Ultraviolet-Absorbing Screens ("Bionet") Serve As Optical Barriers To Protect Crops From Virus And Insect Pests

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Abstract

Plastic screens with UV – absorbency in the UV-A and UV-B range ("BioNet") were compared with conventional nets of the same mesh size for their protective capacity against vegetable insect pests and spread of virus. Conventional and "BioNet" screens with densities of 16 and 30-mesh were not effective in preventing the penetration of the silver leaf white fly *Bemisia argentifolii* Bellows & Perring and the cotton aphid *Aphis gossypii* Glover into walk-in tunnels covered with these nets. 50-mesh "BioNet" significantly reduced the penetration of white flies into tunnels as well as the spread of tomato yellow leaf curl virus (TYLCV) compare to convention 50 mesh. Fifty days after planting, 30% disease incidence was recorded in unsprayed tomatoes grown under 50–mesh "Bionet" screens, compared with 80% incidence in tunnels covered with conventional 50-mesh net. Fifty - mesh "BioNet" screens were significantly more effective than the conventional screens of the same mesh size in protecting tomato against leafminers (*Liriomyza trifolii* Burgess) and red mites (*Tetranychus telarius* Linnaeus) as well as in protecting cucumbers against aphids (*A. gossypii*). None of the tested "BioNet" screens was superior to the conventional screens against the western flower thrips, *Frankliniella occidentalis* Pergande. The size of thrips population under the different screens was similar and unaffected by either the mechanical or optical properties of the net.

Introduction

During the last several years, we have been using insect-proof nets in different agricultural systems as a strategy of pest control. Good pest control has been obtained in vegetables (specifically in tomato), herbs and flower greenhouses, and in fruit orchards (dates, figs, pomegranate apple, mango, peach and grapes). Results from several experiments in all these crops, and from commercial agro-ecosystem that already established the use of nets as a standard agronomic practice (e.g. tomato), show that the main complex of insect pests, and insect vectors, attacking these crops is significantly reduced, or eliminated.

The use of 50-mesh screens is an integral part of the routine IPM procedures maintained in the greenhouse industry of Israel as well as in other countries around the Mediterranean Basin. The use of such screens as physical barriers was imposed by the severe outbreaks of the silver leaf whitefly, *Bemisia argentifolii* Bellows and Perring and the tomato yellow leaf curl virus (TYLCV) disease which is vectored by this insect (Ausher 1997; Berlinger et al. 1991). Since the last few years it has been impossible to grow outdoor tomato crops in Israel, due to the marked increase in the whitefly population and the lack of efficient insecticides to control the pest (Horowitz et al. 1994). The high infection rates with TYLCV normally result in total loss of yield in tomatoes, lisianthus (Cohen et al. 1995) and beans which are sensitive hosts of the virus (Cohen and Antignus 1994).

Recently we have found that vegetable crops are protected from insect pests and virus diseases when grown in 'walk-in' tunnels covered with UV-absorbing polyethylene films. These covers act as filters eliminating the UV part of the light spectrum between 280 and 380 nm. This filtration effect led to a significant reduction in the infestation of crops grown under these covers and susceptible to a wide range of insect pests including aphids, white flies, thrips and leafminers. It was also found that tomatoes and cucumbers grown under these conditions were well protected against infection by the whitefly-borne viruses TYLCV and cucumber yellowing stunting disorder virus (CYSDV), respectively (Antignus et al. 1996 a,b). It is hypothesized that elimination of parts of the UV range of the light spectrum interferes with the 'UV vision' of insects, thus affecting their ability to orient themselves into the crop (Antignus et al. 1996 b). The goal of this study was to improve the performance of insect-proof nets by developing a new product, which combines the mechanical properties of the conventional nets with new optical properties, thus further amplifying their blocking capacity.

Materials and Methods

Nets tested: The nets were produced by Klayman Meteor Ltd., Petah-Tikva, Israel. They were of the following types: 50-mesh 'Anti-virus' net; 30-mesh 'Anti-insect' net; and 16-mesh 'Defense net'. Each of these types was produced in the conventional version and in an 'optical' version ('BioNet'). The 'BioNet' hole size is identical to that of the conventional net but the net has the ability to filter out the UV-A and UV-B range of sunlight.

Effect of nets on infestation with the whitefly *B. argentifolii* and spread of tomato yellow leaf curl virus (TYLCV) disease: Field experiments were conducted out in the Habshor region in southern Israel. Plants were grown in a complex of 36 'walk-in' tunnels (6 X 6 X2.7 m) that were covered with the tested nets. The front and rear ends of each tunnel were covered with the same type of net that served to cover the main body of the construction. Tunnels were spaced 1.5 m apart and the soil between tunnels and around the experimental site was kept bare. The protection effect of the nets was compared in a randomized complete block design with a total of three blocks, each consisting of 12 tunnels. Each block included six replicas of each of the compared screens (conventional and 'BioNet' screens) with the same hole size in a pair design.

Seventy TYLCV-susceptible tomato plants 'Hazera 144' (Cohen and Antignus 1994) were transplanted into each of the tunnels on September 19th 1996. Plants were maintained according to routine commercial procedures, except that insecticides were not applied during the experiment. The population size of *B. argentifolii,* was estimated by means of two yellow sticky traps (14 X 19 cm) positioned horizontally in each tunnel. The numbers trapped were recorded at intervals of 7-10 days, starting immediately after planting. The increase of TYLCV disease incidence in tomato plants was recorded visually. Early infection of plants by TYLCV always results in severe stunting and degeneration in comparison with the effects of late infection (Cohen and Antignus 1994). To demonstrate this effect, plants were divided into three height categories: 0-70 cm, 70-120 cm, and >120 cm.

Effect of nets on infestation of tomato crops with mites and leafminers: The damage by leafminers (*Liriomyza trifolii* Burgess) was estimated on 5 Dec. 1997 shortly before the end of the experiment. The sampling procedure included a random collection of five leaves from the lower part of six plants in each of the tunnels. The infestation level with red mites (*Tetranychus telarius*) and rust mites (*Vasates lycopersici* Massee) was assessed by random sampling of ten leaves in each tunnel. The number of mites was counted in an area of 4 CM 2 on the undersides of the sampled leaves.

Effect of screen type on population densities of aphids: Cucumbers cv. 'Hassan' were grown in the tunnel complex in the experimental design described previously. Cucumber 'speedlings' were planted on 29 March 1997. The crop was maintained according to routine commercial procedures, except that plants were not sprayed with insecticides. The population size of the cotton aphid, *Aphis gossypii* Glover, was monitored by random sampling of ten leaves from each tunnel.

Results

Evaluation of the protective effects of 'BioNet' and conventional screens on the infestation of tomato with B. tabaci and spread of TYLCV disease:

'BioNet' 50 mesh screens gave significantly better protection, resulting in improved inhabitation of whitefly penetration and a drastic reduction of infection by TYLCV (Fig. 1,2). Only 25% of plants grown under 'BioNet' screens were found infected and approximately 90% of the plants reached normal height (Fig 3). While considerable number of white flies were trapped under conventional 50 mesh nets and infection rates by TYLCV in the conventional treatment were as high as 80%, 50 days after planting.

Protection of tomato by 50-mesh 'BioNet' screens reduces infestation with mites and leafminers:

The 50-mesh 'BioNet' screens drastically reduced the infestation of tomato with red spider mites (*T. telarius*). The average number of mites found on leaves under the BioNet screens was ten times less than under the conventional nets (Fig. 4). Similar populations of the rust mite (*V. lycopersici*) were found under both types of net.

The number of leaves infested with the greenhouse leafminer was eight times greater under the conventional 50-mesh screens than under the 'BioNet' screens (Fig. 5).

Effect of screens on population densities of thrips and aphids in cucumber crops:

'BioNet' screens of 16 and 30 mesh were more effective than the conventional nets of the same mesh size, in protecting against aphids unpublished data. Significantly numbers of aphids were found under the conventional 50-mesh screens despite the relatively large size of these insects (Fig. 6). However, 50-mesh "BioNe"' screens drastically reduced the infestation with aphids (*A. gossypii*) and were significantly superior to the conventional 50-mesh screens in this respect. This result is observed by the high percentage of devastated plants caused by aphids under conventional nets compared with zero devastated plants under 'BioNet' screens (Fig. 7). None of the tested "BioNet" screens was found superior to conventional screens in protecting cucumbers against western flower thrips (data not shown).

Discussion

Insect-proof screens are considered one of the major elements of IPM in Israel, aimed at protecting tomato from infection by TYLCV and at reducing chemical pest control on covered crops: vegetables, flowers and fresh herbs (Ausher 1997; Berlinger et al. 1991). The blocking effect of these nets stems from the density of their texture, which interferes with the penetration capacity of insects. However, insect-proof screens of 50-mesh density (0.26-mm hole size) that are used routinely in the Israeli greenhouse industry are penetrated by small insects like the western flower thrips. Moreover, these screens cannot seal the greenhouse hermetically even from the infiltration of larger insects such as whiteflies, leafminers and aphids (Figs. 1, 5, 6). To overcome these limitations it was suggested that net with a double insect-exclusion mechanism, based on both their physical and optical properties, could serve as barriers with an improved blocking activity. Indeed our results indicate that 50-mesh screens with absorbency properties in the UV-A and UV-B range ('BioNet' screens) have an improved blocking effect against a wide range of insects, similarly to the effects reported for UV-absorbing polyethylene films (Antignus et al. 1996). The 'BioNet' were significantly better than the conventional 50-mesh screens in protecting tomato from infestation with *B. tabaci* and the spread of TYLCV (Figs 1,2,3), red spider mites and leafminers (Figs. 4,5); and in protecting cucumbers against aphids (Figs. 6,7). Our earlier studies indicated a positive correlation between the level of UV filtration and the level of protection against insects. It was also proposed that insects differ in their sensitivity to the elimination of UV from the light spectrum (Antignus et al. 1996 a,b). It is suggested, therefore, that the UV filtration by the 50-mesh 'BioNet' screens is at a level which is sufficient to interfere with the penetration of whiteflies, aphids, red spider mites and leafminers. The density of a given net is a major determinant of its ability to eliminate UV from the light spectrum (not shown). The significant improvement in the blocking effect of 'BioNet' screens with 50-mesh density against a relatively wide range of insects reflects their capacity to filter effectively the UV-irradiation from the light spectrum despite the penetration of unfiltered light through the net holes data (not shown). However, none of the 'BioNet' screens of 16- and 30-mesh densities was able to reduce the transmission of UV light below the putative critical level which is required for interference with the 'vision behavior' of insects (not shown). The protection mechanism of these nets remained a mechanical one and was not sufficient to provide practical protection to the crop. One of the disadvantages of using dense insect-proof screens in greenhouses in hot climatic regions is their contribution to reduction of ventilation and to elevation of temperatures in the structures. Small-mesh size screens can improve the greenhouse climate, but our results indicate their ineffectiveness in protecting the crop from insect pests. Recently we have shown that UV-absorbing plastic films provide effective protection to crops against insect pests. Thus, it is suggested that greenhouses covered with UV-absorbing films on their roofs can act as effective UV filters which can compensate for large-size holes of low mesh 'BioNet' screens which have a limited capacity to filter out the UV range. Combinations of this type may provide an improved climatic environment for the plants and concomitantly protect them from invasion of insect pests and virus diseases. Based on the results described in this paper it seems that “BioNet” 50-mesh screens can act as improved barriers for protection of crops against a wide range of insect pests and virus diseases, which the pests vector. This type of net may serve as a major element of IPM to reduce the use of chemical control in covered crops.

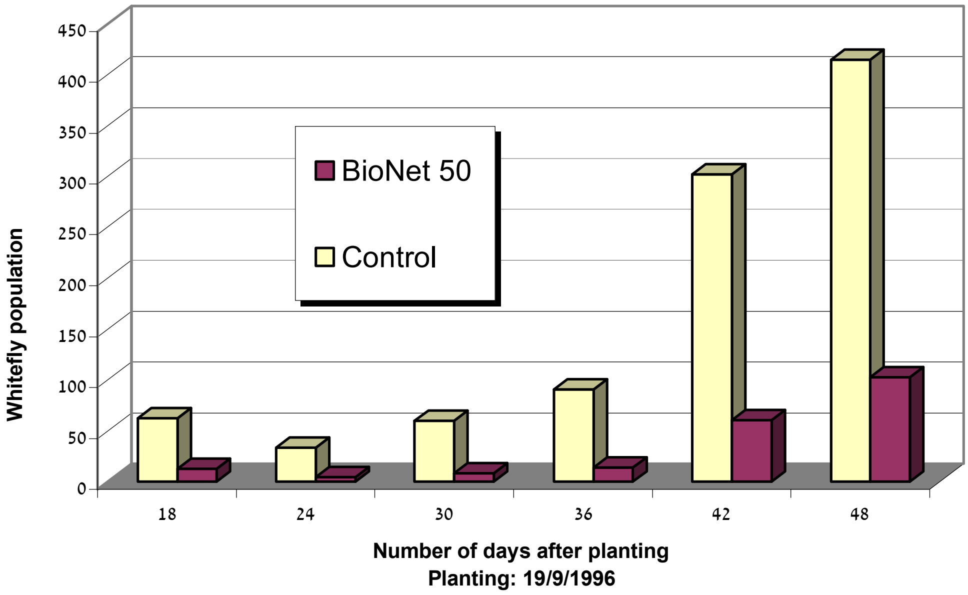

Figure 1 - Trapping of *Bemisia argentifolii* on yellow sticky traps in 'walk in' tunnels covered with conventional and 'BioNet' screens of 50 mesh size.

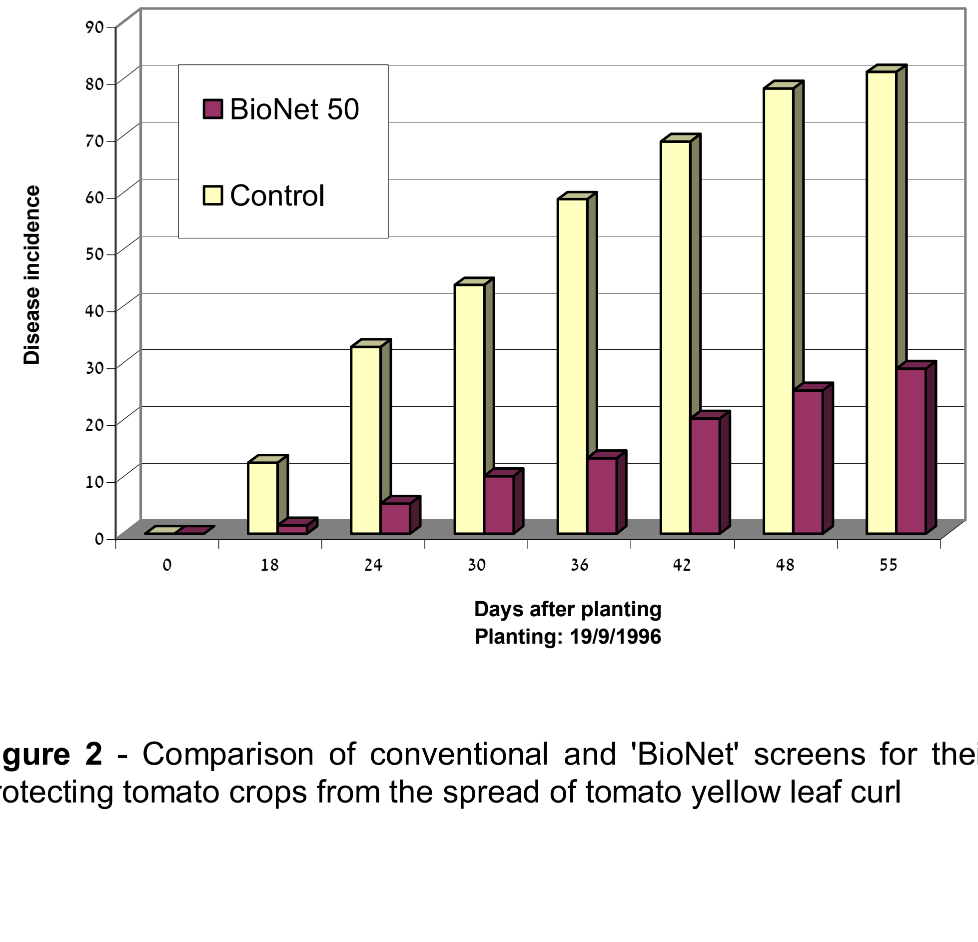

Figure 2 - Comparison of conventional and 'BioNet' screens for their effectiveness in protecting tomato crops from the spread of tomato yellow leaf curl

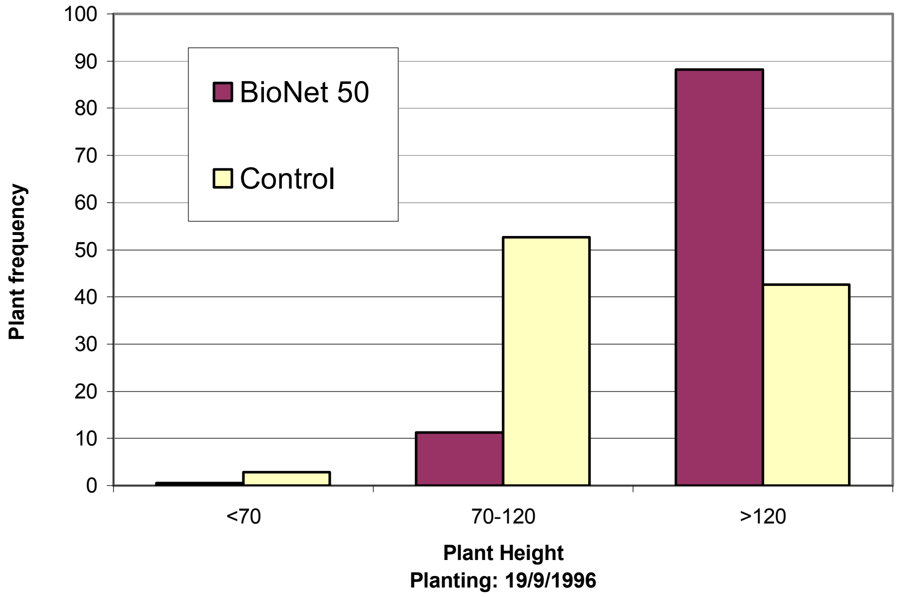

Figure 3 – Tomato yellow leaf curl virus (TYLCV) disease severity in tomato crops grown under conventional and BioNet screens of 50 mesh size.

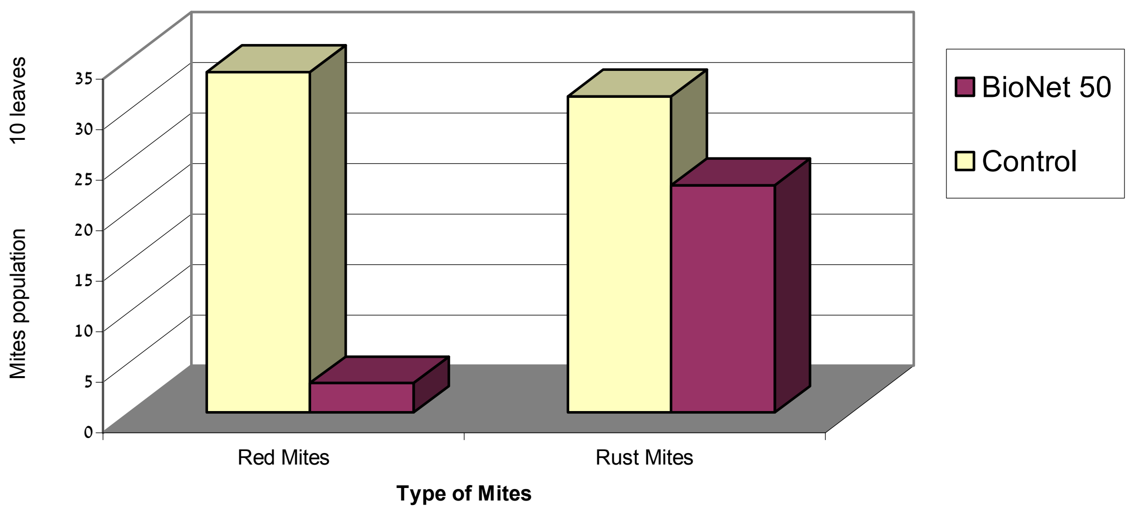

Figure 4 - Comparison of conventional and 'BioNet' screens for their effectiveness in protecting tomato crops from infestation with red mites (*Tetranychus telarius*) and rust mites (*V. lycopersici*)

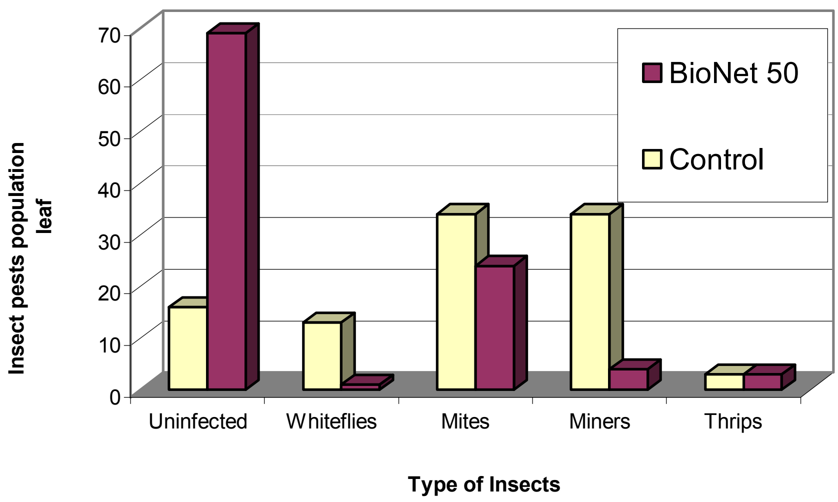

Figure 5 – Comparison of 'BioNet' 50 mesh and conventional 50 mesh net of protection capability against tomatoes insect pests.

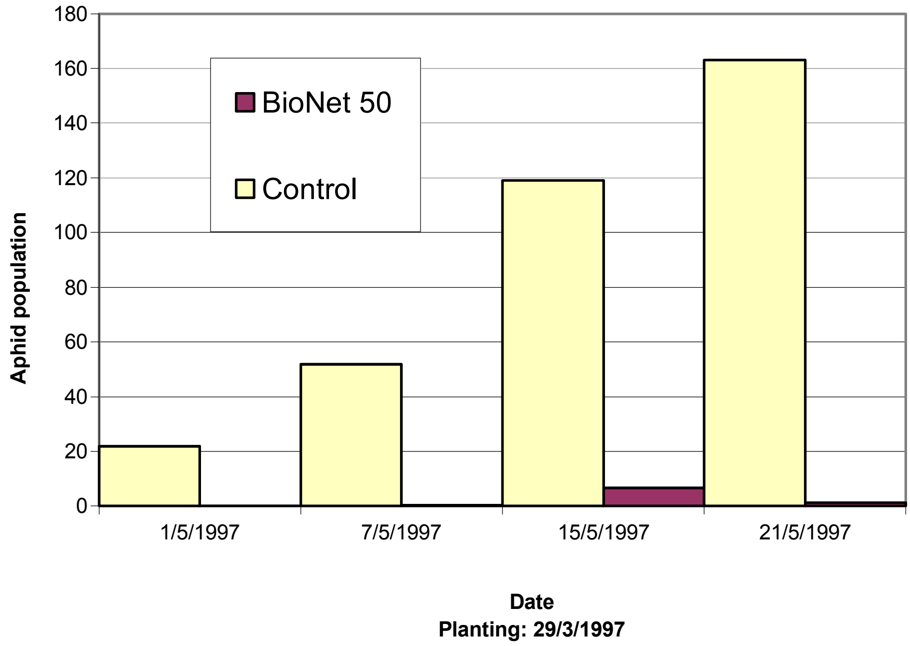

Figure 6 - Trapping of Aphids on yellow sticky traps in 'walk in' tunnels covered with conventional and 'BioNet' screens of 50 mesh size.

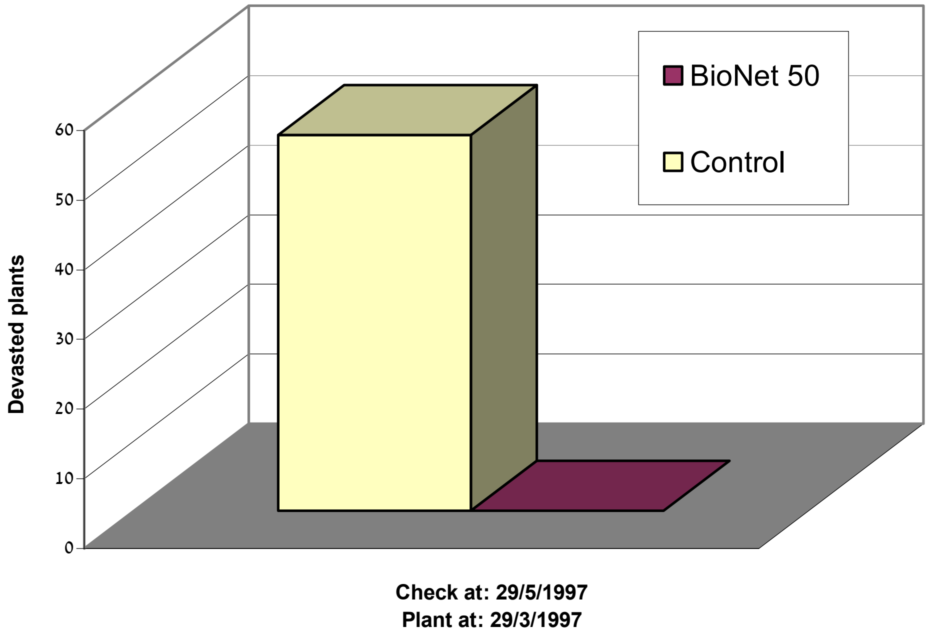

Figure 7– Devastated cucumber plants in 'walk in' tunnels covered with conventional and 'BioNet' screens of 50 mesh size.

Acknowledgments

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