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ORIGINAL ARTICLE

The Effect of Border Crops and Physical Barriers on Incidence of Chilli Leaf Curl Complex and Associated Insect Populations

U.G.A.I. Sirisena[1], D.A.U.D. Devasinghe[1], W.M.R.S.K. Warnasooriya[1], W.M.D.M. Wickramasinghe[1], W.M.J.B. Wijesinghe[2] and M.A.R.A. Mandanayake[3]

[1]*Department of Plant Sciences, Rajarata University of Sri Lanka, Anuradhapura (50000), Sri Lanka.*

[2]*Rangiri Dambulla National School, Dambulla (21100), Sri Lanka*

[3]*Field Crop Research and Development Institute, Mahaillupallama (50270), Sri Lanka.*

Correspondence:
anura@agri.rjt.ac.lk

https://orcid.org/0000-0002-8679-1477

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Abstract

Chilli Leaf Curl (CLC) possesses a significant biotic threat leading to substantial yield losses in chilli cultivation. Various agents such as thrips, aphids, mites and the viruses transmitted by whiteflies have been identified as contributors to CLC. In order to mitigate this issue, three types of physical barriers were used: an insect-proof net (1 m high) surrounded by three rows of maize crops, an insect-proof net (1 m high) alone, and three rows of maize crops. A control was maintained without a physical barrier. The experiment was laid out as randomized complete block design with three replicates. Identification of pests and diseases, CLC disease incidence and yield attributes were assessed. Results revealed that the treatment with an insect-proof net combined with a maize border exhibited the lowest disease incidence (2±0.45, p=0.01) compared to chilli plants with a maize border only. The whitefly population varied across the treatments (p=0.03) and with the age of the crop (p<0.0001). Among the treatments, the control and insect-proof net exhibited a significantly lower population of whiteflies. Thrips did not show a significant response to the treatments (p=0.54) indicating that the presence of physical barriers had no notable effect on thrips counts. Additionally, there was no significant difference in the number of pods per plant (p=0.74) and yield per plant across the treatments (p=0.54). In conclusion, the use of insect-proof net with a maize border surrounding the chilli cultivation would help to develop integrated pest management strategies to reduce chilli leaf curl incidence as well as whitefly population.

Keywords: *Disease incidence, Insect-proof net, Maize border, Thrips, Whiteflies*

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1. Introduction

Chilli is an important condiment crop cultivated in Sri Lanka. In the 2018/19 *Maha* season, chilli was cultivated in 6,611 hectares, yielding approximately 33,838 metric tons of green chilli (DCS 2023). Among the constraints in chilli production, leaf curl significantly affects yield, plant health and the overall quality of the crop with potential economic losses for farmers. The typical symptoms of chilli leaf curl (CLC) include the bending of leaves either upwards or downwards, often accompanied by color changes, wrinkling or smaller leaf size (Kumar et al. 2014). Specifically, signs of CLC caused by viral infections include upward leaf curling, crinkled appearance, puckering, reduced leaf size, blistering between veins, veined bands, shortened petioles and spaces between nodes, clustered leaves and significant stunting in plant growth (Shingote et al. 2022). Chilli leaf curl virus is classified in the genus Begomovirus and family Geminiviridae (Fiallo-Olivé et al. 2021; Mishra et al. 2021).

The whitefly (*Bemisia tabaci*) is identified as the most prevalent vector of Begomoviruses. The leaf curl in chilli is associated with several insect species including thrips (*Scirtothrips dorsalis*), mites (*Hemitarsonemus latus*) and aphids (*Aphis gossypii*) (Priyantha and Chandrasena 2014). In severe cases of CLC, losses of marketable fruits can be extended up to 100% (Wijayaratne et al. 2006; Senanayake et al. 2007; Kumarasinghe et al. 2009; Kumar et al. 2011; Senanayake et al. 2012; Palaniswami 2020).

Research on combating chilli leaf curl (CLC) is essential for understanding virus-vector-plant dynamics which aid in developing targeted control measures. It also enables the identification of resistant varieties which are vital for sustainable, pesticide-reduced crop production, and facilitates integrated management of CLC. Chilli farmers in Sri Lanka have predominantly relied on the application of insecticides as a primary strategy for controlling CLC leading to the indiscriminate and excessive application of these chemicals (Dharmasena 1998). As an alternative approach, investigation of eco-friendly management approaches is necessary and timely needed.

Previous research studies have evaluated various non-chemical strategies such as barrier crops (Udiarto et al. 2023), bio-pesticides (Madhusudhan and Vinayarani 2011; Mondal and Mondal 2012; Chaubey 2017) and integrated management (Riyaz et al. 2019; Rodríguez et al. 2019) demonstrating their potential to reduce the incidence of leaf curl viruses. In general, the presence of physical barriers limits the access of insects to the crop. However, the effect of border crops on the CLC complex in Sri Lanka is poorly studied. With the increasing popularity of the use of insect-proof nets in chilli cultivation among farmers, their effectiveness for protecting chilli crop from whiteflies has not been studied in Sri Lanka. Therefore, this study was conducted to evaluate the effectiveness of individual and combined use of physical barriers (maize crops and insect-proof net borders) in protecting chilli crop from insects and thus to reduce the disease incidence of chilli leaf curl complex.

2. Materials and Methods

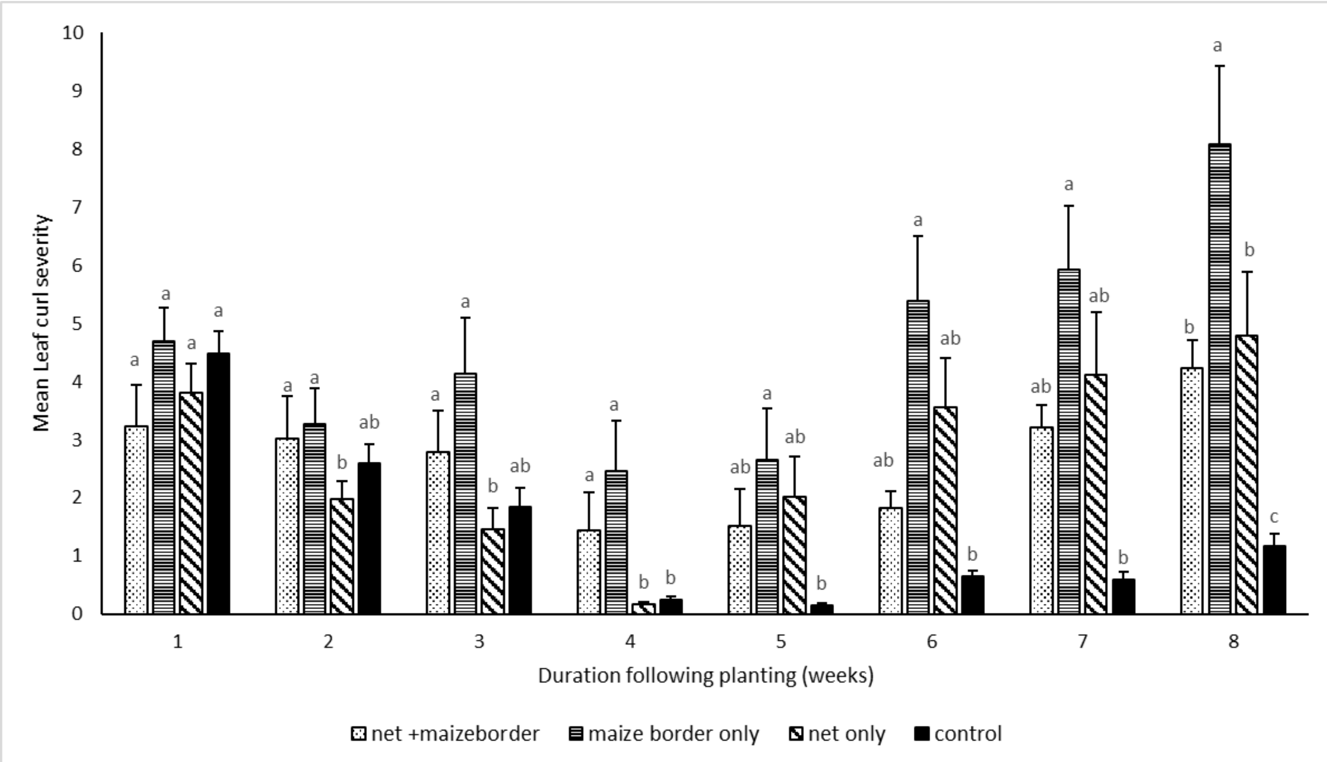
A field experiment was conducted at the farm field of the Faculty of Agriculture, Rajarata University of Sri Lanka, located in the agroecological zone DL1b. Throughout the experimental period, the site experienced an average temperature of 29±2°C and received approximately 500 mm rainfall. The experimental design included four types of physical barrier borders: an insect-proof net border encircled by three rows of maize; an insect-proof net border only; a border consisting of three rows of maize; control with no borders. These treatments were arranged in a randomized complete block design with three replicates. Twelve 4 m x 4 m beds were prepared and organized into four blocks. Within each block, plots were outlined with a 1.2 m gap between them to reduce potential for border overlap. Drainage canals were established surrounding each bed. Organic matter was added to the planting holes as 10 T ha^{-1}. In plots with insect-proof nets, the nets were positioned to form a height of 1 meter from the ground level. In plots with maize borders, three rows of maize were established following spacing 90 cm x 30 cm. Chilli seedlings of variety MI-2, aged 28 days, were transplanted in the plots with the spacing 50 cm x 40 cm.

The experimental plots were treated with NPK fertilizers at uniform rates: 320 kg of Urea, 100 kg of TSP, and 100 kg of MOP per hectare as per the recommendations of the Department of Agriculture in Sri Lanka (DOA 2016). Once the chilli crop was established, all plots were irrigated every two days until the crop reached the flowering stage. Hand weeding was done at 2, 4 and 6 weeks after transplanting. All other agronomic practices were carried out as per the DOA recommendations except for the application of insecticides (DOA 2016). The chilli leaf curl incidences were calculated using the method explained by Nene (1972). The populations of thrips and whiteflies were recorded at weekly intervals. Additionally, yield parameters such as number of pods per plant and weight of pods per plant were recorded for each replicate of treatment. Statistical analysis of the variations between the treatments was conducted using the ANOVA MIXED model procedure in SAS (SAS Institute, 2002–2008) with the LSD method used to distinguish the means at a 5% probability level.

3. Results and Discussion

The effect of different borders on the Chilli Leaf Curl incidence

There was a significant difference ($p<0.05$) among the treatments regarding disease incidence indicating that the physical barriers had a noticeable impact on reducing CLC disease. The treatment with an insect-proof net combined with a maize border exhibited the lowest disease incidence (Fig. 1).



For a given duration following planting, means followed by the same letter are not significantly different at P=0.05 according to LSD test following ANOVA.

Figure 1: The effect of different physical barriers along field borders on the chilli leaf curl incidences over time.

In general, the highest mean CLC incidence was recorded in the plots with the maize border only (5±0.44) while the lowest observed in the insect-proof net+maize border (2±0.45) and the control (2±0.47). Thus, the CLC incidence between the insect-proof net+maize border and the control were similar. The insect-proof net alone resulted in an incidence of 4±0.50 proving more effective than the maize crop border alone. By contrast, combination of insect-proof net+maize border reduced the CLC incidence significantly. The occurrences of CLC were high in the 1st, 2nd and 3rd week after planting and gradually decreased at 4th and 5th weeks after planting (Fig. 1). Further, the CLC severity significance levels were varied in different weeks after planting as shown in the figure 1. Sujay et al. (2015) also recorded lower CLC incidence after using boarder crops such as maize and sorghum in chilli cultivation. Anandam and Doraiswamy (2007) have shown that sorghum and sunflower can effectively be used as barrier crops in addition to maize.

The effect of different borders on the whitefly population

The whitefly populations differed significantly (*p<0.05*) among the treatments (Table 1). The treatment (*p=0.03*) and time (*p<.0001*) had a notable impact on the whitefly population. Among the various physical barriers, the control (no barrier) exhibited the lowest number of whiteflies. By contrast, 'Insect-proof net + Maize border' and 'Maize border only' had the highest whitefly population. The whitefly population when used the 'insect-proof net alone' showed an intermediate level of whitefly population. Ghosal and Sahu (2023) also noted that the CLC can be suppressed using insect-proof nets which can be effectively utilized in integrated pest management. This low population may be attributed to natural control mechanisms in the open plot and the wind blowing across the field reducing the whitefly population. This phenomenon is common in protected houses where sap-feeding insects can multiply rapidly following their entry. Sujayanand et al. (2016) reported that the whitefly population is lowered when maize is used as a border crop in okra cultivation.

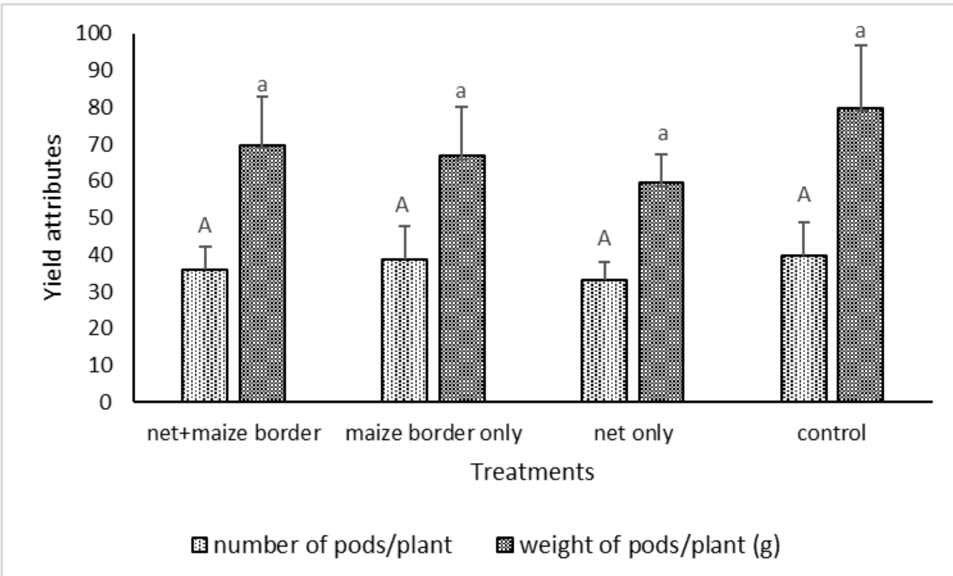
The effect of different borders on the thrips population

The thrips population did not vary significantly with the treatment (*p=0.54*) suggesting that the presence of physical barriers does not have a notable effect on thrips count. However, the thrips population varied significancy over the study period (*p=0.0001*). It may be that the mesh size of the insect-proof net is not sufficient to prevent thrips entering the cultivation. As Kandaswamy et al. (1990) showed 50% yield losses could be solely be caused by thrips. Thus, it is of high importance to find a viable solution to manage populations of thrips in chilli cultivation.

Table 1. The whitefly population (mean±SE) of the different borders

Treatment	Whitefly population per plant (Mean±SE)[a]
Insect-proof net + Maize border	2±0.14[a]
Maize border only	2±0.14[a]
Insect-proof net only	1±0.14[ab]
Control	0±0.16[b]

a. Means followed by the same letter are not significantly different at p=0.05 according to LSD test following ANOVA.



For a given treatment, yield attributes followed by the same uppercase or lowercase letter are not significantly different at P=0.05 according to LSD test following ANOVA.

Figure 2: The effect of different borders on the yield of chilli crop.

The effect of different borders on the crop yield

There was neither a significant difference in the number of pods per plant among the different treatments (*p=0.63*) nor was there a significant difference in pod yield per plant across the treatments (*p=0.46*). Although not differed significantly, apparently the control has the maximum number of pods and weight of the same per plant. On comparable basis, the 'maize border+insect-proof net' showed the second highest average number of pods per plant and average yield (weight of pods) (Fig. 2).

The borders are more effective when used in combination rather than used alone. However, the control (no physical barrier) also recorded high yield and low CLC incidences. In this study, the insect-proof nets were used only up to I m height which may not be sufficient to prevent whiteflies entering the plots. Therefore, it would be advisable to increase the height of the net to 2-3 m and investigate the effect of netting. Ghosal and Sahu (2023) highlighted that if this net is used up to 1.8 m, it can significantly reduce CLC incidence (only 11.52%). This border netting technology with border crops can be effectively used in IPM programs along with other practices.

4. Conclusions

Use of insect-proof nets in combination with maize borders than using them alone is more effective in reducing the chilli leaf curl complex as well as whitefly population. However, the size of the plot and the height of the borders influence their effectiveness. The findings provide valuable insights on using physical barriers as part of integrated pest management strategies for controlling leaf curl in chilli cultivation.

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Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

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