



## On-farm leaf curl disease management of chilli (*Capsicum annuum* L.)

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### Abstract

Chilli is an important vegetable and condiment used widely in Indian food preparations. Chilli leaf curl caused by chilli leaf curl virus transmitted by whiteflies is one of the major limiting factors in cultivation of the crop. Two different integrated disease management practices were compared with regular farmer conventional practices (sole reliance upon chemicals). Field experiments were conducted for the disease management of leaf curl in chilli including seed treatment with imidacloprid 17.8% at the rate 3 g kg<sup>-1</sup> of seed, seedling treatment with imidacloprid 17.8% at the rate 0.3 ml l<sup>-1</sup> of water for 30 minutes and destruction of infested plants and foliar sprays of imidacloprid at the rate 0.3 ml l<sup>-1</sup> of water during two successive years i.e. 2012 and 2013. There was 41 to 74% protection, against disease incidence, observed over conventional practices based solely on use of chemicals. However, IDM practices fairly restricted the leaf curl index from 2.2 to 0.8 and an increased advantage 5.78 to 18.34% yield over farmers' practice. Number of foliar sprays of insecticides was also reduced to a great extent from 10 to 4. Besides, highest benefit cost (B:C) ratio 3.66 to 3.74 was recorded under integrated disease management practices against 3.04 to 3.09 under farmers' practice.

**Keywords:** Chilli, disease incidence, disease management, leaf curl and leaf curl index.

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## Introduction

Chilli (*Capsicum annuum* L.) is an important vegetable crop belongs to the family *Solanaceae*. It is widely cultivated throughout temperate, tropical and subtropical countries. Chilli is known for its pleasant aromatic flavour, pungency and high colouring substance. It is being used very widely in culinary, pharmaceutical, cosmetics and beverage industries throughout the world (Tiwary et al., 2005). It is also an important condiment used for imparting pungency and colour to the food being rich in vitamin C, A, B, oleoresin and red pigment. India is one of the major producers, exporters and consumers of chillies in the world. However, the average productivity is very low in comparison to other chilli growing countries. The chilli crop is infested by more than 21 insects and non-insect pests (Dey et al., 2001). Venkatesh et al. (1998) reported that chilli leaf curl was caused by leaf curl begomovirus (CLCV) transmitted by whitefly (*Bemesia tabaci*) and one of the major limiting factors in cultivation of the crop. Leaf curl virus in chilli has also been reported in India (Ravi, 1991; Muniyappa & Veeresh, 1984; Mishra et al., 1963). Earlier some workers have conducted studies on viral diseases on chilli considering the destructive nature, the extent of yield losses due to leaf curl ranged from 25 to 80% (Ilyas & Khan, 1996; Bidari, 1982; Gouda, 1979). Optimum temperature of disease development is 30 to 35°C and relative humidity was above 85%. Now, due to this disease of chilli, growers have switched over to some other profitable crops (Salane et al., 2006). The farmers engaged in cultivation of chilli always give priority to protect the crop from any type of damage caused by insects-pests and others. Pesticides are used as most commonly tool to combat these insect-

pests. The farmers often use huge quantity of pesticides to protect the crop without proper diagnosis which has led phytotoxicity on fruits (Joia et al., 2001), insecticide resistance, pest resurgence and environmental pollution (Singh & Kumar, 1998). Sharma (1998) also observed the integration of different components within integrated disease management (IDM) systems. In order to find out the major problem in cultivation of chilli, surveys were made by the Krishi Vigyan Kendra (KVK), Bhadohi (a unit of Indian Institute of Vegetable Research, Varanasi) to fields of chilli growers. Leaf curl disease of chilli came out as the major problem during cultivation. Here; the whitefly was the main causal agent to spread the leaf curl disease that is why, the management of vector had only taken into account for this study. Considering the seriousness of leaf curl and higher input of pesticides in successful cultivation of chilli; different management practices were assessed in comparison to farmers' practice to optimize the quality chilli production with an improved benefit cost ratio.

## Materials and methods

Field experiments were conducted for the disease management of leaf curl in chilli including seed and seedling treatment, destruction of infested plants and judicious use of insecticides at farmers' fields of district Bhadohi during 2012 and 2013. The percentage disease incidence, leaf curl index, yield and economics of production of chilli were studied.

**Location of the study:** It was located in between 82°56' east longitude and 25°40' north latitude. The weather was

hot and humid in summer and cold and dry in winter with an intervening rainy season. The temperature in this area throughout the year ranged between 5<sup>0</sup>C to 46<sup>0</sup>C and annual rainfall 1563 mm was reported.

**Field trials:** Field trials were conducted in two successive cropping seasons (2012 and 2013) at farmers' fields. Improved "*Capsicum annuum*" variety Kashi Anmol (developed from Indian Institute of Vegetable Research, Varanasi) was grown in the field to assess the integrated disease management practices. In order to carry out the experiment, seedlings were grown on raised beds in the first fortnight of June (June 1-15), 2012 and 2013. The seed bed was lightly irrigated regularly for ensuring proper growth and development of the seedlings. Thirty days old seedlings were transplanted in the second week of July, 2012 and 2013 with a distance between row to row and plant to plant 45 x 45 cm. All the agronomic practices were followed in similar manner under the technologies assessed. The destruction of infected plant parts by hand was initiated since the curling of leaf took place. The application of insecticides was done by back pack sprayer as and when necessary. The field trials were carried out in a randomized complete block design with five replications. The unit plot size was 12 x 7 m for each treatment where 415 seedlings were transplanted.

**Details of technology assessed against leaf curl:** Treatment-1 (T1): use of different insecticides viz., cypermethrin, profenophos, etc. seperately once in a week interval (Farmers' usual practice over the area of study). Treatment-2

(T2): destruction of infected plants + foliar spray of Imidacloprid 17.8% at the rate 0.3 ml l<sup>-1</sup> water. Treatment-3 (T3): seed treatment (Imidacloprid 17.8% at the rate 3 g kg<sup>-1</sup> seed) + Seedling treatment (Imidacloprid 17.8% at the rate 0.3 ml l<sup>-1</sup> water) for 30 minutes + destruction of infected plants + foliar spray of Imidacloprid 17.8% at the rate 0.3 ml l<sup>-1</sup> water.

**Data collection:** Five plants were selected randomly from the net plot area in each treatment and were tagged to record various observations at 30 days interval up to harvest/last picking from the day of transplanting. The percentage disease incidence was recorded under natural infection at random in different locations in the field by counting total number plants and number of plants showing leaf curl disease symptoms using the formula given below (Nene, 1972).

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased units}}{\text{Total assessed units}} \times 100$$

The leaf curl index (0-4 scale) was also recorded by visual ratings on five randomly selected plants in each plot. The ratings were recorded on terminal leaves (no curling=0, low curling=1(1 to 25% curling), moderate curling=2 (26 to 50% curling), heavy curling=3 (51 to 75% curling), and very high curling=4 (>75% curling)). The ratings were pooled and an overall rating was worked out (Niles, 1980).

**Statistical analysis:** The data collected from the experiments were subjected to Analysis of variance (ANOVA) for different treatments. Fisher's protected critical difference (CD) test was used to

indicate the difference between the treatments at the probability level of  $p < 0.05$  following the procedure as described by Gomez and Gomez (1984).

**Economic analysis:** The costs incurred on different parameters of agronomic practices viz., nursery management, preparation of land for transplantation, fertilizer application, water management, plant protection, harvesting etc. were pooled to analyse the cost of cultivation. Based on the current price of inputs used and the produce obtained during both years, the net profit  $ha^{-1}$  and benefit: cost (B: C) ratio were worked out using the following formula:

$$\text{Net profit (Rs. ha}^{-1}\text{)} = \text{Gross income (Rs. ha}^{-1}\text{)} - \text{Cost of cultivation (Rs. ha}^{-1}\text{)}.$$

$$\text{Benefit: cost ratio} = \frac{\text{Gross return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

## Results

Chilli leaf curl disease incidence during 2012 and 2013 is presented in Table 1. The leaf curl symptoms observed were curling of leaves, light and dark green mosaic, vein clearing, puckering of leaf lets, stunting and bushy appearance due to reduced internodal length with partial to complete sterility.

Table 1: Chilli leaf curl disease incidence percentages after tested treatments during 2012 and 2013 seasons.

Treatments	2012		2013	
	Mean per cent disease incidence	Per cent protection over farmers' practice	Mean per cent disease incidence	Per cent protection over farmers' practice
T1	21.6 <sup>a</sup>	-	18.3 <sup>a</sup>	-
T2	12.8 <sup>b</sup>	41.0	9.2 <sup>b</sup>	50.0
T3	6.2 <sup>c</sup>	71.0	4.8 <sup>c</sup>	74.0
CD (P=0.05)	2.382		1.70	
SEm±	1.03		0.74	

It is apparent from the Table 1 that all the three treatments varied significantly and the least 6.2% disease incidence was observed under T3 which was 71% protected the disease incidence over T1 (farmers' practice), however, T2 (12.8% disease incidence) protected 41% over T1 (21.6% disease incidence) during 2012. Similarly, all the three treatments significantly differed from each other during 2013. The leaf curl in farmers' practice exhibited 18.3%, destruction of infested plants and foliar sprays of insecticide exhibited 9.2% (protected 50% disease incidence over T1) and seed and seedling treatment followed by

destruction of infested plants and foliar sprays of insecticide showed 4.8% (protected 74% disease incidence over T1) disease incidence. Leaf curl indices (LCI) are presented in Tables 2 and 3 for the year 2012 and 2013, respectively. At 60 days after planting farmers' practice exhibited 1.6 LCI, T2 1.0 and T3 0.6 which was statistically non-significant with each other. At 90 days after planting farmers' practice (2.0) and T2 (1.8) both were not varied significantly, however, T3 exhibited 0.8 LCI which was significantly different from T1 and T2. Similar was the case at final pick stage where T3 showed 0.8 LCI which

was significantly different from T2 (1.8) and T1 (2.2) while T1 and T2 both were not differed significantly during 2012. Similar observations were recorded during 2013 where LCI at 60 days after planting farmers' practice (1.4), T2 (1.0) and T3 (0.4) were not found statistically superior with each other. At 90 days after

planting and at final pick stage farmers' practice and T2 showed non-significant LCI values 1.6, 1.6 and 2.0, 1.8, respectively. However, LCI values under T3 were 0.6 at 90 days after planting and 0.8 at final pick stage which differed significantly from farmers' practice and T2 at both the stages of observation.

Table 2: Chilli Leaf Curl Index (LCI) during 2012season.

Treatments	At 60 days after planting	At 90 days after planting	At final pick
T1	1.6	2.0 <sup>a</sup>	2.2 <sup>a</sup>
T2	1.0	1.8 <sup>a</sup>	1.8 <sup>a</sup>
T3	0.6	0.8 <sup>b</sup>	0.8 <sup>b</sup>
CD (P=0.05)	NS	0.82	0.46
SEm±	0.42	0.36	0.20

NS=Non significant

Table 3: Chilli Leaf Curl Index (LCI) during 2013 season.

Treatments	At 60 days after planting	At 90 days after planting	At final pick
T1	1.4	1.6 <sup>a</sup>	2.0 <sup>a</sup>
T2	1.0	1.6 <sup>a</sup>	1.8 <sup>a</sup>
T3	0.4	0.6 <sup>b</sup>	0.8 <sup>b</sup>
CD (P=0.05)	NS	0.60	0.57
SEm±	0.45	0.26	0.24

NS=Non significant

The highest yield (16.80 t ha<sup>-1</sup>) was observed under T3 with 10.52% gain over farmers' practice during 2012 and 17.68 t ha<sup>-1</sup> with 18.34% gain over farmers' practice during 2013 (Table 4). However, moderate yield as 16.08 t ha<sup>-1</sup> was obtained in T2 (5.78% gain over farmers' practice) and 16.49 t ha<sup>-1</sup> (10.37% gain over farmers' practice) during 2012 and 2013, respectively. The least yield was observed in farmer practice during both the years of study. The yield observed under all the three treatments differed significantly

with each other during both the years of study. The cost of cultivation was calculated by adding the costs incurred on different agronomic practices during the cultivation of chilli. The total cost was observed \$867.29 (farmers' practice) and \$809.91 (other than farmers' practice) per hectare during 2012. Similarly, during 2013 the total cost incurred per hectare on farmer practice was \$865.08 and \$834.04 on different management practices other than farmers' practice (Table 5).

Table 4: Average yield of chilli fruits.

Treatments	2012		2013	
	Mean yield (t ha <sup>-1</sup> )	Per cent gain over farmers' practice	Mean yield (t ha <sup>-1</sup> )	Per cent gain over farmers' practice
T1	15.20 <sup>c</sup>	-	14.94 <sup>c</sup>	-
T2	16.08 <sup>b</sup>	5.78	16.49 <sup>b</sup>	10.37
T3	16.80 <sup>a</sup>	10.52	17.68 <sup>a</sup>	18.34
CD (P=0.05)	0.44		0.19	
SEm±	0.19		0.08	

Total number of spraying of insecticides was observed 10 in farmers' practice and 4 each in T2 and T3 during 2012, however, 8 sprayings were applied in farmers' practice and 4 each

in T2 and T3 during 2013 (Table 5). The highest net return (\$2156.08 ha<sup>-1</sup>) and benefit cost (B:C) ratio (3.66) was observed in T3 during 2012.

Table 5: Assessment of economic parameters.

Treatments	No. of foliar sprays		Cost of production (\$ ha <sup>-1</sup> )		Total return (\$ ha <sup>-1</sup> )		Net return (\$ ha <sup>-1</sup> )		B:C ratio	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
T1	10	08	867.29	865.08	2683.52	2637.62	1816.23	1772.54	3.09	3.04
T2	04	04	809.91	834.04	2838.88	2911.27	2028.97	2077.23	3.51	3.49
T3	04	04	809.91	834.04	2966.00	3121.36	2156.08	2287.32	3.66	3.74

\*Flat rate of sale \$176.55 t<sup>-1</sup> during both the years.

The next highest net return was obtained as \$2018.97 ha<sup>-1</sup> and BC ratio 3.51 in T2 and \$1816.23 ha<sup>-1</sup> and BC ratio 3.09 in farmers' practice and similarly, highest net return \$2287.32 ha<sup>-1</sup> with BC ratio 3.74 in T3 followed by \$2077.23 ha<sup>-1</sup> with BC ratio 3.49 in T2 and \$1772.54 ha<sup>-1</sup> with BC ratio 3.04 in farmers' practice was recorded during 2013. The present investigation revealed that T3 not only reduced the number of application of pesticides to cut down the cost of production but also enhanced the yield of fruits with improved benefit cost ratio.

## Discussion

The leaf curl is one of the destructive diseases of chilli and symptoms observed by Vasudeva and Samraj (1948), Sastry and Singh (1973), Muniyappa (1980), Sakia and Muniyappa (1989) are in close resemblance in the experimental field.

The common symptoms were upward curling of leaves, light and dark green mosaic, vein clearing, puckering of leaf lets, stunting and bushy appearance of the plant. Chilli leaf curl symptoms showed abaxial and adaxial curling of leaves accompanied by puckering and blistering of interveinal areas and thickening and swelling of veins (Senanayake et al., 2006). These symptoms were identified and acquainted to the growers to monitor this destructive disease in preliminary stage of the crop. Venkatesh et al. (1998) reported that chilli leaf curl complex was caused by leaf curl begomovirus (CLCV) transmitted by whitefly (*Bemesia tabaci*). This vector is the major limiting factor in cultivation of the crop. Therefore, it is necessary to check the population level of vectors by different means (mechanical, biological, chemical, etc.) in such a manner that the

vectors could not damage the crop economically. The disease protection over farmers' practice might be due to the continuous exclusion of inoculum of disease from the fields and initial protection from seedling treatment with imidacloprid which kept the vector population at low level particularly at early stages of crop growth and showed low disease incidence. Seed and seedling treatment with imidacloprid, destruction of infected plants and foliar sprays of imidacloprid fairly restricted the leaf curl index might be due to check in population level of vectors causing leaf curl problem. Pandey et al. (2005) also revealed that the four diseases viz., damping off, bacterial blight, *Alternaria* blight and leaf curl of tomato were reduced to a great extent by following Integrated Disease Management (IDM) package comprising of biological, cultural, physical and need based use of chemicals. Maximum yields were obtained from the plots sprayed with imidacloprid, which were attributed to the lower LCI in these treatments. It might be due to that imidacloprid has strong local-systemic action and therefore once sprayed the molecule entered into the plant system acutely and then entered into the insect body through cell sap. It is also a matter of fact that a healthy plant (not having the viral disease symptoms) always yields better and also not serves as a source of inoculum of the disease. Pandey et al. (2010) also studied the management of leaf curl of chilli and observed that imidacloprid was most effective than other insecticides used in chilli. The present findings are also in accordance with the reports of Fugrro *et al.* (2005), Kumar and Bhansali (2005) and Salam (2005). In addition to yield,

economics is another important point to consider for the successful cultivation of any crop. The cost of cultivation was lesser in IDM practices in comparison to farmers' practice due to reduced number of sprayings of pesticides. Besides, vectors have least chance to develop the resistance against insecticide as well as the residue of chemicals on fruits. Hewson et al. (1998) stated that level of control and crop yield from IDM programme are often better than conventional method. It has also concluded that average yield in the IDM villages were better as compared to control in non-IDM villages and the average pesticide expenditure of IDM trained farmers was significantly lower than non-IDM farmers (Mondal & Mondal, 2012; Peshin & Kalra, 1997). Present investigation also showed the similar trends. Pandey et al. (2005) also studied the economic parameters similarly in reducing the disease incidence of tomato leaf curl and observed that the integration of disease management practices were quite economic. This integrated disease management practice also improved the stability of agro-ecosystem by curtailing the load and frequency of pesticides. Therefore, it may be concluded that if the growers adopt the leaf curl disease management strategy {seed treatment (Imidacloprid 17.8% at the rate 3 g kg<sup>-1</sup> seed) + Seedling treatment (Imidacloprid 17.8% at the rate 0.3 ml l<sup>-1</sup> water) for 30 minutes + destruction of infected plants + foliar spray of Imidacloprid 17.8% at the rate 0.3 ml l<sup>-1</sup> water}; the economic gain of chilli growers may be enhanced with an added advantage of lower exposure of pesticides to the agro-ecosystem.

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