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Management of Chilli Leaf Curl Disease by Vector Control using New and Novel Insecticides

Mallikharjun Chirumella[1*], Mallikarjun Kenganal[1], Y. S. Amaresh[1], D. S. Ashwathnarayana[1] and Arunkumar Hosmani[2]

[1]Department of Plant Pathology, [2]Department of Agricultural Entomology, College of Agriculture, University of Agricultural Sciences, Raichur, India

**Corresponding author*

ABSTRACT

Chilli being the commercial cash horticultural crop considered as vegetable and spice crop growing across many states. India is the largest producer and exporter of the chilli and still demand is widening compared to production and supply. *Chilli leaf curl virus* is the major hurdle in its cultivation and its management is concentrated on effective vector management. The current study was undertaken to assess the efficacy of new and novel insecticide molecules along with bio-insecticides and organic amendments against leaf curl virus vector whitefly. Field experiment was conducted during the *rabi* 2019-2020. Among the different treatments imposed, minimum disease incidence of (14.05%) was recorded in the treatment T_6 involving seed treatment with cyantraniliprole 19.8 % + thiamethoxam 19.8 % FS and foliar spry of cyantraniliprole 10.26 OD, spinetoram 11.6 SC, spiromesifen 22.9 SC, diafenthiuron 50 WP and thiamethoxam 25 WG at 15 days interval starting from 20 days after transplanting of chilli in the main field. An integrated disease management module stood next in T_9 with disease incidence of 18.18 per cent, which was statically significant with other treatments. The control plot had reached highest (100%) disease incidence by 90 DAT and had lowest yield of 1.59q/ha. The maximum yield was obtained in T_6 (45.88 q/ha) followed by T_9 (43.00 q/ha). The highest cost benefit ratio of 4.25 was also recorded in T_6 followed by in T_9 (3.81) and lowest was in the untreated control plot (1.59). The results could be considered for field application as all the insecticide molecules found effective in T_6 are considered safer to environment with least impact. In addition, subsequent spray of different insecticides shall avoid the risk of developing resistance in the insects due to repeated use of same insecticide.

Keywords

Chilli, Leaf curl disease, Seed treatment, Foliar spray, Vector, Management

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Introduction

Chilli is a commercial cash crop as well as popular vegetable of tropical and subtropical regions around the world, belongs to genus *Capsicum* and family Solanaceae (Olmstead *et al.*, 2008). It is widely cultivated and most sought spice also. Originated in Mexico and is grown since 3500 B.C. Brought to the rest of the world by Christopher Columbus who discovered America in 1493 (Anonymous, 2020). In India, chilli was introduced by

Portuguese explorer Vasco-da-Gama in 1498 (Mehata, 2017). Indian chillies have been dominating international chilli market since many years; as a result, India has become world's largest producer, consumer and exporter of chilli to USA, Canada, UK, Saudi Arabia, Singapore, Malaysia, Germany, Japan, France, Europe, South Korea, Bangladesh, Sri Lanka and many countries across the world. Indian chilli is contributing 25 per cent of world's total production (Mehata, 2017).

Besides its traditional consumption as vegetable and spice, it is also used as condiment, sauce, pickle and in other value addition processes of food industries (Kumar and Rai, 2005). The intensity and pungency of chilli is mainly due to a naturally possessing capsaicin and other chemicals collectively known as capsaicinoids (Dorantes *et al.*, 2000). Oleoresin is another deep red colored, semi viscous liquid form compound extracted from dried red chillies. Chilli is also used as an analgesic in topical ointments, nasal sprays (Sinol-M) and dermal patches to relieve pain (Tiwary *et al.,* 2005).

Worldwide chilli is grown on an area of 20.20 Mha with production of 37.62 Mt respectively. India is leading the world in chilli production with 13.76 (36.57%) million tonnes per annum (Geetha and Selvarani, 2017).

Andhra Pradesh is the largest producer of chilli contributing 26 per cent of national production followed by Maharashtra (15%), Karnataka (11%), Orissa (11%) and Madhya Pradesh (7%). Rest of the states contributes 22 per cent of the total area under chilli (Peer *et al.*, 2020).

In Karnataka chilli is mainly produced in Ballari, Bagalkot, Belgaum, Dharwad, Gadag, Haveri, Koppal, Raichur, Shivamogga and Vijayapura districts contributing 14 per cent of the country's production. Though the area under chilli cultivation in Karnataka is more but, production is limping annually compared to other states owing to heavy pest and disease incidences and their poor management. Among them, Chilli Leaf Curl Disease (ChiLCD) caused by *Chilli leaf curl virus* (ChiLCV) transmitted by whitefly (*Bemisia tabaci*) does highest crop damaging than any other known factors.

Although nearly 65 viruses have been reported to infect chilli of which, *Chilli leaf curl virus* (ChiLCV) is infecting chilli throughout the world (Nigam *et al.,* 2015), causing an yield losses up to 80 per cent in India (Nigam *et al.*, 2015) and 60 to 75 per cent in Karnataka (Raju, 2010 and Sudhapatil, 2018).

The co-infection of virus, thrips, mites and whitefly is termed as chilli murda complex which is the most destructive disease of chilli in India (Zehra *et al.*, 2017).

Abundant vector populations, wide host range, emergence of new viral strains are contributing to increased incidence of chilli leaf curl disease. Prolonged dry spells, favorable weather conditions are favoring increased vector population buildup during the chilli growing season (Raju, 2010; Manjesh, 2018 and Sudhapatil, 2018) and hence, the disease is exponentially spreading annually.

In absence of host resistance against virus as well as vector, the ChiLCD management is solely reliant on its vector control. Whitefly being systemic in its feeding behavior transmits ChiLCV in semi-persistent manner. The current experiment is aimed to identify new, suitable and less hazardous chemical insecticide molecules for management of chilli leaf curl disease.

Materials and Methods

Experimental site and plants growing

A field experiment on chilli was conducted during *rabi* 2019-20 following randomized block design with three replications and eight different treatments at Agriculture Research Station, Kawadimatti surrounded by many chilli plots and is hot spot of chilli leaf curl disease. The treatments included seed treatment and foliar spraying of new insecticide molecules and bio agents in comparison with non treated check. Chilli seeds of Indam-5 hybrid were used for the experiment and treated as per treatments requirements. Seeds were sown in plastic cavity trays filled with sterilised coco peat, for control plot seedlings were raised without any seed treatment. All the trays were kept in insect proof net house and watered regularly. Thirty days old chilli seedlings were transplanted to main plot and each treatment plot of 4.8 m x 2.4 m size with 45 cm x 60 cm spacing was maintained. Recommended doses of fertilizer (N: P: K) and FYM were given at the rate of 100:60:50 kg/ha and 200 q/ha, respectively at main plot. The foliar application of insecticides was followed as per scheduled interval in different treatments. First foliar spay was applied at 20 days after transplanting and subsequent sprays at 15 days interval, total five sprays were given. The leaf curl disease incidence was recorded in each treatment at 15 days interval.

Treatment details

Treatment No	Treatment details
T1	Seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8% FS at 4 ml/kg seed
T2	$\mathbf{T_1}$+Cyantraniliprole 10.26 OD foliar spray at 1ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)
T3	$\mathbf{T_1}$+ Spinetoram 11.6 SC foliar spray at 0.5 ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)
T4	$\mathbf{T_1}$+ Spiromesifen 240 SC at 1.0ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)
T5	$\mathbf{T_1}$+ Diafenthiuron 50 WP at 1.0 g/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)
T6	$\mathbf{T_1}$ + $\mathbf{T_2}$ at 20DAT, $\mathbf{T_3}$ at 35 DAT, $\mathbf{T_4}$ at 50 DAT, $\mathbf{T_5}$ at 65 DAT+foliar application of Thiamethoxam 25WG at 1 ml/l.
T7	$\mathbf{T_1}$ + *Pseudomonas fluorescens* foliar spray at 5 g/l (5 sprays at an interval of 15 days, first spray at 20DAT).
T8	$\mathbf{T_1}$ + *Lecanicillium leccanii* foliar spray at 5 g/l (5 sprays at an interval of 15 days, first spray at 20 DAT).
T9	Seed Treatment with thiamethaxam at 25 % WG at 10 g/kg seeds - ST with *Trichoderma hazarianum* at 10 g/kg of seeds- Raising of seedlings under protected nursey (40 mesh nylon net) - seedling dip in *Pseudomonas fluorescens* at 5 g/l - soil application of neem cake at 1.0 q/acre or vermicompost 1.0 q/acre- installation of yellow sticky traps at 10/acre 20 DAT - foliar spray of cyanitriniliprole 10 SC at 1.0 ml/l at 20 and 40DAT - Acephate 90 SG at 1.0 g/l - foliar spray of fipronil 5SC at 1.0 ml/l (55DAT), difenthiuron 50 WP at 1.0 g/l (70DAT) - commercial neem insecticide (1500ppm) at 3.0 ml/l (85DAT) - *Pseudomonas fluorescens* at 5 g/l (95DAT) - Triazophos 40 EC at 2.0 ml/l (105DAT)- Micro nutrients (B,Mg,Zn) at 5 g/l (120DAT) - foliar spray of *Lecanicillium leccanii* at 2 g/l (130 DAT) - foliar spray of wettable Sulphur 80 WP at 2.5 g/l (145DAT) - Tolfenyprad 1 EC at 1.3 ml/l (155 DAT) - foliar spray of fenazaquin 10 EC at 2.0 ml/l (165DAT)
T10	Control

Experimental data recording

Disease incidence was observed in each plot by counting total number of plants as well as diseased plants. Per cent disease incidence was calculated using the below mentioned formula suggested by Nene (1972).

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of diseases plant}} \times 100$$

Per cent disease reduction was calculated by following formula

$$\text{Per cent disease reduction} = \frac{\text{C-T x 100}}{\text{C}}$$

Where,

C – Per cent disease incidence in untreated plants,

T – Per cent disease incidence in treated plants.

The green chilli fruits harvested from each treatment at different pickings were compiled and tabulated for analysis.

Economic analysis

The cost benefit ratio (B:C) over the control was worked out separately considering different treatment combination on the basis of existing prices of inputs, hired labour wages, market price of chilli fruit during the harvesting period. The per cent increase of yield in treatment over control was calculated from the following formula (Vanisree *et al.*, 2013).

Yield in treatment – Yield in control

$$\text{Per cent increase of yield in treatment over control} = \frac{\text{Yield in treatment – Yield in control}}{\text{Yield in control}} \times 100$$

The fruit yield was recorded during the entire crop season and converted to per hectare. Yield was estimated after final picking of fruits. Cost - benefit ratio was calculated by using formula as follows:

$$\text{Cost benefit ration} = \frac{\text{Gross returns } (ha^{-1})}{\text{Cost of cultivation } (ha^{-1})}$$

Results and Discussion

Effect of treatments on disease incidence

Observations recorded during the experiment indicated significant impact of treatments at reducing the chill leaf curl disease incidence. The leaf curl disease incidence recorded at 30, 45, 60, 75, 90, 105, 120 and 135 Days After Transplanting (DAT) are presented in Table 1. In general, all the treatment combinations had substantial positive effects on reducing the leaf curl disease over control.

Among the different treatments formulated on chilli involving combination of different interventions, lowest leaf curl disease incidence at crop maturity (135 DAT) was recorded in T_6 (14.05%) followed by treatment T_9 (18.18%). The treatments T_1, T_2, T_3, T_4, T_5, and T_8 recorded disease incidences of 33.63, 25.91, 22.33, 26.76, 23.67 and 63.67 per cent leaf curl disease incidence respectively. Maximum disease incidence was recorded in T_7 (68.33%) followed by T_8 (63.67%). Disease incidence in control check plot reached 100 per cent at 90 DAT.

Seed treatment with cyantraniliprole 19.8% + Thiamethoxam 19.8% FS had successfully prevented infestation of chilli seedlings during early growth stage as this practice was reported effective in preventing infestation of whitely in blackgram (Shobharani *et al.*, 2017) and cotton (Dandale *et al.*, 2001).

Table.1 Effect of different novel chemical molecules and IDM approach against Chilli leaf curl virus disease (*rabi* 2019-20)

Treatments	Per cent Disease incidence (%) at DAT							
	30	45	60	75	90	105	120	135
T_1-Seed treatment with cyantraniliprole 19.8% + Thiamethoxam 19.8% FS at 4 ml/kg seed	5.22 (13.20)	6.40 (14.64)	12.23 (20.44)	18.87 (25.71)	21.48 (27.57)	24.43 (29.57)	26.73 (31.11)	33.63 (35.42)
T_2- T_1+ cyantraniliprole 10.26 OD foliar spray at 1ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	3.93 (11.43)	5.10 (13.04)	8.47 (16.88)	13.53 (21.55)	15.73 (23.35)	19.00 (25.83)	24.10 (29.38)	25.91 (30.56)
T_3- T_1+ Spinetoram 11.6 SC foliar spray at 0.5 ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	3.22 (10.33)	4.35 (12.01)	6.39 (14.59)	12.04 (20.27)	14.74 (22.54)	17.64 (24.80)	19.67 (26.26)	22.33 (28.12)
T_4- T_1+ Spiromesifen 240 SC at 1.0ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	4.70 (12.51)	5.51 (13.55)	9.60 (18.02)	14.31 (19.34)	16.63 (24.04)	20.42 (26.84)	24.32 (29.53)	26.76 (31.13)
T_5- T_1+ Diafenthiuron 50 WP at 1.0 g/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	3.36 (10.53)	4.46 (12.18)	8.63 (17.05)	10.99 (19.34)	14.87 (22.65)	17.93 (25.03)	22.00 (27.95)	23.67 (29.07)
T_6- T_1 + T_2 at 20DAT, T_3 at 35 DAT, T_4 at 50 DAT, T_5 at 65 DAT+foliar application of Thiamethoxam 25WG at 1 ml/l.	1.20 (6.19)	2.09 (8.30)	4.02 (11.55)	7.48 (15.70)	9.49 (17.89)	12.40 (20.56)	12.98 (21.06)	14.05 (21.91)
T_7- T_1 + *Pseudomonas fluorescens* foliar spray at 5 g/l (5 sprays at an interval of 15 days, first spray at 20DAT).	5.90 (14.04)	6.68 (14.97)	14.47 (22.34)	19.30 (26.04)	22.03 (27.98)	38.17 (38.13)	59.67 (50.37)	68.33 (55.83)
T_8- T_1 + *Lecanicillium leccanii* foliar spray at 5 g/l (5 sprays at an interval of 15 days, first spray at 20 DAT).	4.91 (12.79)	6.07 (14.25)	11.43 (19.71)	15.43 (23.11)	17.76 (24.89)	35.00 (36.24)	50.33 (45.16)	63.67 (52.91)
T_9-Modifeid package of practices	2.14 (8.39)	3.32 (10.44)	7.02 (15.35)	10.44 (18.83)	12.73 (20.87)	15.12 (22.86)	15.80 (23.41)	18.18 (25.22)
T_{10}- (control)	9.67 (18.06)	33.30 (35.21)	71.00 (57.40)	94.32 (76.37)	100 (88.07)	100 (88.07)	100 (88.07)	100 (88.07)
SEm±	0.271	0.347	0.659	0.956	1.00	0.773	1.104	1.252
CD at 5%	0.813	1.04	1.97	2.87	3.01	2.31	3.3	3.75

*figures in parenthesis are arc sine converted values; DAT: Days after transplanting

Table.2 Cost-benefit analysis in management of Chilli leaf curl virus disease (ChiLCV) using novel fungicides, bio-agents and IDM module (*rabi* 2019-20)

Treatments	Dry chilli Yield (q/ha)	Cost of cultivation (Rs.) ha^{-1}	Gross returns (Rs.) ha^{-1}	Net returns (Rs.) ha^{-1}	B:C ratio
T_1-Seed treatment with cyantraniliprole 19.8% + Thiamethoxam 19.8% FS at 4 ml/kg seed	34.25	116079.74	393875.00	277795.26	3.39
T_2- T_1+ cyantraniliprole10.26 OD foliar spray at 1ml/l first spray at 20DAT and subsequent sprays at 15 days interval (5 sprays)	38.63	124829.74	444187.50	319357.76	3.56
T_3- T_1+ Spinetoram 11.6 SC foliar spray at 0.5 ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	40.50	124585.64	465750.83	341165.19	3.73
T_4- T_1+ Spiromesifen 240 SC at 1.0 ml/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	36.46	121980.71	419270.83	297290.12	3.44
T_5- T_1+ Diafenthiuron 50 WP at 1.0 g/l first spray at 20 DAT and subsequent sprays at 15 days interval (5 sprays)	38.63	120581.24	444187.50	323606.26	3.68
T_6- T_1 + T_2 at 20 DAT, T_3 at 35 DAT, T_4 at 50 DAT, T_5 at 65 DAT+foliar application of Thiamethoxam 25 WG at 1ml/l.	45.88	124083.98	527562.50	403478.52	4.25
T_7- T_1 + *Pseudomonas fluorescens* foliar spray at 5g/l (5 sprays at an interval of 15 days, first spray 20 DAT).	35.29	120187.18	405854.17	285666.99	3.38
T_8- T_1 + *Lecanicillium leccanii* foliar spray at 5 g/l (5 sprays at an interval of 15 days, first spray 20 DAT).	34.88	120387.73	401062.50	280674.77	3.33
T_9-Modifeid package of practices	43.00	129587.14	494500.00	364912.86	3.81
T_{10}- (control)	15.83	114347.28	182083.33	67736.05	1.59
SEm±	0.589				
CD at 5%	1.88				

The module T_9 performed well in reducing the chilli leaf curl with integrated management approach but was next to the chemical's intervention T_6. IPM modules are known for their reduced pesticide usage and integration of bio-pesticides and other pest control mechanisms (Basappa, 2009). In the current study also, IPM modules was found promising if sole use of chemical pesticides has to be withdrawn. The best performing treatment T_6 comprised seed treatment with cyantraniliprole 19.8 % + thiamethoxam 19.8 % FS and foliar spry of cyantraniliprole 10.26 OD, spinetoram 11.6 SC, spiromesifen 22.9 SC, diafenthiuron 50 WP and thiamethoxam 25 WG at 15 days interval. The foliar spray of different insecticides successively was most effective against the vectors of *Chill leaf curl virus* and other pests on chilli, the treatment could reduce the disease effectively and was highly promising compared to rest of the interventions. Since the frequent use of same chemical insecticide is found to induce resistance in the pests (Basappa, 2009), this chronological use of different insecticides in succession has no such apprehensions and is highly recommended.

Effect of treatments on marketable yield

The effect of different treatments on reducing leaf curl incidence showed similar trend in marketable dry chilli yield (Table 2). The treatment T_6 recorded the highest fruit yield of 45.88 q/ha followed by treatment T_9 which recorded 43.00q/ha dry chillies. The next best treatment was T_3 with an yield of 40.50 q/ha. The treatments consisting foliar spray with biocontrol agents *viz.*, T_7 and T_8 recorded 35.29 q/ha and 34.88 q/ha of dry chilli yield respectively. The lowest yield was recorded in the T_1 (34.25 q/ha). Control plot had lowest yield of 15.83 q/ha. The prophlytic application of insecticides significantly reduced the incidence of chilli leaf curl disease at all the stages resulting profuse growth of the crop and ultimately increased the marketable fruit yield compared to untreated control. On the other hand, susceptibility of the crop against chilli leaf curl disease in untreated control exhibited weak growth of the crop resulting very low yield. Such observations in chilli were noticed in earlier studies in chilli (Samanta *et. al*., 2017; Sundria and Singh, 2018) and cotton (Hemalatha *et al.,* 2019)

Cost benefit ratio of leaf curl disease management

Different treatments implemented had varying cost of cultivation ranging from Rs.114347.28/ha to Rs.129587.14/ha. Highest cost of cultivation (Rs.129587.14) was recorded in treatment T_9 and least cost of cultivation was found in treatment T_7 (Rs.120187.18) but the treatment recorded less yield compared to other treatments. In control cost of cultivation was Rs.114347.28.
Highest cost benefit ratio was recorded in T_6 (4.25) followed by T_9 (3.81). In control plot it was 1.59 (Table 2).

The present studies are in conformity with observations made by Hemalatha *et al.,* (2019) who recorded B:C ratio of 3.1 in application of diafenthurion 50WP against whitefly in cotton. Similarly, Matharu and Tanwar (2020), recorded the highest B:C ratio of 3.34 and 3.26 when spinetoram 11.7 SC and Diafenthurion 50 WP were applied in cotton against sucking pests.

The outcomes of the present study advocate sequential spray of different novel insecticide molecules which helps in minimizing the crop loss due to chilli leaf curl virus disease with reduced risk of developing insecticide resistance. All these novel molecules are eco-friendly and safe to beneficial insects with least impact on environment.

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