



## Estimation of yield loss due to chilli leaf curl disease in chilli (*Capsicum annuum* L.) at different stages of the crop

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**ABSTRACT:** The yield loss assessment was done in chilli hybrids (Arka Meghana and Arka Khyati) against chilli leaf curl disease (ChiLCD) at Bengaluru, India. The ChiLCD infected plants were tagged at different stages of the crop from 20 to 60 days after transplanting on the onset of first appearance of the disease. The observations were recorded on different parameters such as plant height, number of branches, number of sub-branches, number of fruits per plant, number of unmarketable fruits, average ten fruit weight per plant, average ten fruit width per plant, average ten fruit length per plant, yield per plant in infected and healthy chilli plant on both the varieties. The analysis revealed that the fruit yield of chilli significantly was affected due to ChiLCD at different growth stages of the crop in both Arka Meghana and Arka Khyati. The highest (> 98%) per cent yield loss was recorded in the plants infested at 20 DAT while the lowest (< 43%) per cent yield loss was recorded in 60 DAT compared to healthy plants. The yield loss had gradually decreased when stage of infection progressed from 20 to 60 days after transplanting.

**Keywords:** Chilli, ChiLCD, leaf curl, symptoms, yield loss estimation

### INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important vegetable and spice crop grown across the tropical and subtropical regions of the world (Makari *et al.*, 2009). In India, green chilli is grown in an area of 3.6 lakh hectares with a production of 34.06 lakh tones (Anon, 2017). Major chilli producing states of India are Karnataka, Bihar, Chhattisgarh, Madhya Pradesh and Maharashtra, Andhra Pradesh, Telangana, West Bengal and Orissa. India is the largest producer and exporter of chilli in the world (Anonymous, 2017). In Karnataka, chilli is grown in all districts with an area of 0.44 lakh hectares and production of 6.35 lakh tones. Viral diseases are major threat for chilli production resulting in low fruit quality and quantity. More than 65 viral diseases have been reported to infect chilli worldwide (Devi *et al.*, 2020). Of these, eleven viruses are reported from India which include, *Cucumber mosaic virus* (CMV), *Chilli vein mottle virus* (ChiVMV), *Tobacco ring spot virus* (TRSV), *Potato virus X* (PVX), *Chilli leaf curl virus* (ChiLCV), *Tobacco leaf curl virus* (TbLCuV), *Potato virus Y* (PVY), *Pepper vein mottle virus* (PeVMV) and *Pepper vein bending virus* (PeVBV), *Capsicum chlorosis virus* (CaCV), *Chilli leaf curl virus* (ChiLCV),

*Chilli leaf curl India virus* (ChiLCINV), *Chilli leaf curl Velland virus* (ChiLCVV), *Tomato leaf curl Joydebpur virus* (ToLCJV) and *Tomato leaf curl New Delhi virus* (ToLCNDV) (Rajamanickam *et al.*, 2020; Vinoth Kumar *et al.*, 2015, Wahyuni *et al.*, 1992; Zehra *et al.*, 2017). Among these, CMV, ChiVMV and ChiLCV were reported to be more serious pathogens causing up to 100% yield loss in marketable fruits and sometimes resulting in abandoning the fields prior to harvest.

Chilli leaf curl disease was first recorded during 1960s in India (Mishra *et al.*, 1963; Dhanraj and Seth, 1968) and has been threatening the commercial cultivation of chilli in the country. The disease occurs at all the growth stages of the crop and characterized by the symptoms *viz.*, vein clearing, curling, puckering, distortion vein thickening, enation, boat shaped leaves with upward bending of leaf tips, blistering of inter-veinal areas and shortening of internodes (Arun Kumar, 2006). The amount of damage caused by disease depends on the stage of the crop at the time of infection. The plant infected at very early stage failed to produce flowers and plants infected at later stages compromised with the quality and quantity of the fruits produced (Senanayake *et al.*, 2007; Senanayake *et al.*, 2012). Hence, the present study was carried to

estimate the losses due to Chilli leaf curl virus disease at different stages of crop growth.

## MATERIALS AND METHODS

Field experiments were carried out at ICAR-Indian Institute of Horticultural Research (IIHR) farm at Hessaraghatta, Bengaluru, India to assess the yield losses in chilli due to chilli leaf curl disease infection during *khari*f, 2018. The crop was sown with a spacing of 25×40 cm in Randomized Block Design having plot size of 7×7 m using the cultivars Arka khyathi and Arka Meghana, which are susceptible to ChLCuD. For the entire crop period, care was taken to follow the all cultural practices as per package of practices developed by the ICAR-IIHR. Ten virus infected plants were tagged when initiation of first symptoms (Yellowing of emerging leaves) at 20, 30, 40, 50 and 60 DAT. Similarly, 10 healthy plants were also tagged as a control treatment. The observations were recorded on different parameters such as plant height, number of branches, number of sub-branches, number of marketable fruits, number of unmarketable fruits, fruit weight, fruit width, fruit length, yield per plant in both infected and healthy chilli plants. Yield loss was calculated on the basis of total weight of the fruits obtained from healthy plants and virus infected plants and expressed in terms of percentage according to the formula (Sastry and Singh, 1973) given below.

Yield of healthy plants – Yield of diseased plants

Per cent yield loss =  $\frac{\text{Yield of healthy plants} - \text{Yield of diseased plants}}{\text{Yield of healthy plants}} \times 100$

## RESULTS AND DISCUSSION

The data on estimation of yield losses in chilli at different stages of crop growth revealed that the plant height was affected at all the stages of ChLCuD infection. However, there was significant difference among the period at which the first symptoms were appeared starting from 20, 30, 40, 50 and 60 DAT. The maximum plant height (98.6 and 99cm) was recorded in the healthy plants of Arka Meghana and Arka Khyati and it was significantly superior to all the plants with symptoms at different days after infection (Tables 1 and 2) which was followed by 60 and 50 days after transplantation (DAT) with recorded height of 88.6-91 and 84.2-86.6cm in both hybrids Arka Meghana and Arka Khyati and lowest plant height was recorded in the plants infected at 20 DAT in both the hybrids.

The fruit yield of five plants was varying significantly at different days of first appearance of symptoms. The lesser fruit yields of 9.84, 151.0, 319.2, 399.2, 533.2 and

921.6 were recorded at 20, 30, 40, 50 and 60 days of first appearance symptoms when compared to highest seed yield of 372.2 g in healthy plants. Based on the fruit yield data, the yield loss was calculated and results varied from 98.93 to 42.14 per cent during the early days of first appearance symptoms. The highest loss was 98.93 per cent recorded when the crop was shown first appearance symptoms at 20 DAS and there after the loss reduced gradually from 83.61 to 42.14 per cent from 30 to 60 days after sowing (Table 1 and Fig. 2).

Similarly, the number of branches formed per plant was recorded at 20, 30, 40, 50 and 60 days of first appearance symptoms. It was observed that more number of main branches (7.2-7.8) was recorded in the plants where disease appeared at 50 and 60 DAT and healthy plants of Arka Meghana and Arka Khyati cultivars. Whereas the lowest number of branches (4.2) was recorded in the plants infected at 20 DAT in both the hybrids. The number of main branches decreased with early appearance of the disease in both Arka Meghana and Arka Khyati. With respect to the average number of fruits per plant was recorded at 20, 30, 40, 50 and 60 days of first appearance symptoms. More number of average fruits (262 - 261.8/plant) was recorded in healthy plants of both the hybrids (Table 1 and 2). The average number of 148-152.2 fruits per plant was recorded at 60 DAT (days after transplanting) in the diseased plants of Arka Meghana and Arka Khyati respectively, whereas 107.6 fruit per plant recorded at 50 DAT in both hybrids. The average less number of fruits per plant was recorded (54.8-85.8) in disease appeared at 30 and 40 DAT and the least average number of fruits per plant was recorded in plants where disease was recorded as early as 20 DAT in both hybrids. The average number of fruits per plant was less when the plants affected by leaf curl disease at early stage. The delay in the appearance of the disease will minimize the loss with respect to the number of fruits produced per plants.

The maximum number of unmarketable fruits (23.2-24.2) were observed in the plants where symptoms started as early as 30 DAT in Arka Meghana and Arka Khyati respectively (Tables 1 and 2). When there was delay in the appearance of disease from 30 to 60 DAT, there was reduction in the number of unmarketable fruits from 23.2 to 11.2 and 24.2 to 11.6 in Arka Meghana and Arka Khyati, respectively. At 60 DAT the unmarketable fruits were 11.2 in Arka Meghana and at 50 and 60 DAT 11.6-12.2 fruits in Arka Khyati. While less number (8-9.80) of unmarketable fruits were recorded in healthy plants. The number of unmarketable fruits was decreased when stage of infection increased from first appearance of symptoms at 20 to 60 DAT plants in both

Table 1. Yield parameters of chilli cv. Arka Meghana in relation to the stage of first Chi LCD appearance at different days after transplanting

Days after transplanting	Plant height (cm)	Number of main branches	Number of sub branches	Number of fruits per plant	Number of unmarketable fruits	Fruit weight (10 fruits) (g)	Fruit width (10 fruits) (mm)	Fruit length (10 fruits) (cm)	Yield (average of 5 plants) (g)	Yield loss (%)
20	40.4 <sup>d</sup>	4.2 <sup>c</sup>	9.2 <sup>c</sup>	4.75 <sup>f</sup>	4.4 <sup>d</sup>	1.72 <sup>f</sup>	0.82 <sup>d</sup>	3.38 <sup>d</sup>	9.82 <sup>f</sup>	98.90
30	61.8 <sup>c</sup>	5.2 <sup>bc</sup>	9.8 <sup>c</sup>	54.8 <sup>e</sup>	23.2 <sup>a</sup>	3.12 <sup>e</sup>	0.98 <sup>c</sup>	4.3 <sup>cd</sup>	166 <sup>e</sup>	81.55
40	67.4 <sup>c</sup>	5.8 <sup>b</sup>	9.8 <sup>c</sup>	83.0 <sup>d</sup>	16.6 <sup>b</sup>	3.76 <sup>d</sup>	1.02 <sup>c</sup>	5.06 <sup>bc</sup>	300 <sup>d</sup>	66.66
50	84.2 <sup>b</sup>	7.2 <sup>a</sup>	12.6 <sup>b</sup>	107.6 <sup>c</sup>	16.4 <sup>b</sup>	4.2 <sup>c</sup>	1.3 <sup>b</sup>	5.58 <sup>ab</sup>	402 <sup>c</sup>	55.33
60	88.6 <sup>b</sup>	7.8 <sup>a</sup>	13.8 <sup>b</sup>	152.2 <sup>b</sup>	11.2 <sup>c</sup>	5.3 <sup>b</sup>	1.32 <sup>b</sup>	6.1 <sup>ab</sup>	532 <sup>b</sup>	40.88
Healthy	98.6 <sup>a</sup>	7.8 <sup>a</sup>	17.6 <sup>a</sup>	262 <sup>a</sup>	8.0 <sup>c</sup>	5.6 <sup>a</sup>	1.36 <sup>a</sup>	6.52 <sup>a</sup>	900 <sup>a</sup>	-
SEM±	14.6	0.35	0.76	1.98	1.41	0.6	0.3	0.38	17.57	-
CD (P=0.05)	4.99	1.0	2.2	5.8	4.1	0.19	0.09	1.1	51.5	-
CV (%)	11.76	9.64	10.89	3.1	18.38	8.44	13.52	12.93	7.92	-

Table 2. Yield parameters of chilli cv. Arka Khyathi in relation to the stage of first Chi LCD appearance at different days after transplanting

Days after transplanting	Plant height (cm)	Number of main branches	Number of sub branches	Number of fruits per plant	Number of unmarketable fruits	Fruit weight (10 fruits) (g)	Fruit width (10 fruits) (mm)	Fruit length (10 fruits) (cm)	Yield (average of 5 plants) (g)	Yield loss (%)
20	38.8 <sup>d</sup>	4.2 <sup>c</sup>	8.4 <sup>d</sup>	3.0 <sup>f</sup>	3.4 <sup>e</sup>	1.5 <sup>e</sup>	0.82 <sup>c</sup>	3.28 <sup>e</sup>	9.84 <sup>f</sup>	98.93
30	63.6 <sup>c</sup>	5.2 <sup>bc</sup>	10.8 <sup>c</sup>	54.2 <sup>e</sup>	24.2 <sup>a</sup>	3.24 <sup>d</sup>	1.00 <sup>bc</sup>	4.18 <sup>d</sup>	151.0 <sup>e</sup>	83.61
40	65.4 <sup>c</sup>	5.6 <sup>b</sup>	11.0 <sup>c</sup>	85.8 <sup>d</sup>	19.4 <sup>b</sup>	3.76 <sup>cd</sup>	1.06 <sup>abc</sup>	4.86 <sup>cd</sup>	319.2 <sup>d</sup>	65.36
50	86.6 <sup>b</sup>	7.6 <sup>a</sup>	11.8 <sup>c</sup>	107.6 <sup>c</sup>	12.2 <sup>c</sup>	4.46 <sup>bc</sup>	1.32 <sup>a</sup>	5.44 <sup>bc</sup>	399.2 <sup>c</sup>	56.68
60	91.0 <sup>ab</sup>	7.6 <sup>a</sup>	12.6 <sup>b</sup>	148.0 <sup>b</sup>	11.6 <sup>cd</sup>	5.12 <sup>ab</sup>	1.34 <sup>ab</sup>	5.92 <sup>ab</sup>	533.2 <sup>b</sup>	42.14
Healthy	99.0 <sup>a</sup>	7.6 <sup>a</sup>	17.6 <sup>a</sup>	261.8 <sup>a</sup>	9.8 <sup>d</sup>	5.68 <sup>a</sup>	1.38 <sup>a</sup>	6.58 <sup>a</sup>	921.6 <sup>a</sup>	-
SEM±	2.73	0.34	0.65	3.4	0.71	0.23	0.9	0.24	12.17	-
CD (P=0.05)	8.0	1.0	1.9	10.0	2.1	0.7	0.3	0.7	35.7	-
CV (%)	6.43	9.24	9.17	5.36	9.09	10.24	14.25	8.36	5.34	-

the varieties. In 20 DAT, plants recorded the highest percentage of unmarketable fruits followed by 30 DAT plants in Arka Meghana and Arka Khyati respectively. Similarly healthy chilli plots recorded more fruit weight (5.6-5.68g) in both the varieties and it was on par with 60 DAT in Arka Khyati. At 30, 40 and 50 DAT recorded moderate fruit weight *i.e.*, 3.12-4.46 in both the cultivars. Whereas in the plots infected after 20 DAT recorded less than 2g of fruit weight in both the cultivars. Whereas the lowest fruit weight per plant was recorded at 20 DAT in both the varieties (Table 1 and 2). The fruit weight was increased when stage of infection increased from first appearance of symptoms at 20 to 60 DAT plants in both the varieties. Similar trend was observed with respect to fruit width and fruit length *i.e.*, highest fruit length and width was recorded in healthy plants, while lowest was recorded in the plants infected after 20 DAT (Table 1 and 2). The fruit width was increased when stage of infection increased from first appearance of symptoms at 20 to 60 DAT plants.

The highest yield per plant of 900-921.6 g was recorded in the healthy plants of Arka Meghana and Arka Khyati cultivars respectively. It was significantly superior to rest of the parameters at different infection stages, followed by 60 DAT (532-533.2g). At 50 DAT the fruit yield was 402 and 399.2g in Arka Meghana and Arka Khyati respectively. The fruit yield at 40 DAT in both the varieties was 300-319.2g. The lowest (9.82-9.84g) yield was recorded in the plants infected at 20 DAT (Tables 1 and 2). The yield had gradually increased when stage of infection advanced from 20 to 60 days after transplanting.

The literature survey showed that ToLCV infected plants produced very few fruits when infected within 20 days after planting and resulting up to 92.3 per cent yield loss in tomato and plants infected at 35-50 days after transplanting resulted in 23-74 per cent yield loss (Sastry and Singh, 1973). Similar in case of sunflower affected by sunflower leaf curl virus disease, significantly affected head diameter, 100gm seed weight, oil content depending on the growth stages at which first symptoms appears. In the plants, first appearance of symptoms at 30 DAS, the diameter of the head, 100gm seed weight, oil content and weight of seeds/ 10 heads were reduced to maximum extent as compared to healthy plants (Sinha and Chakrabarthi, 1978; Deepa *et al.*, 2015). Further they also showed that the plant height was reduced at all the stages of sunflower due to leaf curl disease infection. However, significant difference was observed when the first appearance of symptoms at 30 DAS or earlier (72.60 cm plant height) as compared to the first appearance

of symptoms at 45, 60, 75 and 90 DAS with 89.80 cm, 115.30 cm, 129.6 cm and 142.2 cm plant height respectively. Significant reduction in size of the head, 100 seed weight, oil content and weight of seeds/10 heads as compared to the healthy control plant (Deepa *et al.*, 2015). Simialry, Gopal and Upadhyaya (1991) reported that, early infection of peanut bud necrosis disease caused heavy reduction in dry pod yield, 100 seed weight, and shelling percentage compared to late infection in groundnut.

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