

Assessment of chilli leaf curl virus on chilli (*Capsicum annum L.*) it's management and role of environmental factors in disease incidence

Abstract

The present study was undertaken on "Study of chilli leaf curl virus on chilli (*Capsicum annum*) and their management" which is wide spread disease in chilli growing area. Chilli crop is infected by several fungi, bacteria, viruses and nematodes which cause severe yield losses. Among these factors leaf curl virus is a major threat in chilli production. Ten chilli cultivars namely ZH-927, GYPSY, Pusa Jawala, Surya Pariksha, Surya-31, MEENAM-(074), Mahy-Yasash, Disha, Pride and Arka Harita were screened under field conditions. Among them one cultivar ZH-927 was identified as resistant, 3 cultivars namely Surya Pariksha, Disha, Arka harita showed susceptible reaction. It was found that Imidacloprid and Acetamaprid were most effective in inhibiting the leaf curl disease incidence followed by Thiomethoxam, NSKE, Methyl demeton and dimethoate. The environmental factor maximum temperature was found to have a positive correlation with disease incidence. As the temperature increases, there is a corresponding increase in the incidence of the disease. Relative humidity was found as negatively significant in correlation with disease incidence when relative humidity increased then disease incidence will decrease and rainfall was found as negatively in significant with the disease incidence when rainfall increased then disease incidence will decrease.

Key words: Chilli, Leaf curl virus, Imidacloprid, Environment, Resistance (Please rewrite the abstract clearly as per reviewed article)

Introduction

Chilli (*Capsicum annum L.*), ~~generally known as pepper~~, is an important valuable spice crop belonging to the family *Solanaceae* and is a native to South America (Mexico) where it was cultivated around 6000 years ago and was brought to Asia during the 16th century by Portuguese navigators. Chilli ~~can be grown~~ best at temperature ranges from 20–30°C ~~temperature~~ but its growth and yield suffer when temperature exceeds 35°C or drops below 15°C for extended periods.

Chilli crop is infected by several fungi, bacteria, viruses and nematodes which cause severe yield losses. Among these biotic factors leaf curl virus is one of the a major threat in chilli production, ~~in case of severe infections~~ In severe Infestation, crop losses may reach up to 70 - 95% resulting in total crop failure (Kumar *et al.* 2006b). Chilli leaf curl virus (ChiLCV) belongs to ~~(Genus Begomoviruse and; Family Geminiviridae)~~ which has circular single stranded DNA genome ~~with~~ with associated with beta-satellites (Fauquet and Stanley, 2003) and transmitted by whitefly (*Bemesia tabaci*) in persistent - circulative manner. Main symptoms of disease include vein clearing, curling and puckering of leaves, stunting of plants, fruits remain small (Senanayake *et al.* 2012). The severity of disease depends on the population of whitefly that can rapidly disseminate viruses in field even when population is not appreciable, and causes severe crop ~~damage- loss~~ in susceptible plantings. The population dynamics of whitefly varies during different depends on seasons of the year because it is greatly influenced by atmospheric humidity, temperature and total rainfall (Horowitz, 1984). ~~Chilli leaf curl disease can be managed by the controlling the vector, growing of resistant varieties that~~

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~~provide long term and eco friendly control of viral disease of plants (Gomez et al. 2009). (Please clearly mention about your objective of study which problem you are going to address regarding this disease)~~

Materials and Method and Materials

The ~~investigation entitled 'Study of chilli leaf curl virus on chilli (*Capsicum annuum* L.) and their management'~~ experimental study of ChiLCV was carried out during Rabi season 2018-19 at Research field ~~of College of Agriculture, JNKVV, College of Agriculture~~ Tikamgarh (M.P.). Ten chilli cultivars viz. ZH-927, GYPSY, Pusa Jawala, Surya Pariksha, Surya -31, MEENAM-(074), Mahy-Yasash, Disha, Pride and Arka Harita were sown in nursery bed and transplanted in the main field 24 to 30 days after sowing to test the resistance of chilli genotypes against ~~chilli leaf curl complex disease ChiLCV~~. the experiment was carried out in **completely randomized block design** having 10 cultivars with three replications. ~~(Authours should ensure which type of statistical design they are following)~~

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The experimental field was prepared by plough thrice by cultivator followed by planking to make fine tilt and smooth surface. Standard management practices were followed as recommended. Screening was done based on ~~symptom observation with disease scale rating of the rating scale~~ 0-5 developed by Banerjee and Kalloo (1987). ~~The symptoms were observed at 30, 60, 90 and 120 days interval after transplanting to the main field. The percent disease incidence or disease severity among 10 plants of each row were selected randomly and disease response for each line were scored at 30 days, 60 days, 90 days and 120 days after transplanting on a symptom severity grade of 0-5 and the variable measured based on disease scoring was disease severity.~~

Looking for this an experiment was laid out in randomized block design (RBD) ~~(Authours should ensure that which type of statistical design they are following earlier it was mentioned as Completely Randomized Blocck design, here it mentioned as Randomized Blocck Design)~~ and a susceptible variety of chilli ~~namely~~ 'Pride' was transplanted in the field with the spacing of 50 × 40 cm. ~~Normal fertilizers doses and recommended~~ Standarded agronomical practices were adopted ~~throughout the cultivation~~. A total of six insecticides viz., Methyle dematon 25 EC @ 0.025%, Imidacloprid 17.8 SL @ 0.003%, Acetamaprid 20 SL @ 0.025%, Diamethoate 30 EC @ 0.5%, Thiamethoxam 70 WG @ 0.005% and Neem seed kernel extract @ 5% were tested against disease and all the treatments were applied as foliar spray. **Disease incidence and per cent decrease in disease over control was calculated with the help of following formula given by Vincent (1927).** ~~(highlighted text was not clear. Authours should ensure what they are going to really address here and please mention the formula which you are following/give standard formula which followed earlier by others)~~

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Result and Discussion

~~During the investigation a total ten no. of cultivars were screened gainst ChiLCV. This~~

screening trial revealed that only one ~~tested~~ cultivars (cultivar name) were found completely free from chilli leaf curl ~~complex-virus~~ infection. All the germplasm were found susceptible but some were found as moderate susceptible. ~~In this investigation a total of ten cultivars were screened.~~ Infected plants of chilli leaf curl virus developed small and leaf crinkle or abaxial and adaxial curling of leaf margin accompanied by puckering, thickening, swelling of veins and veinlets, reduction in leaf size, vein clearing and distortion, leaf malformation, and leaves some times may show enations on under surface.

The data ~~represented~~ in the Table 1 shows that the lowest severity percentage of leaf curl disease was recorded in the plot planted with chilli cultivar ZH-927 with 24.30 percent followed by GYPSY (F1 hybrid) (38.69%), Surya 31 (44.93%), MEENAM-074 (46.49%), Mahy yasash (49.83%), Surya pariksha (53.00%), Arka- Harita (56.23%), Disha (57.38), Pride (83.00%), Pusa Jawala (91.23%) percent respectively. As per the rating scale an examination of data presented in Table 1 indicate that, three cultivars viz. Surya pariksha, Disha and Arka-Harita were found as susceptible against leaf curl ~~complex-virus~~ and ~~three-four were cultivars~~ identified as moderate susceptible namely- MEENAM-074, Mahy yasash (hybrid), Surya 31 and GYPSY (F1 hybrid) and two cultivars namely Pusa jawala, ~~and Ppride were found-identified~~ as highly susceptible and only one ~~variety-cultivar~~ ZH-927 was found ~~as-to be~~ resistant. After this screening experiment it can be emphasized that ~~thisese~~ cultivars can be used for cultivation in Madhya Pradesh region with suitable management practices to reduce the leaf curl ~~virus~~ infection in chilli.

Screening results ~~of different chilli cultivar against chilli leaf curl virus are very cclearly indicatedive and it is clear that, there was some quantum ofone~~ chilli cultivars ~~that are is~~ least susceptible to chilli leaf curl virus and this finding will be helpful in chilli cultivation to the farmers. Muhammad *et al.* (2017) ~~had~~ earlier screened fourteen different chilli lines / varieties for their resistance/susceptibility towards ChiLCV in open field trials. Out of fourteen only two cultivars ~~such as~~ Hybrid-46 and Hot Queen were found moderately resistant and remaining ~~here-all are~~ found to be susceptible or highly susceptible. Similarly, Srivastava *et al.* (2017) recorded at the end of four seasons of screening trial, three lines namely DLS-Sel-10, WBC-Sel-5 and PBC-142 showed resistance against leaf curl disease. Mali *et al.* (2006) also identified two resistant cultivars namely HC-28 and HC-44 ~~under field condition~~. The promising resistance ~~sources-wassources (source name)~~ ~~were~~ also reported by Thakur *et al.* (2019). These identified lines can be used as source of resistance.

~~In contrast to fungicide treatment, obtained data were represented in Table 2. The findings of~~ ~~This study evaluated-mentioned~~ that, all the treatments were found significantly superior ~~to-over~~ untreated control. ~~Data-obtain-f~~From the Table 2, ~~it indicates~~ that, the lowest incidence of 33.33% was recorded in plot treated with Imidacloprid followed by Acetamaprid (37.50%), Thiomethoxam (39.72%), NSKE (41.83%), Methyl demeton (43.13%) and Dimethoate (45.17%). ~~The data show that~~ ~~The~~ highest percentage of disease incidence (61.46%) was recorded in untreated (control) plot.

Among the all management practices, the highest disease reduction percentage of chilli leaf curl virus was recorded in plot treated with Imidacloprid (45.76%) followed by Acetamaprid (38.98%), Thiomethoxam (35.37%), NSKE (31.93%), methyl demeton (29.82%) and Dimethoate, (26.50%) respectively.

In contrast to yield data the highest yield was observed under the plot treated with Imidacloprid (47.11 qha⁻¹) and moderate yield as (43.33 qha⁻¹) obtained from plot treated with Acetamaprid followed by Thiomethoxam with (40.55 qha⁻¹), NSKE (39.44 qha⁻¹), Methyl Demeton (32.66 qha⁻¹). The least yield was obtained from the plot treated with Diamethoate as (27.33 qha⁻¹) over control. The lowest yield was obtained from the untreated plot (control) as (16.24 qha⁻¹). Panday *et al.* (2010) reported that the plant seed extract as Neem Seed kernel extract (5%) was found to be most effective for reducing chilli leaf curl disease incidence (60%) while in chemical insecticides Imidacloprid 17.8 SL (0.003%) gave the highest per cent reduction in disease incidence of leaf curl (78.95%) over control. Similar results trend were also found obtained by Naveed *et al.* (2015). Kumar *et al.* (2017) evaluated efficacy of different newer insecticides viz., thiamethoxam 25 WG, imidacloprid 17.8 SL, acephate 20 SP, fipronil 5 SC, thiacloprid 240 SC and one conventional insecticide i.e. dimethoate 30 EC against *Bemisia tabaci* and revealed that thiamethoxam 25 WG @ 100g/ha was found most effective insecticide in reducing the population of whitefly.

The data presented in From Table 3 shows it was clearly understood that the disease incidence was significantly affected by environmental factors. The first leaf curl disease symptoms were observed from first week of January and in the week 1st the disease incidence was recorded as 14.17 percent which is increased highly with a variable increasing rate up to 92.50 percent at last weekend of the observation. The leaf curl disease was first observed in 1st week of January as standard meteorological week and Notably the disease incidence was raised in 2nd and 3rd week, then percent increase abruptly reduced abruptly on 4th week and slightly increased in 5th week which again gradually decreased from 6th to 8th week. At 9th week the rate of disease incidence was suddenly increase hiked from 3.33 to 11.67 percent and again reduced from 10 to 12 week with 5.83, 7.5 and 3.33 respectively. Again the incidence was suddenly increased from 3.33 to 11.67 % on 13 week and 11.67 to 12.50 % on 20th week, whereas lowest incidence rate increasing rate was found recorded in 7th week with 0.83 percent.

It was reveal from the data presented evident in from the Table 3, that, there is a significant positive correlation of temperature either minimum or maximum indicated by r-value r=0.94 and r=0.95 respectively. The maximum disease incidence was observed between 21.8 °C to 40.9 °C whereas lowest incidence was observed between 6.0 °C to 24.6 °C these data shows that, the incidence was increased along with temperature increase. The incidence was drastically decreased when rainfall occurred 2.2 mm on 4th week, 1.0 mm on 6th week and 3.2 mm on 7th week

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respectively. The disease incidence was recorded as 5.83% to 4.17%, 5% to 3.33 and 3.33% to 0.84% respectively, but disease incidence was slightly increased from 0.84% to 3.33% in the week 8th when rainfall decreased. (these lines are not clear, may authors can go through it clearly)

Thus, ~~the experiment~~ these experiments results clearly revealed that the disease incidence was directly influenced by the environmental factors ~~because of these environmental factors effects influence~~ the vector populations ~~which resulted in transmission of leaf curl~~ since it has been vector transmitted begomovirus. Similar studies were carried out by Likewise, Naveed et al. (2015) studied in the correlation between TLCV incidence on different lines/varieties and the environmental factors (temperature, relative humidity and rainfall). Furthermore, he explained thae the whitefly population was also correlated with the environmental factors. From hHis finding strongly supported that revealed that there is a strong positive and significant interaction in case of maximum and minimum temperature (8°C-32°C) and TLCV incidence but negative and significant interaction was observed in case of relative humidity and rainfall.

Conclusion

Chilli leaf curl ~~virus disease~~ is an important disease of chilli caused by chilli leaf curl virus (ChiLCV), and causes crop loss ~~all the continents of the world, in India it caused~~ up to 70 – 95 % ~~world wide. erop losses. In~~ The screening of 10 cultivars of chilli against ChiLCV, only one cultivar ZH – 927 was found ~~as to be resistant and remaining all are moderate to highly susceptibe. and 4 cultivars namely Surya –31, MEENAM (074), Mahy – Yasash and GYPSY was found as moderately suseceptible. In field, all the six systemic insecticides spray all the insecticides under study were significantly effective in controlling the disease incidence of ChiLCV ehilli leaf curl virus over control. The least percent incidence and highest yield was recorded for Imidacloprid, Which was significantly superior over all other treatments. The environmental factors like maximum and temperature, minimum temperature were found as to be significantly positive correlated with disease incidence, and while relative humidity, and rainfall was found as negatively significant in correlated ion~~ with disease incidence.

References

- Banerjee MK and Kalloo. 1987. Sources and inheritance of resistance to leaf curl virus in Lycopersicon. *Theoretical and Applied Genetics* 73: 707–710.
- Fauquet CM and Stanley J. 2003. Geminivirus classification and nomenclature: progress and problems. *Ann. Appl. Biol.* 142: 165–189.
- Gomez P, Hernandez AR, Moury B and Aranda M. 2009. Genetic resistance for the sustainable control of plant virus diseases, breeding, mechanisms and durability. *Eur. J. Pl. Pathol.* 125 (1): 1-22.
- Horowitz AR, Podoler H and Gerling D. 1984. Life table analysis of the tobacco whitefly *Bemisia tabaci* (Gennadius) in cotton fields in Israel. *Acta Oecologica-Oecologia Applicata*, v.5,

p.221233.

Kumar R, Kumar V, Kadiri S and Palicherla SR. 2017. Epidemiology and Diagnosis of Chilli leaf curl virus in Central India, a major chilli growing region. *Indian Phyto pathology*, 69: 61-64.

Mali PC, Kumar A and Verma SK. 2006. Screening of Chilli Cultivar against Leaf Curl Disease and their Biochemical Components. *Annals of Arid Zone* 45(1): 63-66.

Muhammad S, Hussain, Khalid N, Muhammad A. 2017. Susceptibility of chilli lines / varieties towards chilli leaf curl virus and its management through vector control. *Pakistan Journal of Phytopathology*, 29(1): 17- 22.

Naveed K, Imran M, Riaz A, Azeem M and Tahir MA. 2015. Impact of environmental factors on tomato leaf curl virus and Its management through plant extracts. *International Journal of African and Asian Studies* ISSN 2409-6938 An Vol.11.

Pandey SK, Mathur AC and Srivastava M. 2010. Management of Leaf Curl Disease of Chilli (*Capsicum annum L.*). *International Journal of Virology* 6(4): 246-250.

Senanayake DMJB, Varma A, Mandal B. 2012. Virus–vector Relationships, Host Range, Detection and Sequence Comparison of Chilli leaf curl virus Associated with an Epidemic of Leaf Curl Disease of Chilli in Jodhpur, India. *Journal of Phytopathology*. Volume 160.

Srivastava A, Mangal M, Saritha RK and Kalia P. 2017. Screening of chilli pepper (*Capsicum spp.*) lines for resistance to the begomoviruses causing chilli leaf curl disease in India. *Crop Protection* 100:177-185.

Thakur H, Jindal SK, Sharma A, Dhaliwal MS. 2019. A monogenic dominant resistance for leaf curl virus disease in chilli pepper (*Capsicum annum L.*). *Crop Protection* Volume 116, Pages 115-120.

Vincent JM. 1927. Distortion of fungal hyphae in the presence of certain inhibition. *Nature*, 159: 850.

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Table 1: Screening of chilli cultivars against chilli leaf curl virus Complex under field condition

S. No.	Name of Cultivars	Grade (0-5)	Percentage infection (%)	Severity Percentage (%)	Disease reactions
1.	ZH-927	2	6-25	24.30	R
2.	Gypsy (F1 hybrid)	3	26-50	38.69	MS
3.	Pusa jawala	5	>75	91.23	HS
4.	Surya pariksha	4	51-75	53.00	S
5.	Surya 31	3	26-50	44.93	MS
6.	MEENAM- 074	3	26-50	46.49	MS
7.	Mahy-yasash	3	26-50	49.83	MS
8.	Disha	4	51-75	57.38	S
9.	Pride	5	>75	83.00	HS
10.	Arka-Harita	4	51-75	56.23	S

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Table 2: Effect of chemical treatments on chilli leaf curl disease

S. No.	Name of treatments	Doses (%)	Disease Incidence (%)	PDC	Yield (qha ⁻¹)
1.	Methyl demeton 25EC	0.025	43.13*	29.82	32.66
2.	Imidacloprid 17.8SL	0.003	33.33	45.76	47.11
3.	Acetamaprid 20SL	0.025	37.50	38.98	43.33
4.	Diamethoate 30EC	0.5	45.17	26.50	27.33
5.	Thiomethoxam 70WG	0.005	39.72	35.37	40.55
6.	Neem seed kernel extract	5	41.83	31.93	39.44
7.	Control	-	61.46	-	16.24
	SEM±	-	1.41	-	2.90
	CD at 5%	-	8.71	-	8.44
	CV	-	13.87	-	14.25

If you are present this data as diagram format (e.g. bar diagram) it will be good. Try to avoid more number of tables.

Table 3: Effects of environmental factors on disease incidence

Standard weeks	Relative Humidity (%)	Rainfall (in mm)	Min Temp (°C)	Max. Temp (°C)	Disease incidence	Disease increase (%)
1	69.00	0.0	6.4	24.0	14.17	14.17
2	74.00	0.0	5.2	20.8	17.50	3.33
3	72.00	0.0	5.8	24.8	23.33	5.83
4	79.00	2.2	9.4	21.5	27.50	4.17
5	68.00	0.0	6.6	22.4	32.50	5.00
6	68.00	1.0	6.4	24.1	35.83	3.33
7	70.00	3.2	5.9	24.8	36.67	0.84
8	60.00	0.0	12.1	25.1	40.00	3.33
9	59.00	0.0	10.7	27.9	51.67	11.67
10	61.00	0.0	14.1	32.8	57.50	5.83
11	56.00	0.0	13.8	32.8	65.00	7.50
12	44.00	0.0	16.0	36.5	68.33	3.33
13	44.00	0.0	17.8	39.5	80.00	11.67
14	37.00	0.0	21.8	40.9	92.50	12.50
Correl.	-0.93	-0.25	0.94	0.95	-	-
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t cal.	-9.544	-0.932	9.544	10.539	-	-

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