Eco-friendly management of leaf curl disease of tomato

SAVARNI TRIPATHI and ANUPAM VARMA
Advanced Centre for Plant Virology, Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi 110 012

ABSTRACT: A high degree of leaf curl disease (LCD) incidence (83%) was observed in the winter crop planted in October as compared to the summer crop planted in February where only 14% incidence of LCD was recorded. Least incidence of the LCD was found in polythene mulch (PM) treatment and in perforated polythene cover (PC) treatment as compared to the other treatments. During the summer crop whitefly population was less at the initial stages of the crop, whereas during the winter crop the whitefly population was very high at the similar stages of the crop. This variation in the whitefly population was due to the differences in temperature and relative humidity. The use of polythene bags to cover tomato plants (PC) and polythene sheets as mulch (PM) were found most effective in reducing the disease incidence and promoting the growth and yield of tomato plants as compared to other treatments.

Key words: Disease incidence, management, Tomato leaf curl virus, whitefly population

Leaf curl disease (LCD) of tomato (Lycopersicon esculentum Mill.) caused by Tomato leaf curl geminivirus (ToLCV) which is vectored by whitefly Bemisia tabaci, is a serious threat to tomato production world wide (Varma, 1993). Tomato cultivation, especially in autumn in North India and in summer in South India is adversely affected due to the high incidence of the disease and losses often exceed 90% (Butter and Rataul, 1981; Saikia and Muniyappa, 1989). The progress of the disease coincides with the build-up of whitefly population. Earlier workers have found positive correlation between the LCD incidence and population of B. tabaci (Varma, 1986; Borah and Bordoloi, 1998). Several factors (viruliferous whiteflies, temperature, humidity, wind direction and velocity, sunshine, rainfall and precipitations) either singly or in combination contribute to the widespread incidence/epidemic of LCD. Under the North Indian conditions min temp and min relative humidity has been shown to influence the whitefly population (Krishnareddy, 1989), but under the South Indian conditions max temp and rainfall have been found to be more important (Murugesan et al., 1977). These factors have helped in developing forecasting models for the geminiviruses transmitted by whiteflies.

For the management of the disease, several insecticides have been used to control the vector reported by various workers (Rataul and Butter, 1976; Mishra, 1984). The potential environmental pollution, health hazard and adverse effect on non-target insects in the use of insecticidal chemicals for the control of LCD necessitated the development of alternative eco-friendly management strategies. Alternatively, non-chemical control methods such as use of mineral oil (Sharma and Varma, 1982), mulching (Suwan et al., 1988), protecting the plants in nurseries by physical barriers have been promising (Nakhaia and Maxwell, 1998). In the present investigation some eco-friendly methods were tried for the management and epidemiological studies of LCD.

MATERIALS AND METHODS

Experiments were conducted at IARI Farm between 42nd and 49th yearly weeks (October to December, 1996) and 8th to 21st yearly weeks (February to May, 1997) to develop eco-friendly management practices to reduce the incidence of LCD. Tomato var. Pusa Early Dwarf was used in 1996 and Pusa Hybrid 1 in 1997 developed earlier at IARI for cultivation in summer. The seeds were
sown in nursery beds and in earthen pans in an insect-proof glasshouse.

Flat bed plot each measuring 2.5 x 3 m were made. One month old seedlings were transplanted at a distance of 45 x 30 cm as per agronomical practices. The plots were given fertilizer dose of 120 N, 80 P and 60 K kg/ha. The plots were flood irrigated once immediately after transplanting followed by irrigation at 20-25 days interval during winter and 7-15 days interval during summer.

The various treatments included - nursery plants grown under field conditions (NF), nursery plants grown under glasshouse conditions (NG), nursery plants grown under field conditions and treated with 2% neem oil spray at 10-15 days interval starting with the first spray after transplanting (NO), nursery plants grown under field conditions and covered with perforated polythene bags (PC), and nursery plants grown under field conditions and transplanted in plots mulched with transparent polythene sheet of 1800 gauge (PM).

The disease incidence was recorded by visual symptoms at weekly during winter and fortnightly in the summer and % incidence was determined per plot. The area under disease progress curve (AUDPC) was calculated following the procedure adopted by (Nagarajan and Muralidharan, 1995).

The data were analyzed statistically in software packages SPSS and G-STAT at the Bio-informatics Centre.

For determining whitefly population one yellow cylindrical sticky trap with surface area of 13.5 x 18 cm was placed in the centre of the field at 30 cm above the crop canopy. The sticky sheet was change at weekly intervals and whitefly counts were recorded daily. Weather data were collected from the observatory at IARI. The yield of tomato was measured. The fruits were harvested seven times during the entire season between the yearly week 13 and 21, at maturity judged by the red color of the fruits.

RESULTS

The incidence of LCD was more in the winter crop (between 42 to 49 weeks) as compared to the summer crop (between 8 to 21 weeks). In the summer crop no disease was observed in any of the treatments up to 4 weeks after transplanting. By the 6th week after transplanting, however, 1-1.5% disease was recorded in NF and PM treatments and 2 weeks later infection also occurred in NG and NO. Least incidence of the disease was noted in PC in which very low incidence was observed up to 12th week after transplanting. Reduction in the incidence of the disease was best with PC followed by PM treatment. The differences in the other treatments were not significant (Fig. 1).

As compared to the max incidence of 14% in the summer, the incidence in winter crop was very high resulting in more than 80% infection in NF. During winter, in all the treatments overall incidence of the disease was significantly less as compared to NF which was taken as untreated control. Like the summer crop, in the winter crop also PC provided good control of the disease but the best control was provided by PM in which maximum incidence of the disease was 58.6% as compared to 83.6% in the NF (Fig. 1). The AUDPC also indicated that during winter, PM and in summer PC provided the best control of the disease (Table 1).

Table 1. Area under disease progress curve (AUDPC) of different treatments in two different cropping seasons.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Winter crop</th>
<th>Summer crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF (field grown nursery)</td>
<td>1875.4</td>
<td>427.5</td>
</tr>
<tr>
<td>NG (Glasshouse grown nursery)</td>
<td>1165.5</td>
<td>352.5</td>
</tr>
<tr>
<td>NO (Neem oil)</td>
<td>1659.9</td>
<td>333.7</td>
</tr>
<tr>
<td>PC (Polythene cover)</td>
<td>1110.1</td>
<td>52.5</td>
</tr>
<tr>
<td>PM (Polythene mulch)</td>
<td>995.7</td>
<td>326.2</td>
</tr>
</tbody>
</table>

During the summer, whitefly population was low at the initial stages of the crop growth, whereas during winter the whitefly population was very high at the similar stages of the crop growth. This variation in whitefly population was due to the differences in temperature and relative humidity during the two cropping seasons. During the summer crop the whitefly population suddenly dropped after the 20th yearly week which could be due to high temperature and low relative humidity.
The drop in the whitefly population after the 46th week could be mainly due to the fall in min temp. Other weather factors like sunshine, evaporation and wind velocity were also considered but none of these factors were found consistent in influencing the whitefly population. Best correlation was found with the mean temperature in the winter season.

During winter 1996, the plants did not fruit due to low temperature, therefore, plant growth in the form of wet and dry weight, shoot length, shoot branching, internodal length, root length and root branching were recorded (Table 2). All the growth characteristics were superior with PC and PM treatments in comparison to the other treatments.
The summer crop fruited well in 1997 and the more fruit yield was obtained in PC followed by PM treatment (Fig. 2). Both the treatments yielded significantly higher than the other three treatments. The advantage in yield with PC was 30.7% as compared to NF which was taken as control.

**Fig.2.** Effect of the leaf curl disease on tomato yield. The total average fruit yield in grams was calculated for each plant at the end of harvesting season. Bars and graph with the same letters do not differ significantly at $P=0.05$. Angular values of disease incidence (avdi) were calculated by angular transformation of per cent disease incidence recorded in each treatment. NF: field grown nursery, NG: glasshouse grown nursery, NO: neem oil, PC: polythene covered and PM: polythene mulch

**DISCUSSION**

In the present investigation, an increase in disease incidence coincided with the build-up of whitefly population. A higher degree of disease incidence (83%) was found in the winter crop planted in October as compared to the summer crop planted in February. This difference could be due to high vector population at the initial stages of the crop during the winter, when the plants are young and susceptible. During the summer build-up of whitefly population started late in the season when plants had matured and were less susceptible to the viral infection due to adult plant resistance, a common phenomenon for virus-host combinations (Varma, 1993). In contrast to the findings of the present investigations, Saklani and Mathai (1977) recorded lesser LCD incidence in the crop planted in October (35%) as compared to the crop planted in February (69%). They however, did not record the population of whitefly. It is possible that the pattern of whitefly population build-up may be different in Pantnagar from that of Delhi. The population of whitefly varies from year to year and place to place (Varma, 1984). At Diphu, Assam, Borah and Bordoloi (1998) observed good positive correlation between the incidence of LCD in tomato and whitefly population, where max incidence of the disease was found in the August planted crop and min in November planted crop. In Karnataka, the tomato crop planted between July to November have less incidence of LCD (up to 53%) than in the crops planted from February to May (up to 100%). The incidence of LCD was correlated with the whitefly population (Saikia and Muniyappa, 1989).

Among all the weather factors, no single factor was found to correlated with whitefly population.

**Table 2.** Effect of treatments and the leaf curl disease (LCD) on growth of tomato plants during winter

<table>
<thead>
<tr>
<th>Plant growth parameters</th>
<th>NF</th>
<th>NG</th>
<th>NO</th>
<th>PC</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot length (cm)</td>
<td>11.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>32.2&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Internodal length (cm)</td>
<td>1.6</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Shoot branching (No)</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.0&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Root length (cm)</td>
<td>6.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.5</td>
<td>19.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Root branching (No)</td>
<td>1.0</td>
<td>3.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dry weight of plants (g)</td>
<td>3.1</td>
<td>10.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fresh weight (g)</td>
<td>20.4</td>
<td>59.8</td>
<td>71.0</td>
<td>126.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>126.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values followed by the same letters within a row indicate non-significant differences between the means at $P=0.05$. *NF: field grown nursery, NG: glasshouse grown nursery, NO: neem oil, PC: polythene covered and PM: polythene mulch
However, the whitefly population suddenly dropped after the 20th yearly week which could be due to the high temperature and low relative humidity. The drop in whitefly population was also recorded after the 46th yearly week which could be attributed to the fall in min temp. Temperature and relative humidity were also found to be positively correlated with whitefly population in Pantnagar (Saklani and Mathai, 1977). Whereas in South India, low rainfall, min humidity and min temp favoured the build-up of the whitefly population (Murugesan et al., 1977; Sastry et al., 1978).

The polythene bags to cover the plants (PC) and polythene sheet as mulch (PM) were most effective in reducing the incidence of LCD and promoting the growth and yield of tomato plants as compared to the other treatments in both the seasons. The reduction in the incidence of LCD, however, was more prominent in the winter crop than in the summer crop (Fig. 1). Reduction in the disease and increase in yield was also observed by Suwwan et al. (1988) when the plots were mulched with silver and black/white plastic sheet. They also noted improvement in root growth, dry matter and fruiting. Covering plants with perforated polythene bags during summer provided best protection, but not in winter. This could be due to the high whitefly population, during the first five weeks after transplanting, and entry of viruliferous whitefly from the open end of the perforated polythene bags. In the summer crop also infection started in the PC treatment after the whitefly population reached the levels similar to the early stages of the winter crop (Fig. 1). Berlinger et al. (1983) also reported reduction in yellow LCD when tomato plants were covered with perforated plastic cover. Ali and Said (1987) reported complete protection when the tomato plants were covered with 1074 mesh white muslin cloth. Thus covering of plants with perforated polythene bags or muslin cloth appears to be a good strategy for the management of LCD in tomato. Treatment with neem oil (NO) did not give significant reduction of LCD. Neem oil has also not been found effective in reducing the incidence of Mungbean yellow mosaic virus, another whitefly transmitted geminivirus in black-gram (Krishnareddy, 1989) and mungbean (Patel, 1989; Dhar, 1992). Neem oil spray also did not promote plant growth, but it induced excessive flowering indicating adverse effect of neem oil on plant growth (Sharma and Varma, 1982). The use of perforated polythene bags to cover plants at the initial stages of the crop and/or polythene mulching along with raising nursery under protective conditions are recommended for the eco-friendly management of LCD in tomato.

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REFERENCES


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