Protecting Muskmelons Against Aphid-Borne Viruses

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ABSTRACT

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Field tests conducted in Southern California demonstrated that a protection crop of wheat, *Triticum aestivum*, significantly delayed frequency and decreased severity of chlorotic mottle, distortion, and stunting attributed to nonpersistent viruses transmitted by aphids (mostly green peach aphids, *Myzus persicae*) in cantaloupe, *Cucumis melo*. It improved fruit appearance and soluble solids. However, cantaloupe growth was delayed by the wheat. Weekly applications of miscible oil delayed mottle symptoms and reduced their frequency to about 50% of that in the check plot near harvest; total yield was comparable to and included fewer sunburned culls than that of the check. Marketable fruits from oil-sprayed plants were equal to or better than those from the checks in 16 quality characters. Radish, *Raphanus sativus*, and swiss chard, *Beta vulgaris* var. *cicla*, caused stunting in cantaloupes and served as hosts for potato leafhopper, *Empoasca fabae*. The stunted plants showed either no or few symptoms incited by viruses, but they set only a few fruits that failed to mature by the time harvest was completed in other treatments.

Additional key words: plant viruses, protecting cantaloupe against.

Aphid-borne plant viruses have caused economic losses to growers of spring muskmelons, *Cucumis melo* L. (cantaloupe, honeydew, and casaba cultivars Crenshaw and Golden Beauty) in the southwestern United States because they cannot be controlled adequately by one or a combination of several known methods: removal of the original virus source, roguing of infected plants, killing the aphids before they inoculate the plants, removal or reduction of the aphid source, and isolation of crop fields from the source and from each other. Removal of the source and isolation of crop fields was moderately successful in the Imperial Valley of California and gave marked success in some areas in Arizona for several years (2, 17). However, viruses still cause severe losses. Watermelon mosaic viruses, WMV 1 and 2, are the most prevalent of these viruses in the Imperial Valley (9, 15, 22), and the green peach aphid, *Myzus persicae* (Sulz.), is probably the most important of the aphid vectors there because it is the most efficient species (6) and was caught in greatest numbers in 1948 and 1949 (7).

The spread of virus infection in cantaloupes is usually spectacular partly because cantaloupe plants are large and have a low population density in the field (17). Equal numbers of infected plants in a large population of a smaller species covering the same land area would be a smaller proportion of the population and, therefore, less striking. Since the spread of an infective systemic disease agent by a vector is proportional to the size (or number) of plants (19), the spread of nonpersistent viruses in cantaloupe fields could conceivably be decreased as the density of plants in the field is increased (17), assuming that flying aphids alight and feed (probe) indiscriminately on all plants and that the vector population remains constant. Thus, the inclusion of noncrop plants that provides additional feeding sites for infectious aphids in or around a crop field is herewith termed a "protection crop". It is necessary that the protection crop be immune from the target virus or viruses and suitable for probing by the aphid, but, preferably, it should not serve as a host for aphid reproduction. This method has been shown to protect crop plants against several nonpersistent viruses on various hosts (5, 10, 11). Another method of protecting crop plants involves the application of nontoxic light summer oil directly on the plants, which seems to inhibit virus introduction into living cells, but does not prevent aphid feeding (4). Several crops have been protected by this method (12, 20, 23). Because available controls for virus mosaic in spring muskmelons yielded only partial success (2), we undertook to determine whether oil sprays and protection crops would reduce or delay virus infection in muskmelons.

MATERIALS AND METHODS

Irvine test, 1973.—A field trial was conducted at the University of California South Coast Field Station, Irvine, California, during summer 1973, in three plots each measuring 90 × 30 m. One plot was broadcast-seeded 30 May with a protection crop of radish, *Raphanus sativus* 'White Icicle'. On June 11, when the radish was 3-5 cm high, 16 beds (30 m long and 1.5 m apart) in the center of each of the three plots were planted with cantaloupe seeds. Four beds in each plot were planted with each of the cultivars PMR 45, Top-Mark, Gulfstream, and breeding line 29W. Single plants were 76 cm apart. All plots were sprinkle-irrigated once a week. Of the two plots without radish, one was used as the untreated check, and the other was treated with oil.

We used Citrus Soluble Oil® (Niagara Chem. Div., FMC Corp., Middleport, NY 14105),light medium, which is used against mites and scales on citrus trees (8, 18), selected from several tested earlier because a 5% emulsion of it was nontoxic to, and had no apparent effect on growth of, cantaloupe plants in greenhouse tests. A 5% emulsion in water was applied at an average rate of 2.4 liters per 30-m row (approximately 55 gal/acre) with a Hudson Suburban® power sprayer (H. D. Hudson Mfg. Co., Chicago, IL 60611). The first application was made 4 wk after the melons were planted when they were in the second true leaf stage; other applications (for a total of five) were made weekly thereafter.

To insure availability of virus to aphids in the test plots, we inoculated muskmelon plants with WMV2 in the greenhouse and transplanted the resulting mottled plants three at each end of each of the three plots on 10 July. The WMV2 culture was collected by G. W. Bohn from a WMV1-resistant muskmelon breeding line (WMR 29) grown at Brawley, CA during spring 1968. To obtain a pure culture of WMV2, it was serially transferred through Graybelle watermelon, WMV1-resistant muskmelon 90105-LL, Stringless Greenpod bean (systemic in one plant), and CMV-resistant muskmelon 34340. It caused no symptoms in *Nicotiana glutinosa* L., but produced typical necrotic flecks in *Chenopodium amaranticolor* Coste & Reyn. The culture was maintained alternatively in squash, watermelon, and muskmelon. Also, both WMV1 and WMV2 were known to occur in the area, because they had been isolated repeatedly from naturally mottled plants in earlier years.

To insure WMV2-infective aphids in the test area, we released laboratory-reared alate green peach aphids on the WMV2-source plants on 10 and 16 July, covered the plants with cheesecloth for 1 hr and then removed it. Native alate aphids alighting and feeding on the WMV2 source plants (and, perhaps, on naturally infected weeds and other hosts in neighboring fields) also served as vectors.

To minimize effects of natural sources of virus, the land area for several hundred meters surrounding the test plots was maintained free of living plants, excepting that a field border row of Italian Buckthorn, *Rhamnus alaternus* L., occurred approximately 50 m from one end of the field. However, alate aphids feeding on naturally infected weeds and other hosts in the general area could have served as virus sources. No cucurbits occurred in nearby fields and we believe that such virus sources had little effect on the data reported here.

Winged aphids in the test area were monitored by placing a yellow-pan trap (polyethylene dishpan measuring 32 × 27 × 11 cm) containing water at each end of the three test plots.

On 13 August, the percentages of mosaic mottled plants were determined by examining each cantaloupe plant in each plot. No data were obtained on yield and quality of fruits.

Brawley test, 1974.—In spring 1974, a field test was conducted at the USDA Imperial Valley Conservation Research Center, Brawley, California. Four test plots (replicated three times) each contained about 700 plants on 10 beds (27 m long, 203 cm apart, and 45 cm high measuring from the bottom of the irrigation furrow). Protection crops were planted 25 January as follows: Swiss chard (*Beta vulgaris* var. *cicla* Moq. 'Lucullus') seeds were drilled approximately 20 cm apart in eight rows on both sides of each bed; in a second plot, wheat seeds, *Triticum aestivum* L. 'Anza' were broadcast. One of the remaining plots was the untreated check; the other was to receive oil treatment. On 27 February, a growth retardant, chlorflurenol (methyl 2-chloro-9-hydroxyfluorene-9-carboxylate) (Maintain CF 125), was sprayed on the wheat (15 cm high) at the rate of 2.24 kg AI/ha in 100 gal of water to delay heading and senescence. This retardant was chosen from earlier tests of several candidate compounds conducted in the greenhouse and in the field (H. H. Toba, *unpublished*). The next day, 28 February, cantaloupe seeds (cultivar Top-Mark) were planted 76 cm apart, five per hill, in all plots (on the south slopes of beds oriented in an east-west direction). Plants were later thinned to two per hill.

Watermelon mosaic viruses have been prevalent in the Imperial Valley every year since the early 1940's (9, 14, 15, 22, and G. W. Bohn and others, *unpublished*). Most or all plants show mottle symptoms at or before harvest in most seasons. Therefore, the plants were exposed to natural infection and no cultures were used.

The oil spray was applied when the cantaloupe plants were at the cotyledon stage, and weekly thereafter. The last application was made 22 May. First, a 5% emulsion in water of Citrus Soluble Oil, light medium, was agitated in a Hudson power sprayer; then the material was applied with a Schefenacker® (current U.S. supplier unknown to us) power air-blast sprayer at an average rate of 1.14 liters/27-m row (approximately 22 gal/acre). This rate was about half of that used in the 1973 test for several reasons: the rate used in the previous test had delayed plant growth; the plots in 1974 were furrow-irrigated instead of sprinkler-irrigated; we expected to obtain better coverage of the plants with the air-blast sprayer than with the standard sprayer; and greenhouse tests with oil applied at the low rate had no apparent effect on plant growth.

Additionally, during the test, each plot received special attention. The rapid-growing Swiss chard had to be heavily rogued on either side of each melon hill along the row, particularly those that shaded melon plants from the sun. Also, it became necessary to double the amount of oil suspension applied on the last three dates to achieve good coverage of the large melon plants that covered both sides of the beds. In the wheat-protected plots, the wheat plants also shaded the melon plants because the retardant did not adequately slow down the growth of wheat. Therefore, the tops of the wheat plants were trimmed and

TABLE 1. Symptom progression, plant condition at midharvest, yield, and fruit soluble solids of muskmelons, cultivar Top-Mark, protected against plant viruses by oil sprays or protection crops[a]

Treatment	No.	Plants mottled (%), by dates					Plant condition[b]	Yield, by dates				Marketable fruits	Adjusted plot yield	Avg. % soluble solids, by dates			
	plants	5/3	5/15	5/21	5/28	6/4	6/18	6/12	6/18	6/24	Total	(%)[c]	(no.)	6/12	6/18	6/20	6/24
Check	682	0.1	12.3	34.7	69.7	82.3	4.6	87	1,260	319	1,660	52	863	12.1	12.1	10.7	10.2
Oil-sprayed	703	0.1	2.2	9.0	13.0	40.3	6.7	96	1,072	450	1,618	67	1,084	13.2	12.8	11.2	11.5
Wheat	649	0	0.1	0.3	1.4	3.7	8.0	15	54	205	274	78	214	...[d]	12.6	12.2	11.8
Swiss chard	641	0	0	0	0.1	0.4	...[e]	0	0	0	0						

[a]Means of three replicates; data from field plots at Brawley, California, in spring 1974.
[b]Quality ratings increasing from 1 to 9.
[c]Fruits that were sunburned, cracked, thin-netted, and rotted were considered unmarketable.
[d]Fruits were inadvertently discarded before samples were obtained.
[e]Plants severely stunted, but otherwise appeared to be healthy.

each two-plant melon hill was rogued of wheat plants within a diameter of about 40 cm.

The population of flying aphids, particularly green peach aphids, was monitored by 14 yellow-pan traps around the test plots. The traps were checked once a week, trapped aphids were counted, and samples were taken to determine the percentage of green peach aphids in the alate population.

All melon plants were observed for mottle symptoms on five dates from 3 May, when symptoms first appeared, to 4 June, just before harvest began. Also, at midharvest (18 June), the plants were rated for condition (retention of live, mature leaves).

Total ripe fruits were counted as they were harvested on 12, 18, 20, 24, and 26 June. The results were grouped as early (12 June), midseason (18 + 20 June), and late (24 + 26 June) harvests for convenience. Observations made during early harvest suggested that fewer fruits were sunburned in the wheat-protected and oil-sprayed plots than in the check plots; therefore, fruits taken in the later harvests were classified as firm, marketable fruits or sunburned culls.

Finally, five-fruit samples from each of the plots for the 12 June harvest and 10-fruit samples from each of the plots for the three other harvests were rated 1 to 9 for 15 external and internal characters (see Table 2). Also, percentage soluble solids in juice pressed from each of these fruits was recorded using a hand refractometer (3). These data were used to determine whether the appearance of the treated fruits was the same as that of check fruits, whether the oil treatment or protection crops had any adverse effect on quality, and whether the treated fruits were comparable to fruits that would normally be harvested and shipped.

RESULTS

Irvine test.—In the 1973 test at Irvine, the cantaloupe plants in the check plots were first to show virus symptoms: two mottled plants were observed 25 July. Blooms were observed only in the check plot on 30 July. On 13 August, a mean of 48% of the check plants exhibited mottle symptoms; there were no differences between cultivars.

The oil-sprayed plants appeared as green and vigorous as the check plants, but mottle symptoms appeared 1-2 wk later on the oil-sprayed plants and appeared milder. On 13 August, a mean of 26% of the plants showed mottle which was about half as many as in the check plot; there were no differences between cultivars. Development of the plants was about 7-10 days slower on the basis of the onset of flowering, and maturation of the fruits was late though this observation was not quantified.

The radish-protected plants were severely stunted and had yellow-green leaves, probably because they had to compete with the radish for light, nutrients, and water. Mottle symptoms were not detected on the melon plants due either to lack of infection or to failure of the stunted and starved plants to develop mottle, or both. Although the radish was rogued around the cantaloupe plants twice and additional fertilizer was applied, the melon plants remained stunted and did not set fruit. Potato leafhoppers, *Empoasca fabae* (Harris), which bred in abundance on the radish, also heavily infested the melon plants and contributed to their poor condition.

On 24 September, at about the time of fruit ripening, the plants in the oil-sprayed and check plots were rated for general condition, prevalence of powdery mildew, and incidence of virus. Plants in the oil-sprayed plot generally had higher ratings than those in the check plot. There was little difference in the incidence of mottle between cultivars, but Top-Mark had the most powdery mildew and poorest general condition. Breeding line 29W had the least powdery mildew, but Gulfstream had the best general condition.

The yellow-pan traps placed adjacent to the radish-protected plot caught an average of five aphids per trap per day; those adjacent to the oil-sprayed and check plots caught 29 and 21 aphids per trap per day, respectively. Also, traps located at the end of the field bordered by tall shrubs caught significantly more aphids than those at the opposite end of the field.

Brawley test.—In the 1974 test at Brawley, the check plants planted in February (instead of May as in 1973 at Irvine) grew vigourously and set fruits during late April before virus symptoms appeared. Mottle was first observed 3 May (Table 1), and many plants without mottle had stunted shoot tips with aborted flower buds. Mottle steadily increased until 82% of the plants had symptoms a week before harvest. Also, plant condition in the check plots deteriorated steadily during May, that is, new growth was stunted, flowers aborted, mature leaves

TABLE 2. Effects of oil spray and a protection crop of wheat on quality of marketable cantaloupe, cultivar Top Mark[v]

Treatment	External[w]			Internal[w]			Index of acceptability[z]
	Size[x]	Net (%)	Color	Thickness	Color	Soluble solids[y]	
Check	7.9 a	6.4 a	6.2 b	6.7 a	6.2 b	6.2 a	7.0 a
Oil spray	8.2 a	7.0 a	7.1 a	6.6 a	7.0 a	6.7 a	7.2 a
Wheat	7.1 b	6.7 a	6.6 b	6.2 a	6.9 a	6.6 a	7.0 a

[v]Means of three replicates; quality ratings increasing from 1 to 9. Means followed by the same letter are not significantly different, $P = 0.05$, by Duncan's multiple range test. Data from field plots at Brawley, California in spring 1974.

[w]Characters not included that showed little or no differences were: external–appearance, shape, net size, vein tracks, stem size, cracks, and rots; and internal–appearance, flesh firmness, and placenta dryness.

[x]Fruit sizes: 7 = 45 in a crate, 8 = 36, and 9 = 27.

[y]Soluble solids rating scale: 6 = 10.0 to 11.9% soluble solids, and 7 = 12.0 to 13.9% soluble solids.

[z]Index of acceptibility was the mean of all 16 character ratings.

died, and late fruit load was reduced. The plant condition rating of 4.6 on 18 June (Table 1) reflected the fact that about half of the mature leaves were dead at midharvest. The plants were large when virus symptoms first appeared, so the checks produced more than two fruits (average "crate size" 36) per plant. However, many of the fruits were sunburned, and only about half could be marketed (Table 1). Soluble solids in the marketable fruits was high initially but had dropped to 10% by late harvest (Table 1). There was no second set. No large fruits and very few small ones remained on the vines at last harvest.

The oil-sprayed plants were vigorous and green and looked like the check plants before symptoms appeared. These plants also set fruits in late April, and mottle first appeared 3 May. However, mottle symptoms were less severe in the oil-sprayed plots, and most of the plants were vigorous and had uniformly green leaves and normal shoot tips with normal flowers. Subsequently, the percentage of plants with mottle increased steadily, though at a slower rate than in the checks, so only 40% showed symptoms 1 wk before harvest. In addition, most of the plants that did not exhibit mottle had normal shoot tips late in the season and still retained most of their mature leaves at midharvest (Table 1, an average condition of 6.7 on 18 May). The oil-sprayed plants produced about the same number of fruits as the check plants, but more of them (67%) were marketable. In addition, throughout the harvest period, the marketable fruits from the oil-sprayed plots averaged about 1% higher in soluble solids than did those from the checks (Table 1). Some medium-large fruits and several small ones remained on the vines after final harvest.

The wheat-protected plants were stunted early in the season, but they grew with increasing vigor as the season progressed. This steady increase seemed to be associated with freedom from virus symptoms. Most of the plants remained obviously healthy. They were aided by application of fertilizer, increasing temperature and light, reduction of crowding and shading by progressive roguing of wheat plants in and around the muskmelon hills, trimming of wheat plants, and maturation of the wheat, which headed in May and began to mature and dry in June. Thus, the Top-Mark plants in the wheat-protected plots were green and vigorous and still flowering and setting fruits when the experiment was terminated 24 June. Virus mottle appeared 2 wk later in the wheat-protected plots than in the checks and increased very slowly. Less than 4% of the plants were mottled 1 wk before first harvest (Table 1). On 18 June most of the plants were in excellent condition, but they were late in setting fruit (Table 1). Consequently, a few fruits had been harvested when the experiment was terminated, and many nearly mature large and small fruits were left on the plants. Most (78%) of the harvested fruits were marketable, and the samples of marketable fruit were higher in soluble solids than were those of the checks.

The Swiss chard-protected Top-Mark plants were stunted and had few, small, pale yellow-green leaves early in the season. Their color and appearance improved but they failed to respond vigorously to weekly roguing of the chard. They remained stunted and set only a very few, runty fruits late in the season. The chard grew with increasing vigor and had not flowered when the experiment was terminated. Potato leafhoppers, which bred in abundance on the chard, also fed heavily on the small cantaloupe plants. These cantaloupe plants exhibited no virus symptoms (Table 1), but growth was so poor that they may have been unable to express symptoms.

The indices of acceptability, that is, the measurements of the overall quality of fruit samples, showed few differences between treatments, which indicated that the oil and wheat treatments had no deleterious effects (Table 2). However, samples that were rated consisted of only marketable fruits with acceptable overall appearance. Therefore, the superiority of the treated fruits was not as great as it would have been if the samples had been taken randomly from the entire harvest, which included sunburned fruits (Table 2).

The weekly average number of alate aphids caught in yellow-pan traps increased from 29 per trap per day on 20 December to 326 per trap per day on 7 March; of these, over 90% were *M. persicae*. The numbers then declined, reaching 1-3 per trap per day from 25 April through 23 May; during this period the percentage of *M. persicae* also declined to 11% on 23 May. It is interesting that mottle symptoms first appeared nearly 2 months after the peak alate aphid catch occurred.

DISCUSSION

Muskmelon plants exhibiting mottle symptoms had reduced plant growth and rat-tailing of shoots (greater suppression of leaf than of stem growth), a decline of plant condition including that of mature leaves, abortion of buds and flowers, increased number of culls, decreased number of marketable fruits, and poor quality of marketable fruits. Similar effects have been documented in greenhouse experiments with WMV1 and WMV2 (1, 9, 13, 14, 16, 21). They have been observed repeatedly in the field, but they have not been documented there by comparison of mottled and proven virus-free plants. However, the syndrome of symptoms is comparable with that observed following inoculation with WMV1 and WMV2, and those viruses have been recovered repeatedly from mottled plants collected in the test area during spring in most years from 1959 to 1970 (9, 15, 22, and G. W. Bohn and others, *unpublished*). Symptoms on watermelon and squash indicator hosts indicated that one or both WMV viruses were present during the test at Brawley. Tomato, planted as an indicator host,remained healthy, indicating that curly top virus and cucumber mosaic virus were not present.

Jenkinson (11) pointed out that the protection species for any crop must be selected carefully to prevent damage by other insect and disease pests or competion by the protection crop. Our results point up the validity of those principles. Radish and Swiss chard were unsuitable for use with muskmelons because they provided undesirable competition and also because they served as hosts for potato leafhoppers which also infest cucurbits. Wheat appeared promising because it seemed compatible with muskmelons, its erectness caused little shading, it seemed attractive to aphids, but did not serve as hosts for aphid reproduction, it was not a host of the viruses, it was not a host of leafhoppers or other insect or disease pests known to attack muskmelons, and it could be easily disposed of and would not become a noxious plant pest.

It is also important that control measures must have no deleterious effect on a crop. Our ratings indicated that marketable cantaloupes from both the oil-sprayed and the wheat-protected plants had equal or better quality than those from the control plots. In addition, repeated nonrecorded tests by several individuals failed to disclose any deleterious effect of either treatment on flavor.

Because of the difficulty in protecting muskmelons against aphid-borne plant viruses, we are in agreement with Grogan et al. (9) that "the only control measure with much likelihood of success is the development of resistant varieties." However, until such time as we do have resistant cultivars, we should develop and employ such methods as protection crops and oil. Basically, both methods involve "living with" the virus and its vector and delaying the introduction and spread of viruses in the crop field by preventing inoculation of viruses into the crop plants. We have shown that both methods have potential as control measures that can increase the yield of marketable muskmelons and the quality in areas and in seasons when aphid-borne viruses are present. Both methods should be compatible with, and complimentary to, those now in use, and should thus increase total control.

LITERATURE CITED

1. BOHN, G. W. 1969. Virus-induced crown blight in muskmelon. Phytopathology 59:1018-1019 (Abstr.).
2. BOHN, G. W. 1973. Muskmelon virus problems in Imperial Valley. Pages 10, 17 *in* Western Grower Shipper. July 1973 issue.
3. BOHN, G. W., C. F. ANDRUS, and R. T. CORREA. 1969. Cooperative muskmelon breeding program in Texas, 1955-67: New rating scales and index selections facilitate development of disease resistant cultivars adapted to different geographical areas. U.S. Dep. Agric. Tech. Bull. No. 1405. 25 p.
4. BRADLEY, R. H. E. 1963. Some ways in which a paraffin oil impedes aphid transmission of potato virus Y. Can. J. Microbiol. 9:369-380.
5. BROADBENT, L. 1969. Disease control through vector control. Pages 593-630 in K. Maramorosch, ed. Viruses, vectors, and vegetation. Interscience, New York. 666 p.
6. COUDRIET, D. L. 1962. Efficiency of various insects as vectors of cucumber mosaic and watermelon mosaic viruses in cantaloupes. J. Econ. Entomol. 55:519-520.
7. DICKSON, R. C., J. E. SWIFT, L. D. ANDERSON, and J. T. MIDDLETON. 1949. Insect vectors of cantaloupe mosaic in California desert valleys. J. Econ. Entomol. 42:770-774.
8. EBELING, W. 1950. Spray oils. Pages 165-215 *in* Subtropical entomology. Lithotype Process Co., San Francisco. 747 p.
9. GROGAN, R. G., D. H. HALL, and K. A. KIMBLE. 1959. Cucurbit mosaic viruses in California. Phytopathology 49:366-376.
10. HIDAKA, Z. 1960. Coordinated control experiments on cucumber mosaic in tobacco. (In Japanese, English Summary). Hatano Tobacco Exp. Stn. (Hatano, Kanagawa, Japan) Bull. 46. 123 p.
11. JENKINSON, J. G. 1955. The incidence and control of cauliflower mosaic in broccoli in Southwest England. Ann. Appl. Biol. 43:409-422.
12. LOEBENSTEIN, G., M. DEUTSCH, H. FRANKEL, and Z. SABAR. 1966. Field tests with oil sprays for the prevention of cucumber mosaic virus in cucumbers. Phytopathology 56:512-516.
13. MC LEAN, D. M., and H. M. MEYER. 1961. Survey of cucurbit viruses in the lower Rio Grande Valley of Texas. Plant Dis. Rep. 45:137-139.
14. MIDDLETON, J. T. 1949. The occurrence, distribution and sources of the cantaloupe mosaic viruses in 1949. Plant Dis. Rep. Suppl. 187:285-286.
15. MILNE, K. S., R. G. GROGAN, and K. A. KIMBLE. 1969. Identification of viruses infecting cucurbits in California. Phytopathology 59:819-828.
16. NELSON, M. R. 1962. Effect of mosaic viruses on cantaloupes. Phytopathology 52:363-364 (Abstr.).
17. NELSON, M. R., and D. M. TUTTLE. 1969. The epidemiology of cucumber mosaic and watermelon mosaic 2 of cantaloupes in an arid climate. Phytopathology 59:849-856.
18. RIEHL, L. A. 1969. Advances relevant to narrow-range spray oils for citrus pest control. Proc. 1st Int. Citrus Symp. 2:897-907.
19. VAN DER PLANT, J. R. 1947. The relation between size of plant and the spread of systemic diseases. I. A discussion of ideal cases and a new approach to the problems of control. Ann. Appl. Biol. 34:376-387.
20. VANDERVEKEN, J., and J. SEMAL. 1966. Aphid transmission of beet yellow virus inhibited by mineral oil. Phytopathology 56:1210-1211.
21. WALKER, M. N. 1933. Occurrence of watermelon mosaic. Phytopathology 23:741-744.
22. WEBB, R. E., G. W. BOHN, and H. A. SCOTT. 1965. Watermelon mosaic viruses 1 and 2 in southern and western cucurbit production areas. Plant Dis. Rep. 49:532-535.
23. WYMAN, J. A. 1971. The use of oils and other materials in the reduction of aphid-transmitted plant viruses. Ph.D. Thesis, Univ. Wisconsin, Madison. 153 p.