johnson et al. 1967). Gladiolus plants from large size corms often grow to a height of five feet. Since the effectiveness of aluminum foil is slight at distances above two feet, foil "protection" of full-size plants is questionable.

SUMMARY AND CONCLUSIONS

1. Twenty-two aphid species (alate) were collected in gladiolus plantings. Of these, at least 10 species had not previously been reported from this crop.
2. Practically no aphid build-up occured on the experimental gladiolus, either treated or untreated.
3. Aphids preferred gladiolus spike and flower tissue over foliar areas, a finding which may have practical implications.
4. In 1972 significantly fewer alate aphids were observed on plants treated with carbofuran 4 F or oxydemeton-methyl than on the untreated controls.
5. The untreated control plots showed the highest virus incidence in both 1971 and 1972. However, none of the insecticide treatments had a significantly lower virus incidence than the untreated controls.
6. Three of the granular insecticide treatments (aldicarb, disulfoton, and oxamyl) had stimulatory effects on plants as shown by one or more of three growth indicators: plant height, flowerhead length, and number of buds. For the above mentioned growth indicator catagories granular insecticide treatments, analyzed as a group, were significantly better than the foliar spray applications grouped. Flowerhead lengths and number of buds per head in granular-treated plots were significantly

better than the untreated control.

7. Aluminum foil treatment did not appreciably reduce virus incidence in gladiolus grown from full size corms. However, this treatment greatly reduced the numbers of alate aphids captured in yellow-pan water traps.

APPENDIX

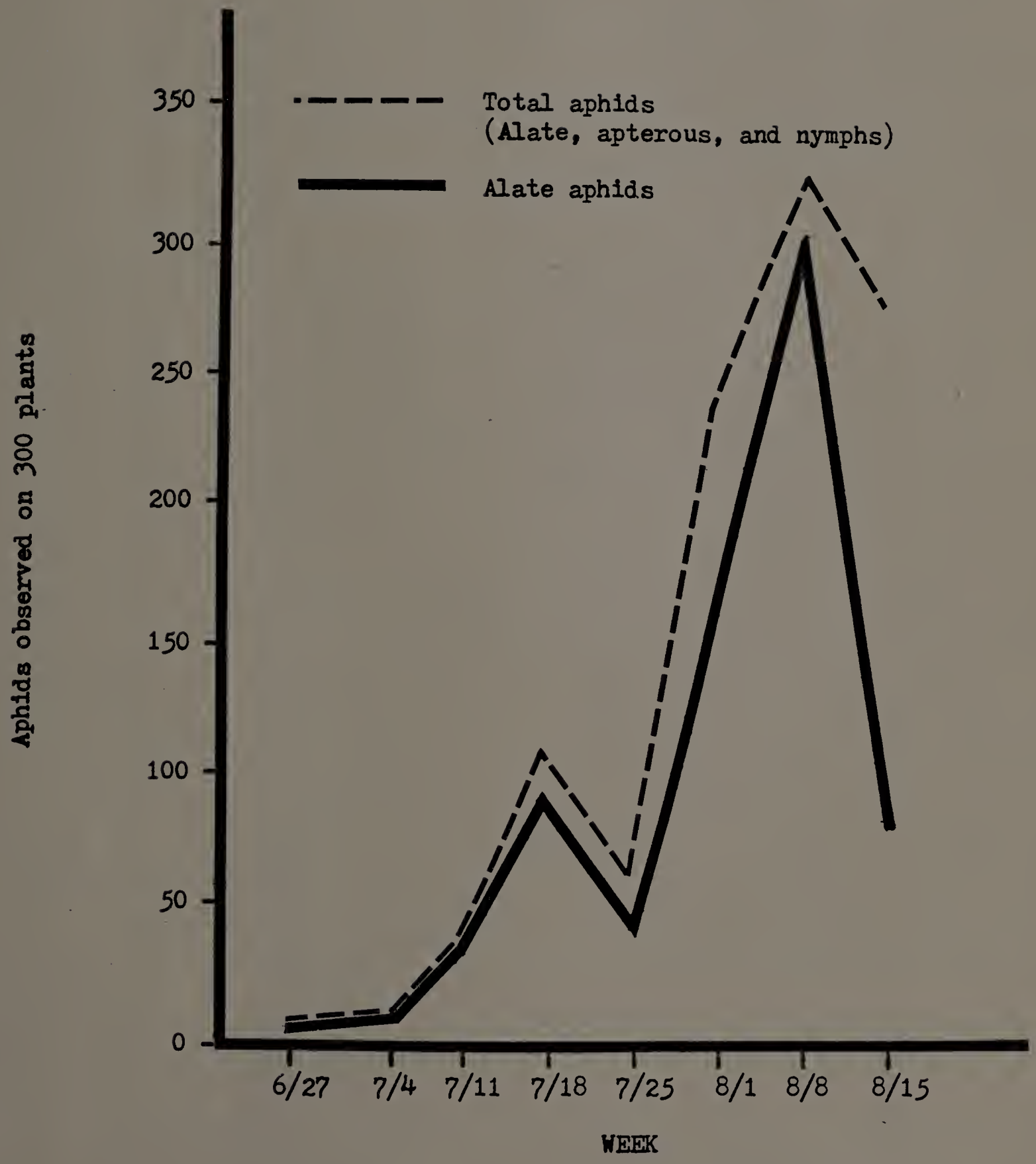

Figure 1. Aphid populations on gladioli - 1971.

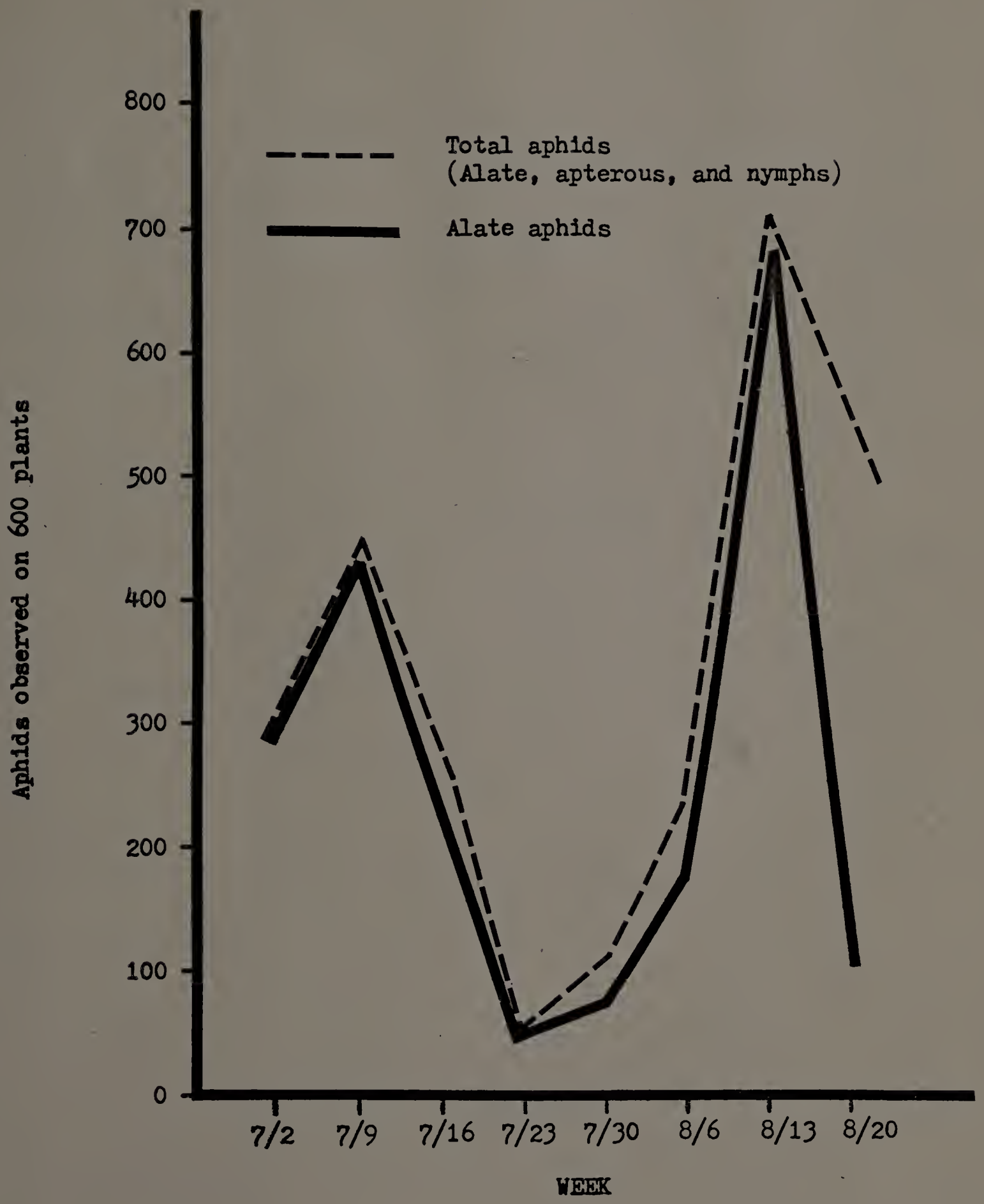

Figure 2. Aphid populations on gladioli - 1972.

Table 1. Insecticide treatments on gladiolus - 1971.

Insecticide	Formulation	Applications	Dosage of actual insecticide/acre/ application	Amount of formulation/five-foot plot/ application
1. Untreated control	-----	-----	-----	-----
2. Aldicarb	10 G	2	1.00 lb.	1.56 gms.
3. Bio-film control	S	3	8.00 fl. ozs.	0.10 ml.
4. Carbofuran	4 F	3	1.00 lb.	0.30 ml.
5. Carbofuran	10 G	2	1.00 lb.	1.56 gms.
6. Dimethoate	2 EC	3	0.50 lb.	0.33 ml.
7. Disulfoton	2 G	2	2.00 lbs.	15.60 gms.
8. Oxamyl	10 G	2	1.50 lbs.	2.34 gms.
9. Oxydemeton-methyl	2 EC	3	0.38 lb.	0.25 ml.
10. Oxydemeton-methyl plus bio-film	2 EC	3	0.38 lb.	0.25 ml.

Table 2. Insecticide treatments on gladiolus - 1972.

Insecticide	Formulation	Applications	Dosage of actual insecticide/acre/ application	Amount of formulation/five-foot plot/ application
1. Untreated control	-----	-----	-----	-----
2. Acephate	75 S	3	1.00 lb.	0.23 gm.
3. Aldicarb	10 G	2	1.00 lb.	1.56 gms.
4. Carbofuran	4 F	3	1.00 lb.	0.35 ml.
5. Carbofuran	10 G	2	1.00 lb.	1.56 gms.
6. Dimethoate	2 EC	3	1.00 lb.	0.71 ml.
7. Disulfoton	15 G	2	1.00 lb.	1.04 gms.
8. Oxamyl	10 G	2	1.00 lb.	1.56 gms.
9. Oxydemeton-methyl	2 EC	3	1.00 lb.	0.71 ml.
10. Pirimicarb	50 WP	3	1.00 lb.	0.34 gm.

Table 3. Alate aphids observed on gladioli treated with various insecticides - 1971.

Treatment	Average number of alatae per plant
1. Aldicarb	1.96
2. Oxydemeton-methyl	2.00
3. Disulfoton	2.11
4. Carbofuran 4 F	2.12
5. Oxamyl	2.44
6. Untreated control	2.44
7. Oxydemeton-methyl plus bio-film	2.50
8. Bio-film	2.65
9. Carbofuran 10 G	3.04
10. Dimethoate	3.47

Table 4. Apterous aphids observed on gladioli treated with various insecticides - 1971.

Treatment	Average number of apterae per plant
1. Oxydemeton-methyl	0.08
2. Aldicarb	0.20
3. Carbofuran 10 G	0.24
4. Oxydemeton-methyl plus bio-film	0.27
5. Disulfoton	0.32
6. Carbofuran 4 F	0.35
7. Untreated control	0.35
8. Oxamyl	0.36
9. Dimethoate	0.68
10. Bio-film	1.65

Table 5. Nymphal aphids observed on gladioli treated with various insecticides - 1971.

Treatment	Average number of nymphs per plant
1. Aldicarb	0.00
2. Oxydemeton-methyl plus bio-film	0.08
3. Disulfoton	0.11
4. Oxydemeton-methyl	0.23
5. Dimethoate	0.53
6. Oxamyl	1.00
7. Carbofuran 4 F	1.08
8. Untreated control	1.30
9. Bio-film	2.00
10. Carbofuran 10 G	2.12

Table 6. Alate aphids observed on gladioli treated with various insecticides - 1972.

Treatment	Average number of alatae per plant
1. Carbofuran 4 F	2.63
2. Oxydemeton-methyl	3.00
3. Acephate	3.29
4. Aldicarb	3.33
5. Disulfoton	3.39
6. Pirimicarb	3.56
7. Carbofuran 10 G	3.66
8. Dimethoate	3.75
9. Oxamyl	3.75
10. Untreated control	4.34

Table 7. Apterous aphids observed on gladioli treated with various insecticides - 1972.

Treatment	Average number of apterae per plant
1. Aldicarb	0.16
2. Disulfoton	0.23
3. Oxamyl	0.28
4. Oxydemeton-methyl	0.45
5. Untreated control	0.46
6. Dimethoate	0.51
7. Acephate	0.66
8. Carbofuran 10 G	0.80
9. Pirimicarb	0.92
10. Carbofuran 4 F	1.33

Table 8. Nymphal aphids observed on gladioli treated with various insecticides - 1972.

Treatment	Average number of nymphs per plant
1. Aldicarb	0.00
2. Dimethoate	0.05
3. Disulfoton	0.07
4. Oxydemeton-methyl	0.12
5. Untreated control	0.17
6. Carbofuran 4 F	0.20
7. Oxamyl	0.30
8. Pirimicarb	0.61
9. Acephate	0.62
10. Carbofuran 10 G	0.66

Table 9. Analysis of variance for alate aphids observed in gladiolus plots - 1971. (Each value represents an average of the seasonal total of alate aphids observed in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3
A Untreated control	3.86	1.50	2.13
B Carbofuran 4 F	2.11	2.88	1.44
C Carbofuran 10 G	3.17	1.90	4.22
D Aldicarb	3.25	1.11	1.67
E Oxydemeton-methyl	2.00	1.67	2.38
F Oxydemeton-methyl plus bio-film	2.11	1.50	3.78
G Bio-film	2.60	2.50	2.86
H Dimethoate	4.50	4.44	1.25
I Oxamyl	2.20	3.57	1.63
J Disulfoton	1.89	2.32	2.10

ANOVA

Source	df	SS	MS	Observed F
Total	29	27.11		
Replicates	2	1.21	0.61	
Treatments	9	5.82	0.65	0.58
Error	18	20.08	1.12	

Table 10. Analysis of variance for apterous aphids observed in gladiolus plots - 1971. (Each value represents an average of the seasonal total of apterous aphids observed in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3
A Untreated control	0.57	0.13	0.38
B Carbofuran 4 F	0.67	0.13	0.22
C Carbofuran 10 G	0.00	0.30	0.22
D Aldicarb	0.00	0.33	0.22
E Oxydemeton-methyl	0.00	0.11	0.13
F Oxydemeton-methyl plus bio-film	0.67	0.00	0.11
G Bio-film	0.90	1.67	2.71
H Dimethoate	0.00	1.44	0.00
I Oxamyl	0.40	0.43	0.25
J Disulfoton	0.22	0.67	0.10

ANOVA

Source	df	SS	MS	Observed F
Total	29	10.10		
Replicates	2	0.15	0.08	
Treatments	9	6.23	0.69	3.29 *
Error	45	3.72	0.21	

*Significant at the 0.05 level.

Table 11. Results of Duncan's multiple range test for the apterous aphid data presented in Tables 4 and 10.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.97	3.12	3.21	3.27	3.32	3.35	3.37	3.39	3.41
Rp	0.78	0.82	0.85	0.86	0.88	0.88	0.89	0.90	0.90
Treatment[4]	E	D	C	F	J	B	A	I	H	G
Mean[5]	0.08	0.20	0.24	0.27	0.32	0.35	0.35	0.36	0.68	1.65

p	2	3	4	5	6	7	8	9	10
.01 rp	4.07	4.27	4.38	4.46	4.53	4.59	4.64	4.68	4.71
Rp	1.07	1.13	1.16	1.18	1.20	1.21	1.22	1.24	1.24
Treatment	E	D	C	F	J	B	A	I	H	G
Mean	0.08	0.20	0.24	0.27	0.32	0.35	0.35	0.36	0.68	1.65

[4]Treatment and letter designations are given in analysis of variance table for the corresponding data.

[5]Means underlined by the same line are not significantly different from each other.

Table 12. Analysis of variance for nymphal aphids observed in gladiolus plots - 1971. (Each value represents an average of the seasonal total of nymphal aphids observed in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3
A Untreated control	1.71	1.25	1.00
B Carbofuran 4 F	2.89	0.13	0.11
C Carbofuran 10 G	2.33	2.10	1.64
D Aldicarb	0.00	0.00	0.00
E Oxydemeton-methyl	0.44	0.22	0.00
F Oxydemeton-methyl plus bio-film	0.00	0.00	0.22
G Bio-film	1.60	2.00	2.57
H Dimethoate	0.17	0.67	0.75
I Oxamyl	0.90	0.86	1.25
J Disulfoton	0.00	0.22	0.10

ANOVA

Source	df	SS	MS	Observed F
Total	29	23.01		
Replicates	2	0.42	0.21	
Treatments	9	16.47	1.83	5.38 **
Error	18	6.12	0.34	

** Significant at the 0.01 level.

Table 13. Results of Duncan's multiple range test for the nymphal aphid data presented in Tables 5 and 12.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.97	3.12	3.21	3.27	3.32	3.35	3.37	3.39	3.41
Rp	1.00	1.05	1.08	1.10	1.12	1.13	1.13	1.14	1.15

Treatment	D	F	J	E	H	I	B	A	G	C
Mean	0.00	0.08	0.11	0.23	0.53	1.00	1.08	1.30	2.00	2.12

p	2	3	4	5	6	7	8	9	10
.01 rp	4.07	4.27	4.38	4.46	4.53	4.59	4.64	4.68	4.71
Rp	1.37	1.43	1.47	1.50	1.52	1.54	1.56	1.57	1.58

Treatment	D	F	J	E	H	I	B	A	G	C
Mean	0.00	0.08	0.11	0.23	0.53	1.00	1.08	1.30	2.00	2.12

Table 14. Analysis of variance for alate aphids observed in gladiolus plots - 1972. (Each value represents an average of the seasonal total number of alate aphids observed in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	4.80	4.10	3.40	4.00	4.20	5.67
B Disulfoton	4.56	3.63	2.60	3.20	2.11	4.30
C Acephate	4.80	4.50	2.10	2.30	2.20	4.10
D Oxamyl	3.20	3.30	2.90	3.60	5.40	4.10
E Carbofuran 10 G	4.40	3.20	2.70	3.00	2.40	6.56
F Oxydemeton-methyl	2.00	3.44	2.90	1.89	3.10	4.60
G Pirimicarb	4.33	2.80	3.00	3.22	4.14	4.11
H Dimethoate	4.78	2.78	2.67	4.10	3.20	4.90
I Carbofuran 4 F	2.50	2.80	2.30	2.90	2.40	2.90
J Aldicarb	2.80	2.89	3.20	2.50	3.22	5.30

ANOVA

Source	df	SS	MS	Observed F
Total	59	61.35		
Replicates	5	22.33	4.47	
Treatments	9	12.00	1.33	2.22 *
(a) A vs. rest	1	5.14	5.14	8.57 **
(b) BDEJ vs. CFGHI	1	1.09	1.09	1.82
Error	45	27.02	0.60	

Table 15. Results of Duncan's multiple range test for the alate aphid data presented in Tables 6 and 14.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	0.92	0.96	0.99	1.01	1.03	1.05	1.06	1.07	1.07
Treatment	I	F	C	J	B	G	E	H	D	A
Mean	2.63	3.00	3.29	3.33	3.39	3.56	3.66	3.75	3.75	4.34

p	2	3	4	5	6	7	8	9	10
.01 rp	3.82	3.99	4.10	4.17	4.24	4.30	4.34	4.37	4.41
Rp	1.22	1.28	1.31	1.33	1.36	1.38	1.39	1.40	1.41
Treatment	I	F	C	J	B	G	E	H	D	A
Mean	2.63	3.00	3.29	3.33	3.39	3.56	3.66	3.75	3.75	4.34

Table 16. Analysis of variance for apterous aphids observed in gladiolus plots - 1972. (Each value represents an average of the seasonal total number of apterous aphids observed in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	0.70	0.40	0.60	0.00	0.60	0.44
B Disulfoton	0.33	0.38	0.40	0.00	0.22	0.10
C Acephate	0.20	0.13	0.20	0.10	2.80	0.40
D Oxamyl	0.30	0.20	0.80	0.00	0.00	0.40
E Carbofuran 10 G	0.60	0.00	0.70	1.80	1.60	0.00
F Oxydemeton-methyl	0.10	1.00	0.60	0.22	0.30	0.50
G Pirimicarb	1.56	0.30	1.30	0.67	0.71	1.00
H Dimethoate	0.44	1.22	0.11	0.00	0.60	0.70
I Carbofuran 4 F	0.10	1.30	2.80	2.70	0.80	0.30
J Aldicarb	0.40	0.00	0.10	0.00	0.22	0.20

ANOVA

Source	df	SS	MS	Observed F
Total	59	26.00		
Replicates	5	0.45	0.09	
Treatments	9	6.92	0.77	1.88
(a) A vs. rest	1	0.10	0.10	0.24
(b) BDEJ vs. CFGHI	1	2.21	2.21	5.39 *
Error	45	18.63	0.41	

Table 17. Results of Duncan's multiple range test for the apterous aphid data presented in Tables 7 and 16.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	0.74	0.78	0.81	0.82	0.84	0.85	0.86	0.87	0.87
Treatment	J	B	D	F	A	H	C	E	G	I
Mean	0.16	0.23	0.28	0.45	0.46	0.51	0.66	0.80	0.92	1.33

Table 18. Results of Duncan's multiple range test for the nymphal aphid data presented in Tables 8 and 19.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	0.48	0.50	0.52	0.53	0.54	0.55	0.55	0.56	0.56
Treatment	J	H	B	F	A	I	D	G	C	E
Mean	0.00	0.05	0.07	0.12	0.17	0.20	0.30	0.61	0.62	0.66

Table 19. Analysis of variance for nymphal aphids observed in gladiolus plots - 1972. (Each value represents the average of the seasonal total number of nymphal aphids for a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	0.50	0.00	0.10	0.00	0.10	0.33
B Disulfoton	0.00	0.00	0.40	0.00	0.00	0.00
C Acephate	0.70	0.00	0.00	0.10	1.90	0.90
D Oxamyl	0.00	1.40	0.40	0.00	0.00	0.00
E Carbofuran 10 G	1.00	0.00	1.00	1.30	0.60	0.00
F Oxydemeton-methyl	0.00	0.11	0.40	0.00	0.00	0.20
G Pirimicarb	0.56	0.30	0.80	1.33	0.00	0.56
H Dimethoate	0.00	0.00	0.00	0.00	0.00	0.30
I Carbofuran 4 F	0.00	0.40	0.50	0.10	0.20	0.00

ANOVA

Source	df	SS	MS	Observed F
Total	59	10.99		
Replicates	5	0.13	0.03	
Treatments	9	3.35	0.37	2.17 *
(a) A vs. rest	1	0.071	0.071	0.42
(b) BDEJ vs. CFGHI	1	0.045	0.045	0.26
Error	45	7.51	0.17	

Table 20. Species of aphids collected in gladioli grown in West Suffield, Connecticut during 1972.

Species	Not previously reported in gladiolus	Reported vectors of CMV
Aphis fabae Scop.		*
Capitophorus hippophaes (Wik.)		
Myzus persicae (Sulz.)		*
Rhopalosiphum maidis (Fitch)		*
Myzocallis punctata (Monell)	*	
Macrosiphum venaefuscae (Davis)	*	
Aphis gossypii Glov.		*
Macrosiphum euphorbiae (Thos.)		*
Myzocallis walshii (Monell)	*	
Nasonovia ribisnigri (Mosley)	*	*
Therioaphis trifolii (Monell)	*	
Acrythosiphum pisum (Harris)		*
Aphis craccivora Koch		*
Aphis maidiradicis (Forbes)		
Calaphis betulaecolens (Fitch)	*	
Capitophorus elaeagni (DelGuer.)		*
Macrosiphum sp.		
Monellia sp.	*	
Myzocallis alnifoliae (Fitch)	*	
Pemphigus populitransversus Riley	*	
Rhopalosiphum fitchii (Sand.)		*
Tinocallis ulmifolii (Monell)	*	

Table 21. Aphid preference for gladiolus spike and floral tissues versus foliage.

Aphid form	Number of aphids observed	
	Foliage	Spike and flowers
Alatae	22	50
Apterae	43	179
Nymphs	6	103
Totals	71	332

Table 22. Virus disease incidence observed in gladioli treated with various insecticides - 1971.

Treatment	Percentage of plants virus-infected
1. Aldicarb	7.69
2. Disulfoton	10.71
3. Carbofuran 4 F	11.54
4. Carbofuran 10 G	12.00
5. Oxydemeton-methyl	15.38
6. Oxydemeton-methyl plus bio-film	15.38
7. Oxamyl	20.00
8. Bio-film	21.74
9. Untreated control	30.43
10. Dimethoate	36.84

Table 23. Virus disease incidence observed in gladioli treated with various insecticides - 1972.

Treatment	Percentage of plants virus-infected
1. Carbofuran 10 G	1.69
2. Acephate	1.72
3. Carbofuran 4 F	3.33
4. Disulfoton	3.57
5. Pirimicarb	3.70
6. Aldicarb	5.17
7. Dimethoate	5.26
8. Oxamyl	6.67
9. Untreated control	8.47
10. Oxydemeton-methyl	13.79

Table 24. Analysis of variance for virus disease incidence in gladiolus plots - 1971. (Each value represents an average of the total number of virus-infected plants in a particular replicate divided by the number of plants in the replicate. Per cent virus incidence for a particular replicate may be obtained by multiplying the values given below for the treatment by 100).

Treatment	Replicate 1	2	3
A Untreated control	0.29	0.25	0.38
B Carbofuran 4 F	0.11	0.13	0.11
C Carbofuran 10 G	0.00	0.10	0.22
D Aldicarb	0.13	0.00	0.11
E Oxydemeton-methyl	0.22	0.22	0.00
F Oxydemeton-methyl plus bio-film	0.11	0.25	0.11
G Bio-film	0.20	0.17	0.29
H Dimethoate	0.00	0.67	0.25
I Oxamyl	0.20	0.14	0.25
J Disulfoton	0.22	0.00	0.10

ANOVA

Source	df	SS	MS	Observed F
Total	29	0.535		
Replicates	2	0.007	0.0035	
Treatments	9	0.180	0.0200	1.04
(a) A vs. rest	1	0.0584	0.0584	3.03
(b) CDIJ vs. BEFGH	1	0.0300	0.0300	1.55
Error	18	0.348	0.0193	

Table 25. Analysis of variance for virus disease incidence in gladiolus plots - 1972. (Each value represents an average of the total number of virus-infected plants in a particular replicate divided by the number of plants in the replicate. Per cent virus incidence for a particular replicate may be obtained by multiplying the values given below for the treatment by 100).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	0.10	0.00	0.00	0.10	0.10	0.22
B Disulfoton	0.00	0.00	0.00	0.10	0.11	0.00
C Acephate	0.00	0.00	0.00	0.00	0.00	0.10
D Oxamyl	0.00	0.00	0.10	0.30	0.00	0.00
E Carbofuran 10 G	0.00	0.00	0.00	0.00	0.10	0.00
F Oxydemeton-methyl	0.20	0.22	0.10	0.11	0.10	0.10
G Pirimicarb	0.00	0.00	0.00	0.22	0.00	0.00
H Dimethoate	0.00	0.00	0.11	0.10	0.10	0.00
I Carbofuran 4 F	0.00	0.00	0.00	0.00	0.10	0.10
J Aldicarb	0.00	0.00	0.10	0.00	0.11	0.10

ANOVA

Source	df	SS	MS	Observed F
Total	59	0.314		
Replicates	5	0.037	0.0074	
Treatments	9	0.074	0.0082	1.82
(a) A vs. rest	1	0.0074	0.0074	1.64
(b) BDEJ vs. CFGHI	1	0.0022	0.0022	0.49
Error	45	0.203	0.0045	

Table 26. Results of Duncan's multiple range test for the virus disease incidence data presented in Tables 22 and 24.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.97	3.12	3.21	3.27	3.32	3.35	3.37	3.39	3.41
Rp	0.238	0.250	0.257	0.262	0.266	0.268	0.270	0.271	0.273
Treatment	D	J	C	B	E	F	I	G	A	H
Mean	0.077	0.107	0.115	0.120	0.154	0.154	0.200	0.217	0.304	0.368

Table 27. Results of Duncan's multiple range test for the virus disease incidence data presented in Tables 23 and 25.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	0.078	0.082	0.085	0.087	0.088	0.090	0.090	0.091	0.092
Treatment	E	C	I	B	G	J	H	D	A	F
Mean	0.017	0.017	0.033	0.036	0.037	0.052	0.053	0.067	0.085	0.138

Table 28a. Plant heights of gladioli treated with various insecticides - 1972.

Treatment	Average height per plant (inches)
1. Aldicarb	52.32
2. Disulfoton	51.25
3. Oxamyl	50.70
4. Acephate	50.03
5. Carbofuran 4 F	49.24
6. Carbofuran 10 G	48.90
7. Untreated control	48.75
8. Oxydemeton-methyl	48.61
9. Dimethoate	48.14
10. Pirimicarb	47.11

Table 28b. Plant height data from Table 28a grouped on the basis of method of insecticide application.

Treatment	Average height per plant (inches)
Granular	50.79
Foliar spray	48.63
Untreated control	48.75

Table 29. Analysis of variance for average heights of gladiolus plants - 1972. (Each value Represents an average of the total heights of all plants in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	52.40	47.40	51.90	44.70	51.67	44.44
B Disulfoton	49.44	55.12	53.10	50.00	49.87	50.00
C Carbofuran 4 F	53.33	44.80	48.60	50.90	47.00	50.80
D Carbofuran 10 G	51.60	52.33	48.50	44.80	46.00	50.00
E Dimethoate	52.56	44.78	48.98	45.22	47.10	50.30
F Acephate	53.80	46.87	52.20	47.00	48.67	51.60
G Oxydemeton-methyl	51.56	47.00	48.70	48.33	46.50	49.56
H Pirimicarb	48.87	48.70	47.40	46.67	45.14	45.89
I Oxamyl	52.70	51.00	51.10	52.50	51.70	45.20
J Aldicarb	51.20	56.00	53.60	50.78	51.33	51.00

ANOVA

Source	df	SS	MS	Observed F
Total	59	495.51		
Replicates	5	91.99	18.40	
Treatments	9	132.39	14.71	2.44 *
(a) A vs. rest	1	3.80	3.80	0.63
(b) BDIJ vs. CEFGH	1	62.84	62.84	10.42 **
Error	45	271.31	6.03	

Table 30. Results of Duncan's multiple range test for the plant height data presented in Tables 28a and 29.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	2.87	3.03	3.12	3.19	3.24	3.29	3.32	3.35	3.37
Treatment	H	E	G	A	D	C	F	I	B	J
Mean	47.11	48.14	48.61	48.75	48.90	49.24	50.03	50.70	51.25	52.32

p	2	3	4	5	6	7	8	9	10
.01 rp	3.82	3.99	4.10	4.17	4.24	4.30	4.34	4.37	4.41
Rp	3.84	4.01	4.12	4.19	4.26	4.32	4.36	4.39	4.43
Treatment	H	E	G	A	D	C	F	I	B	J
Mean	47.11	48.14	48.61	48.75	48.90	49.24	50.03	50.70	51.25	52.32

Table 31a. Flowerhead[6] lengths of gladioli treated with various insecticides - 1972.

Treatment	Average flowerhead length per spike (inches)
1. Aldicarb	30.44
2. Oxamyl	29.63
3. Disulfoton	29.60
4. Acephate	27.78
5. Carbofuran 10 G	27.33
6. Untreated control	27.11
7. Oxydemeton-methyl	27.03
8. Carbofuran 4 F	27.02
9. Dimethoate	26.66
10. Pirimicarb	25.88

Table 31b. Average flowerhead lengths data from Table 31a grouped on the basis of method of insecticide application.

Treatment	Average flowerhead length per spike (inches)
Granular	29.25
Foliar spray	26.87
Untreated control	27.11

[6]Flowerhead length measurements were made from the bottom floret to the tip of the spike.

Table 32. Analysis of variance for average flowerhead lengths of gladiolus spikes - 1972. (Each value represents an average of the total flowerhead lengths for all the plants in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	29.70	25.90	29.20	24.30	28.33	25.22
B Disulfoton	28.05	33.13	31.50	27.60	29.13	28.20
C Carbofuran 4 F	27.00	24.90	26.30	28.40	26.70	28.80
D Carbofuran 10 G	29.95	28.44	26.60	24.80	26.89	27.22
E Dimethoate	31.22	24.00	26.78	24.78	25.60	27.60
F Acephate	30.90	25.68	28.50	25.40	27.22	29.00
G Oxydemeton-methyl	29.11	27.00	26.10	26.56	25.50	27.89
H Pirimicarb	27.50	26.00	26.30	25.33	24.14	26.00
I Oxamyl	31.10	29.50	29.80	29.50	30.20	27.70
J Aldicarb	30.50	33.00	30.40	30.33	28.78	29.60

ANOVA

Source	df	SS	MS	Observed F
Total	59	284.71		
Replicates	5	45.30	9.06	
Treatments	9	122.62	13.62	5.24 **
(a) A vs. rest	1	3.63	3.63	1.40
(b) BDIJ vs. CEFGH	1	75.06	75.06	28.87 **
Error	45	116.79	2.60	

Table 33. Results of Duncan's multiple range test for flowerhead length data presented in Tables 31a and 32.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	1.88	1.98	2.04	2.09	2.12	2.15	2.17	2.19	2.20
Treatment	H	E	C	G	A	D	F	B	I	J
Mean	25.88	26.66	27.02	27.03	27.11	27.33	27.78	29.60	29.63	30.44

p	2	3	4	5	6	7	8	9	10
.01 rp	3.82	3.99	4.10	4.17	4.24	4.30	4.34	4.37	4.41
Rp	2.51	2.63	2.70	2.74	2.79	2.83	2.86	2.88	2.90
Treatment	H	E	C	G	A	D	F	B	I	J
Mean	25.88	26.66	27.02	27.03	27.11	27.33	27.78	29.60	29.63	30.44

Table 34a. Numbers of buds per spike on gladioli treated with various insecticides - 1972.

Treatment	Average number of buds per spike
1. Aldicarb	22.59
2. Oxamyl	21.93
3. Disulfoton	21.90
4. Acephate	21.25
5. Carbofuran 10 G	21.13
6. Untreated control	20.88
7. Dimethoate	20.84
8. Carbofuran 4 F	20.72
9. Oxydemeton-methyl	20.70
10. Pirimicarb	20.44

Table 34b. Average number of buds per spike data from Table 34a grouped on the basis of method of insecticide application.

Treatment	Average number of buds per spike
Granular	21.89
Foliar spray	20.79
Untreated control	20.88

Table 35. Analysis of variance for average numbers of buds on gladiolus spikes - 1972. (Each value represents an average of the total number of buds of all gladiolus plants in a particular replicate divided by the number of plants in the replicate).

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	21.80	20.90	21.50	20.10	21.55	19.44
B Disulfoton	21.22	21.56	22.80	20.60	21.50	21.00
C Carbofuran 4 F	20.33	19.70	20.30	21.10	20.80	22.10
D Carbofuran 10 G	22.90	21.22	20.80	20.20	20.56	21.11
E Dimethoate	23.44	20.11	20.67	19.33	20.90	20.60
F Acephate	22.10	21.12	21.20	20.30	20.56	22.20
G Oxydemeton-methyl	21.44	21.11	20.50	20.22	19.80	21.11
H Pirimicarb	20.62	20.50	20.50	20.67	20.14	20.11
I Oxamyl	22.20	21.70	21.70	22.10	22.90	21.00
J Aldicarb	22.20	24.45	23.10	22.33	21.56	21.80

ANOVA

Source	df	SS	MS	Observed F
Total	59	70.03		
Replicates	5	8.00	1.60	
Treatments	9	25.40	2.82	3.48 **
(a) A vs. rest	1	0.84	0.84	1.04
(b) BDIJ vs. CEFGH	1	16.06	16.06	19.83 **
Error	45	36.63	0.81	

Table 36. Results of Duncan's multiple range test for the buds per spike data presented in Tables 34a and 35.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	1.05	1.10	1.14	1.16	1.18	1.20	1.21	1.22	1.23
Treatment	H	G	C	E	A	D	F	B	I	J
Mean	20.44	20.70	20.72	20.84	20.88	21.13	21.25	21.90	21.93	22.59

p	2	3	4	5	6	7	8	9	10
.01 rp	3.82	3.99	4.10	4.17	4.24	4.30	4.34	4.37	4.41
Rp	1.40	1.46	1.50	1.53	1.56	1.58	1.59	1.60	1.62
Treatment	H	G	C	E	A	D	F	B	I	J
Mean	20.44	20.70	20.72	20.84	20.88	21.13	21.25	21.90	21.93	22.59

Table 37. Comparative results of average plant heights (inches) for healthy and virus-infected gladioli - 1972.

Treatment	Healthy Plants	Diseased plants
1. Aldicarb	52.48	49.00
2. Disulfoton	51.34	47.50
3. Oxamyl	51.09	45.22
4. Acephate	50.23	46.00
5. Carbofuran 4 F	49.49	40.00
6. Oxydemeton-methyl	49.44	43.38
7. Untreated control	49.34	42.80
8. Carbofuran 10 G	49.09	37.00
9. Dimethoate	48.58	40.67
10. Pirimicarb	47.41	41.50
Total	498.49	433.07
Average	49.85	43.31

Table 38. Comparative results of the average flowerhead lengths (inches) for healthy and virus-infected gladioli - 1972.

Treatment	Healthy plants	Diseased plants
1. Aldicarb	30.59	27.33
2. Oxamyl	29.82	25.22
3. Disulfoton	29.58	27.50
4. Acephate	27.82	25.00
5. Carbofuran 10 G	27.38	23.00
6. Untreated control	27.38	24.40
7. Oxydemeton-methyl	27.24	25.00
8. Carbofuran 4 F	27.16	23.00
9. Dimethoate	26.74	22.00
10. Pirimicarb	25.98	24.50
Totals	277.68	246.95
Average	27.77	24.70

Table 39. Comparative results of the average numbers of buds per spike for healthy and virus-infected gladioli - 1972.

Treatment	Healthy plants	Diseased plants
1. Aldicarb	22.56	23.00
2. Oxamyl	22.09	19.75
3. Disulfoton	21.91	20.00
4. Acephate	21.23	23.00
5. Carbofuran 10 G	21.14	21.00
6. Untreated control	21.03	19.60
7. Dimethoate	20.96	18.67
8. Carbofuran 4 F	20.77	19.50
9. Oxydemeton-methyl	20.73	20.38
10. Pirimicarb	20.43	21.00
Total	212.85	205.90
Average	21.95	20.59

Table 40. Overall comparative yield data for healthy versus virus-infected gladioli - 1972.

Condition of plant	Average plant height (inches)	Average flowerhead length (inches)	Average number of buds per spike
Healthy	49.85	27.77	21.95
Diseased	43.31	24.70	20.59
Difference	6.54	3.07	1.36
Per cent reduction	13.12	11.06	6.20

Table 41. Numbers of gladiolus plants emerged 17 days after planting.[7]

Treatment	Number plants emerged	Average number emerged/ replicate	Percentage of total number eventually emerged
* 1. Aldicarb	37	6.14	63.79
* 2. Disulfoton	34	5.66	60.72
* 3. Oxamyl	31	5.17	51.67
4. Untreated control	28	4.67	47.45
5. Oxydemeton-methyl	26	4.33	44.82
* 6. Carbofuran 10 G	25	4.17	42.37
7. Pirimicarb	24	4.00	44.44
8. Acephate	21	3.50	36.21
9. Carbofuran 4 F	20	3.33	33.33
10. Dimethoate	19	3.17	33.33
Group averages:			
Granulars	31.75	5.29	54.64
Untreated controls	23.00	3.83	39.93

[7]Those treatments preceeded by an asterisk were granular insecticides, and at the time the data were gathered had previously received one application of material in the trench at planting. All other treatments were considered controls since initial applications had not been made prior to gathering of data.

Table 42. Analysis of variance for the total emergence of gladiolus plants 17 days after planting - 1972.

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	7	3	7	5	3	3
B Disulfoton	5	2	6	7	7	7
C Acephate	5	4	2	3	2	5
D Oxamyl	5	5	3	8	7	3
E Carbofuran 10 G	4	3	3	6	3	6
F Oxydemeton-methyl	7	5	5	1	4	4
G Pirimicarb	4	7	5	5	2	1
H Dimethoate	3	1	0	4	5	6
I Carbofuran 4 F	6	2	2	6	1	3
J Aldicarb	5	8	4	6	7	7

ANOVA

Source	df	SS	MS	Observed F
Total	59	238.58		
Replicates	5	17.28	3.46	
Treatments	9	54.41	6.05	1.63
Error	45	166.89	3.71	

Table 43. Results of Duncan's multiple range test for gladiolus plant emergence data presented in Tables 41 and 42.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	2.25	2.37	2.44	2.49	2.53	2.57	2.59	2.62	2.63
Treatment	H	I	C	G	E	F	A	D	B	J
Mean	3.17	3.33	3.50	4.00	4.17	4.33	4.67	5.17	5.66	6.14

Table 44. Results of Duncan's multiple range test for the gladiolus plant height data presented in Tables 46 and 47.

p	2	3	4	5	6	7	8	9	10
.05 rp	2.86	3.01	3.10	3.17	3.22	3.27	3.30	3.33	3.35
Rp	1.19	1.25	1.29	1.32	1.34	1.36	1.37	1.39	1.39
Treatment	J	E	C	B	F	A	I	D	G	H
Mean	1.80	1.91	2.50	2.51	2.53	2.71	2.78	2.81	3.31	3.33

Table 45. Gladiolus corm weights - 1972.

Treatment	Number of corms harvested	Average weight per cured corm (ozs.)	Average weight per corm when planted (ozs.)	Average corm weight increase (ozs.)
1. Disulfoton	56	3.13	1.50	1.63
2. Acephate	58	3.14	1.53	1.61
3. Pirimicarb	54	3.04	1.47	1.57
4. Untreated control	59	3.00	1.45	1.55
5. Oxamyl	60	3.07	1.45	1.54
6. Carbofuran 10 G	59	3.03	1.52	1.51
7. Dimethoate	57	2.96	1.47	1.49
8. Aldicarb	58	2.95	1.53	1.42
9. Oxydemeton-methyl	58	2.84	1.50	1.34
10. Carbofuran 4 F	60	2.73	1.40	1.33
Average		2.99	1.49	1.50

Table 46. Gladiolus plant heights 23 days after planting - 1972.[8]

Treatment		Average height per plant (inches)
1.	Dimethoate	3.33
2.	Pirimicarb	3.31
* 3.	Oxamyl	2.81
4.	Carbofuran 4 F	2.78
5.	Untreated control	2.71
6.	Oxydemeton-methyl	2.53
* 7.	Disulfoton	2.51
8.	Acephate	2.50
* 9.	Carbofuran 10 G	1.91
*10.	Aldicarb	1.80
	Group averages:	
	Granular	2.26
	Untreated control	2.88

[8]See footnote for Table 41.

Table 47. Analysis of variance for gladiolus plant heights 23 days after planting - 1972.

Treatment	Replicate 1	2	3	4	5	6
A Untreated control	2.32	4.42	3.25	1.75	1.83	3.08
B Disulfoton	2.30	2.00	3.00	2.82	2.54	2.04
C Acephate	2.35	2.25	4.00	1.50	4.88	1.90
D Oxamyl	2.10	3.25	3.08	2.81	3.21	2.25
E Carbofuran 10 G	1.81	2.00	1.17	2.54	0.50	2.38
F Oxydemeton-methyl	2.18	2.85	2.50	2.50	2.69	2.63
G Pirimicarb	3.44	3.04	2.70	3.15	6.00	3.00
H Dimethoate	2.92	0.75	0.00	3.13	3.65	3.83
I Carbofuran 4 F	2.75	2.00	2.75	2.33	1.00	4.83
J Aldicarb	1.35	2.13	1.31	1.54	1.32	2.75

ANOVA

Source	df	SS	MS	Observed F
Total	59	64.71		
Replicates	5	2.43	0.49	
Treatments	9	15.36	1.71	1.64
Error	45	46.92	1.04	

Table 48. Aphids observed and virus disease incidence data from aluminum foil test - 1971.

Aluminum foil-treated plots

Variety	Numbers of aphids observed				Number virus-infected plants (out of 10)
	Alatae	Apterae	Nymphs	Total	
Mountie	0	0	1	1	0
Vicki Lin	2	45	47	94	2
Blue Mist	1	0	0	1	5
Rainier	3	1	0	4	1
Peter Pears	0	0	0	0	0
Empire Yellow	0	0	1	1	1
King David	0	0	0	0	0
Totals	6	46	49	101	9

Control plots (no foil)

Variety	Numbers of aphids observed				Number virus-infected plants (out of 10)
	Alatae	Apterae	Nymphs	Total	
Mountie	1	1	0	2	0
Vicki Lin	8	9	24	41	1
Blue Mist	1	0	0	1	10
Rainier	3	2	0	5	1
Peter Pears	1	1	10	12	0
Empire Yellow	2	0	0	2	0
King David	0	0	0	0	1
Totals	16	13	34	63	13

Table 49. Alate aphids collected in yellow-pan water traps placed in aluminum foil-treated and control (no foil) gladiolus plots - 1972.

Date	Number of aphids in three traps	
	Aluminum foil	Control
July 7	0	128
July 18	0	93
July 30	2	110
August 15	6	54
August 23	3	96
Totals	11	481

Table 50. Virus disease incidence observed in aluminum foil-treated and control (no foil) gladiolus plots - 1972.

Variety	Number of virus-infected plants	
	Aluminum foil	Control
Lemon Lime	0	0
Bluebird	1	2
Dewdrop	0	1
Vicki Lin	1	1
Empire Yellow	2	1
Doubloon	0	0
Carnelian	0	0
Totals	4	5

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