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Control of insect-transmitted viruses utilizing insect's response to color and contact stimuli

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Control of Insect Transmitted Viruses Utilizing Insect's Response to Color and Contact Stimuli

Aphids which are the most important group of vectors of plant viruses are repelled from landing by high reflective surfaces. This led to the development of mulching methods with different reflective materials (aluminum, plastics etc.), in order to reduce introduction of aphid transmitted viruses in the protected field. The main problems with these methods are: high cost and the fact that crops cover and shade the mulch, reducing its activity to a short period at the crop's start.

The main idea in the present work was to apply reflective materials directly onto the plant and to assess different aspects of these applications in regard to virus control. Among many materials tested, two whitewashes Loven and Yalbin and two clays (L and I) were chosen to work with in Israel and a commercial bright Kaolin (K) in Portugal. All materials were tested for their reflectance and except for clay L, all were highly reflective in the visible spectrum.

A. Effect on virus incidence

Sprays of whitewashes reduced significantly incidence of persistent potato leaf roll virus (PLRV) in potato and incidence of potato virus Y (PVY) in potato, PVY and cucumber mosaic virus (CMV) in pepper, CMV, Zuchinni yellow mosaic virus (ZYMV) and watermelon mosaic virus-2 (WMV_2) in squash, all of them non persistent viruses. Similar results with Kaolin K were also obtained in Portugal where PVY was reduced by 77.3% in pepper. Some of these results were reconfirmed elsewhere by Lowery et al. (8) who reduced turnip

mosaic virus (TuMV) in rutabaga with whitewash sprays. It was also demonstrated that clays may have a similar effect (7) reducing non persistent viruses in squash at a similar level to the whitewashes. All the above mentioned results may indicate that the main assumption is valid and incidence of aphid-transmitted viruses can be reduced by application of reflective materials directly onto the plants.

B. Effect on aphid populations

The efficiency of the virus control achieved by the reflective materials varied from no control to almost 100% protection. In order to optimize control one of the objectives of this work was to investigate the mode of action of those materials. One obvious way of reducing viral disease incidence, seems to act by reducing the landing of virus vectors in the treated plots. Quite a deal of work was dedicated to elucidate the effect of whitewashes on aphids. Interestingly enough, the results obtained in Israel and elsewhere (8) were not confirmed by the results of our cooperators in Portugal. Publications 2,7,8 show clearly a reduction in the population of landing aphids in whitewash treated crops while the Portuguese team show an increase in the aphid catches in treated pepper. This contradiction raises also the question how in treated plots larger aphid populations still resulted in lower virus infection (10). Those questions are partially answered by the phenomenon we found, that reaction of different species of aphids to the reflective surfaces is different and though most species are repelled by the high reflectivity of whitewashes, *Aphis gossypii* is rather attracted to it (2). Yet in Portugal *Myzus persicae* that we found to be repelled (2) was found in higher numbers in treated

pepper plots (11). This contradiction remains to be elucidated in the future.

It should be emphasized that during this work the Portuguese team also identified some new aphid species not known before in Portugal (11). As to the results that in spite of higher aphid numbers which landed in treated pepper, virus incidence was lower than in control, a possible explanation would be that the reflective materials do affect, beside landing, also aphid's efficiency of virus transmission after their landing on the treated plants.

C. Effect on aphid behaviour and virus transmission

It was shown that aphids (alatae and apterae) prefer to settle on non treated half leaves than on whitewash or clay treated halves. It was also demonstrated that this preference is related to the sensory mechanisms of the mouth parts. Beside, aphids forced on treated half leaves, acquire and inoculate virus (PVY) to a lower extent than those fed on the control halves.

D. Effect on the plant

In most experiments no direct damage could be observed, though that accumulation of material may cause some stunt and other stress symptoms. In tobacco there is a certain degree of quality reduction and in squash variable results were obtained in experiments carried out in different seasons. It appears that the physiological effects are probably related to the decreased illumination whitewash treated leaves obtain and accordingly yield may increase or decrease as compared to the controls. This very important aspect remains to be assayed in future work.

COOPERATION

Dr. Marco visited Portugal and participated in planning some of the main exps. The Kaolin tested in Portugal was assayed for its physical properties in Israel and a vivid correspondence of consultancy was undertaken between the Portuguese and Israeli team.

Resulted Publications

1. Marco, S. (1985) Reducing incidence of aphid-transmitted virus by reflective materials. In: 5th Conference of the ISHS - Vegetable Working Group. Abstracts. Bet Dagan, Israel. Phytoparasitica 13:279.

2. Marco, S. (1986) Incidence of aphid-transmitted virus infections reduced by whitewash sprays on plants. Phytopathology 76:1344-1348.

3. Marco, S. (1987) Effect of whitewash sprays onto potato crop on aphid landing and virus incidence. Meeting of European Association for Potato Research, Alborg, Denmark.

4. Marco, S. (1989) Possible modes of action of whitewash in reducing virus incidence. Meeting of European Association for Potato Research, Bologna, Italy.

5. Marco, S. (1989) Clays and whitewashes - effect on vegetable virus transmission. Meeting of ISHS-Vegetable Working Group. Assilomar, USA.

6. Marco, S. and Levy, D. (1989) Spraying potato with whitewash reduces aphid-transmitted viruses. Hassadeh, 89:618-621 (in Hebrew).

7. Marco, S. (1992) Reducing aphid-transmitted viruses in squash by sprays of clay suspensions. Submitted Plant Disease.

8. Marco, S. (1992) Control of non persistent viruses in pepper with applications of whitewash, oil, insecticides and their combination. Submitted Plant Disease.

9. Marco, S. and Ziv, O. (1992) Control of powdery mildew in squash with whitewash and clays. submitted Plant Pathology

10. Vieira, M., Margarida, Ilharco, F.A. and Marco, S. (1990) Analise das capturas de afideos em ensaio de pimenlos em Peqoes. 1st Iberian Congress of Horticulture, Lisbon, Portugal.

11. Vieira, M., Margarida (1991) Virus transmitidos por afideos: meios de luta na sua prevencao 1st National Meeting Integrated Pest Management, Evora, Portugal.

Disease Control and Pest Management

Incidence of Aphid-Transmitted Virus Infections Reduced by Whitewash Sprays on Plants

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ABSTRACT

Marco, S. 1986 Incidence of aphid-transmitted virus infections reduced by whitewash sprays on plants. Phytopathology 76:1344-1348.

Weekly sprays of potato crops with 15% whitewashes of Loven and Yalbin reduced potato leaf roll virus (PLRV) incidence in tubers from 0-61% of the level in the untreated plots in seven independent experiments. Similar sprays with 2% Virol oil, did not reduce PLRV in three experiments. Loven and Yalbin sprays reduced potato virus Y (PVY) incidence in potato to 0-68% of the level in controls, which is roughly comparable to the reduction obtained with Virol oil (0-52%). Whitewash sprays were less efficient for PLRV and PVY control than coarse, white net covers. Weekly sprays with whitewash reduced total tuber yield by about 30%, about the same yield decrease caused by oil treatment in our conditions. However, the number and weight of tubers between 30 and 120 g (seed size) in whitewash-treated plots was not affected. Two effects could explain the activity of whitewash. The whitewashes increased leaf reflectivity in the visible spectrum by 130-250%, whereas oil treatment caused no change. This change in reflectivity agrees with the reduced number (30-50%) of aphids landing in whitewash-treated plots, whereas no reduction in aphid landing occurred in Virol treatments. However, different aphid species responded differently; for example *Aphis gossypii* was attracted to whitewash-treated plots. In our experiments, whitewash and oil treatments did not affect PLRV acquisition by aphids. Loven and Yalbin plus a sticking agent Dabak reduced PLRV inoculation by aphids, although Virol plus Dabak and Dabak itself had no effect compared with untreated plots.

Additional key words: pepper.

Mulching crops with a reflective surface like aluminum foil or white or gray plastic reduces the number of aphids landing and virus incidence (8,10,11,17,19,20). Aluminum foil mulch was found to be more effective than white or gray plastic (10,11), presumably because of its higher reflectivity. This method seems to reduce virus incidence effectively, but is not widely practiced, mainly because of its high cost and the fact that crops shade or cover the mulch, limiting the repellency effect to a rather short, early period (21). A more recent development aimed at overcoming this problem is to cover crops with white, reflective, coarse nets. This method was found to decrease aphids and the incidence of both nonpersistent (6,7) and persistent (7,13) viruses. The coarse net is not a barrier for aphids but rather repels their landing, presumably because of its high reflectivity (6). The high cost of materials and labor are the main disadvantage of the above-mentioned methods, and, therefore, their use has been limited to small plots of high-value crops. The objective of the present work was to investigate the possibility of reducing virus incidence by applying whitewashes of reflective materials directly onto plants.

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MATERIALS AND METHODS

Field experiments were carried out in potato research plots during spring, summer, and autumn over several years. Potato plots were cultivated similarly to commercial fields and the treatments (three to six replications) were distributed at random. The spring experiments of 1984 and 1985 were carried out in commercial potato plots on the Golan Heights. Each replication consisted of three rows of different lengths, with the middle row serving for measurements. The reflective materials used were whitewashes of Loven (Tapazol Co., Rishon LeZiyon, Israel), which contains inert reflective materials and 6% Zn, and Yalbin (Tapazol), which contains 2.5% Zn and inert reflective materials, among them Ca (3). Dabak (0.2%) (consisting of 40% polyvinyl and 60% inert material; Tapazol Co.) was added to solutions of the whitewash (10-15%) to increase stickiness and sprayed by a SOLO knapsack hand sprayer type 425 equipped with a T.j. 8004 nozzle. These sprays increased potato leaf reflectivity throughout the

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sible spectrum wavelengths by 130–250% (Fig. 1), as measured by Bausch & Lomb spectrophotometer (Spectronic 20) with a flectance attachment. Virol (Pazchim, Co., Tel Aviv, Israel), hich consists of 80% medium light oil and 20% water and nulsifiers, was sprayed similarly to the whitewashes, but at a ncentration of about 2%. Because all experiments were carried it in overhead irrigated plots, the solutions were sprayed onto the ants once a week (the day after irrigation), starting from about 0% emergence. Protection by net cover was previously described Marco (13); net tunnels were stretched on flexible plastic sticks a height of 90 cm in the center.

Virus. From the middle row of each replication a medium-sized ber was sampled at random from each plant. The tubers were tificially sprouted by Rindite treatment (9). PLRV was assayed til 1979 by the sprout test (12): aphid transmission from apical routs to the indicator plants *Datura stramonium* L. and/or *ysalis floridana* Rydb. Starting in 1980, PVY and PLRV were sayed by direct, double antibody sandwich enzyme-linked munosorbent assay (ELISA), as described previously (14). ilutions of PVY antiserum were 1:1,000 for coating and 1:500 for njugate and dilutions of PLRV were coating 1:1,500 and njugate, 1:1,000. Apical sprouts were homogenized in PBS-ween (1:5) with no additives. Because the tests were done at least duplicates, not all the sprouts could be assayed for both PLRV d PVY.

Aphids. Winged (alate) aphid populations were estimated by ing yellow sticky traps and yellow water traps (9). The sticky aps consisted of rigid, yellow plastic cards (20 × 14 cm) sprayed ith a sticky transparent glue (Rimifoot, Jewnin & Joffe, Tel Aviv, rael) mounted horizontally on stands and adjusted to about crop ight. The cards were changed every 1–3 days, and the number of apped alatae was counted.

The water traps were yellow plastic pans (30 × 35 cm) about lf-full with water, to which about 10 ml of Dimanin A (33.3% kyl dimethyl benzyl ammonium chloride; Chimgat Lidor, Co., amat HaSharon, Israel) was added to prevent development of cteria and algae. Pan height was also adjusted to the haulm ight, and once a week the trapped aphids were collected, divided to groups (*Myzus persicae* Sulz. and all other aphids), and unted.

Wingless (apterae) aphid populations were estimated in the tato experimental plots by counting the total number found on 0 randomly chosen plants approximately 1 wk before harvest.

Landing of different aphid species on Loven-treated and control lots was assessed in pepper plots during the spring of 1981. The xperiment included six replications, each of which consisted of o 1-m² plots (15 plants), spaced 2 m apart. One of the plots was rayed with Loven at about 5% (higher concentrations damage young pepper seedlings) and the other was unsprayed. In each plot a water trap was located and the traps were handled as above, except that, in this case, all trapped aphids were prepared for microscope examination according to Bodenheimer and Swirski (5) and identified under the guidance of Dr. J. F. Eastop (British Museum, London).

The possible interference of the presence of whitewash materials on the leaves with the PLRV acquisition by aphids was determined as follows. Undetached leaves of PLRV-infected potatoes from our laboratory were smeared by a hair brush over half their surface with the tested materials plus 0.2% Dabak, whereas the opposite (control) half-leaf was smeared with Dabak 0.2% only. On each half-leaf, virus-free *M. persicae* apterae from the culture source were placed in leaf cages and allowed a 24–48-hr acquisition period. Subsequently, two aphids were transferred onto young *D. stramonium* seedlings for an inoculation period of 48 hr. Then the seedlings were sprayed with pirimicarb (0.05% Pirimor 50WP) and maintained in an insect-proof greenhouse for symptom development; the incidence (percentage) of infection as detected by ELISA, was compared in treated and control groups.

The possible interference of Loven with PLRV inoculation also was examined. Aphids that acquired virus from infected potato in the same leaf cage were allowed (two aphids per plant) to inoculate indicator seedlings that were dipped in or sprayed with the tested materials. Seedlings treated similarly with water (untreated) served as the controls. The plants were handled thereafter as described above.

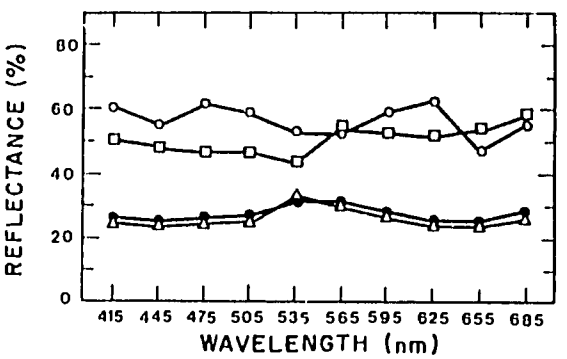

Fig. 1. Reflectivity (% reflectance of white porcelain) of the upper side of a potato leaf following a spray with: 15% Loven plus 0.2% Dabak (o—o); 15% Yalbin plus 0.2% Dabak (□—□); 2% Virol 0.2% Dabak (Δ—Δ); and 0.2% Dabak (•—•).

BLE 1. Percentage of potato leaf roll virus infection in potato tuber populations from plots treated with Loven, Yalbin, Virol, or covered with white, arse net, compared with untreated controls[a]

	1978[b]	1979	1980	1980	1981	1982	1984	
eatment	3[c]	6	3	4	5	6	4	Total
ntrol	13.3 (30) a	7.3 (247) a	10.0 (80) a	16.4 (181) a	3.0 (136) a	4.1 (197) a	2.8 (182) a	7.4 (1,053) a
ven	3.2 (30) a	1.0 (197) a	0.0 (29) b	7.8 (423) bc	0.9 (227) a	1.4 (208) a	1.7 (410) b	3.1 (1,524) b
% Protection[d]	76	86	100	52	70	66	39	
lbin				5.4 (322) c	0.0 (182) a	1.0 (201) a		2.7 (705) b
Protection				67	100	76		
rol				12.2 (115) ab	2.5 (120) a	3.2 (186) a		5.5 (421) a
Protection				26	17	22		
arse net				0.0 (92) d		0.0 (110) b		0 (202) c
Protection				100		100		

ata with the same letter not significantly different as analyzed by Duncan's multiple range test for $P \leq 0.05$. In parentheses: Number of samples assayed by ouble sandwich ELISA except for 1978 and 1979 when the sprout test (13) was used.
ear.
umber of replications.

$$\text{Protection} = 100 - \frac{(\text{infection in treated} \times 100}{\text{infection in control})}.$$

TABLE 2. Percentage of potato virus Y infection in potato tuber populations from plots treated with Loven, Yalbin, Virol, or covered with white, coarse net, compared with untreated controls[a]

Treatment	1980[c] 4[b]	1981 5	1982 6	1984 4	Total
Control	1.9 (106) a	2.2 (90) a	3.1 (98) a	2.2 (182) a	2.3 (476) a
Loven	0.8 (118) a	0.0 (68) b	2.1 (94) a	1.2 (427) a	1.1 (707) b
% Protection[d]	58	100	32	45	
Yalbin	0.0 (120) a	0.0 (96) b	0.9 (115) a		0.3 (331) bc
% Protection	100	100	71		
Virol	0.0 (95) a	0.0 (62) b	1.6 (64) a		0.5 (221) bc
% Protection	100	100	48		
Coarse net	0.0 (71) a	...	0.0 (104) b		0.0 (175) c
% Protection	100	...	100		

[a] Data with the same letter are not significantly different as analyzed by Duncan's multiple range test for $P \leq 0.05$.
[b] Year.
[c] Number of replications.
[d] % Protection = $100 - \frac{(\text{\% infection in treated} \times 100}{\text{\% infection in control}}$).

TABLE 3. Yield parameters of potato tubers from plots treated by reflective whitewash, oil, a combination of the two, and untreated control[a]

Parameter	Loven	Yalbin	Virol	Loven Virol	Yalbin Virol	Control
Number of tubers (30 g)	28	31	29	32	27	37
Number of tubers (30-120 g)	105	101	79	90	79	86
Number of tubers (120 g)	20 c	35 b	33 b	6 d	13 cd	55 a
Total numbers of tubers	153	167	141	128	119	178
Weight of tubers (30 g)	1,910	2,040	1,970	2,090	1,790	2,780
Weight of tubers (30-120 g)	7,352	6,783	5,898	5,530	5,565	6,103
Weight of tubers (120 g)	3,375 cd	4,933 bc	5,748 b	995 e	2,025 de	11,245 a
Total yield (g)	11,205 b	12,226 b	12,139 b	7,048 c	8,021 c	18,043 a

[a] Data with the same letter not significantly different as analyzed by Q-test for $p < 0.05$. Results are means of four replications from the middle row of three 5-m long rows.

Statistics. Yields were analyzed by the Q-test, the arc sine of infection percentages by Duncan's multiple range test, whereas results related to alatae trappings and apterae development were analyzed by the Mann–Whitney U-test (16) for $p \leq 0.05$.

RESULTS

Effect of sprays with Loven, Yalbin, and Virol on PLRV and PVY incidence. In seven experiments over 6 yr in different seasons and areas, Loven treatments reduced PLRV incidence in potato tubers to 24, 14, 0, 48, 30, 34, and 61% of the incidence found in the control plots ($p < 0.05$) (Table 1). In three independent experiments, Yalbin treatments reduced PLRV incidence to 33, 0, and 24% of that found in the control plots ($p < 0.05$), whereas oil treatment was not significantly different from the control. Net cover conferred absolute protection (Table 1).

In four experiments, Loven sprays reduced PVY incidence in potatoes to 42, 0, 68, and 55% of that in the controls ($p < 0.05$), and in three experiments Yalbin treatments reduced incidence to 0, 0, and 29% ($p < 0.05$). The efficiency of Loven and Yalbin was roughly comparable to that of Virol, which reduced PVY incidence to 0, 0, and 52% of the incidence in controls ($p < 0.05$), whereas, again, under the net no PVY infection was found (Table 2).

Effect of Loven, Yalbin, and Virol treatments on potato tuber weight, number, size, and shape. During harvest in spring 1980, a 1-m row was randomly sampled in the three replications of Loven-treated and control plots. A mean of 63 tubers per meter-row was found in the treated plots compared with a mean of 51 tubers for the controls, which is not significantly different. In autumn 1980, the middle row of each three-row replication was harvested separately. The results (Table 3) demonstrate a significant reduction of about 30% in total yield (weight) by each of the treatments and a further reduction (about 55%) by mixing Loven or Yalbin with Virol. The reduction is the consequence of the decrease in the number and weight of the large tubers (> 120 g). Weight and number of tubers between 30 and 120 g were not affected (Table 3). It should be noted that all the various treatments reduced ($p < 0.05$) the number of misshapen tubers: Loven to 3%, Yalbin to 1.8%, Virol to 5%, Loven plus Virol to 3.9%, and Yalbin plus Virol to 2.5% vs. 10.7% in the control. This may be related to the development in the control of larger tubers (Table 3), which are subject to a higher rate of deformation.

TABLE 4. Mean number of alatae of different aphid species captured per water trap in six pepper plots sprayed with Loven compared with the number trapped in six control plots

Species	Alatae (no.) Loven plots	Alatae (no.) Control plots
Aphis citricola van der Goot	3,271	7,521**
Myzus persicae Sulzer	272	484*
A. gossypii Glover	235	146*
A. craccivora Koch	186	270
A. fabae Scopoli	56	169*
Unidentified	2,170	2,657
Total	6,190	11,247*

[a] Asterisks indicate significant differences between control and treated plots as analyzed by the Mann–Whitney U-test (17) at $p < 0.05$).

Effect of crop sprays with Loven, Yalbin, and Virol on alatae and apterae populations in the field. Loven or Yalbin treatment reduced the total number of aphids (Fig. 2) and the number of *M. persicae* (Fig. 3) that landed on spring and autumn potato crops to 30–40% of the number trapped in the control plots ($p < 0.05$). Virol sprays did not reduce the total number of trapped alatae, which may be related to the fact that the application of Virol did not change leaf reflectivity markedly (Fig. 1).

Loven sprays in pepper reduced *Aphis fabae* Scopoli to 33% of the number found in the controls, of *A. citricola* van der Goot to 42%, and of *M. persicae* to 56% (all different from control at $p < 0.05$). Loven sprays had no effect on the number of trapped *A. craccivora* Koch but increased the number of *A. gossypii* Glover to 161% ($p < 0.05$) (Table 4).

No differences were found in the number of apterae that developed in Loven-, Yalbin-, and Virol-treated plots (means of 11.4, 28.1, and 15.3 aphids per plant, respectively) compared with the untreated controls (mean of 7.2 aphids per plant).

Effects of Loven, Yalbin, and Virol on the process of virus acquisition or inoculation by the aphids. In addition to the effect

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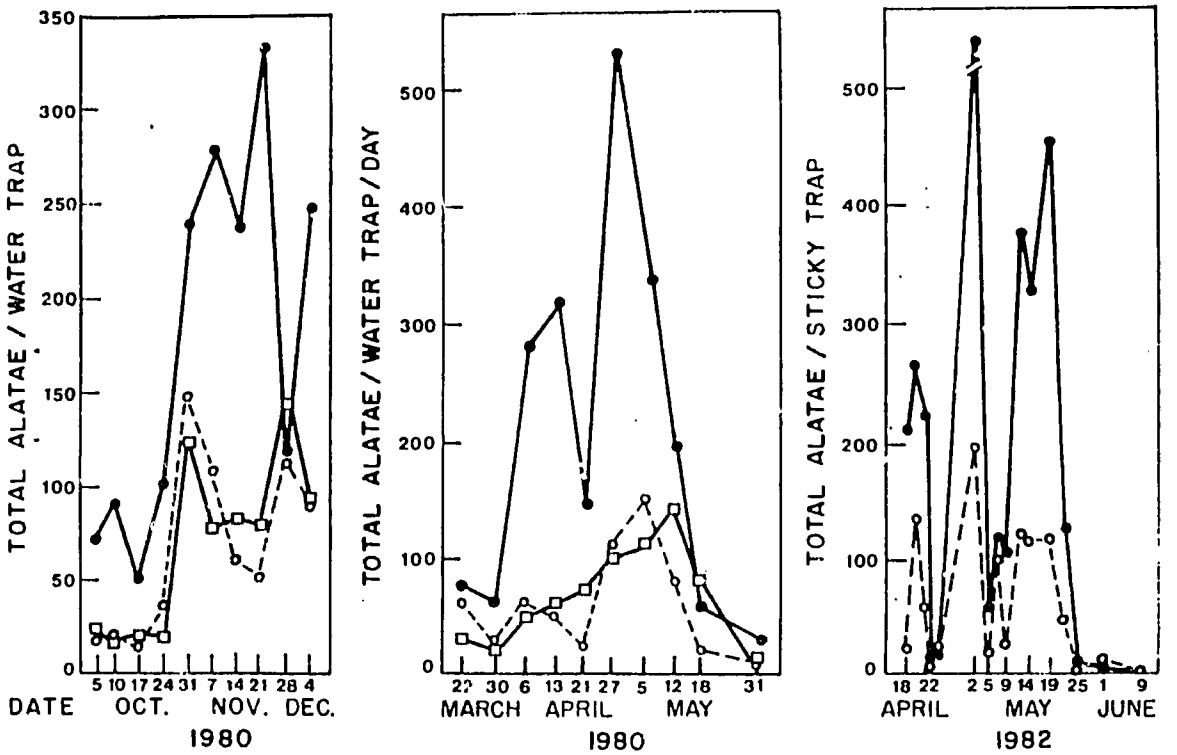

Fig. 2. Number of alatae trapped during spring and autumn, in whitewash-treated potatoes plots; Loven, (o – o) and Yalbin (□ – □) in comparison with untreated controls (• – •).

on aphid landing, the presence of whitewash or oil on a plant leaf may interfere with the process of virus acquisition and/or inoculation by aphids. In five experiments, PLRV acquisition of aphids from half-leaves treated with Loven plus Dabak, Yalbin plus Dabak, Virol plus Dabak, or Dabak was not different from PLRV acquisition on control (untreated) half-leaves.

As for PLRV inoculation, Loven plus Dabak and Yalbin plus Dabak reduced the aphid inoculation rate in comparison with that of untreated controls, whereas no differences were found between Virol plus Dabak and Dabak itself to the controls (Table 5).

DISCUSSION

Weekly sprays with the reflective whitewash materials Loven and Yalbin reduced PLRV- and PVY-incidence in potato crops (Tables 1 and 2). In spite of the low virus incidences, the whitewash effect was consistent in different places and seasons for quite a number of years. A plausible reason might be the reduced landing of aphids on whitewash-treated plants probably because of their increased leaf reflectivity. The effect of these materials on aphid landing would probably depend on their reflective properties, on the ambient climatic conditions, and on the specific vector specimen involved. In our situation, the landing (total) of natural aphid populations in spring or in autumn was always reduced by Loven and Yalbin treatments. However, some aphid species, like *A. citricola*, were repelled to a greater degree than others, whereas *A. gossypii* was attracted to whitewash-sprayed plots. These results are similar to those obtained by Bar-Joseph and Fraenkel with kaolin sprays (1) and by Smith and Webb with reflective mulch (17). The selective repellency indicates that, for practical use of whitewash spray, one should take into account not only the climatic conditions but also the vector species involved in the crop and the area.

Another way by which whitewashes may decrease virus incidence is the possible interference of these materials while on

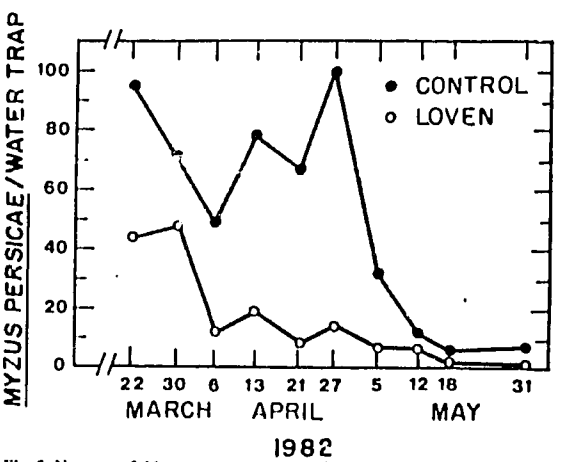

Fig. 3. Number of *Myzus persicae* trapped in yellow water traps in Loven-treated (o - o) and control (• – •) potato plots.

leaves, with the acquisition and inoculation of these viruses by aphids. We were not able to demonstrate interference with the acquisition process, but whitewash plus Dabak reduced aphid inoculation of PLRV compared with untreated controls, whereas oil (Virol) plus Dabak and Dabak treatments did not (Table 5). However, whitewash plus Dabak treatments did not differ from Dabak, so it is possible we have an additive effect of Dabak and whitewash. From the practical point of application this is of minor importance because whitewashes are to be mixed with Dabak anyway.

Loven and Yalbin treatments reduced PVY and PLRV in potatoes to about 30 and 40%, respectively. In areas where

TABLE 5. Effect of whitewash and Virol on inoculation of potato leaf roll virus (PLRV) by *Myzus persicae*[1]

Exp. no.	Percentage infection with PLRV				
	Love + Dabak	Yalbin + Dabak	Virol + Dabak	Dabak	Untreated
1	0(0/7)[2]	0(0/8)	11.1(1/9)	0(0/11)	12.5(1/8)
2	46.2(6/13)	0(0/14)	26.7(4/15)	57.2(8/14)	41.7(5/12)
3	35.9(14/39)	26.7(8/30)	33.3(12/36)	43.9(18/41)	40.2(17/40)
4	3.8(1/26)	7.4(2/27)	4.3(1/23)	15.4(4/26)	14.3(4/28)
5	18.8(3/16)	10.7(3/28)	8.3(2/24)	26.3(5/19)	22.7(5/22)
6	5.0(1/20)	0(0/18)	9.5(2/21)	7.4(2/27)	23.1(6/26)
7	6.1(2/33)	13.9(5/36)	8.8(3/34)	17.1(6/35)	12.9(4/31)
8	21.4(6/28)	75.0(21/28)	37.0(10/27)	75.0(21/28)	84.6(22/26)
9	20.0(2/10)	15.0(3/20)	11.5(3/26)	4.6(1/22)	12.5(3/24)
10	0(0/22)	16.0(4/25)	13.3(2/15)	14.3(3/21)	87.5(21/24)
11	8.3(2.24)	0(0/22)	36.8(7/19)	4.0(1/25)	72.0(18/25)
Total	15.5(37/328) b	18.0(46/256) b	19.0(47/249) ab	28.3(69/244) ab	39.8(106/266) a

[1] Apterae acquired PLRV from the same infected leaf and were allowed to inoculate treated and control *Datura stramonium* seedlings (two aphids per seedling).

[2] In parentheses: numerator, number of infected plants; denominator total number of plants. Data with the same letter not significantly different as analyzed by Duncan's multiple range test for $P<0.05$.

infection rates of potatoes are low, this treatment could enable production of seed potatoes. Net covers are more efficient, but it seems impossible to use this method on a large scale because of the high cost of labor and materials and technical problems involved. Whitewash is a cheap material and easy to apply. We had to spray weekly because of the overhead irrigation in our plots; however, in other systems of irrigation frequency of sprays would probably decrease.

The whitewash sprays done in these experiments decreased the total yield of potato tubers. This is in disagreement with previous reports that yields of sorghum (18), dryland cotton (4,15), melon (2), and artichoke (3) were increased after Yalbin treatments. In spite of the total weight decrease, the yield and the number of tubers between 30 and 120 g were not affected, and for seed purposes this is most important. Among other possibilities increasing whitewash reflectivity and understanding its effect on aphid behavior may improve the action of this treatment and work on these aspects is in progress.

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Reducing aphid-transmitted viruses in squash by sprays of clay suspensions

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Abstract

Weekly sprays of whitewash (Yalbin 10%) and sticker (Dubak 0.1%) significantly reduced aphid-transmitted virus incidence in squash providing an average of 62% protection as assessed at the first harvest in experiments carried out during 4 years. Similar sprays with the same concentrations of clays (consisting mainly of Kaolin) of high (clay I) and low reflectance (clay L), resulted also in virus reduction by providing 61% and 42% protection, respectively ($P<0.05$). The protection level of clay I was similar to that of whitewash and both were significantly higher than that of clay L. Increasing clay I concentration to 20% or adding clay to whitewash to a final 20% concentration, did not improve protection efficiency.

In whitewash-, clay I- and clay L-treated plots, lower numbers of aphids landed as tested either by direct observations on plants (5%, 8% and 78% of the numbers which landed in the control) or by catches in water yellow traps (1%, 2% and 48%, respectively). In clay L-treated plots aphid numbers were higher than in either Yalbin- or clay I-treated plots, while there was no difference between Yalbin and clay I. This is in agreement with their relative reflectance: the higher the reflectance, the lower the number of landing aphids.

None of the 142 landing aphids collected from plants was found to be infective. Of the trapped aphids 95% were *Aphis spiracola* and *Myzus persicae*.

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Whitewash applied at 15% may visibly damage young squash plants at the cotyledonary stage. No effect was observed at lower concentrations or on older plants. Clays did not damage squash at any stage or any concentration up to 30%. In the field, the plots which received five to seven sprays of clays or whitewash looked taller, healthier, and revealed a significantly higher proportion of green to dried leaves, along with a significantly lower incidence of leaf silvering, which is a stress symptom.

Introduction

Weekly sprays of potato (8), rutabaga (7) and pepper (unpublished results) with whitewash reduced the incidence of aphid-transmitted viruses presumably by deterring aphid landing due to their high reflectivity. The whitewashes used (7,8) are commercial products which, in addition to reflectant materials, have many other known and unknown ingredients (minerals, emulgators, emulsifiers and stickers) which may damage the sprayed plants (8) and have a detrimental effect on plant growth when they accumulate in soil in large quantities (unpublished results). Thus, 15% whitewash sprays reduced potato tuber yield (8) and a 10% spray damaged young pepper seedlings (unpublished results).

Natural clays containing mainly Kaolin may be highly reflectant and Kaolin sprays were shown to reduce spiraea aphid colonization on lime plants (2). Clays are presumably inert materials, are a large natural component of soil, and may be less damaging to plants than is whitewash. The present work investigates the possibility of reducing aphid-transmitted virus diseases in squash by spraying clay and whitewash suspensions and assaying their direct effect on squash plants.

Squash (Cucurbita pepo), like most cucurbits, are severely affected by the aphid transmitted viruses. In Israel the following such viruses have been

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identified: cucumber mosaic virus (CMV), zucchini yellow mosaic virus (ZYMV) and watermelon mosaic virus-2 (WMV-2) (1,4,10).

Materials and Methods

Experimental

Seeds of the hybrid cv. Maayan (Hazera Seed Co., Israel) were sown by hand in an experimental field which had been fumigated previously with methyl bromide at the Bet Dagan Experiment Station. Four independent experiments were carried out with plots arrayed in a random block design and replicated five times. Sprinkler irrigation was provided once a week, and "Nutricol" 20:20:20 was added at every other irrigation to an equivalent of 50 kg/ha. Field plantings were conducted on May 10, 1987 (Exp. 1); Sept. 16, 1988 (Exp. 2); March 21, 1989 (Exp. 3); and April 24, 1990 (Exp. 4). The plots were 10x1.86 m in size, 1 m apart and consisted of one row in which plants were thinned after emergence to 5-6 plants per m.

Spray treatments

Two commercially available whitewashes (Loven and Yalbin, obtained from Tapazol Co., Rishon le-Zion, Israel) were tested, and two commercially available clays: a local product gray in color (AIPM, Makteshim, Haifa, Israel), herein designated 'clay L', and an imported white clay (China Clays, Pars Paper Co., P.C. 3086, Haft, Tappeh), designated clay I. These two clays were chosen out of 11 different products because of their extreme reflectances. Clay I conferred to treated leaves the highest reflectance, similar to the whitewashes, and clay L the lowest (Fig. 1). The reflectance in the visible spectrum was measured as described previously (8). All materials, unless otherwise stated, were used as 10% suspensions to which 0.1% Dabak (40% polyvinyl; Tapazol) was added to increase adherence. The materials were sprayed once a week, 1 day after the

irrigation with a 'Solo' knapsack sprayer type 425 equipped with a Tee jet 8004 nozzle.

Virus

Virus incidence was assessed at different intervals according to visual symptoms. The efficiency of reducing infection is expressed in percent protection

$$= 100 \left(1 - \frac{\%\ \text{infected in treatment}}{\%\ \text{infected in control}}\right)$$

In plots treated with whitewashes or clays, virus symptoms were less obvious, mainly on the older leaves, because of coverage with the sprayed material. To reduce this problem, virus evaluations were made on young leaves the day after irrigation, before the new spray application. In experiments 3 and 4 in the treated plots we collected leaf tissue from ca. 100 randomly chosen plants with virus disease symptoms and from 100 symptomless plants and tested them by ELISA (9) for the presence of ZYMV, WMV-2, CMV, papaya ringspot virus (PRsV) and squash mosaic virus (SqMV). ELISA results were related to the visual estimations of the same plants.

Aphids

Landing alatae were counted in exp. 3 directly on the young plants every day for 4 weeks starting from the cotyledonary stage. In exp. 4 the landing aphids which were caught in yellow water traps (6) were collected and counted once a week; they were identified only as Myzus persicae and as "all the others". In each treatment one trap was located in the center of a randomly chosen replication and its height was adjusted to the height of the plants.

Infectivity of live aphids (12) was assessed in exp. 3. Once a week the alatae found on the plants were gently collected with an artist's brush and placed individually in leaf cages for an overnight inoculation period on young

squash seedlings. Then they were introduced (either alive or dead) into 70% alcohol, numbered in relation to the indicator plants, and subsequently identified (12). The squash indicator plants were kept for 6 weeks in an insect-proof greenhouse for observations of symptom development.

Direct effect of treatments on squash plants

Four squash seedlings grown in pots were dipped at different stages of growth (cotyledons, 2, 4 and 6 true leaves) in 0.1% Dubak solutions and in increasing concentrations of the clays and whitewashes tested (0-30%). Plants were kept for 4 weeks in a greenhouse and assessed for visual damage. Observations were also made on the plants grown in the field, which received five to seven sprays.

Leaf silvering

The number of plants showing leaf silvering, presumably a general stress symptom in squash (11), were counted in exps. 2 and 4 at the four- to six-leaf growth stage. No attempt was made to evaluate severity of the silvery symptoms as described by Paris et al. (11).

Green <u>versus</u> dry leaves on plant

In exp. 4, ten plants from the center of each plot were removed after the last harvest and the numbers of green and dead (dry) leaves were counted on each plant.

Statistics

Percent infection data were transformed according to Gregory (5). These and the data on aphid numbers were subjected to multiple analysis of variance (MANOVA, PROC. GLM (SAS)) and means were separated by Duncan's multiple range test for $\alpha=0.05$.

Visual evaluations of symptoms were related to the ELISA results for the same plants by calculating the correlation coefficient (r).

<u>Results</u>

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Virus

The first experiment was aimed at assaying the effect of whitewashes on the incidence of aphid-transmitted viruses in squash and determining if similar treatments with clays have any comparable effect. Virus incidence in this experiment was low for the first 2 months but sharply rose within 3-4 weeks after the first harvest to almost total infection (Fig. 2). This sharp increase in virus infection following the harvest was common in all the spring experiments. We believe it was due to the mechanical transmission occurring during the harvest process, since very low aphid populations were observed at this time (Figs. 3 and 4). These late infections have also a lower impact on yields. Since we attempted to verify the effect of the treatments on the aphid transmission process, we compared the virus incidences occurring until the first harvest (Table 1). It is assumed that these reflect mainly aphid-transmitted infections because of the presence (Fig. 3 and 4) of aphids and the lack of any agromechanical work at that time.

In the first experiment, the tested whitewashes and clays reduced virus incidence to 13-33% of that found in the control plots (Table 1). Exp. 2 was conducted late in autumn and was aimed at assaying the possibility of enhancing clay protection by increasing its concentration and assaying incidence of leaf silvering. Unfortunately, early rainfall damaged the plants badly, and virus incidence in this experiment was very low (control, 3.6%; Yalbin, 10%, 2.6%; clay I 10%, 2.1%; clay I 20%, 2%; and clay I 30%, 2.1%); therefore the data on virus incidence were disregarded for the final statistical analysis. Exps. 3 and 4 indicate that increasing clay I percentage to 20% or mixing clay I with whitewash (Yalbin) to a final concentrtion of 20% did not have a marked effect on protection levels (Table 1). The overall analysis of the data in exps. 1, 3 and 4 shows a significant reduction of virus incidence in plots sprayed with 10% clay I or L (mean of 61% and 42% protection, respectively) and with 10%

whitewash (62% protection). Clay I did not differ significantly from Yalbin (whitewash) but both were significantly more efficient than clay L (Table 1).

In exps. 3 and 4, results of ELISA assay were highly correlated with visual evaluations (r=0.84 and 0.91 respectively). ZYMV was found in 81% and 95% of the infected samples, WMV-2 in 11% and 4%, and CMV in 6% and 0%, in exps. 3 and 4, respectively. No RsMV or SqMV was detected, and 18% and 10% of the infected samples involved mixed infections.

Aphids

In exp. 3, the number of alatae landing on squash plants was significantly higher on control plots than on any of the treatments (Fig. 3). In plots treated with 10% clay L, the number of alatae found on plants was 80% of the number found in control ($P<0.05$), but significantly higher than the numbers found in 10% clay I- and 10% Yalbin-treated plots, in which only 8% and 5%, respectively, of the aphid number in control was found (Fig. 3). No significant difference was noted between the Yalbin and clay 1 treatments.

The aphid species identified were: Aphis spiracola (ca. 92%), M. persicae (ca. 3%), A. fabae, A. craccivora and A. gossypii - approximately 1% each, and the remaining 2% were unidentified. The reduction of aphid landing in treated plots involved mainly A. spiracola and M. persicae. No significant differences were found in the numbers of the other species, probably because of their low numbers. None of the 142 alatae allowed for inoculation was found to be infective.

In the yellow traps exposed in exp. 4 the general trend was similar to the results in exp. 3. Significant lower populations of alatae were trapped in clay L treated plots (50% of the aphids in control), but these were significantly higher than in clay I- (19%) or whitewash- (14%) treated plots (Fig. 4). According to Figs. 3 and 4, alatae activity seems to decrease toward, and practically cease by the end of May.

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Direct effect of treatments on squash plants

Whitewashes in high concns have a visible, detrimental effect when applied on pepper (unpublished results), and reduce tuber potato yields (8). At 10% concentration no effect was observed on the squash test plants treated with clays or whitewashes. At 15% concn, squash plants at the cotyledonary stage were damaged by the whitewashes and sometimes the 15% Loven treated plants developed the first true leaf slower and it was smaller, chlorotic and deformed. No effect was observed on the same age treated plants with the 15%-30% concn clays. Older test plants (2, 4 and 6 true leaves) were not affected by 15% or lower concentrations of whitewash or by clay treatments up to 30%. In the field experiments, where five to seven sprays were applied, a beneficial effect was observed in 10% whitewash- and 10% clay-treated plots. At the end of the season the plants in these plots were taller, healthier and greener. All the treatments in exp. 4 revealed a significantly higher proportion of green versus dead leaves as compared with the control. No significant difference was found among the treatments (Fig. 5).

Leaf silvering

In exp. 2, 48% of the control plants exhibit clear leaf silvering. No plants with silvering leaf were observed in plots treated with Yalbin, clay I 10% or 20%. Less than 1% of the clay I 30% - treated plants evinced leaf silvering symptoms. In exp. 4, 6% of the control plants exhibited leaf silvering vs 2% in clay L-treated plots and none in the clay I-, clay + Yalbin or Yalbin-treated plots.

Discussion

Whitewash sprays reduced the incidence of aphid-transmitted viruses in squash (Table 1), thus confirming the few reports on similar effects in potato (8), rutabaga (7) and pepper (unpublished results). The results summarized in

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Table 1 indicate that clays with high reflectance act very much like whitewashes, suggesting that the main effect of whitewashes and clays in reducing virus incidence is due to their repelling aphids landing because of their high reflectance, as suggested earlier (8). This is reinforced by the fact that indeed fewer aphids landed in the plots treated with the clays and whitewash as compared with the control (Figs. 3 and 4), and that fewer aphids landed in the plots treated with clay I (high reflectance) versus clay L (low reflectance) (Figs. 3 and 4). Clay L, however, still reduced virus incidence significantly (Table 1), suggesting that clays (and maybe whitewashes) may have additional effects in virus-disease epidemiology beside deterring aphid landing. Anyway, from the practical aspect, clays are inexpensive, completely safe to the environment, and their accumulation in soil is inoffensive. Concentrations of up to 30% do not damage the plants, and even have a beneficial effect on squash, increasing the plants' longevity, as expressed in the higher ratio of green/dry leaves (Fig. 5). Leaf silvering, a symptom which expresses reaction to stress (11), was also drastically reduced by applications of clay and whitewash, probably by improving the plant's water status (11,13) and reducing heat stress (3).

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Table 1.

Percent of virus-infected plants in squash plots receiving the various treatments plus sticker (Dabak 0.1%). Data are means of five replications of 50-55 plants each as evaluated by symptoms at the first harvest.

(In parenthesis, percent protection = $100 \left(1 - \frac{\text{\% infected in treatment}}{\text{\% infected in control}}\right)$.

Means with different letters are significantly different according to (as separated by) Duncan's Multiple Range Test.

Exp. No.	Sowing date	Control	Clay I	Clay L	Yalbin	Yalbin + Clay	Clay 20%	Loven
1.	10 May	12	2.2 (82)	4.0 (67)	1.6 (87)			1.7
3.	21 March	21.1	13.1 (38)	16.2 (23)	12.6 (40)	10.6	11.5	
4.	24 April	12.8	4.8 (62)	8.1 (37)	5.2 (59)	3.6		
Mean		15.3^{a}	6.7^{c} (61)	9.4^{b} (42)	6.5^{c} (62)			

Figure Captions

Fig. 1. Reflectivity (% reflectance of white porcelain) of the upper side of a squash leaf following a dip in suspensions of 10% Loven (■—■), 10% clay I (◆—◆), 10% clay L (◇—◇) and water (□—□).

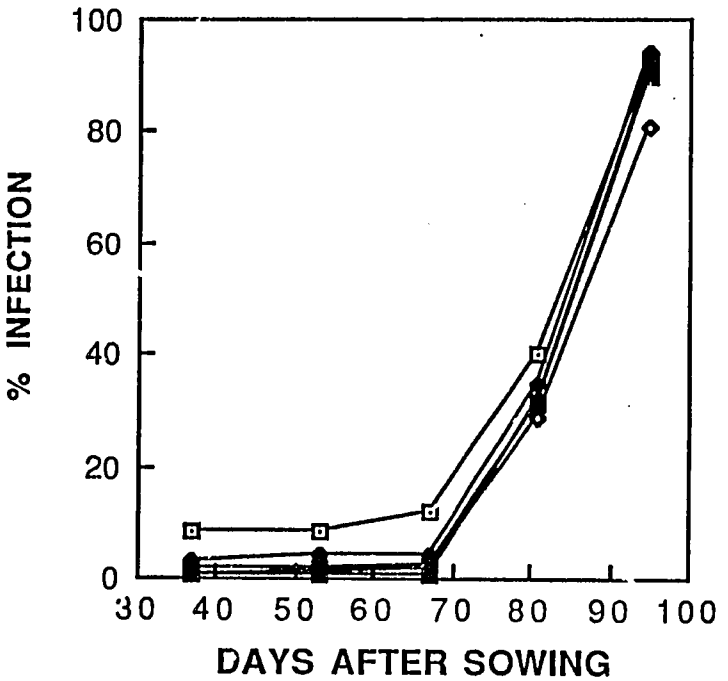
Fig. 2. Mean percentages (five replications) of virus infection in squash plots of experiment 1 sprayed weekly with mixtures of 0.1% Dabak and 10% Loven (■—■), with 10% Yalbin (◇—◇); with 10% clay I (■ - ■); with 10% clay L (◆—◆); and left untreated (□—□).

Fig. 3. Mean number of alatae per replication (50-55 plants) observed on squash plants in plots of experiment 3 treated with 0.1% Dabak to which 10% Yalbin (◆—◆), 10% clay I (■—■) or 10% clay L (◇—◇) was added, and untreated (□—□).

Fig. 4. Number of alatae found in yellow water traps located in squash plots of experiemnt 4 treated with 0.1% Dabak to which 10% Yalbin (◆—◆) 10% clay I (■ - ■) or 10% clay L (◇—◇) was added, and untreated (□—□).

Fig. 5. Number of green leaves (▤) and dry leaves (▨) per squash plant in the different treatments of experiment 4. Data are means of ten plants x five replications.

Fig 2. MARCO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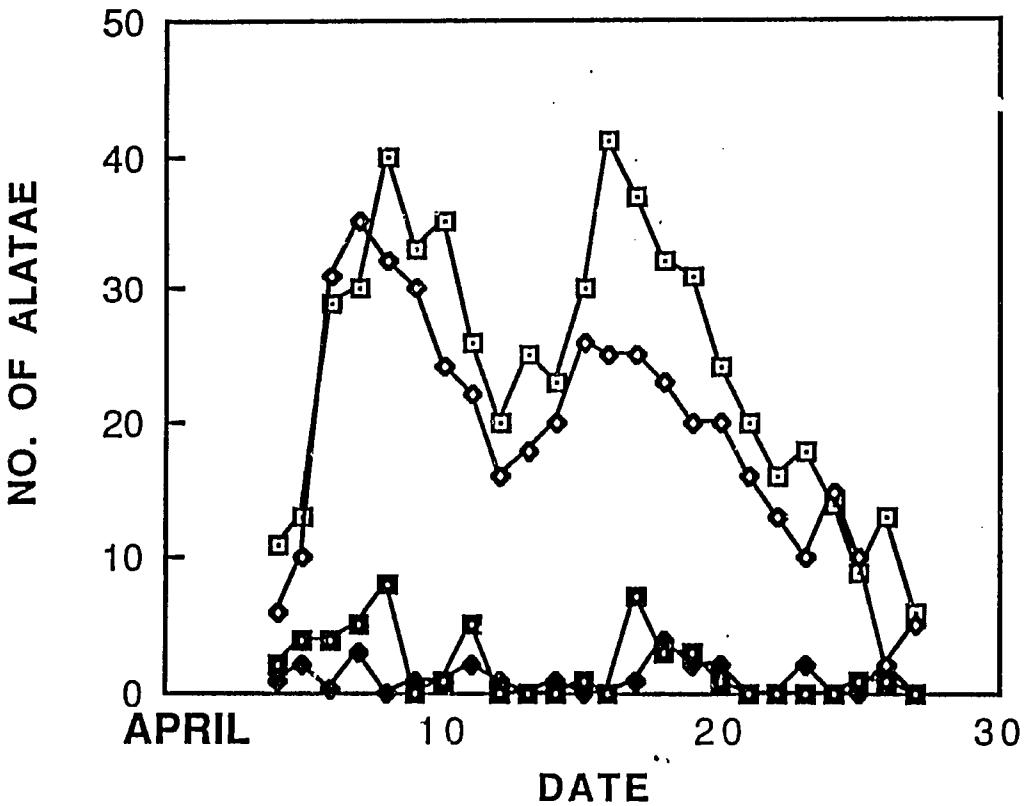
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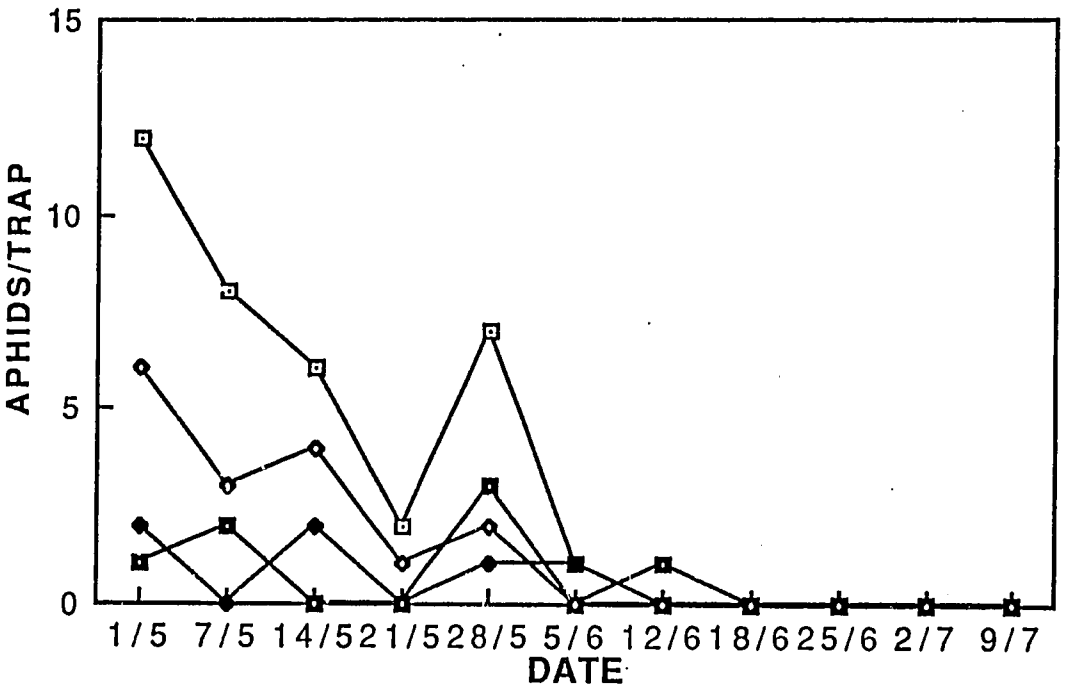
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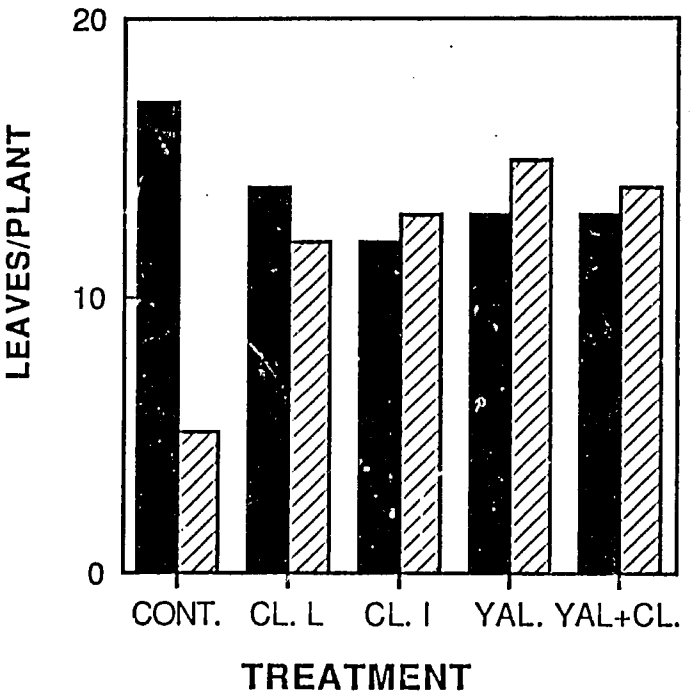
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TREATMENT

Control of non-persistent viruses in pepper with applications of whitewash, oil, insecticides, and their combinations

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ABSTRACT

Several methods of protecting pepper against aphid-borne virus diseases were evaluated in field experiments for six years. Weekly sprays of the insecticides Pirimor (carbamate) or Talstar (pyrethroid) at 0.1%, or weekly sprays of a mixture of Pirimor 0.1% plus whitewash 10% (Yalbin) did not differ from the controls. Applications of Virol 1% (light oil) or of the whitewashes Yalbin or Loven at 10% reduced significantly virus infection by about 40%. The best control was achieved by treatments with mixtures of whitewash (Yalbin 10%) plus pyrethroid (Talstar 1%), or by whitewash plus oil (Virol 1%), which reduced virus infection by about 60%. Whitewashes (Yalbin and Loven) at 10% caused slight damage to young pepper seedlings and their combination with Pirimor (0.1%) and oil (1%) increased damage. The most prevalent virus detected was potato virus Y (PVY) occurring in 86% of the infected plants. Cucumber mosaic virus was found in 23%. Alfalfa mosaic virus was detected in only one sample. Several plants contained more than one virus.

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Pepper (*Capsicum annuum* L.) is an important crop worldwide. Virus diseases cause serious losses and can be the most limiting factor affecting production (10). In Israel, the crop is severely affected by the nonpersistent aphid-transmitted viruses potato virus Y (PVY) and cucumber mosaic virus (CMV)(16). Not only are yields reduced, but these viruses affect fruit set quality and size, drastically reducing the marketable yield. In the early spring and autumn, virus diseases actually prevent cropping in certain areas of Israel.

Bradley *et al.* (1962) showed that oils coating plant surface interfere with aphid transmission of nonpersistent viruses (1). Since then, vegetable and mineral oils have been used on many crops, including peppers, with variable levels of control (7, 8, 15). Variability in the effectiveness of oil sprays is related to many variables (21) like special spraying equipment and unpredictable weather factors. Quite often oils may damage the plants, especially when applied at high temperatures (23).

Nonpersistent viruses are not adequately controlled with most insecticides (7, 22). Pyrethroids were found to reduce PVY infection (5) in the laboratory, but they seldom give adequate control in the field, and their combination with oil is preferred (17).

Mulching with reflective foils (aluminum or plastic) deter aphids from alighting on the crop, thereby reducing virus spread (7, 20, 23). However, the growing crops shade and cover the mulch, limiting repellency to a rather short, early growth period (23).

Applications of reflective whitewash on the plants were shown to reduce incidence of the nonpersistent viruses PVY, in potato (13) and turnip mosaic virus (TuMV), in rutabaga (8).

Oils, insecticides, and whitewashes presumably reduce viral incidence by different mechanisms. Therefore, combinations of these materials may increase control efficiency. The present work compares the effectiveness of the above materials and their different combinations on virus incidence in pepper grown in Israel during various seasons.

MATERIALS AND METHODS

Experiment. Seeds of the cv. 'Maor' were sown in beds. At the first or second true leaf stage the seedlings were transferred to small pots (7 cm diam) or seedling trays and kept in an insect-proof greenhouse. At the 8th-10th leaf stage, after hardening of 2-4 days outdoors (under a white coarse net in order to prevent infection)(2, 3, 12), the seedlings were planted in the experimental field, previously fumigated with methyl bromide.

Six independent experiments were carried out with plot arrayed in a random block design and replicated four to six times. Plots were cultivated similarly to commercial fields cultured during spring, summer, or autumn. Sprinkler irrigation was provided once a week adjusted to the evapotranspiration values. The plots were 5 x 2 m, 1.5 m apart, consisting of 3 rows (total of ~~45-50~~ 50-60 plants). Field planting dates were: exp. 1, Aug 10, 1983; exp. 2, Apr 24, 1984; exp. 3, Sept 3, 1985; exp. 4, Mar 15, 1987; exp. 5, Apr 10, 1988; and exp. 6, May 5, 1990.

Spray treatments. Spray materials used were as follows: commercial whitewashes Loven (v/v) and Yalbin (w/v) at 10% (Tapazol Co., Rishon Le-Zion, Israel) with Dabak (v/v)(40% polyvinyl; Tapazol) added at ca. 0.1% to increase adherence; the insecticides Pirimor (w/v)(Pirimicarb 50% WP, ICI) and Talstar (v/v)(Biphentrin 10% LI, FMC), at 0.1% concentration, and the oil Virol (v/v)(light oil 80%, OI, Machteshim) at 1%. Sprays were applied

once a week, 1 day after irrigation, with a 'Solo' knapsack hand sprayer type 425 equipped with a T.J. 8004 nozzle. Combinations of the above materials were sprayed at the same initial concentrations. The last spray treatments were given when first fruits were 2-5 cm in diam. Treatments were not continued beyond this stage because whitewash sticks to and dirties the fruits, and infection after fruit set in our determinant cv., has little effect on fruit yield and quality (Marco, unpublished results). Final virus incidence assays were conducted ca. 1 wk after final treatment.

Effect of treatments on pepper plants. In preliminary tests, whitewashes applied at 15% as used in a previous work on potatoes (13) damaged young pepper plants. Therefore, we conducted two experiments to determine the maximum nondamaging whitewash concentrations. Four pepper plants at 1st leaf, 4th leaf, 10-12th leaf, and branching stages of growth were dipped in increasing concentrations (5-25%) of Loven and Yalbin, and in combinations of these with Pirimor 0.1%, Talstar 0.1%, Virol 1%, and Dabak 0.1%. Plants were observed for general appearance to nontreated controls for up to six weeks. The test plants were grown in the greenhouse in the first and outdoors in a second replication of the experiment.

Virus. Virus incidence was visually assessed at different intervals according to symptoms. In plots treated with whitewashes and their combinations, virus symptoms on plants were less obvious because of the whitewash cover, thereby raising the possibility of incorrect visual evaluations. To reduce this problem, virus evaluations were always done on young leaves the day after irrigation before the new application. In addition, in experiments 1 and 3, batches of about 100 plants with symptoms and 100 symptomless plants, as assessed visually, were sampled from the different whitewash treated plots and assayed by the double sandwich ELISA

(14) against antiserum of PVY, CMV, and AMV. The visual evaluations of symptoms were related to ELISA results for the specific plants and the correlation coefficients (r) were highly significant in both experiments (r = 0.91 and 0.88, respectively), indicating the validity of the visual assessments.

Virus incidence

Statistics. Data was subjected to the multiple infection transformation (6) and analyzed by the multiple analysis of variance for repeated measurements MANOVA, PROC GLM (SAS) for $\alpha = 0.05$. Treatment means were separated by Duncan's multiple range test and data of visual evaluations of infections was related to ELISA results of the same plants by calculating the coefficient of correlation (r).

Efficiency of reducing infection is expressed in "percentage protection" = $100 \left(1 - \frac{\text{\% infected in treatment}}{\text{\% infected in control}}\right)$

RESULTS

Effect of treatments on pepper plants. No direct damage was perceptible on pepper at different growth stages when treated with Pirimor 0.1%, Talstar 0.1%, Virol 1%, Dabak 0.1%, Yalbin 5%, and Loven 5%. At 10% concentrations of Loven and Yalbin slight damage occurred in the youngest plants. Plant damage increased as whitewash concentration increased above 10%; younger plants were more sensitive; greenhouse grown were more sensitive than outdoors grown plants; mixtures of whitewashes with Virol or Pirimor increased damage while addition of Dabak or Talstar did not. This direct damage was mainly related to desiccation symptoms followed by stunt and did not resemble the typical mosaic virus symptoms.

Since planting in our conditions takes place at about 8-10th leaf stage, 10% whitewash plus 0.1% Dabak was chosen as the standard treatment.

In the field where 6-8 sprays were applied, the plots treated with mixtures of whitewash with Pirimor or whitewash with oil, showed stress, lower canopy, height, and were greener and more epinastic.

Virus incidence. The effect of the eight treatments tested in the different experiments during the six years, fell in three distinct categories (Fig. 1) which were significantly different (Table 1): 1) Neither insecticide spray (Pirimor or Talstar) was significantly different from the control, nor was the combination of whitewash (Yalbin) and Pirimor. 2) Both whitewashes (Yalbin or Loven) provided significant protection (means of 39 and 38% protection) at a level similar to oil (Virol) sprays (mean of 37% protection). 3) Best protection was obtained by the combination of whitewash (Yalbin) and insecticide (Talstar)(mean 56% protection), and the combination of whitewash with oil (mean 70% protection). These combinations provided significantly higher protection levels than the ingredients applied individually (Table 1).

As determined by the ELISA tests on a total of ca. 200 diseased samples, PVY was the most prevalent virus occurring in 88% and 85% of the infected samples of experiments 1 and 3. CMV was found in 19% and 26% of these samples sometimes in mixture with PVY, and one sample was found infected with AMV.

DISCUSSION

Whitewash sprays reduced PVY and CMV incidence on pepper (Fig. 1). These results confirm the reports of similar effects on PLRV and PVY incidence in potato (13) and TuMV in rutabaga (8). The levels of protection by whitewashes (39% and 38% for Yalbin and Loven) were very similar to that achieved by oil (37%)(Fig. 1). Whitewash is relatively inexpensive, safe, and is easier to apply than oil which requires ~~high spray~~ sophisticated spraying machinery (1~~pressures (19)~~.

The levels of protection achieved by whitewashes or oil are far from satisfactory but are still important since very few alternatives are available. Our results (Table 1) confirm that pesticides provide no protection against nonpersistent viruses in pepper (7, 22) even though, like Pirimor, they are most efficient aphicides (9, 11). Even pyrethroids which reduced PVY infection in potatoes (5, 18) and ZYMV in melons (15) did not protect pepper in the field to any significant extent (Table 1). (Fig. 1.) confirming many other & reports

Oil sprays are known to reduce nonpersistent virus incidence (1, 7, 15, 19). However effective results found were not consistent (8, 15, 21) and are dependent on many variables (21) including the pressure and volume of the spray, which is expensive to apply and weather factors (23) which are impossible to control. Oil efficiency in our work was also low (37% protection) (Fig. 1) and might be explained by the relative low concentration used (1%) (in the hot climate of Israel higher concentrations often cause dam and by our simple knapsack sprayer where volume and pressure were not adequate. However under the same conditions, addition of whitewash to oil increased its protective efficiency (70% protection) which was significantly higher than oil and than whitewash alone. It appears we obtain in the mixture an additive effect (Fig. 1) suggesting that whitewash and oil ~~to~~ do protect against viruses by different mechanisms. Unfortunately, this mixture caused the most damage to plants. Work is in progress to determine the actual effect on yields, define optimum spray concentration and timing and desired plant densities. If the damaging effect can be controlled, whitewash and oil mixtures are a promising alternative to insecticides and could reduce the percentage of oil needed (8, 9), thus reducing oil's direct damage. This is crucial to crops easily damaged by oil (9, 15), in areas of hot climates (23) and important to growers of organic products who cannot use insecticides

10/14

The effect of the combinations of whitewash (Yalbin) and insecticides seems to depend on the type of the insecticide used. The protective efficiency of the mixture of whitewash (10%) and a pyrethroid (Talstar 0.1) was significantly higher (56% protection) than the whitewash alone (40% protection), though the insecticide itself at the same concentration did not exhibit any significant protection (Table 1). Addition of a carbamate (Pirimor 0.1%) resulted in an opposite effect--canceling the initial protection of the whitewash. This effect is not yet understood but it is reasonable to assume that it has to be related to the different modes of action of these insecticides on aphids. Common insecticides, like Pirimor, are presumably increasing aphids activity during the ~~spray time~~ or agony (7), while ~~in addition~~ pyrethroids cause repellency (15) rapid knockdown and paralysis of aphids (3, 15, 18).

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Table 1. ~~Viral infection~~ Virus incidence transformed for multiple infections[1] in the different treatments at the final assessment[2]. Data are the means of the total replications in the experiment.

Exp.	Rep.	Date	Control	Yalbin	Loven	Yalbin + Pirimor	Yalbin + Talstar	Pirimor	Talstar	Virol	Yalbin + Virol
1	4	8/10/83	15 a	9 ab	9 ab	14 a				11 a	5 b
2	6	4/24/84	19 a	9 bc		17 a		21 a		11 b	7 c
3	4	9/3/85	58 a	40 b	42 b		33 bc			43 b	25 c
4	5	3/15/87	73 ab	53 b		51 b	31 c	87 a	60 ab		
5	6	4/10/88	33 a		21 b	29 ab	15 c	30 a	26 ab		
6	5	5/5/90	39 a	22 b			16 bc		36 a	19 b	11 c

Data with different letters are significantly different ($P < 0.05$). ~~as analyzed by multiple analysis of variance and separated by the Duncan's multiple range test.~~

[1]Transformed according to Gregory, 1948 (6).

[2]When first fruits were 2-5 cm in diameter.

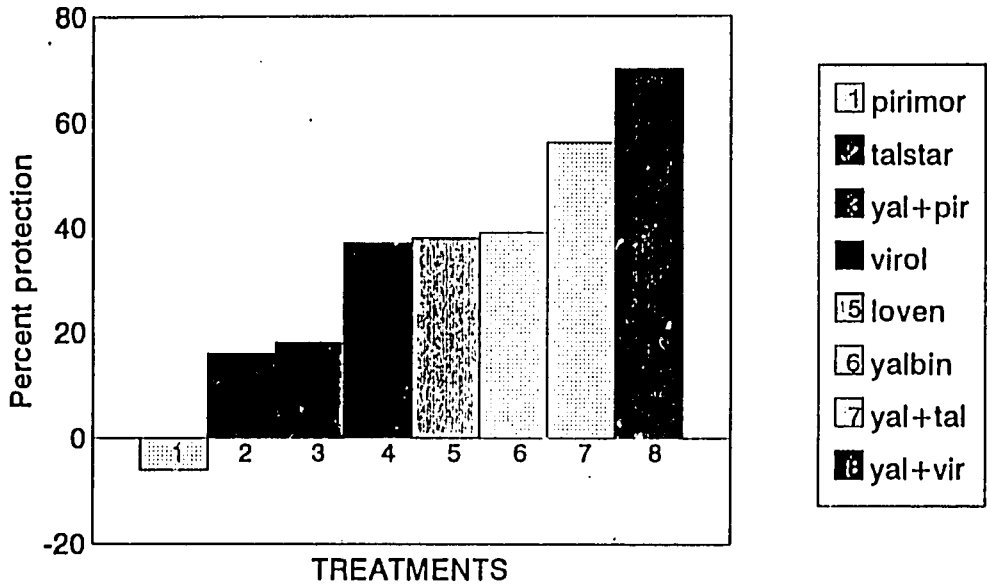

Figure 1. Protection efficiency[1] against viral infection[2] in pepper plants sprayed weekly with the different compounds.

Data are the mean of the total 6 experiments.

[1] Efficiency is expressed in percent protection

$$100\left(1-\frac{\%\ \text{infected in treatment}}{\%\ \text{infected in control}}\right)$$

[2] As found in the final virus incidence assessment (crop development stage of fruits 2-5 cm in diameter).

ANALISE DAS CAPTURAS DE AFÍDEOS EM ENSAIO DE PIMENTOS EM PEGÕES*

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Abstract

We analyse the aphid catches and virus incidence in pepper trial where whitewash sprays, mineral oil sprays and coarse white net were applied.

The 3802 trapped specimens belong to, at least, 71 species and five of them are indicated for the first time to Portugal.

When compared with control covers of white net reduced landing aphids and protected the peppers from potato virus Y (PVY) to 100%. The whitewash sprays were less efficient for the PVY than white net (77.3%), and had graetest aphid catches. The mineral oil sprays did not affect the aphid catches but provided a percent protection of 3 .2%.

Resumo

Analisam-se as capturas de afídeos e a percentgem de vírus em ensaio de pimentos onde foram aplicados branqueadores, óleo mineral e rede branca. Durante os 85 dias em estudo foram capturados 3802 afídeos pertencentes a, pelo menos, 71 espécies das quais cinco são pela primeira vez citadas para Portugal.

A rede conferiu 100% de protecção em relação ao vírus Y, sendo a modalidade que capturou significativamente menos afídeos. Os tratamentos semanais com branqueador reduziram a incidência de vírus mas aumentaram o número de afídeos (não significativo). O óleo mineral parece não ter interferido com as capturas mas conferiu 39.2% de protecção.

1. Introdução

Com o objectivo de reduzir a incidência de vírus transmissíveis por afídeos nas culturas, têm sido experimentados diferentes métodos, como a pulverização com óleos minerais (Bradley, Wade & Wood, 1962; Loebenstein, Alper & Levy, 1970), cobertura das culturas com rede de malha larga (Cohen, 1981; Marco, 1981) e mais recentemente a pulverização de plantas com branqueador (Marco, 1986). Também em Portugal foram já ensaiadas, na cultura da batateira, as técnicas da pulverização com óleo mineral e da cobertura com rede branca, sendo esta, no entanto, diferente da agora experimentada (Vieira, 1989).

No âmbito do projecto C7-056 "Control of Insect-transmitted viruses utilizing insect's response to color and contact stimuli" mantido com o Volcani Center através do US-Israel Cooperative Development Research, foi instalado um ensaio de pimentos onde foram aplicadas as técnicas acima referenciadas.

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2. Material e métodos

O ensaio foi instalado no Posto Experimental de Pegões, da Direcção Regional de Agricultura do Ribatejo e Oeste, utilizando a variedade de pimento Flórida Vr/2, e decorreu entre 14 de Maio e 17 de Setembro de 1989.

Instalaram-se 20 talhões dispostos em blocos casualizados de 4 modalidades e 5 repetições. Para cada uma das três linhas do talhão foram transplantadas 10 plantas desenvolvidas previamente em viveiro protegido de insectos. A distância entre plantas na linha foi de 40 cm, tendo a entre-linha 80 cm.

Aplicação das modalidades:

Branqueador - Tratamentos semanais com pulverização das plantas com uma suspensão de caulino a 5% nos primeiros nove tratamentos e a 10% nos restantes dez.

Óleo mineral - Tratamentos semanais com óleo de verão a 0,5%, nos primeiros nove tratamentos e os outros dez a 1%.

Rede - Sobre cada linha de pimentos foi colocada rede branca de malha larga (PEME/PEM 46 C 00 - Quimigal) sobre suportes de PVC, formando um tunel com cêrca de 70 cm de altura. A cobertura foi colocada imediatamente após a plantação, mantendo-se até final do ensaio.

Testemunha - Sem qualquer tratamento.

Populações de afídeos - Os afídeos alados foram capturados através de armadilhas amarelas de água colocadas no centro de cada talhão. Nos talhões com rede estas armadilhas ficaram colocadas sob a mesma, tendo sido instalada outra armadilha sobre a rede. As capturas eram levantadas semanalmente, e todos os afídeos foram identificados.

Vírus - Os vírus foram contabilizados através da análise visual de sintomas, tendo sido identificado apenas o Vírus Y da Batateira. A identificação do vírus foi realizada através da observação em microscópio electrónico e por inoculação em plantas indicadores herbáceas (C. Sequeira, comunicação pessoal).

Estatística - Os resultados foram analizados através do teste-t, utilizando no caso das capturas, os dados transformados pela expressão: $\sqrt{\text{nº afídeos}}$.

3. Resultados

Apesar do ensaio ter sido concluído em 14 de Setembro, os resultados que se apresentam dizem respeito apenas até ao dia 10 de Agosto, por quanto uma doença cuja etiologia não foi possível esclarecer, afectava àquela data 41% das plantas, pelo que os talhões com mais de 50% de plantas mortas foram abandonados.

Capturas de afídeos - Da análise das capturas de afídeos referentes aos 85 dias verifica-se que foram capturados 3802 afídeos distribuídos por, pelo menos, 71 espécies.

A lista de afídeos capturados bem como o quantitativo relativo a cada espécie é apresentada seguidamente:

Acyrthosiphon malvae	1
Acyrthosiphon pisum	107
Anoecia sp.	7
Aphis craccivora	175
Aphis fabae/solanella	161
Aphis gossypii	1
Aphis pomi	2
Aphis ranicis	3
Aphis sambuci	3
Aphis spiraecola	1169
Aphis sp.	331
Aphis verbasci	1
Aploneura lentisci	25
Baizongia pistaciae	1
Brachycaudus cardui	11
Brachycaudus helichrysi	1
Brachycaudus prunicola	31
Brachycaudus rumexicolens	134
Brachycaudus sp.	1
Brachycolus cucubali	2
Brevicoryne brassicae	14
Capitophorus elaeagni	5
Capitophorus hippophaes	17
Cavariella aegopodii	11
Cavariella theobaldi	3
Chaetosiphella sp.	1
Chondrilobius blattnyi	3
Dysaphis anicis	3
Dysaphis plantaginea	9
Dysaphis sp.	89
Eucarazzia elegans	3
Hayhurstia atriplicis	83
Hoplocallis pictus	1
Hyadaphis coriandri	1
Hyalopterus pruni	301
Hyperomyzus lactucae	40
Hyperomyzus sp.	2
Lipaphis erysimi	24
Macrosiphoniella abrotani	15
Macrosiphoniella tapuskae	15
Macrosiphum euphorbiae	98
Megoura viciae	17
Metopolophium dirhodum	8
Myzocallis boerneri	1
Myzocallis castanicola	1
Myzus cerasi	2
Myzus lythri	2
Myzus persicae	130
Nearctaphis bakeri	1
Ovatus insitus	2
Phorodon humuli	1
Phylloxera sp.	2
Pleotrichophorus filaginis	1
Protaphis terricola	274
Rhopalosiphum insertum	1
Rhopalosiphum maidis	10
Rhopalosiphum nymphaeae	31
Rhopalosiphum padi	23
Rhopalosiphum rufiabdominalis	186
Schizaphis graminum	7
Sitobion avenae	19
Sitobion fragariae	1
Smynthurodes betae	1
Tetraneura caerulescens	1
Tetraneura ulmi	5
Thecabius affinis	4
Thelaxes suberi	11
Therioaphis trifolii	28
Uroleucon aeneum	6
Uroleucon campanulae	15
Uroleucon chondrillae	9
Uroleucon jacea	4
Uroleucon picridis	4
Uroleucon sonchi	17
Uroleucon sp.	1
Wahlgreniella arbuti	1
Desfeitos	70
TOTAL	3802

A espécie mais capturada foi *A. spiraecola* representando 30,7% do total, seguida de *Aphis spp.* com 8,7% e *H. pruni* com 7,9%. As espécies *P. terricola, R. rufiabdominalis* e *A. craccivora* representam respectivamente 7,2% , 4,9% e 4,6% do total. As espécies consideradas vectoras do vírus Y - *A. fabae, M. euphorbiae* e *M. persicae* representam 4,2%, 3,4% e 2,6% respectivamente, correspondendo na globalidade a 10,2%.

Na figura 1 representam-se graficamente as médias diárias de capturas de afídeos e de *M. persicae* por armadilha e por modalidade.

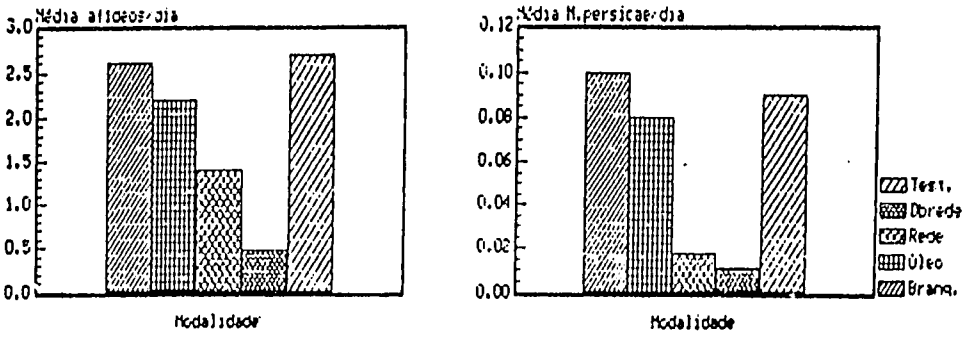

Figura 1 - Médias diárias de capturas de afídeos e de *M. persicae* por armadilha e por modalidade.

A análise da figura 1 mostra que as diferenças de capturas de afídeos e de *M. persicae* na modalidade branqueador são mínimas em relação à testemunha, não havendo diferenças significativas entre elas ($p \leq 0,05$). Embora a modalidade óleo tenha capturado menor número de afídeos e de *M. persicae* que a testemunha as diferenças também não foram significativas. Com as redes houve um nítido decréscimo das capturas (mesmo considerando as armadilhas fora da rede) diferença essa que é estatisticamente significativa ($p \leq 0,05$).

No dia 10 de Agosto foram contabilizadas as plantas com sintomas de vírus, tendo sido calculada a percentagem de protecção conferida por cada uma das modalidades a partir da fórmula utilizada por Marco (1986):

$$\% \text{ Protecção} = 100 \frac{\% \text{ infecção no tratamento} \times 100}{\% \text{ infecção na testemunha}}$$

Quadro 1 - Percentagem de vírus Y e de protecção

Modalidade	% vírus	% protecção
Branqueador	6,4	77,3
Óleo	17,0	39,7
Rede	0,0	100,0
Testemunha	28,2	

Em relação à produção não são apresentados elementos pois a morte prematura das plantas tornou impossível a análise das produções. Indica-se, no entanto, no quadro 2 o peso médio dos frutos colhidos na linha central de cada talhão.

Quadro 2 - Peso médio dos frutos da linha central

Modalidade	Nº plantas	Nº frutos	Peso médio
Branqueador	42	260	66,7
Óleo	40	319	63,2
Rede	43	255	52,8
Testemunha	42	274	50,3

Não foram encontradas diferenças significativas ($p < 0,05$) nos pesos médios dos frutos nas diferentes modalidades.

4. Discussão

As pulverizações semanais com branqueador não provocaram uma diminuição das capturas de afídeos, sendo mesmo a modalidade que capturou maior número destes insectos, embora se tenha verificado um decréscimo das capturas de *A. spiraecola* (menos 19%) tal como foi observado por Ben-Joseph & Fraenkel (1983) e Marco (1986). *P. terricola* parece ter sido atraído pelo branqueador (mais 37%). Apesar do maior número de capturas, incluindo as espécies vectoras do vírus se ter verificado nesta modalidade (123), ela conferiu um elevado grau de protecção, o que poderá estar relacionado com a possível interferência no processo de aquisição e inoculação do vírus.

O óleo de verão não parece ter exercido grande acção sobre os afídeos revelando no entanto um certo grau de protecção.

A cobertura com rede revelou-se muito eficaz quer em termos de repelência de afídeos quer em termos de protecção da cultura.

Entre as espécies de afídeos capturadas *Chodrillobium blattnyi*, *Macrosiphoniella tapuskae*, *Pleotrichophorus filaginis*, *Uroleucon aeneum* e *Uroleucon campanulae* são pela primeira vez citadas para Portugal.

Chondrillobium blattnyi vive sobre *Chondrilla juncea* e é conhecido da região euro-asiática.

Macrosiphoniella tapuskae é uma espécie holárctica, que vive em Compostas Tubulifloras principalmente Antemídeas. Em território português era já conhecida da Ilha de Porto Santo (Ilharco, 1973).

Pleotrichophorus filaginis vive sobre espécies dos géneros *Gnaphalium* e *Filago*, sendo conhecido da Europa ocidental. É novo para a Peninsula Ibérica.

Uroleucon aeneum, inicialmente considerada como uma subespécie de *U. jaceae*. É uma espécie europeia, cujos hospedeiros são Compostas do géneros *Carduus*, *Cirsium* e *Carthamus*.

Uroleucon campanulae vive em Campanuláceas dos géneros *Campanula* e *Jasione*. É uma espécie europeia.

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VIRUS TRANSMITIDOS POR AFIDEOS: MEIOS DE LUTA NA SUA PREVENÇAO

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ABSTRACT

In this study we tried different kinds of techniques to prevent the infection of seed-potato, pepper and tobacco crops, by aphid transmitted viruses, such as avoiding the peak flights of vectors, the use of mineral oils and whitewash sprays and net covers.

The results of aphid cathes and the incidence of virus infection are mentioned and the used control methods are discussed.

RESUMO

Com o efeito de prevenir a transmissão de vírus por afídeos às culturas de batata-semente, pimentos e tabaco, diferentes técnicas tais como a fuga aos vectores, a utilização de redes sobre as culturas, pulverizações com óleo mineral e pulverizações com branqueador, têm sido por nós ensaiadas.

Apresentam-se os resultados das capturas de afídeos e da incidência de viroses nestes ensaios e analisam-se os efeitos destes meios de luta.

INTRODUÇAO

Os vírus transmitidos por afídeos podem causar elevadas perdas nas culturas.

Na cultura da batateira verificam-se perdas de produção entre 50-70% quando 100% das plantas se encontram infectadas (Van der Zaag, 1982). A presença de vírus na cultura de batata-semente é particularmente importante, pois para valores superiores a 10% de tubérculos infectados é impedida a sua comercialização como semente.

No tabaco, a incidência de viroses pode provocar a perda total da planta (Evaristo, 1981).

No pimento, o vírus do mosaico do tabaco e o vírus do mosaico das cucurbitáceas, ambos transmitidos por afídeos, causam importantes prejuízos (Gardé & Gardé, 1971).

Atendendo a que, de modo geral, os pesticidas não resolvem a situação relativa aos vírus, podendo mesmo agravá-la (Gabriel, Szulc & Wislocka, 1982) e que o controlo

biológico dos afídeos também é difícil de ser conseguido, dada a baixa densidade populacional de vectores necessária para infectar os campos de cultura, outros meios de luta têm sido procurados. Entre eles destacamos a fuga aos vectores, o uso de redes sobre a cultura, pulverizações com branqueador e com óleo mineral, técnicas estas, experimentadas noutros países, com bons resultados.

Neste trabalho damos conta da nossa experiência com a aplicação destas técnicas, em batata, pimentos e tabaco.

O ensaio de batata foi realizado no Posto Experimental de Pegões, da Direcção Regional de Agricultura do Ribatejo e Oeste, e decorreu no ano de 1990, no período de 21 de Março a 19 de Junho.

Ensaios de pimentos realizaram-se nos anos de 1989 e 1990, decorrendo de 17 de Maio a 14 de Setembro e de 6 de Junho a 29 de Agosto, respectivamente. Estes ensaios foram realizados no Posto Experimental de Pegões.

O ensaio de tabaco, realizado em 1989 na Quinta dos Lamaçais, Braga, contou com a colaboração da Direcção Regional de Agricultura de Entre-Douro e Minho, e decorreu de 3 de Julho a 19 de Setembro.

Este trabalho foi possível graças ao projecto de colaboração mantido com o Volcani Center, Israel, através da US-Israel Cooperative Development Research e financiado pela USAID.

MATERIAL E METODOS

Os ensaios constaram de talhões de blocos casualizados com a aplicação de diferentes modalidades.

O uso de branqueador (suspensão de caulino a 10%) foi experimentado nas três culturas, sendo realizada uma pulverização semanal.

A cobertura da cultura com rede de malha larga (PEME/PEM 46 C 00) foi utilizada em batata e pimentos.

A pulverização das plantas com óleo mineral foi experimentada em pimentos e tabaco, com uma aplicação semanal, na concentração de 1%.

No centro de cada talhão foi colocada uma armadilha amarela de água para captura de afídeos, no sentido de se tentar relacionar as capturas com a incidência de víroses. No caso da batateira, para para além deste aspecto , as armadilhas forneciam indicações sobre a necessidade de proceder à destruição precoce da rama.

As armadilhas montadas no campo de batata funcionaram durante 63 dias.

O período de funcionamento das armadilhas nos ensaios de pimentos foi de 85 e 84 dias em 1989 e 1990 respectivamente.

Na cultura do tabaco as armadilhas estiveram montadas durante 78 dias.

Em todos os ensaios as capturas das armadilhas eram recolhidas semanalmente e de imediato analisadas.

RESULTADOS

BATATA

Os resultados obtidos em termos de capturas e de produções por hectare constam nos Quadros I e II, respectivamente.

QUADRO I
CAPTURAS

Modalidade	Afideos M.d.a	*Myzus persicae* M.d.a.
Branqueador	4,6	0,11
Rede	1,8	0,01
Testemunha	5,7	0,09

M.d.a. - Média diária por armadilha

A modalidade com rede capturou significativamente menos afideos e *M. persicae* que a testemunha ($p \leq 0,05$).

QUADRO II
PRODUÇAO

Modalidade	Total(Kg/ha)	Semente(Kg/ha)
Branqueador	16 182	13 946
Rede	19 010	16 083
Testemunha	17 703	15 123

Feita a análise estatística não foram encontradas diferenças significativas entre modalidades quer na produção total quer na de semente ($p \leq 0,05$).

Incidência de Viroses

A incidência de viroses foi avaliada por análise visual de sintomas no campo e em plantas desenvolvidas em estufa (30 tubérculos/talhão).

Na inspecção realizada no campo antes da colheita não foi detectada a presença de vírus em qualquer das modalidades. A análise visual das plantas desenvolvidas em

estufa conduziu aos seguintes resultados: Branqueador 0%, Rede 0% e Testemunha 1,8%.

PIMENTOS

Os resultados das capturas nos ensaios de pimentos, realizados em dois anos consecutivos constam no Quadro III.

QUADRO III
CAPTURAS

Modalidade	Afídeos M.d.a.		*M. persicae* M.d.a.	
	1989	1990	1989	1990
Branqueador	2,6	5,2	0,1	0,18
Oleo	2,2	6,5	0.08	0.2
Rede	1,4	2,3	0.01	0.01
Testemunha	2,7	6,5	0,09	0,13

As redes provocaram um nítido decréscimo das capturas de afídeos e de *M. persicae*, diferença essa que é significativa ($p \leq 0,05$).

Não se apresentam elementos sobre a produção, pois a morte prematura de muitas plantas devido à presença do fungo *Sclerotium rolfssi* tornou impossível a análise das produções. Refere-se, no entanto, o peso médio dos frutos da linha central (Quadro IV).

QUADRO IV
PESO MEDIO DOS FRUTOS DA LINHA CENTRAL
(g)

Modalidade	1889	1990
Branqueador	66,7	62,8
Oleo	63,2	56,6
Rede	52,8	68,8
Testemunha	50,3	59,7

Não foram encontradas diferenças significativas entre modalidades.

Incidência de Viroses

A incidência de viroses foi avaliada pela análise visual de sintomas, no campo, cujos resultados constam no Quadro V.

QUADRO V
PERCENTAGEM DE VIRUS

Modalidade	1989	1990
Branqueador	6,4%	1,5%
Oleo	17,0%	0,0%
Rede	0,0%	0,0%
Testemunha	26,2%	9,5%*

* As plantas apresentavam sintomas muito ténues, tendo apenas uma planta originado sintomas em plantas indicadoras.

TABACO

Os resultados referentes a 78 dias de capturas de afídeos e de *M. persicae* constam no Quadro VI, representando as capturas de *M. persicae* 60,3% do total de afídeos capturados.

QUADRO VI
CAPTURAS

Modalidade	Afídeos m.d.a	*M. persicae* m.d.a.
Branqueador	46,5	29,2
Oleo	30,4	18,0
Testemunha	33,9	19,5

A modalidade com branqueador capturou significativamente mais afídeos e *M. persicae*.

A produção do tabaco foi avaliada em verde e após a secagem (Quadro VII).

QUADRO VII
PRODUÇAO (Kg/ha)

Modalidade	Verde	Seco
Branqueador	22320	5072
Oleo	23208	6262
Testemunha	23929	6916

Em termos de produção não foram encontradas diferenças significativas entre modalidades.

A incidência de viroses foi avaliada pela análise visual de sintomas, efectuada antes da colheita, obtendo-se os seguintes resultados: Branqueador 88,6%, Oleo 71,8% e Testemunha 86,6%.

DISCUSSAO

Das técnicas utilizadas nos ensaios ressalta a redução significativa do número de capturas de afídeos e de *M. persicae* no caso da utilização da rede, tanto em batata como em pimentos. Esta redução do número de vectores traduziu-se numa protecção total da cultura.

Como efeito secundário da rede na cultura da batata verificou-se um maior desenvolvimento vegetativo, o que se traduziu num aumento (embora não significativo) da produção.

No caso dos ensaios de pimentos verifica-se que não houve uma diferença acentuada nas capturas de *M. persicae*, nos dois anos consecutivos, nas restantes modalidades, registando-se, no entanto, em 1989, percentagens de virus muito superiores. Estas diferenças poderão estar relacionadas com uma maior presença no campo de fontes de inóculo, ou com a presença de uma estirpe de vírus mais infecciosa, pois nesse ano, as plantas apresentavam sintomas mais aparentes.

As pulverizações com óleo mineral revelaram reduzida eficácia em qualquer das culturas ensaiadas.

O branqueador, ao contrário de que se esperava, parece ter atraido o *M. persicae*, tendo induzido a um aumento das capturas em todas as culturas. Estas foram significativamente mais elevadas na cultura do tabaco, o que se traduziu igualmente numa maior percentagem de virus nas plantas dessa modalidade. Contudo, as diferenças relativamente àsoutas duas modalidades são muito reduzidas, pois todo o campo apresentou elevada percentagem de incidência de viroses já que a pressão de infecção (entendida segundo De Bokx, 1979) foi muito elevada, ao longo do ciclo vegetato da cultura.

Nesta cultura há ainda a registar o efeito prejudicial do depósito de caulino sobre as folhas, dificultando a sua secagem e impedindo o seu aproveitamento industrial.

Em resumo podemos concluir que nas nossas condições de ensaio, o uso de branqueador se revelou contraproducente, e que o uso de pulverizações com óleo mineral também não parece resolver os problemas das transmissões de vírus nas culturas. Ao contrário, a rede ao actuar como repelente de afídeos parece ser eficaz, conferindo elevada protecção às culturas. Contudo, o seu uso parece-nos ter grandes limitações devido aos seus elevados custos. Assim, antevemos a sua aplicação, apenas quando se pretenda produzir plantas isentas de vírus de culturas altamente rentáveis

Face a estes condicionalismos, o método mais eficaz e económico de produzir plantas isentas de vírus será a procura à fuga aos vectores e às fontes de inóculo, pelo que o conhecimento das curvas de voo dos afídeos vectores e dos hospedeiros alternativos destes, é particularmente importante.

Para além dos conhecimentos adquiridos com estes ensaios, eles vieram mais uma vez confirmar a necessidade de se proceder a uma experimentação prévia de técnicas usadas com bons resultados noutras regiões do globo, antes de serem adoptadas no nosso País.

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