CHAPTER FOUR - EFFICACY OF STYLET-OIL® IN SUPPRESSING THE OF SPREAD OF TEV INFECTIONS IN A 'SCOTCH BONNET' PEPPER (*CAPSICUM CHINENSIS* JACQUIN) FIELD IN JAMAICA

Abstract

Stylet-Oil® was effective in reducing incidence of *tobacco etch virus* (TEV) (Genus: Potyvirus, Family: Potyviridae) in 'Scotch Bonnet' pepper (*Capsicum chinense* Jacquin) plots by about 24% and delaying its spread by 7 days. A backpack mist blower (low volume) was used to apply JMS Stylet-Oil® at pressures of about 1000 kPa to pepper plants weekly, from transplant until the end of the crop. Seedlings were kept virus free prior to transplanting by protecting them under aphid exclusion cages. TEV incidence was based on the appearance of symptoms in naturally infected pepper plants, and confirmed serologically. The first symptoms of TEV appeared 56 days after transplanting (DAT) and were correlated with aphid flight activities. TEV symptom appearance was most closely associated with the presence of *Aphis gossypii* Glover, a known vector of TEV, and two other aphids of unknown TEV vector status, *A. amaranthi* Holman and *Uroleucon ambrosiae* (Thomas). Stylet-Oil® did not affect the growth of healthy pepper plants but the total number of fruit produced by plants of the Stylet-Oil® treatment was less than plants of the two control treatments. Stylet-Oil® treated plants in the absence of TEV were also less affected by the broad mite, *Polyphagotarsonemus latus* (Banks) and so produced a greater proportion of marketable fruit than untreated plants.

KEYWORDS: aphid abundance, TEV-vector, Potyvirus, disease incidence, new records, pest management.

Introduction

Reports in Jamaica of a mosaic syndrome in hot peppers, *Capsicum chinense* (Jacquin), have been associated with increased acreage of the crop due to commercial production over the last 30 years (Ministry of Agriculture, Jamaica, unpublished report). McGlashan *et al*. (1993) and Martin[1] *et al.* (1998) reported that *tobacco etch* (TEV) (Genus: *Potyvirus*, Family: Potyviridae) and *potato virus Y* (PVY) (Genus: *Potyvirus*, Family: Potyviridae) are the main mosaic-causing viruses found on hot pepper farms surveyed in Jamaica. These two viruses were found in samples taken from 80-100 % of hot pepper farms (McGlashan *et al*. 1993, Martin *et al.* 1998). After 6 months of age, most hot pepper crops are normally entirely infected with viruses (McGlashan *et al*. 1993) and production ceases to be profitable. Without virus, the harvestable crop can be picked over several years. TEV has been encountered more frequently than PVY in hot pepper crops in Jamaica and produces more severe symptoms in hot pepper than does PVY (McGlashan 1993, Myers 1996).

TEV is carried on the maxillary stylets and the foregut of their aphid vectors (Pirone and Blanc 1996, Bos 1999) and are transmitted in a non-persistent manner (Sylvester 1969, Nault 1997) as they probe prospective host plants. Five known TEV vectors, *Aphis gossypii* Glover, *A. spiraecola* Patch*, Myzus persicae* (Sulzer) (Laird and Dickson 1963), *A. craccivora* (Herold 1970), and *Lipaphis erysimi* Hille Ris Lambers (Eckel 1990, Eckel and Lampert 1993), have been trapped on hot pepper farms in Jamaica (Chapter 2). Natural infections of TEV in hot pepper have been associated with flight activity of *A. gossypii*, and to a lesser extent, *A. spiraecola,* and *A. craccivora,* on a hot pepper farm in Jamaica (Chapter 3).

TEV can reduce yield of *C. chinense* var. 'Scotch Bonnet' by up to 50% (Myers *et al*. 1998). Scotch Bonnet is the hot pepper variety grown by about 80% of Jamaican farmers yet 65% of farmers surveyed did not consider viruses a serious problem[1]. Farmers have no effective

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[1] Martin, R., L. Myers, S. McDonald, and F. Ravlin. 1998. Incidence of pests of hot pepper in various agroecological zones in the parishes of St. Mary, St. Catherine and St. Elizabeth, IPM CRSP Annual report

management program for viruses infecting peppers in the field. Moreover, pepper seedlings are sometimes infected before they are transplanted to the field (S.A.M., personal observation).

Infections of nonpersistently transmitted aphid-borne viruses, like TEV, have been delayed and/or reduced by protecting seedlings and transplants with aphid excluding covers and regular application of oil sprays. In West Java Indonesia, Vos and Nurtika (1995) showed that hot pepper seedlings (*Capsicum* spp.) maintained under aphid exclusion screens for 1.5 months from sowing until transplanting were protected from the aphid-transmitted viruses. Such plants matured faster and produced more fruit than plants from unprotected nurseries.

Oils are known to suppress acquisition and inoculation of nonpersistently transmitted aphid-borne viruses (Loebenstein *et al*. 1970, Zitter and Simons 1980) by preventing attachment of the virus to the stylets (Powell 1992, Wang and Pirone 1996). Use of many early formulations of oils for virus management was limited due to phytotoxicity but a new, less toxic formulation, JMS Stylet-Oil®, was developed later (Simons and Zitter 1980, Zitter and Simons 1980, Simons 1982). Weekly applications of 0.75% emulsions of JMS Stylet-Oil® have been shown to effectively control several aphid-transmitted viruses in peppers, tomatoes and squash (Simons and Zitter 1980, Zitter and Simons 1980, Simons 1982).

For JMS Stylet-Oil® to be most effective, it should be applied with a high volume air blast sprayer at a pressures of 2800 kPa (Simons and Zitter 1980, Zitter and Simons 1980, Simons 1982). However, Thomas (1984) was successful in controlling aphid transmitted viruses in cucurbits by applying JMS Stylet-Oil® with a hand pumped CP-3 knapsack sprayer, equipped with high volume cone jets which delivered the oil emulsion at a pressure of only 200 kPa. Loebenstein *et al*. (1970) used a motorized knapsack sprayer to deliver a commercial oil (Blancol® (Pazchem Ltd., Tel Aviv)) emulsion at low volume with a single nozzle to pepper (*C. annuum*). Sprays were very effective in reducing the spread of PVY and *cucumber mosaic* cucumovirus to peppers at oil concentrations of 1-2% (v:v) in nurseries and 2.5% (v:v) in the field (Loebenstein *et al*. 1970).

Successful application of Stylet-Oil[®] with a motorized knapsack mist blower, such as the Solo[®] 423 model, which produces a pressure of about 1000 kPa, would be ideal for most Jamaican pepper/vegetable farmers. The average size of a pepper field in Jamaica is less than 1 ha (McGlashan 1993, Martin *et al* 1998) and often located on hillsides (McGlashan 1993), which would not accommodate tractor-mounted, boom sprayers. It would also be convenient because many farmers already own such a sprayer or can afford to purchase one. Attempts to control viruses of peppers with JMS Stylet-Oil[®] in Jamaica in the 1980's failed because application techniques were poor (McGlashan 1993). There is no report of phytotoxic effects of Stylet-Oil[®] on Scotch Bonnet peppers.

The objectives of this study was to: 1) assess the effects of JMS Stylet-Oil[®] on growth and yield of Scotch Bonnet pepper, and 2) reduce and/or delay the spread of TEV in a Scotch Bonnet pepper field by protecting seedlings with aphid exclusion cages and later protecting plants by using JMS Stylet-Oil[®], applied with the motorized Solo[®] 423 knapsack mist blower.

Materials and Methods

Seedling preparation

The experiment was conducted on a private farm in Bushy Park, St Catherine parish, Jamaica, West Indies, from 2 September 1998 and through 17 March 1999 (196 days). Scotch Bonnet pepper seeds were sown in sterile potting mixture (Easi-Grow, Bulrush Peat Co. Ltd., Co Londonderry, UK). Two thirds of the seedlings were grown inside screen cages (described in Chapter 3), whereas the remainder of the seedlings was exposed. Seedlings were transplanted in the field six weeks after sowing on 2 September 1998. Before transplanting, tissue blots were taken from a sample of seedlings to confirm the absence of TEV. Blots were prepared and processed as described in Chapter Three.

The field site

The on farm field site was 0.1 ha (16 x 61 m) and comprised of 13 rows, about 1.2 m apart with pepper plants spaced at 0.8 m. Seedling holes were hand dug, filled with a mixture of soil, dried cow manure (227 cm^3 per hole) and N:P:K fertilizer (11:22:22 at 14 cm^3 per hole). Additional applications of fertilizer (28 cm^3 of N:P:K, 11:22:22 per plant) were made 7 and 25 weeks after transplanting.   All plots were treated with dimethoate (Dimethoate®, Agriculture Chemical Plants, Jamaica W.I.   Rate 1-1.5 litre/hectare[2]) and diafenthiuron (Pegasus® 500, Novartis, Cartagena, Colombia, S.A.   Rate = 0.125-0.300 litre/hectare) to suppress broad mite and aphid populations. Dimethoate and diafenthiuron are recommended for use with Stylet-Oil® (Simons *et al.* 1995).

Experimental design

Three treatments, each comprised of 100 plants per experimental unit, replicated three times, were arranged systematically due to restricted land space. This experiment was treated as having a completely randomized design on the suggestion of K. Hinkelmann[3], who also said that the design, though forced to fit the limited on farm land space, is one of the possible outcomes of a completely randomized design.   Treatment one comprised of plants that were covered with screen cages as seedlings and sprayed weekly with JMS Stylet-Oil® (JMS Flower Farms, Inc., Vero Beach, FL) after transplanting. In treatment two, plants were covered with screen cages as seedlings but were not treated with Stylet-Oil® after transplanting. In treatment three, plants were neither covered nor treated with Stylet-Oil® after transplanting in September 1998 through April 1999. All replications of treatment one were located north-west from the other treatments, in order to minimize drift to non-Stylet-Oil® treated plots. Stylet-Oil® was mixed in water at a concentration of 0.75% and applied at the manufacturer's recommended rate of 234 to 1,401 liters per hectare (rates varied with the size of the plants) using a 12 L Solo® model 423 motorized knapsack mist blower (single nozzle) at a pressure of about 1000 kPa.

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[2] Based on recommendation from extension publication: P. Chung. 1995. Growing hot peppers. Eastern Region, Ministry of Agriculture, Jamaica, W.I., and F. Johnson. 1993. Insect control of peppers. University of Florida, Cooperative Extension Service, IFAS. Fact Sheet ENY-437.
[3] Professor, Department of Statistics, Virginia Tech

Effect of Stylet-Oil® on growth and yield of Scotch Bonnet pepper in the absence of virus

Ten plants were randomly selected from within each replicate and records were taken of heights and widths along- and perpendicular to- the rows. This procedure was conducted for new sets of 10 (uninfected) plants at 6, 13, 21, 49, 84 and 111 days after transplanting (DAT).

Data collected during the period of harvest from 22 December 1998 (111 DAT) through 3 February 1999 (189 DAT) was used to assess the effects of Stylet-Oil® on yield because appearance of TEV symptoms occurred late in the field. Six harvests were conducted over seven weeks; no yield data were collected on the second week of harvest (119 DAT). Fruit were harvested weekly from approximately fifteen randomly selected plants within each of the three treatments (covered seedlings/stylet oil treated (CS), covered seedlings/no Stylet-Oil® (UC), and uncovered seedlings/no Stylet-Oil® (UN)). The fruit from each plant were graded according to marketability, counted and weighed (fresh weight). Marketable fruit were defined as those fruit ≥ 3 cm in diameter, without bruises, insect, mite or fungal damage (Myers *et al*. 1998). Broad mite, Polyphagotarsonemus latus (Banks), assessment was conducted with mature fruit harvested. Fruit damaged by broad mite were hardened and rounded.

Effect of Stylet-Oil® in reducing or delaying the spread of TEV in the field

The progress of TEV spread was monitored based on symptoms as described in Chapter Three. Presence of TEV and absence of PVY were confirmed serologically (Chapter Three). Tissue blots prepared taken from one leaf on each of 10 randomly chosen non-symptomatic plants to confirm the absence of TEV within each experimental unit. Samples were taken weekly until 28 days after transplanting (DAT) (during the month September) and then monthly until symptoms were observed on some plants. Once symptoms of TEV appeared within the plots, symptomatic plants were tagged with a different color for each week. Plants were tagged beginning at 133 through 196 DAT.

Monitoring of aphids and other field observations

Aphid flight in the field was monitored using three pan traps, placed diagonally across the field. Each trap (Chapter Two) was filled with approximately 500 ml 1:1 ratio of monoethylene glycol:water (modified from DiFonzo *et al.* 1997b). The glycol:water mixture was collected and replaced weekly. In the laboratory, aphids were removed from the mixture counted and stored in 70% ethanol until identified. Aphid species were identified by Dr. Susan Halbert[4] and by S.A.M. Casual observations were also made of for detecting aphids on plants in or near pepper plots. Weeds noticed to be of high frequency were noted.

Statistical analyses

The data were analyzed using analysis of variance (GLM procedure, SAS Institute 1996) to determine whether mean plant height and canopy 6 DAT through 122 DAT, and yield (number and weight of fruit) differed among the three treatments. Non-orthogonal contrasts were used to compare the following: (1) the two covered treatments and the uncovered treatment (covered seedlings/stylet oil treated and covered seedlings/non-Stylet-Oil® treated plants versus uncovered seedlings/non-Stylet-Oil® treated plants), (2) the two covered treatments (covered seedlings/stylet oil treated versus covered seedlings/non-Stylet-Oil® treated plants), and (3) the two non-Stylet-Oil® treatments (covered seedlings/non-Stylet-Oil® treated versus uncovered seedlings/non-Stylet-Oil® treated plants).

Time series cross-correlation analyses (ARIMA procedure, SAS Institute 1996) were conducted to determine an association between number of aphids trapped per week and the percentage of pepper plants with TEV symptoms within the three treatments. Rates of TEV disease progress in the three treatments were fitted to the following logistic model:

$$\% \text{ TEV infection} = t_{max}/(1+exp(-(t_x-t_{median})*\ _1))$$

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where t_{max} = maximum TEV infection at 196 DAT, t_x = any given day after transplanting, t_{median} = number of days between transplanting and median percentage TEV infection, and $_1$ = slope of the fitted line. Least square method was used to improve the fit between the observed and predicted values for the incidence of TEV. Ninety-five percent confidence intervals were obtained for the parameters of interest by calculating a range within which the residual sum of squares (RSS_{min}) for the model was less than the critical level (CL) (Sharov *et al.* 1995):

$$CL = RSS_{min}(1 + F\ v_1/v_2),$$

where F is the critical value of the F statistic at P = 0.05, v_1 and v_2 are 1 and N-1 degrees of freedom, and N is the number of observations (weeks) over which TEV incidence was calculated.

Results

Effect of Stylet-Oil[®] on growth and yield of Scotch Bonnet pepper in the absence of virus

The mean height of pepper plants in the covered seedlings/stylet oil treatment (CS) and covered seedlings/non-Stylet-Oil[®] (CN) treatment was significantly greater than the mean height of plants from the uncovered seedlings/non-Stylet-Oil[®] (UN) treatment from 6 DAT (F = 294.3; df = 1, 6; p < 0.0001) through 28 DAT (F = 27.0; df = 1, 6; p < 0.002 (Figure 4.1). From 49 DAT until 111 DAT when the last measurements were taken, there were no significant differences (F = 0.02 to 6.0; df = 1, 6; p ≥ 0.05) between the heights of the two covered seedling treatments and the uncovered seedling treatment. CN plants were similar in height to CS (F = 0.6 to 5.4; df = 1, 6; p > 0.05), but were taller than UN (F = 11.1 to 209.2; df = 1, 6; p < 0.02) throughout most of the growing period. No significant differences (F = 0.0 to 5.6; df = 1, 6; p > 0.05) were found among the canopies of plants from contrasts among the three treatments on 6, 28, 49, 84, and 111 DAT (Figure 4.1).

No significant differences (F = 0.9 to 2.8; df = 1, 6; p > 0.05) were found when total number or marketable numbers of fruit from CS and CN plants were contrasted with UN plants (Table 4.1).
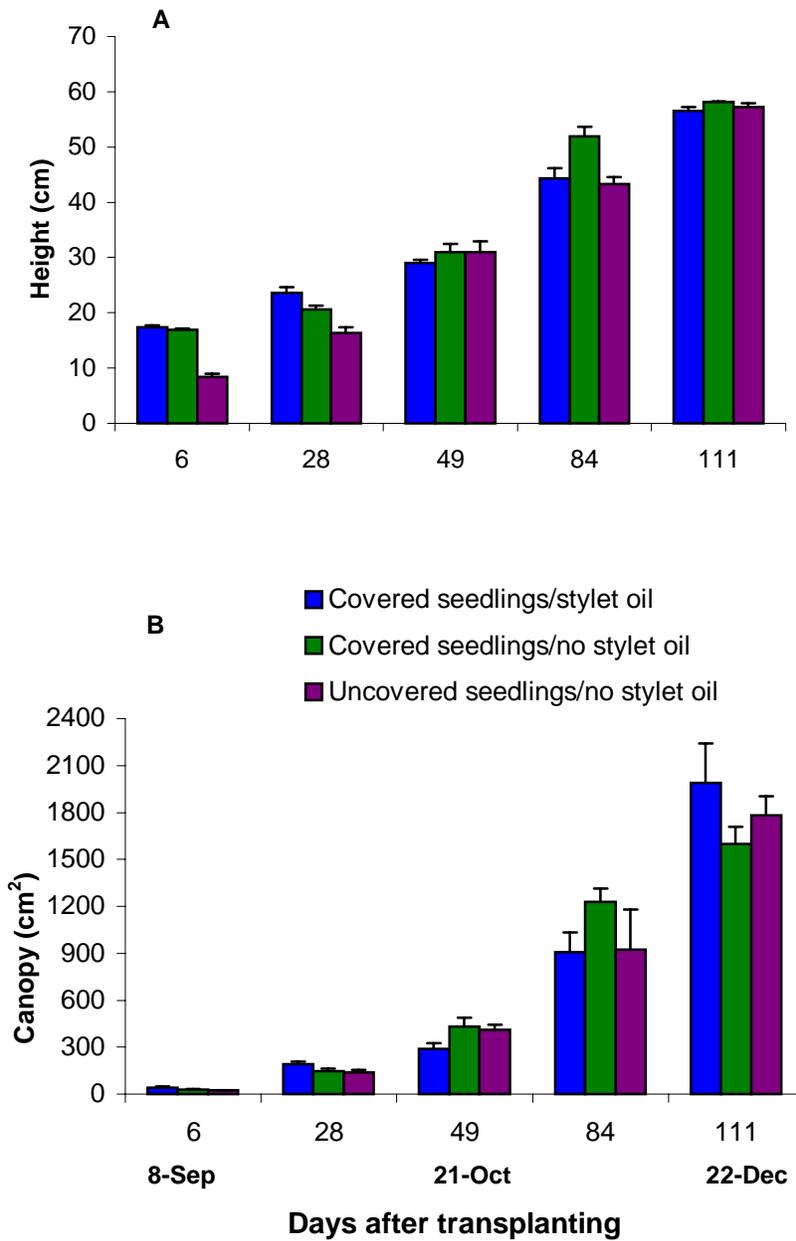
Figure 4.1. Mean (± SE) height (A) and mean (± SE) canopy (B) of 'Scotch Bonnet' pepper in plots treated weekly with Stylet-Oil® and in untreated plots during 2 September through 22 December 1998 at Bushy Park, St. Catherine, Jamaica, W.I.

Table 4.1. Mean (± SE) number, mean (± SE) weight of fruit, and mean (± SE) weight per marketable fruit produced by 'Scotch Bonnet' pepper plants treated with or without Stylet-Oil® in the absence of virus. The experiment was conducted at Bushy Park St. Catherine Jamaica, W.I., and plants were harvested weekly from 22 December 1998 (111 DAT) to 3 February 1999 (189 DAT).

Treatment	Total number of fruit per plant per week[a]	Number of marketable fruit per plant per week	Weight (g) of marketable fruit per plant per week	Percentage of marketable weight per plant per week	Weight (g) per marketable fruit
Covered seedling/ Stylet-Oil® treated (CS)	3.5 ± 0.39	2.8 ± 0.10	21.6 ± 0.27	84 ± 13.11	7.3 ± 0.50
Covered seedling/non-Stylet-Oil® treated (CN)	5.9 ± 0.60	2.0 ± 0.37	17.0 ± 3.45	42 ± 7.29	8.4 ± 0.15
Uncovered seedling/non-Stylet-Oil® treated (UN)	5.9 ± 0.75	2.9 ± 0.58	27.9 ± 6.9	54 ± 7.87	9.4 ± 0.37
	$F = 5.5$; df = 2, 6; $p = 0.045$	$F = 1.5$; df = 2, 6; $p > 0.1$	$F = 1.5$; df = 2, 6; $p > 0.1$	$F = 14.2$; df = 2, 6; $p = 0.005$	$F = 8.3$; df = 2, 6; $p = 0.015$

[a]Yield data for subsamples and weekly harvests were averaged within the three replicates (n = 3).

However, the total number of fruit produced by CN plants was greater (F = 8.1; df = 1, 6; p = 0.03) than the total number of fruit produced by CS plants, though not significantly different (F = 0.0; df = 1, 6; p > 0.1) from that produced by UN plants. Marketable number of fruit produced by CN plants did not differ from the marketable number of fruit produced by CS plants (F = 2.1; df = 1, 6; p > 0.1) or that produced by UN plants (F = 2.3; df = 1, 6; p > 0.1) (Table 4.1).

There were no significant differences (F = 0.5 to 3.0; df = 1, 6; p > 0.1) in the marketable weight of fruit produced per plant in any of the three contrasts. Percentage marketable weight of fruit produced by CS and CN plants together was not significantly different (F = 1.4; df = 1, 6; p > 0.1) from the percentage marketable weight of fruit produced by UN plants. However, the percentage marketable weight of fruit produced by CN plants was less (F = 26.8 and 26.9; df = 1, 6; p = 0.002) than the percentage marketable weight of fruit produced by CS plants but similar (F = 2.5; df = 1, 6; p > 0.1) to that produced by UN plants (Table 4.1). Similar relationships were obtained when the percentage marketable number of fruit was contrasted among treatments. Compared to damage from insects, fungi and mechanical damage, the single most important factor contributing to losses in marketability was the broad mite, which was responsible for 9 and 4% loss in the total yield of CN and UN plants, respectively. Yield of CS plants was not affected by losses due to the broad mite during the first harvest period when fruit set occurred before TEV was detected.

Mean weight of individual fruit varied among treatments. Weights of individual fruit from CS and CN plants, when contrasted against weight of individual fruit from UN plants, were significantly lower (F = 11.5; df = 1, 6; p = 0.015). Weight of individual fruit from CN plant was similar to weight of fruit from CS plants (F = 5.1; df = 1, 6; p > 0.05) and fruit from UN plants (F = 3.6; df = 1, 6; p > 0.05) (Table 4.1).

Effect of Stylet-Oil[®] in reducing or delaying the spread of TEV in the field

TEV was the only virus confirmed from random samples of leaves for tissue blots taken from non-symptomatic Scotch Bonnet plants and symptomatic Scotch Bonnet plants. All the randomly sampled leaves taken from nonsymptomatic pepper plants during the first 28 DAT

tested negative by tissue blots for TEV. Some leaves sampled on 49 DAT tested positive for TEV for all treatments but complete data are not available because some of the blot membranes were damaged. From 84 DAT through 133 DAT > 60% of plants from all three treatments tested positive for TEV although they showed so symptoms of TEV. All the leaves sampled from plants showing symptoms of TEV disease during 147 DAT through 182 DAT tested positive for TEV.

The first symptoms of TEV were observed 56 DAT during routine monitoring (Figure 4.2. A). In addition, serological testing of all plants exhibiting symptoms of TEV during a census of the field 56 DAT confirmed the presence of TEV on 0.3% of all 300 CS, 4.0% of all 300 CN and on 3.7% of all 300 UN plants. These plants exhibited very early TEV symptoms, in which the youngest leaves had initial vein clearing but there appeared to be a recovery in which symptoms did not develop. Furthermore, with the exception of 3 plants that exhibited symptoms of TEV 63 DAT (Figure 4.2. A), no new symptomatic plants were observed during routine monitoring of plots until 111 DAT.

There was regular rainfall each week from transplant through 56 DAT (Figure 4.2. B), when early TEV symptoms were first observed. However, from 57 DAT through 91 DAT there was only one week when > 24 mm of rain fell. It was during this period when only three new plants developed TEV symptoms, although random sampling for serological testing indicated high incidences of TEV in all treatments. Between 91 and 105 DAT there were four days of rainfall totaling 1,320 mm (Figure 4.2. B). Associated with the rainfall was the proliferation of weeds within the plots. By 111 DAT, the plots were very weedy with mostly *Amaranthus* spp. (Amaranthaceae) and *Parthenium hysterophorus* L. (Asteraceae). It was also at 111 DAT that new symptoms of TEV began to appear, and continued to appear although the rainfall became infrequent again.
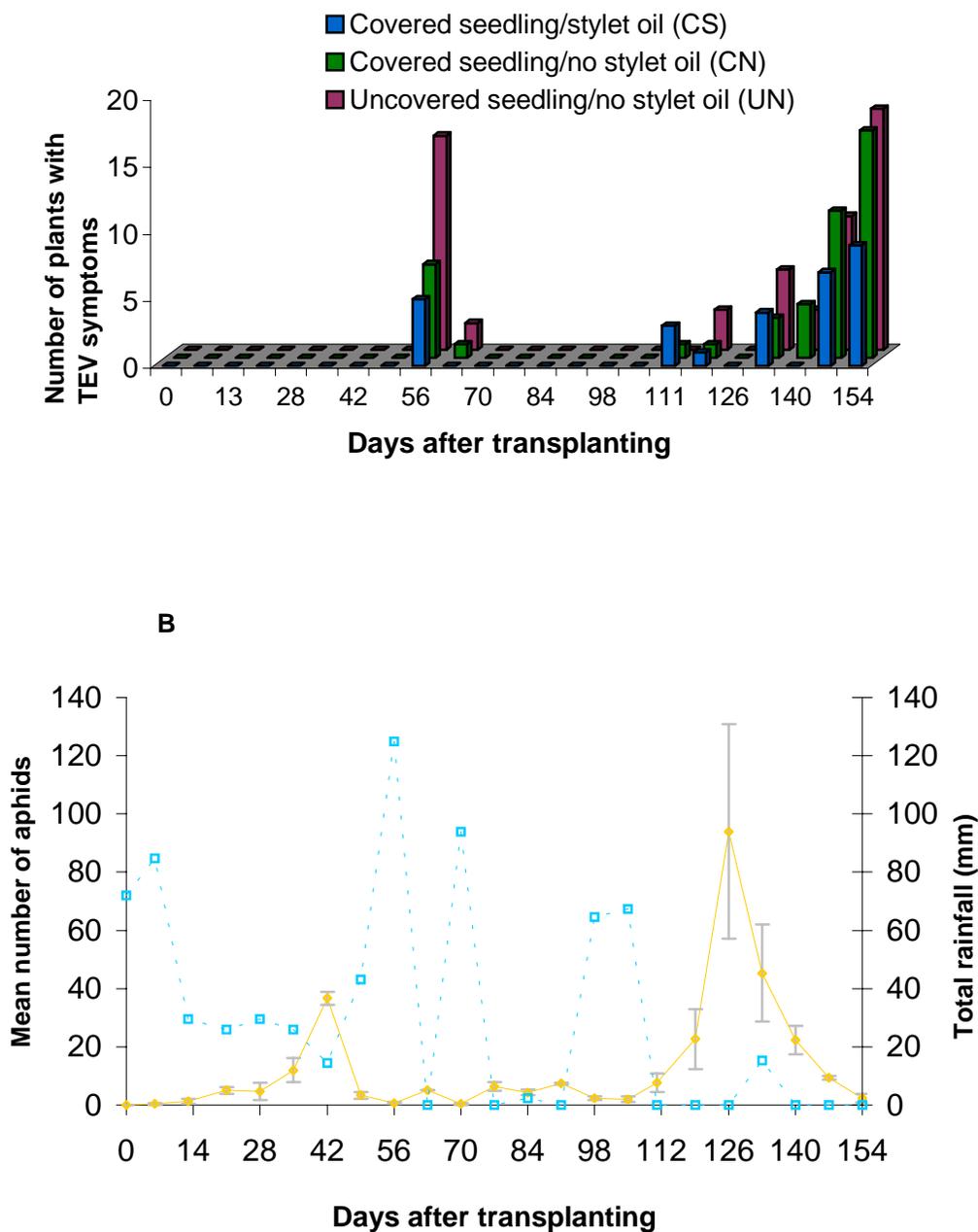
Figure 4.2. Number of 'Scotch Bonnet' pepper plants with TEV symptoms per week from a total of 30 plants monitored in plots treated weekly with Stylet-Oil® and from untreated plots (A). Mean (± SE) number of alate aphids captured with pan traps (⎯◇⎯), and total weekly rainfall (- - ▫ - -) (B) during 2 September 1998 through 3 February 1999 (6-154 days after transplanting). The experiment was conducted at Bushy Park, St. Catherine, Jamaica, W.I.

The incidence of TEV (Figure 4.2. A) was correlated to the flight activity of the aphids (Figure 4.2. B). A two-week lag was found between aphid flight activity and the appearance of TEV symptoms in CN (r^2 = 0.49) and UN plots (r^2 = 0.45) but a three-week lag between aphid flight activity and the appearance of TEV symptoms in CS plots (r^2 = 0.67). There was an increase in the mean aphid flight between 35 and 42 DAT (Figure 4.2. B), two weeks before the first TEV symptoms were observed (Figure 4.2. A). Then between 112 and 140 DAT, when there was a second increase in aphid activity two weeks preceding an increase in virus symptoms (Figure 4.2. A and B).

A. gossypii accounted for 90% of the total aphid species captured during 35-42 DAT (Figure 4.3. A) but only represented 32% of the total aphids during 85-119 DAT, and 5% of the total aphids during 120-147 DAT (Figure 4.3. A). *A. gossypii* was found to colonize pepper but no correlation (r^2 = 0.07) was found between the *A. gossypii* population on the plants and alates in the traps. *Uroleucon ambrosiae* (Thomas) complex accounted for 53% of the total number collected during 85-119 DAT and 85% of the total aphids during 120-147 DAT. During 148-175 DAT, *U. ambrosiae* only accounted for 8% of the aphid species caught while *A. gossypii* accounted for 24%. It was observed that *U. ambrosiae* formed dense colonies on *P. hysterophorus* and this weed was removed from the plots on 126 DAT. *A. amaranthi* Holman accounted for 1, 5 and 36% of the aphids collected during 85-119 DAT, 120-147 DAT and 148-175 DAT, respectively. Four other aphid species, all of which are reported to be TEV vectors, *A. craccivora* Koch, *A. spiraecola* Patch, *Lipaphis erysimi* Hille Ris Lambers and *M. persicae* (Sulzer), together accounted for 9, 3 and 24% of the total aphid species during 85-119 DAT, 120-147 and 148-175 DAT, respectively (Figure 4.3. B).

Weekly census of the field from 133 through 196 DAT showed that the spread of TEV closely followed the logistic model within CS plots (F = 1809.5; df = 1, 8; p < 0.0001, r^2 = 0.99), CN plots (F = 1700.9; df = 1, 8; p < 0.0001, r^2 = 0.99), and UN plots (F = 1120.1; df = 1, 8; p < 0.0001, r^2 = 0.99), (Figure 4.4). At 196 DAT the predicted TEV incidence (t_{max}) was 74% within CS plots but 100% within the two non-Stylet-Oil[®] treated plots. The 95% confidence interval
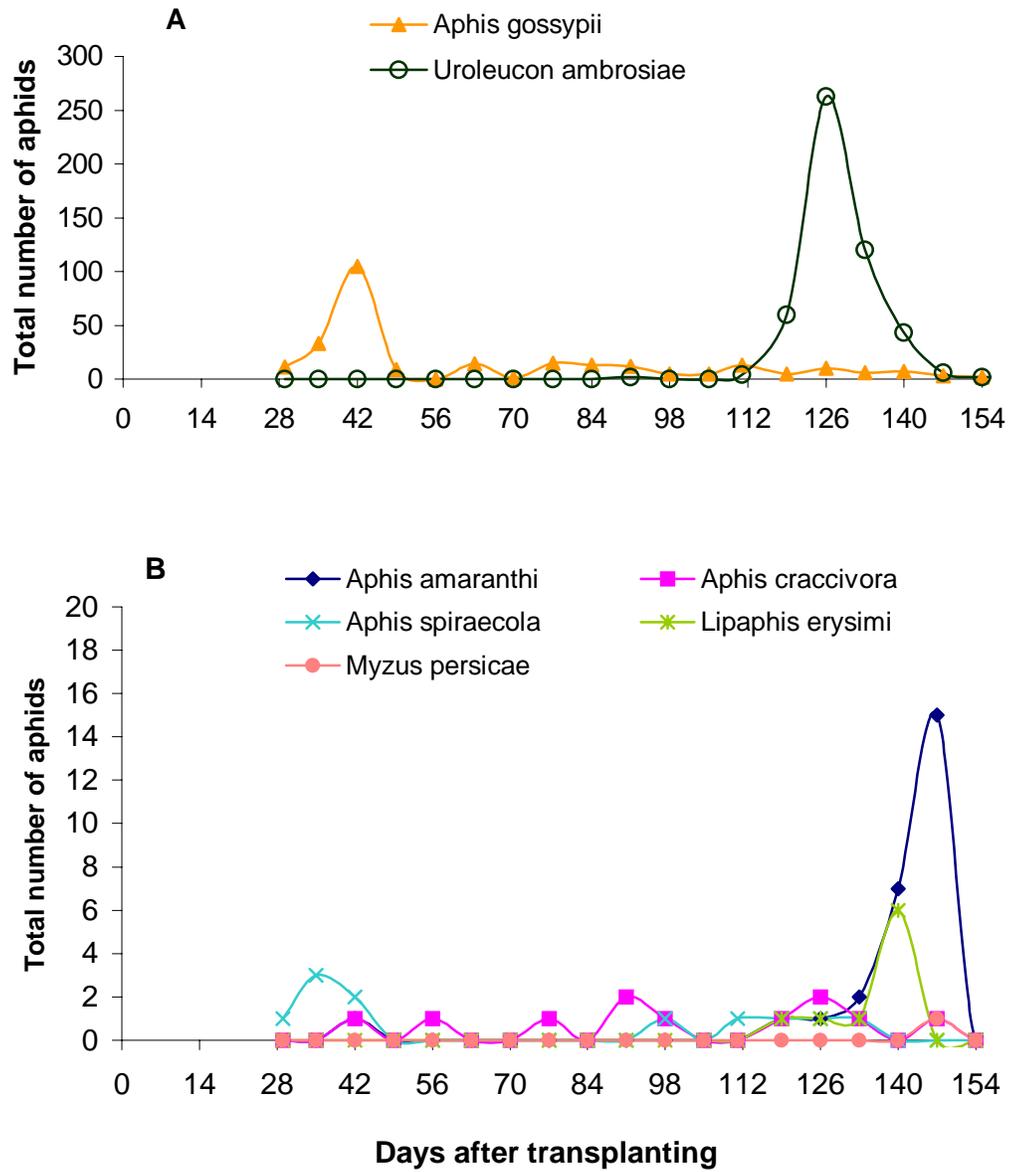
Figure 4.3. Total numbers of selected winged aphids captured with pan traps (A and B) from 2 September 1998 to 3 February 1999 (0-154 days after transplanting). The experiment was conducted at Bushy Park, St. Catherine, Jamaica, W.I.
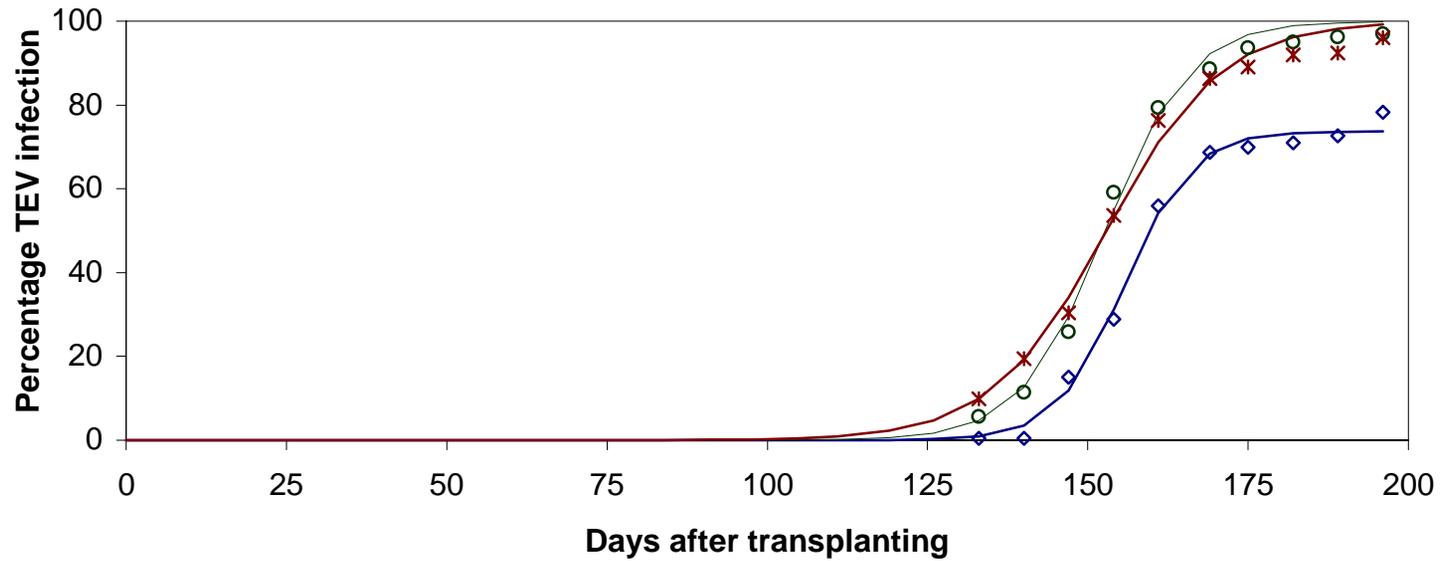
Figure 4.4. Logistic model-predicted (____) and observed incidence (mean %) of TEV over time within (A) covered seedling/Stylet-Oil® treated (◊), (B) covered seedling/non-Stylet-Oil® treated (○), and (C) uncovered seedling/non-Stylet-Oil® treated (*) 'Scotch Bonnet' pepper plots during 2 September 1998 through 17 March 1999 (0-196 days after transplanting). The experiment was conducted at Bushy Park, St. Catherine, Jamaica, W.I. The logistic models were, (A) Y= 74/(1-exp(-(x - 152.9)*0.19)); (B) Y = 100/(1-exp(-(x - 152.7)*0.15)); and (C) Y = 100/(1-exp(-(x - 152.9)*0.11)) .

(CI) for t_{max} within the CS treatments ranged from 71 to 76% and was therefore significantly different from 100 (p < 0.05). The slope of the logistic model for the spread of TEV within CS plots was 0.19 (95% CI = 0.16 - 0.24) whereas the slope of the logistic models for the spread of TEV in CN and UN plots were 0.15 (95% CI = 0.13 - 0.19) and 0.11 (95% CI = 0.09 - 0.14). The median infection time ($t_{37\%}$) of TEV in CS plots occurred 155.6 DAT (95% CI = 154.4 - 155.9 DAT), while the median infection times ($t_{50\%}$) of TEV were 152.7 DAT (95% CI = 151.4 – 154.0 DAT) in CN and 152.9 DAT (95% CI = 151.2 – 154.6 DAT) in UN plots (Figure 4.4). The predicted $t_{50\%}$ for TEV infection within the Stylet-Oil® treated plots occurred at 159.4 DAT, about 6.6 days later than it occurred within the non-Stylet-Oil® treated plots.

The greatest delay in the spread of TEV infection occurred within the inner of the three contiguous plots that were treated with stylet oil. From actual counts of plants the experimental unit forming the inner third of the sprayed plots had only 66% of its plants, infected with TEV 196 DAT, while the two outer thirds sustained 83 and 86% infection. On the other hand, each experimental unit of the two non-Stylet-Oil® treatments, all of which were contiguous, had attained ≥ 94% TEV infection by 196 DAT.

Discussion

Plant height and canopy of healthy Scotch Bonnet plants were not adversely affected when seedlings were grown under aphid exclusion cages until transplanting or by regular applications of Stylet-Oil® to the plants in the field. Plants treated with Stylet-Oil® produced fewer fruit but a greater percentage of marketable fruit than plants that were not treated with stylet oil. While there was no fruit loss to broad mite from plants within the CS plots, there was fruit loss to broad mite from plants within CN and UN plots. The infestation of broad mite might have been prevented by the Stylet-Oil® treatment (Simons *et al*. 1995). Another reason could be because the broad mite infestation started at the end of the plot farthest from the plots that were being sprayed with stylet oil; its spread to the Stylet-Oil® treated plots could have been hindered when the broad mite population was managed with applications of acaricides. Differences in number

of fruit between Stylet-Oil[®] and non-Stylet-Oil[®] treated plants might have been due to the location of the plots and a period of water stress.

In plots treated with Stylet-Oil[®] the predicted spread of TEV was reduced by 28% at 196 DAT and delayed by about 7 days when compared with the spread of TEV in the other two treatments. The spread of TEV in the two untreated plots were similar. Both were almost entirely infected by 196 DAT as was found to be typical of most Jamaican hot pepper fields (McGlashan *et al*. 1993). Inadequate spray applications and edge effects due to small plot size might have prevented the oil from being more effective in this experiment. It was not possible to spray twice per week during weeks when it rained or when aphid flights were high as is recommended by the manufacturer of the oil.

Varied results have been reported regarding the efficiency of mineral oils in reducing the spread of viruses transmitted by aphids. Benner and Kuhn (1985) found no significant difference in the incidence and severity of TEV, PVY and CMV in pepper (*Capsicum annuum* L.) with and without JMS Stylet-Oil[®] treatment in Georgia. In their experiments, field sizes ranged from 0.007-2 ha. Umesh *et al* (1995) reported that Stylet-Oil[®] failed to suppress field spread of watermelon mosaic 2 potyvirus and CMV under heavy inoculum pressure but that it was able to delay the onset of these diseases. Simons and Zitter (1980) and Simons (1982) confirmed that oil sprays lose their effectiveness when the percentage of virus-infected plants exceeded 10-20%.

Thomas (1984) reported successful control of aphid-transmitted viruses in cucurbits with applications of Stylet-Oil[®]. Loebenstein *et al*. (1970) were able to effectively delay and reduce the spread of CMV and PVY in pepper with a mineral oil, Blancol[®]. Both groups of researchers used knapsack sprayers to apply the mineral oils as was done in this experiment. Further studies need to be conducted to determine the efficacy of motorized knapsack sprayers as tools for applying mineral oils as their success could offer a practical means of managing aphid transmitted viruses in hot pepper and other vegetable cropping systems in Jamaica.

In this study, we observed likely associations between aphid flight activity, weed composition within the field and the incidence of TEV. TEV symptoms appeared and increased shortly after peak aphid flights. *U. ambrosiae* and *A. amaranthi* were implicated as possible vectors of TEV, although they have apparently not been tested for their transmission capability or efficiency. These two species of aphids were common on *P. hysterophorus* and weed species of amaranths found within the pepper field. Studies need to be conducted to ascertain the abilities of these two species to transmit TEV and to determine their transmission efficiencies.

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