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EFFICACY OF ECOFRIENDLY MANAGEMENT PRACTICES AGAINST CHILLI (*Capsicumannuum L.*) LEAF CURL COMPLEX

C. Mulin Minoka, R.F. Niranjana*

Department of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka

Abstract. Chilli (*Capsicum annuum* L.) is an important cash crop of Sri Lanka and vulnerable to the Chilli leaf curl complex problem. The problem is serious to dry zone especially to the Batticaloa district of Sri Lanka. As the causal organism of this problem is virus, particularly difficult to control in open field due to the widespread presence, wide host range and population of white flies. Disease management may include vector control either directly by pest repellents, poisonous applied substance to the pest or indirectly by the natural balance in the chilli ecosystem. A questionnaire survey and field study were conducted at the Kaluthavallai, Batticaloa and Agronomy farm of the Eastern University Sri Lanka respectively during August to November 2017 to examine the leaf curl complex incidence at the Batticaloa district. The questionnaire survey revealed that PC1 was highly preferred chilli variety by the farmers at this area and used numerous applications of chemical pesticides to control the leaf curl complex. The field experiment was conducted to select best eco friendly management practices against leaf curl complex versus different chilli varieties viz., MI2, PC1, Galkiriyagama, KA2 and MICH3. It was concluded from the field study that cow urine was the best treatment against chilli leaf curl complex problem at the Batticaloa district.

Keywords: *Chilli varieties, Chilli leaf curl complex, cow urine, PC 1, eco-friendly management.*

****Corresponding Author:*** *R.F. Niranjana, Department of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka, e-mail: niranjanaf@esn.ac.lk*

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1. Introduction

Chilli native to southern North America and northern South America (Anon, 2018) is an important cash crop of Sri Lanka and cultivated with an average extent 14,100 ha per year (Anon, 2015). Batticaloa, a coastal district and the central part of Eastern Province of Sri Lanka, falls under the dry zone climatic conditions. Vegetable except up-country of Sri Lanka are being selling in the Batticaloa district are mainly grown in the villages of Batticaloa. Manmunai South and Eruvil Pattu Divisional Secretariat (DS) division is the predominantly vegetable cultivating area among the 14 DS divisions in the Batticaloa District and popular for chilli, onion, betel and vegetable cultivation. Kaluthavalai is the prominent village for chilli cultivation in Manmunai South and Eruvilpattu DS Division (Anon, 2013).

Such low yields in chilli cultivation in the Batticaloa district are mainly due to high incidences of pest and diseases, moisture stress, use of inferior quality seeds, poor crop management and high input costs. According to the information received from the chilli farmers in the Kaluthavalai area, the biotic stress condition mainly leaf curl complex (LCC) is the main reason behind the lower extent of cultivation and the poor yield levels reported in *yala* season in the Batticaloa district.

Chilli leaf curl was observed in Sri Lanka as early in 1938. In the early investigations, it was noted that the causal agent of chilli leaf curl in Sri Lanka was whitefly (*Bemisia tabaci*), which successfully transmitted the virus to chilli, tomato and tobacco, and the virus was named as vein clearing virus. Previously, begomoviruses were not known, but recently, several begomovirus species were reported to cause leaf curl in chilli (Senanayake *et al*., 2013; Senanayake *et al.,* 2012). Further it was reported by Senanayake *et al*., (2015) that the presence of thrips (*Scirtothrips dorsalis*), mites (*Hemi tarsonemus latus*) and chilli leaf curl Sri Lanka virus transmitted by whitefly (*Bemisia tabaci*) is the reason for Leaf Curl Disease Complex in chilli, which is the major factor of yield reduction in chilli.

Previous studies stated that the adaptation of farmers to the indiscriminate use of pesticides in protecting the crops from leaf curl disease has aggravated the problem (Dharmasena, 1998; 1994; Anon, 1994a; b). It is well aware that the drawbacks *viz*., environmental pollution, development of resistant biotypes in insect pests, health hazardous effect in human, etc. are associated with the indiscriminate use of pesticide. The present scenario thus necessitated the study of management practices through organics to save the environment from the adverse degradation. Thus the present study was conducted in combination with suitable eco-friendly management practices against chili leaf curl complex in order to evaluate its efficacy.

2. Materials and Methods

Questionnaire Survey

Kaluthavallai area in the Batticaloa district was selected to do a questionnaire surveyas chilli is highly cultivated by farmers in this area. Thirty farmers from Kaluthavallai, were randomly selected for questionnaire survey. The farmers were questioned to know, variety of chilli highly grown in this area, susceptibility of chilli variety to chilli leaf curl complex, management practices adapted by farmers, cultivating seasons, highly infested period, etc.

The population of whiteflies and natural enemies were also counted during the survey period from June to August 2018 fortnightly at the fields of selected chilli growing farmers at the study area to find the relationship with chemical insecticide application. From each selected farmer field 20 chilli crops were randomly selected to analyze population of whiteflies and natural enemies.

Preparation of Eco-friendly Bio-pesticides

a. Vermiwash

Vermiwash was collected from two vermiwash units prepared as per the setup described by Ecoscience Research Foundation, each with a 50 L plastic bucketfitted by a tap near the base. The lower most part of the buckets was filled up to 20 - 25 cm with broken bricks and pebbles with a layer of coarse sand (20 - 30 cm) above it. On the top of the sand layer around 25 cm layer of moist loamy soil was laid. The dried leaves of neem, *Azadirachta indica* and nochi, *Vitex negundo,* which has insecticidal properties in itsleaves, were laid each in one unit over the partially decomposed cow dung. Around 150-200 earthworms were released to each unit. Water was sprinkled on this unit overnight with the help of a perforated pot hovered above the unit. After two weeks, every morning the tap was opened to collect the vermiwash, which was diluted 10 times with water and it was used as treatment.

b. Vermicompost

Vermicomposting unit (Aalok *et al*., 2008) was established using plastic bin with 45 cm diameter and 40 cm height. The locally available earthworms were used for the purpose of vermicomposting preparation. Holes about 5mm in diameter were drilled around the upper and bottom of the bin to facilitate air circulation and drainage of excess water. Vermicompost was prepared using shredded paper as the bedding material and laid over the bottom of the bin after moistening. Small amount of dry leaves and high amount of fresh green leaves of gliricidia (*Gliricidia sepium*), neem and nochi were added over the shredded paper. A handful of soil from worms' original habitat and about sixty local earthworms were added. Water was sprinkled to the unit to keep them moist and the unit was placed in a cooled shady area. The product of vermicompost harvested after 90 days were used as treatment.

c. Neem leaf extract

The method described by Nahak and Sahu, (2014) was slightly modified to prepare aqueous neem leaf extract. As per it, one kilogram of ground neem leaves by motor and pistil was soaked in 1L of water in a mud pod. The pod containing neem leaves mixture was buried into the ground up to the neck of the pod after covering of mouth by cotton cloth for seven days. The methodology was repeated prior to each spraying.

d. Cow urine mixture

Cow urine was collected freshly at livestock farm of Eastern University Sri Lanka and diluted with water (1:1) before use it as treatment (Dharma *et al*., 2005).

3. Experimental Design

Five chilli varieties namely, PC1, MI2, MI-CH3, Galkiriyagama and KA2 and six management practices *viz*., vermicompost, vermiwash, neem leaf extract, cow urine, Abamectin18g/l EC, which was selected by questionnaire survey and un-treated control were chosen to testify the efficacy.

The chilli varieties obtained from Department of Agriculture, Sri Lanka were raised in properly maintained nursery beds separately. The beds were prepared on north-south direction to obtain maximum solar radiation for seedlings.

Thirty days old well grown, healthy, free from pests and diseases and identical seedlings were selected from the nursery beds for field establishment. Selected seedlings from each chilli variety were planted in six plots, each with 2m x 2m dimensions along with 60cm x 60cm planting spacing. The treatments were laid out in the Factorial Randomized Complete Block Design (RCBD) with three replications. The chilli crops were maintained properly as per the recommendation given by the Department of Agriculture, Sri Lanka.

Application of Treatments

Except chemical insecticide, Abamectin18g/l EC other management practices were sprayed to the respective plots in weekly interval. The chemical insecticide was sprayed once the insect pests were observed at the respective plot. Untreated control plot was maintained without application of any management practices.

Parameters Measured

a. Population of whiteflies, Bemisia tabaci

Five plants were randomly selected from each treated and untreated plot to count the whitefly population. The numbers of nymphal and pupal whiteflies associated with each selected plant were counted by the cautious direct observation using 2x hand lens. The counting was done weekly interval especially the day prior to the spraying of eco-friendly management practices.

b. Population of natural enemies

The entire each plot was monitored to count the natural enemies *viz*., dragonflies, ladybird beetle (*Coccinella* sp.), spiders, etc. in weekly interval especially the day prior to the spraying of eco-friendly management practices.

c. Infested plants

Numbers of the infected plants by leaf curl disease were counted at weekly interval. Leaf curl infected plant percentage were calculated by following formula suggested by Nene, (1972):

$$\text{leaf curl infected plants percentage} = \frac{\text{Number of diseased plants}}{\text{total assessed plants}} \times 100$$

d. Yield

First picking of fruits was undertaken after three months of transplanting. At each picking yield was measured separately for each treated and un-treated plot.

Data Analysis

The data collected by questionnaire survey and field experiments were subjected SPSS (Statistical Package of Social Science) and PROC MIXED in SAS (two-factor ANOVA) respectively. Multiple comparisons were done on least square means. All the comparisons were considered significant when $p < 0.05$.

4. Results and Discussion

Occurrence of chilli leaf curl complex in the Batticaloa district

The data obtained from the questionnaire survey were analyzed for studying the details of the chilli varieties highly cultivated, its susceptibility to chilli leaf curl complex, cultivating seasons, farmers' management practices against it, highly infesting season, leaf curl complex disease incidence of the chilli and prevalence of whiteflies and natural enemies in the Batticaloa district.

The analysis stated that almost all the farmers at the study area have continuously been cultivating the chilli variety, PC1 as sole variety since last decade mainly during *yala* season. It was believed that the variety, PC1 was highly preferred by the consumers at the study area because of its pungency.

Further the study revealed that the incidence of chilli leaf curl complex disease was severe at the eastern region of Sri Lanka, which showed the susceptibility of PC1 to chilli leaf curl complex and it was recorded the presence of thrips, mite and whitefly with the infested chilli plants. Whiteflies are the vectors of chilli leaf curl Sri Lanka virus (a begomovirus), it was recently reported by Senanayake, (2012). The incidence of

leaf curl complex was serious during *yala* season, which is true that the piercing and sucking insects and mites can be promoted by dry weather conditions (Potai & Chandrakar, 2018).

It was noted from the survey that around 66% of the farmers were applying chemical insecticides 22 times during the cropping season and 90% of the farmers were not rely on the recommended dosage. The survey also revealed that 89% of the farmers harvested the produce before the recommended pre harvest interval. As a whole the study evidenced the reluctance of farmers at the eastern region of Sri Lanka to the recommended rules in chemical insecticide usage.

The statistical analysis on the population of whiteflies and natural enemies against the frequency of chemical insecticide application showed a positive($r=0.698$, $p<0.05$) and negative ($r=-0.686$, $p<0.01$) relationship respectively. Gill and Garg, (2014) reported that pesticides could adversely affect natural enemies' behavior and their life-history parameters including growth rate, development time and other reproductive functions.

Efficacy of management practices against chilli leaf curl complex

a. Whitefly population

According to the study, numbers of the whitefly were lowest at two days before first application. Significant difference was not gained among the management practices and varieties. There was no interaction ($p=0.9144$) at the data of two days before first application of management practices. This might be occurred because up to two weeks after transplanting all agronomic practices were managed in the same way.

However once after the aging of plants the numbers of whiteflies trapped were varied significantly with the management practices (Table 1). The numbers of whiteflies increased in all treated and untreated plots. Interaction was occurred between the management practices and varieties.

The study revealed that numbers of whiteflies increased along with the cultivation period. It was observed from the study that almost all the treatments effective in controlling the whiteflies. However cow urine was par with Abamectin18g/l EC in controlling the population of whiteflies. Apart from the variety, maximum numbers of whiteflies were observed in untreated control plots. However, fluctuation in the level of population was noted throughout the cropping season might be due to the presence of the natural enemies or influence by other factors such as weather, plant vigor, surrounding vegetation as well as wind. The association of low numbers of whiteflies at the early stage of crop was too stated by Khalid et al., (2009).The authors reasoned that physiological condition of the plant for the increment of number of whitefly. It might be true because plant vigor provides some habitat and available feeding material to more number of whiteflies. Khalequzzaan et al., (2016) also revealed the maximum potency of cow urine against the vectors of leaf curl complex in chilli, which supported the present study.

b. Natural enemy population

In early days natural enemies normally present in high number when prey population are high in the field and keep the whitefly population declines towards the end of cropping season. However, the ecological balance was now collapsed by the man-made activities (Ngin *et al*., 2017). The study evidenced the destruction of natural enemies by the farmer spraying insecticide (Abamectin18g/l EC) in chilli cultivation.

Table 1 shows significant variation in the natural enemy population among different management practices treated plots. However maximum numbers of natural enemies were recorded in untreated control plot, which was statistically equivalent to vermi compost, vermi wash and cow urine treated plots. Though higher population of natural enemies *viz*., Coccinellid beetle, spiders, dragonflies were noted at the untreated plots, the population of whiteflies too greater in these untreated plots. It might due to the reasons that whiteflies are non-host for these natural enemies or migration of whiteflies from adjacent treated plots or distraction of feeding behavior of natural enemies by the chemical application to the adjacent plots (Lu *et al*., 2015).

Table 1. Pooled mean population of whiteflies and natural enemies, percentage of infested plants and yield in different treated and untreated plots

Chilli varieties	Management practices	Number of whiteflies per plant*	Number of natural enemies per $4m^{2*}$	Percentage of infested plants*	Yield (weight of the fruits (g) per plant)*
PC1	Vermi compost	8.9^{efghi}	4.4^{abcd}	82.3^{c}	153.7^{f}
	Vermi wash	9.2^{fghi}	4.1^{abcde}	73.8^{c}	158.0^{e}
	Abamectin18g/l EC	3.2^{a}	2.1^{defgh}	53.7^{b}	172.0^{c}
	Neem extract	8.7^{defghi}	3.5^{bcdfeg}	54.2^{b}	161.4^{d}
	Cow urine	3.9^{abcd}	4.6^{abcd}	31.3^{a}	176.2^{b}
	Un-treated control	15.8^{ij}	5.6^{abc}	98.5^{d}	130.0^{h}
MI2	Vermi compost	$9.2f^{ghi}$	3.8^{abcdef}	70.9^{c}	30.0^{p}
	Vermi wash	8.8^{defghi}	4.2^{abcde}	77.0^{c}	31.7^{o}
	Abamectin18g/l EC	4.1^{abcde}	1.7^{efgh}	51.4^{b}	35.7^{m}
	Neem extract	8.6^{defgh}	3.8^{abcdef}	63.6^{b}	28.7^{q}
	Cow urine	4.2^{abcdef}	4.2^{abcde}	27.6^{a}	37.3^{l}
	Un-treated control	18.2^{j}	5.8^{abc}	90.9^{d}	19.0^{s}
MICH3	Vermi compost	8.6^{defgh}	3.2^{cdefgh}	76.8^{c}	161.0^{d}
	Vermi wash	9.1^{efghi}	3.8^{abcdef}	66.2^{c}	160.3^{de}
	Abamectin18g/l EC	$4.8^{abcdefg}$	0.8^{h}	50.3^{b}	176.0^{b}
	Neem extract	7.8^{bcdefg}	4.1^{abcde}	57.0^{b}	161.7^{d}
	Cow urine	$5.1^{abcdefg}$	$3.4^{bcdefgh}$	35.5^{a}	181.0^{a}
	Un-treated control	15.1^{hij}	6.7^{a}	90.2^{d}	110.0^{j}
Galkiriyagama	Vermi compost	9.3^{fghi}	$3.7^{abcdefg}$	73.0^{c}	120.3^{i}
	Vermi wash	8.7^{defghi}	$3.6^{abcdefg}$	71.0^{c}	121.0^{i}
	Abamectin18g/l EC	3.3^{ab}	1.8^{fgh}	50.9^{b}	144.0^{g}
	Neem extract	8.2^{cdefgh}	4.5^{abcd}	60.2^{b}	120.0^{i}
	Cow urine	3.6^{abc}	3.1^{cdefgh}	37.3^{a}	146.0^{g}
	Un-treated control	17.3^{j}	6.1^{abc}	91.1^{d}	91.0^{k}
KA2	Vermi compost	9.5^{ghi}	4.4^{abcd}	73.5^{c}	31.0^{op}
	Vermi wash	8.1^{cdefg}	$3.3^{bcdefgh}$	65.6^{c}	31.5^{o}
	Abamectin18g/l EC	4.2^{abcdef}	1.2^{gh}	42.7^{b}	34.3^{n}
	Neem extract	8.3^{cdefgh}	3.8^{abcdef}	50.1^{b}	30.0^{p}
	Cow urine	3.2^{a}	$3.7^{abcdefg}$	27.4^{a}	36.3^{lm}
	Un-treated control	16.1^{j}	6.3^{ab}	91.3^{d}	21.0^{r}

Values are the average of 12 observations of 3 replicates.
Values are transferred to square root ($\sqrt{(X+0.5)}$) and arcsine transformations.
In each column, means with similar alphabets do not vary significantly at P=0.05 and P=0.01 by DMRT.

c. Infested chilli plants

Table 1 reveals that there was significant variation among the management practices. But among the varieties no any significant variation and no interaction effect between the management practices and varieties. The lowest leaf curl complex disease incidence was due to the cow urine than the other treatments. Highest leaf curl complex

disease incidences were noted in the untreated control plots. Some other management practices *viz*., vermiwash, vermicompost and neem extract reduced the leaf curl incidences to a certain level than the untreated control. According to the leaf curl disease incidence data cow urine was the best management practice among the tested management practices because it act as strong pest repellent (Mallapur & Lingappa, 2005; Anon, 2000).

d. Yield of chilli

The study showed that there was significant difference among the treatments in obtained yield (Table 1). Apart from the treatments high yield were recorded in PC1,MICH3 and Galkiriyagama than other tested varieties, MI2 and KA2. Varietal adaptability to the study area may be the reason for this finding.

This study highlighted the maximum yield at cow urine treated with MICH3 (181g per plant), PC 1 (176.2g per plant) and Galkiriyagama (146 g per plant) chilli varieties followed by Abamectin18g/l EC treated with MICH3 (176 g per plant), PC 1 (172g per plant) and Galkiriyagama (144 g per plant).

Though Abamectin18g/l EC is the derivative of soil bacterium, by comparing the hazardous effect to environment the cow urine can be recommended to chilli leaf curl complex problem in chilli cultivation.

5. Conclusion

The study revealed that chilli leaf curl complex might be controlled by management practices and varietal selection. The study evidenced that the chilli variety PC1 was highly preferred by the farmers at Kaluthavallai area of the Batticaloa district of Sri Lanka. Further it was noted from the study that farmers used to control the leaf curl complex by the tremendous application of chemical pesticides.

It was concluded from the study that cow urine was the best treatment against chilli leaf curl complex problem at the Batticaloa district.

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