



# Natural and Artificial Screening of Various Chilli Genotypes to Assess Resistance for Chilli Leaf Curl Virus under South Gujarat Conditions

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## Authors' contributions

This work was carried out in collaboration among all authors. Author TAP designed the study, managed the literature searches and wrote the first draft of the manuscript. Author DDC managed the literature searches, reviewed and edited the manuscript. Author AIP supervised the experiment and performed the statistical analysis. All authors read and approved the final manuscript.

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## ABSTRACT

**Aims:** The purpose of this work was to evaluate and identify chilli (*Capsicum annuum* L.) genotypes resistant to Chilli Leaf Curl Virus under natural and artificial screening circumstances, with an emphasis on their suitability for cultivation in south Gujarat.

**Study Design:** The investigation used a Randomised Complete Block Design (RCBD) with 25 chilli genotypes and 3 replications.

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**Place and Duration of Study:** The research was carried out during the winter season of 2024-2025 at Jarvi Seeds Pvt. Ltd. at Bharadia, Bharuch, Gujarat.

**Methodology:** 25 genotypes were examined in natural field circumstances and artificially inoculated with virulent whiteflies. Standard rating scales were used to assess disease incidence, severity and reaction. Data were statistically analysed to divide genotypes into resistance categories.

**Results:** The results showed that genotype responses varied significantly. Under natural screening, 2 genotypes - KSP 1234 Mithila and US 730 were highly resistant while, 20 genotypes were resistant and 3 genotypes were moderately resistant. Under artificial screening, only 3 genotypes - KSP 1234 Mithila, US 730 and US 1081 remained resistant, 16 genotypes showed moderate resistance and 6 genotypes became vulnerable. Disease pressure and reaction severity were often higher under artificial settings.

**Conclusion:** KSP 1234 Mithila and US 730 have been discovered as stable and long-lasting resistance sources. Artificial screening was more reliable in finding real resistance, providing useful insights for chilli leaf curl virus resistant genotype in Gujarat.

*Keywords: Chilli; disease reaction; disease severity; leaf curl virus and percent disease incidence.*

## 1. INTRODUCTION

The farming sector may be threatened by climate change linked to global warming since pest and disease outbreaks have a significant impact on vegetable productivity (Champaneri & Patel, 2022). Although vegetables constitute an essential component of every dietary plan and are crucial to both food and nutritional security, vegetable crops are a significant pillar of the agricultural industry. Because they offer vital minerals, vitamins and nutrients required for survival and the health of the human body system, vegetables are regarded as protective foods (Champaneri et al., 2024). In addition, the world's population may exceed 12 billion people by 2050, making it difficult for the farming industry to provide them with food and nutritional security (Champaneri et al., 2024).

One of the most important and extensively grown spice crops in India, both for local consumption and for export, is chilli (*Capsicum annum* L.) (Reddy et al., 2014). Although the crop is grown in a variety of agroclimatic zones, the main states that produce chillies are Andhra Pradesh, Telangana, Karnataka, Maharashtra and Gujarat. The horticulture economy of Gujarat depends heavily on chilli, especially in the southern districts where it is widely farmed for the markets for dried spices and fresh greens (Pundir et al., 2025). A vital source of income for small and marginal farmers, chilli farming is characterized by its high commercial value, versatility and ability to create jobs. But frequent viral disease outbreaks, particularly those caused by the chilli leaf curl virus, have become a significant production hindrance, frequently resulting in yield

losses of 80-100% in susceptible cultivars. Until during the previous decade, the primary control technique used against chilli leaf curl virus was the extensive use of pesticides targeting the vector whitefly. However, attempts are currently underway to create chilli leaf curl virus resistant chilli varieties/ F<sub>1</sub> hybrids suitable for commercial farming (Dangore et al., 2015). In order to maintain productivity and profitability in Gujarat's chilli-growing belts and throughout the nation, it is imperative to improve resistance to chilli leaf curl virus by identifying and implementing resistant genotypes.

Aiming to find the most appropriate and resilient genotypes for the area, the current study screened 25 chilli genotypes for resistance against the virus under both natural and artificial inoculation conditions in the context of south Gujarat, taking into account the importance of the chilli leaf curl virus as a major constraint in chilli cultivation.

## 2. MATERIALS AND METHODS

The experiment was carried out throughout the winter season of 2024-2025 at Jarvi Seeds Private Limited in Bharadia, Bharuch, Gujarat. It involved evaluating 25 chilli genotypes using a Randomized Complete Block Design (RCBD) with three replications. Seedlings were cultivated in pro trays and transplanted at a 60 cm x 45 cm spacing after 35 days. The study location and season have historically favoured whitefly population growth. All recommended agronomic strategies were followed during the trial. Virus incidence was measured at both the early and grand growth stages.

For artificial screening under mass inoculation circumstances, viruliferous whiteflies were housed on susceptible, symptomatic chilli plants in wooden cages wrapped in nylon netting. Adult whiteflies obtained from these plants were given a 48-hour Acquisition Access Period (AAP) on the chilli genotypes under study. Inoculation was performed at the three-leaf stage, with 10-12 viruliferous whiteflies per seedling and a 48-hour Inoculation Access Period (IAP). Following inoculation, the seedlings were replanted in open fields and disease incidence was reported.

Ten plants from every genotype for each replication were selected at random, tagged and all observations from the tagged plants were recorded throughout both natural and artificial screening.

## 2.1 Chilli Leaf Curl Index

The chilli leaf curl index was determined for each chilli genotypes based on the ratings using the scale of Kumar *et al.* (2006).

**Table 1. Indexing of chilli leaf curl virus**

Symptom severity grade	Symptoms	Reaction (%)	Category
0	No symptom	0	Immune
1	0-5% Curling and clearing of upper leaves	1 - 10	Highly Resistant
2	6-25% Curling, clearing of leaves and swelling of veins	11 - 25	Resistant
3	26-50% Curling, puckering and yellowing of leaves and swelling of veins	26 - 40	Moderately Resistant
4	51-75% leaf curling and stunted plant growth and blistering of internodes	41 - 60	Susceptible
5	>75% curling and deformed small leaves, stunted plant growth with small flowers and no or small fruit set	>60	Highly Susceptible

## 2.2 Percent Disease Incidence

The incidence of leaf curl virus was calculated by using the following formula developed by Kumar *et al.* (2006) and statistically analysed.

$$\text{Percent disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

## 2.3 Disease Severity

The severity of chilli leaf curl virus was calculated by using the following formula developed by Wheeler (1969) and statistically analysed.

$$\text{Diversity severity} = \frac{\sum \text{Disease class} \times \text{No. of plants in each class}}{\text{Total number of plants selected} \times \text{Maximum disease grade}} \times 100$$

## 2.4 Disease Reaction

Based on the genotype performance against leaf curl virus reaction, they were categorized into six categories by adopting the method of Reddy *et al.* (2001).

## 3. RESULTS AND DISCUSSION

Significant variation in the responses of 25 genotypes of chilli investigated for resistance to the chilli leaf curl virus under both natural and

artificial screening conditions is displayed in Tables 2-4.

## 3.1 Natural Screening

With disease severity scores of 9.00% and PDIs of 10.00% and 9.67%, respectively, 2 genotypes - US 730 and KSP 1234 Mithila showed the highest level of resistance under natural screening settings and were classified as highly resistant (HR).

20 genotypes in all were categorized as resistant (R), with PDI varying between 15.00% and 21.67%. This group's notable genotypes, which maintained low disease severity scores (12.00-18.00%), include US 1081 (17.67%), US 341 (18.00%), US 1003 (20.33%) and NS 2701 (16.00%).

Viraat, Sagar Kalyani and VNR Unnati were the three genotypes that shown moderate resistance (MR), with increased disease indices (32.33% to 37.33%) and severity (21.00% to 26.00%). According to Table 3, no genotype was identified as immune, sensitive, or highly susceptible in the natural environment.

### 3.2 Artificial Screening

In the majority of instances, a more severe disease response was seen under artificial inoculation. US 730 (15.33%), US 1081 (23.33%) and KSP 1234 Mithila (19.00%) were the only 3 genotypes that were still classified as resistant (R), despite having somewhat higher PDI and severity ratings than those obtained through spontaneous screening.

Mardani 1476, US 1003, US 341, Armour, Kranti and SVHA0786 were among the 16 genotypes classified as moderately resistant (MR); their disease severity ranged from 19.00% to 42.00% and their disease indices ranged from 26.67% to 41.33%. Increased disease pressure in the controlled environment is indicated by this change from resistance to moderate resistance under artificial conditions.

In contrast, 6 genotypes were identified as susceptible (S): Bangaram, Navtej, Viraat, Sagar Kalyani, SVHA2222 and VNR Unnati. Their severity ratings exceeded 43.00% and their PDIs ranged from 41.00% to 64.33%, showing poor tolerance under inoculation conditions (Table 4).

### 3.3 Comparative Analysis

The efficiency of artificial inoculation in identifying minute variations in resistance levels is demonstrated by the fact that, when comparing the two screening techniques, disease severity and PDI values were typically higher under artificial screening. Under artificial pressure, Bangaram and Navtej changed from resistant to susceptible, whereas some genotypes, such as US 1003 and US 341, deteriorated from resistant to moderately resistant. KSP 1234 Mithila and US 730, out of all the genotypes, continuously shown

high resistance under both screening conditions, making them attractive options for disease resistance initiatives aimed at reducing chilli leaf curl virus resistance.

### 3.4 Discussion

In line with earlier observations on diversity in chilli germplasm, the distinct responses of chilli genotypes to the chilli leaf curl virus under both natural and artificial screening circumstances demonstrate the substantial genetic variability in resistance (Palled et al., 2024; Kumar et al., 2019). These results are essential for locating reliable sources of resistance that can be successfully applied in upcoming disease resistance initiatives targeted at controlling viral illnesses in chillies (Mathur et al., 2019).

About 80% of genotypes showed resistance to moderately resistant reactions in natural field circumstances, suggesting that many commercial genotypes might be naturally tolerant of natural inoculum levels (Kumar et al., 2019). To distinguish genuinely resistant genotypes from those displaying environmental or tolerance-based resistance, however, the artificial screening setup-which applies consistent and high inoculum pressure through whitefly-mediated virus transmission-was more successful (Palled et al., 2024; Mopidevi et al., 2019). This pattern was also seen in previous research (Mathur et al., 2019), as evidenced by the continuously higher severity scores and Percent Disease Index (PDI) values obtained under fake screening.

It is noteworthy that KSP 1234 Mithila and US 730 exhibited minimal PDI and severity scores while maintaining high levels of resistance in both natural and artificial settings. This implies the existence of strong and consistent resistance mechanisms that may be connected to vector deterrence, hypersensitive response, or reduction of viral replication (Rai et al., 2014). For disease resistance initiatives, these genotypes consequently constitute important genetic resources, particularly in areas like south Gujarat where chilli leaf curl virus is endemic.

However, after artificial screening, a number of genotypes, including SVHA2222, Bangaram, Navtej and Viraat, which shown resistance in natural settings, were demoted to susceptible, most likely as a result of environment-dependent tolerance rather than actual genetic resistance (Koeda et al., 2021). The significance of

Table 2. Reaction of chilli genotypes screened against chilli leaf curl virus

Sr. No.	Genotypes	Company/Source	Natural screening			Artificial screening		
			Per cent disease index (%)	Disease severity (%)	Disease reaction	Per cent disease index (%)	Disease severity (%)	Disease reaction
1	US 730	Numhems Seeds	10.00	9.00	HR	15.33	13.00	R
2	US 1081	Numhems Seeds	17.67	13.00	R	23.33	21.00	R
3	US 341	Numhems Seeds	18.00	16.00	R	26.67	28.00	MR
4	US 1003	Numhems Seeds	20.33	12.00	R	31.33	29.00	MR
5	US 917	Numhems Seeds	17.33	18.00	R	27.67	31.00	MR
6	Armour	Numhems Seeds	18.00	15.00	R	38.67	42.00	MR
7	Kranti	Numhems Seeds	19.00	20.00	R	33.00	45.00	MR
8	Viraat	Numhems Seeds	32.33	21.00	MR	41.00	48.00	S
9	KSP 1234 Mithila	Kalash Seeds	9.67	9.00	HR	19.00	23.00	R
10	Bangaram	Kalash Seeds	20.67	13.00	R	41.33	55.00	S
11	Mardani 1476	Kalash Seeds	15.00	14.00	R	29.67	39.00	MR
12	KPS 1483 Albeli	Kalash Seeds	18.33	19.00	R	35.67	42.00	MR
13	Sitara - Seminis	Seminis Seeds	16.33	21.00	R	28.00	33.00	MR
14	SVHA2222	Seminis Seeds	36.00	24.00	R	45.00	39.00	S
15	SVHA0786	Seminis Seeds	18.00	14.00	R	34.67	23.00	MR
16	SVHA1049	Seminis Seeds	18.33	15.00	R	35.67	28.00	MR
17	VNR 305	VNR Seeds	17.67	14.00	R	31.00	28.00	MR
18	VNR Unnati	VNR Seeds	37.33	25.00	MR	62.67	60.00	S
19	NS 2701	Namdhari seeds	16.00	12.00	R	39.67	34.00	MR
20	NS 2572	Namdhari seeds	18.67	12.00	R	33.33	19.00	MR
21	HPH 5531	Syngenta Seeds	18.67	13.00	R	37.33	20.00	MR
22	KYI 189	Known You (India) Private Ltd.	16.67	13.00	R	29.00	19.00	MR
23	FB-JWALA	Farmson Biotech	17.67	15.00	R	31.33	23.00	MR
24	Sagar Kalyani	Sagar Seeds	35.00	26.00	MR	64.33	60.00	S
25	Navtej	MAHYCO Seeds	21.67	18.00	R	55.33	43.00	S
		<b>S.Em.±</b>	2.36	2.36		4.12	4.12	
		<b>C.D. at 5%</b>	6.78	6.78		13.10	13.10	

**Table 3. Categorization of chilli genotypes for resistance to chilli leaf curl virus based on virus symptoms under natural condition**

<b>Disease reaction</b>	<b>No. of genotypes</b>	<b>Genotypes</b>
Immune	00	-
Highly resistant	02	KSP 1234 Mithila and US 730
Resistant	20	Mardani 1476, NS 2701, Sitara - Seminis, KYI 189, US 917, US 1081, VNR 305, FB-JWALA, US 341, SVHA0786, Armour, KPS 1483 Albeli, SVHA1049, NS 2572, HPH 5531, Kranti, US 1003, Bangaram, Navtej and SVHA2222
Moderately resistant	03	Viraat, Sagar Kalyani and VNR Unnati
Susceptible	00	-
Highly susceptible	00	-

**Table 4. Categorization of chilli genotypes for resistance to chilli leaf curl virus based on virus symptoms under artificial condition**

<b>Disease reaction</b>	<b>No. of genotypes</b>	<b>Genotypes</b>
Immune	00	-
Highly resistant	00	-
Resistant	03	KSP 1234 Mithila, US 730 and US 1081
Moderately resistant	16	Mardani 1476, NS 2701, Sitara - Seminis, KYI 189, US 917, VNR 305, FB-JWALA, US 341, SVHA0786, Armour, KPS 1483 Albeli, SVHA1049, NS 2572, HPH 5531, Kranti and US 1003,
Susceptible	06	Bangaram, Navtej, Viraat, Sagar Kalyani, SVHA2222 and VNR Unnati
Highly susceptible	00	-

incorporating artificial inoculation techniques during genotype evaluation to guarantee the durability and dependability of disease resistance in pipelines is underscored by this instability under virus assault (Sirawata & Karcho, 2023).

## 5. CONCLUSION

The research revealed significant genetic heterogeneity across 25 chilli genotypes in response to the chilli leaf curl virus in both natural and artificial screening. KSP 1234 Mithila and US 730 consistently displayed high resistance in both scenarios. While several genotypes seemed resistant in the field, artificial screening revealed concealed sensitivity, highlighting the importance of controlled inoculation in genotype evaluation. Overall, the work sheds light on the resistance behaviour of commercial chilli genotypes and stresses the need of using stable and long-lasting resistance sources to limit the catastrophic impact of chilli leaf curl virus. The findings will help breeders, pathologists and farmers select appropriate genotypes for long-term chilli production, especially in virus-prone locations like south Gujarat.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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