International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664
Received: 25-05-2026, Accepted: 24-06-2026, Published: 09-07-2026
Volume 8, Issue 3, 2026, Page No. 46-50

Survey and incidence of Papaya leaf Curl Virus in Andhra Pradesh and Bengaluru

Chandana H R, Pradeep Manyam, P Arunasri, Rajashri Mandali
Department of Plant Pathology, ANGRAU, S.V Agricultural College, Tirupati, Andhra Pradesh, India

Abstract
A survey conducted, at the orchards of papaya at southern districts of Andhra Pradesh (AP) and Bengaluru, revealed that the incidence of papaya leaf curl virus ranged from 17.18-40.80% during September-October 2025. Maximum disease incidence of 40.80% was observed in Peddayekkalur village of Ananthapuram. The average disease incidence observed was 30.5% in AP and 27.1% in Bengaluru. Symptoms observed were severe inward and downward leaf curling. Twisted petiole, vein clearing and thickening. Leaf become leathery, brittle ad dark green. Reduced flowering, malformed fruits and defoliation observed in severe cases.

Keywords: Papaya leaf curl virus, Papaya, Andhra Pradesh, Bengaluru, disease incidence

Introduction

Papaya (*Carica papaya L.*) is one the economically significant fruit crop grows majorly in tropical and sub-tropical regions (Srivastava *et al*., 2024) [25]. Papaya fruits rich in vitamins such as A, C and E, minerals, antioxidants and digestive enzyme such as papain. In addition to fresh consumption, papaya is commercially important in juice processing, leather, cosmetic, pharmaceutical and food industries.

Papaya is believed to originated from Mexico and Central America and spread to several tropical and sub-tropical regions across the world. Papaya is cultivated in approximately 148.2 thousand hectares with an annual production of about 5.23 million metric tonnes in India and 13.04 thousand hectares and annual production of 0.9 million metric tonnes in year 2022 [22]-23 (Horticulture statistics unit, Department of Agriculture and Farmers Welfare, Government of India).

Papaya is subjected to various biotic and abiotic stresses. Abiotic stresses include drought, temperature fluctuations, salinity, and cold shock. Biotic stresses caused by fungal, bacterial, nematode, and viral pathogens. Among viral diseases Papaya ring spot virus (PRSV) is most destructive followed by Papaya leaf curl virus (PaLCuV), and Papaya mosaic virus (PMV) in India (Varun *et al*., 2017; Udavatha *et al*., 2023 and Priyanka *et al*., 2024) [12, 27, 29].

PaLCuV, a begomovirus belongs to the family geminiviridae and transmitted by whitefly (Wang *et al*., 2004; Zhang *et al*., 2010; Shahid *et al*., 2013; Priyanka *et al*., 2017 and Srivastava *et al*., 2022) [13, 18, 22, 30, 32]. Whiteflies transmit begomovirus by persistent and circulative manner. Papaya leaf curl disease first described by Thomas and Krishnaswamy in 1939, although the causal organism was identified later. PaLCuV is symptomatically characterized by severe downward and inward curling of leaves forming inverted cup like appearance. Infected leaves become leathery, brittle and dark green in appearance, twisted petiole and upper leaf surface raised due to hypertrophy. Infected plants also produce distorted flowers and malformed fruits (Saxena *et al*., 1998; Shahid *et al*., 2013; Varun *et al*., 2017; Saxena *et al*., 2023; Priyanka *et al*., 2024 and Srivastava *et al*., 2024) [4, 12, 18, 21, 29].

PaLCuV is either monopatite genome containing only DNA-A or bipartite genome containing both DNA-A and DNA-B. Monopartite genome usually associated with alpha and beta satellites. The genome of begomovirus of DNA-A contains six open reading frames (ORFs) arranged in two opposite transcriptional orientations, separated by an intergenic region (IR) (Nehra *et al*., 2019). Two virion sense ORF's include AV1 and AV2 and four complementary sense ORF's include AC1, AC2, AC3, and AC4. The AV1 gene encodes the coat protein responsible for encapsidation and vector transmission, while AV2 is involved in viral movement and suppression of host defense responses. Among the complementary-sense genes, AC1 encodes the replication-associated protein (Rep) essential for viral DNA replication, AC2 functions as a transcriptional activator protein and suppressor of gene silencing, AC3 enhances viral DNA replication, and AC4 plays a role in pathogenicity and suppression of host antiviral defense mechanisms (Reddy *et al*., 2010 and Priyanka *et al*., 2024) [12, 16].

The DNA-B component contains two genes arranged in opposite orientations: the Nuclear Shuttle Protein (NSP; BV1) and the Movement Protein (MP; BC1). NSP facilitates the transport of viral DNA from the nucleus to the cytoplasm, whereas MP mediates cell-to-cell movement through plasmodesmata, enabling systemic infection of the host plant.

Alpha satellites are not true satellites having circular ssDNA molecules, which are depend on the helper virus for its movement encapsidation and transmission and play role in symptoms attenuation and reducing the accumulation of beta satellite in the affected crop plants (Briddon *et al*., 2006) [5]. Beta satellite molecule encodes βC1 protein on the complementary-sense strand. The βC1 protein plays a crucial role in symptom development, pathogenicity, suppression of host defense responses, and enhancement of viral accumulation within infected plants (Varun and Saxena, 2018) [28].

Materials and methods

Survey for incidence and symptomatology of papaya leaf curl virus

A survey was conducted to record the incidence of Papaya leaf curl virus in major papaya growing regions of southern districts of Andhra Pradesh (Ananthapuram, Annamayya, Nandyal and Kurnool) and Karnataka (Bengaluru) during September-October 2025. In each field, 5 zones were selected randomly, covering minimum 20-30 plants and per cent disease incidence was calculated by using formula:

PDI=Total number of PaLCuV infected plants in field / Total number of plants (infected + healthy) in field 100

During survey, data was also recorded on symptom expression, hybrid, stage of crop, nearby crop, previous crop, weeds and management practices followed by farmers. PDI of other viruses namely PRSV and PMV was also calculated.

Results and Discussion

In surveyed districts of Andhra Pradesh, Papaya leaf curl disease incidence ranged from 17.18-40.80%. The highest disease incidence of 40.80% was recorded in Peddayekkalur village of Ananthapuram district followed by Akkampalli (Nandyal) of 38.24% and P. Kondapuram (Ananthapuram) of 38.72%, whereas lower disease incidence of 17.18% was observed in Turubali village of Annamayya district. The mean disease was 30.5 percent in Andhra Pradesh and 27.1% in Bengaluru, Karnataka (Table.1).

Symptoms of papaya leaf curl disease were observed in the form of severe leaf curling and crinkling. Severe downward and inward rolling forming inverted cup like appearance. Vein clearing, vein thickening and vein enations. Leaf become leathery, brittle and dark green in appearance. Petiole twisted in zig-zag manner. In severe cases, stunted growth, malformed fruit and defoliation occurs (Fig. 1 and 2).

Previous studies conducted in Uttar Pradesh by Singh *et al*. (2017) [19] recorded Disease incidence ranged from 13.00–32.00% during 2006–07 and 12.00–28.00% during 2007–08. In another study conducted in Uttar Pradesh by Dubey *et al*. (2015) [2], disease incidence ranged from 5% to 35% were recorded. In karnataka, disease incidence of papaya leaf curl ranged from 10-31% (Udavatha *et al*., 2023) [27].

Other than PaLCuV, PRSV (Papaya ring spot virus) and PMV (Papaya mosaic virus) was also observed virus diseases in papaya orchard during survey. Turubali village of Annamayya showed higher disease incidence for PRSV of 70.86% followed by Akkampalli (Nandyal) of 67% and Peddapolamada (Ananthpur) of 65.78%. Peddayekkalur village of Ananthpur district showed disease incidence for PMV of 50.40% followed by Thimmapura (Kurnool) of 43.00% and P. Kondapuram (Ananthapuram) of 40.70%. Disease incidence observed and calculated during survey for viral diseases indicate that PRSV has higher distribution across Andhra Pradesh followed by PaLCuV and PMV.

Survey results also indicated that, Red Lady 786 is widely grown in southern parts of Andhra Pradesh due to its high yield potential, early bearing of fruit and flowers, uniform fruit quality, fruit size and excellent fruit quality (Gunnannavar *et al*., 2017) [3]. It is highly susceptible to leaf curl virus may be due to lack of genetic resistance to begomovirus infection and its continuous cultivation led to higher susceptibility for different viruses due to adoptability.

In southern Andhra Pradesh, papaya seedlings usually plant during December to February (summer) which provide sufficient high temperature and humidity for whitefly multiplication and PaLCuD occurrence was observed severe during March– July. Our study observed that, papaya plantation in Andhra Pradesh surrounded by the crops like tomato, brinjal, cotton *etc* which acts as main host for whiteflies. When these main host crops are removed, whiteflies feed on nearby papaya plants and cause the disease. Dubey *et al*. (2015) [2] also reported that disease incidence was highest during March to June, indicating that seasonal environmental conditions and vector abundance play a crucial role in disease spread.

PaLCuV is also reported to be surrounded and propagated in other hosts: *Gossypium sp.* (Mansoor *et al*., 2003) [10], *R. capitata* (Ilyas *et al*., 2010) [6], *A. alpinus* (Srivastava *et al*., 2013) [23], *A. cruentus* (Srivastava *et al*., 2015), tomato (Raj *et al*., 2008) [15, 20], aster (Srivastava *et al*., 2013) [23], and tobacco (Kumar *et al*., 2009).

The presence of papaya leaf curl Guangdong virus on passion fruit was reported in Taiwan (Cheng *et al*., 2014) [1]. In other studies papaya leaf curl china virus was reported on three hosts, namely, *Corchoropsis tomentosa* (Haung and Zhou 2006) [5], *Sigesbeckia orientalis* (Yang *et al*. 2011), and tomato (Zhang *et al*. 2010) [31, 32] in China.

Our survey data also indicate that weeds like Parthenium, croton and Euphorbia were frequently observed in papaya orchard, which act as reservoir for whiteflies. When climatic circumstances are favorable and primary hosts are not available, weeds act as an alternate host and are crucial in maintaining the viral inoculums during the non-cropping season and spreading the virus during the subsequent cropping season (Khan *et al*., 2012, 2014) [7, 8]. Weeds are an alternate host for monopartite begomoviruses that cause tomato leaf curl disease, according to molecular findings presented by Pramesh *et al*. (2013) [11]. Weeds like Triumfetta, ageratum, croton, and Malvastrum are known to harbour geminiviruses during off-season (Hallan *et al*. 1998a [4], b). In almost all surveyed districts, previous crop to papaya were papaya, muskmelon, banana, tomato and cotton. Due to continuous cultivation papaya of same variety may made changes in the host resistance system and susceptible to leaf curl virus. Previous crops which is reservoir of leaf curl virus also spread the virus through vector (whiteflies) naturally.

Our study also collected information on management practices adopted by farmers to minimise vector population such as use of reflective mulches, yellow sticky trap and systematic insecticides likes dimethoate-2ml/l (Rogar) and Imidachloprid- 0.3ml/l (Confidor). Reflective mulches, which repel whiteflies by reflecting ultraviolet rays and interfering with host finding behaviour. Yellow sticky trap was also used for monitoring and mass trapping of adult whiteflies, helping to supress vector population in field. The systematic insecticides act by affecting the nervous system of the insect, resulting in reduced feeding activity and mortality of the vector.

Table 2: Survey details and Papaya leaf curl disease incidence in Andhra Pradesh and Karnataka

SI No.	Location	District	Stage of Crop	Hybrid	Types of Symptoms	Avg. PDI (%) PaLCuv	Avg. PDI (%) PRSV	Avg. PDI (%) PMV	weeds	Nearby crop	Previous crop	Management practices
1.	Peddayekkalur	Ananthpur	Fruit bearing stage	Red lady 786	Downward curling and inward rolling of margin to form inverted cup, vein clearing, vein thickening, leathery and brittle leaves, twisted petiole and few small and distorted fruit.	40.80	64.56	50.40	Parthenium and Euphobia	Tomato	Papaya	Application of Systematic insecticide
2.	Peddapolamada	Ananthpur	Flower forming stage	Red lady 786	Downward curling of leaf, vein clearing, leathery and brittle leaves and without fruit formation.	30.64	65.78	30.64	Parthenium and croton	Cotton	Papaya	Application of Systematic insecticide
3.	P. Kondapuram	Ananthpur	Fruit bearing stage	Red lady 786	Downward curling of leaf, inward rolling of margin to form inverted cup, vein clearing, vein thickening, leathery and brittle leaves, twisted petiole and few small and distorted fruit.	35.72	57.00	40.70	Parthenium	Cotton	Papaya	Application of Systematic insecticide and reflective mulches.
4.	Turubali	Annamayya	Harvesting stage	Red lady 786	Severe downward curling and inward rolling of margin to form inverted cup, vein clearing, leathery and brittle leaves, twisted petiole and small and distorted fruit. Also infected with PRSV.	17.18	70.86	20.00	Parthenium and croton	Tomato	Banana	Application of Systematic insecticide and reflective mulches.
5.	Yerrapalli	Annamayya	4^{th} month plant	Red lady 786	Downward curling of leaf, vein clearing and leathery and brittle leaves	20.46	60.40	30.60	Parthenium	Papaya and Tomato	Muskmelon	Application of Systematic insecticide and reflective mulches.
6.	Akkampalli	Nandyal	Fruit bearing stage	Red lady 786	Severe downward curling and inward rolling of margin to form inverted cup, vein clearing and thickening, leathery and brittle leaves, twisted petiole and few small and distorted fruit.	38.24	67.00	40.20	Parthenium and croton	Cotton	Papaya	Application of Systematic insecticide
7.	Thimmapura	Kurnool	Flower forming stage	Red lady 786	Downward curling of leaf, vein clearing, leathery and brittle leaves and without fruit formation.	30.48	65.00	43.00	Parthenium	Cotton	Papaya	Application of Systematic insecticide
MEAN PDI						**30.5**	**58.65**	**36.5**				
Karnataka												
8.	IIHR, Hessaraghatta	Bengaluru	Flower forming stage	Red lady 786	Downward curling of leaf and vein clearing.	28.34	30.56	20.00	Parthenium and croton	Lemon	Papaya	Application of Systematic insecticide and yellow sticky trap
9.	Hessaraghatta	Bengaluru	Flower forming stage	Red lady 786	Downward curling of leaf and vein clearing.	25.86	30.00	15.26	Parthenium and croton	Lemon	Papaya	Application of Systematic insecticide
Meam PDI						**27.1**	**30.28**	**17.63**				

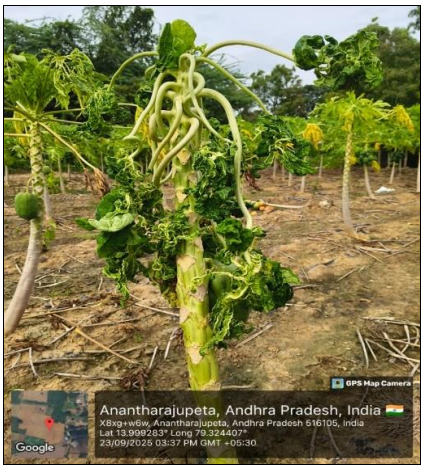
Begomovirus infected papaya plants showing different symptoms under field condition

Peddeyekkalur

Peddapolamada

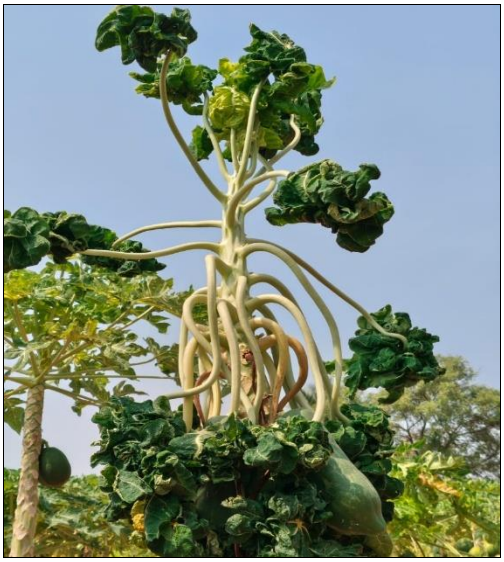
P. Kondapuram

Thimmapura



Yerrapalli

Akkampalli



References

1. Cheng YH, Deng TC, Chen CC. First report of Euphorbia leaf curl virus and papaya leaf curl Guangdong virus on passion fruit in Taiwan. Plant Diseases,2014:98(12):1746.
2. Dubey DK, Tiwari AK. Survey, incidence and serological identification of Papaya leaf curl virus in eastern Uttar Pradesh. Indian Phytopathology,2015:68(1):123-126.
3. Gunnannavar T, Prakash DP, Hipparagi K, Satish D, Gandolkar K, Sagar BS, *et al*. Performance of papaya varieties for growth parameters under northern dry zone of Karnataka, India. International Journal of Current Microbiology and Applied Science,2017:6:2398-2404.
4. Hallan V, Saxena S, Singh BP. Ageratum, croton and malvastrum harbour geminiviruses: evidence through PCR amplification. World Journal of Microbiology & Biotechnology,1998:14:931-932.
5. Haung JF, Zhou XP. First report of papaya leaf curl China virus infecting *Corchoropsis tomentosa* in China. Plant Pathology,2006:55:291.
6. Ilyas M, Qazi J, Mansoor S, Briddon RW. Genetic diversity and phylogeography of begomoviruses infecting legumes in Pakistan. Journal of General Virology,2010:91:2091-2101.
7. Khan MS, Tiwari AK, Ji SH, Chun SC. *Ageratum conyzoides* and its role in begomoviral epidemics; *Ageratum enation virus*: an emerging threat in India. An International Journal of Plant Research & Biotechnology,2012:24(2):20-28.

a. Khan MS, Tiwari AK, Raj SK, Srivastava A, Ji SH, Chun SC. Molecular epidemiology of begomoviruses occurring on vegetables, grain legume and weed species in Terai belt of north India. Journal of Plant Disease Protection,2014:121(2):53-57.

8. Kumar S, Stecher G, Li M, Knyaz C, Tamura K. MEGA X: molecular evolutionary genetics analysis

across computing platforms. Molecular Biology and Evolution,2018:35(6):1547.
9. Mansoor S, Briddon RW, Bull SE, Bedford ID, Bashir A, Hussain M. Cotton leaf curl disease is associated with multiple monopartite begomoviruses supported by single DNA beta. Archives of Virology,2003:148:1969-1986.
10. Pramesh D, Mandal B, Phaneendra C, Muniyappa V. Host range and genetic diversity of croton yellow vein mosaic virus, a weed-infecting monopartite begomovirus causing leaf curl disease in tomato. Archives of Virology,2013:158:531-542.
11. Priyanka, Priyanka V, Yusuf A, Saxena S. Molecular evidence of novel Begomoviruses and associated Betasatellite complexes linked to Papaya Leaf Curl Disease in Indian Provinces. Ecological Genetics and Genomics,2024:33:100286.
12. Priyanka V, Sangeeta S. Leaf Curl Disease of *Carica papaya*. Springer, 2017.
13. Priyanka V, Ranade SA, Saxena S. A molecular insight into papaya leaf curl—a severe viral disease. Protoplasma,2017:254:2055-2070.
14. Raj SK, Snehi SK, Khan MS, Singh R, Khan A. Molecular evidence for association of Tomato leaf curl New Delhi virus with leaf curl disease of papaya (*Carica papaya* L.) in India. Australasian Plant Disease Notes,2008:3:152-155.
15. Reddy MK, Venkataravanappa V, Madhuvanthi B, Jalali S. Molecular characterization of Begomoviruses associated with papaya leaf curl disease in India. Acta Horticulturae,2010:465-472.
16. Saxena S, Hallan V, Singh BP, Sane PV. Nucleotide sequence and intergeminiviral homologies of the DNA A of Papaya leaf curl geminivirus from India. Biochemistry and Molecular Biology International,1998:45:101-113.
17. Shahid MS, Yoshida S, Khatri-Chhetri GB, Briddon RW, Natsuaki KT. Complete nucleotide sequence of a monopartite Begomovirus and associated satellites infecting *Carica papaya* in Nepal. Virus Genes,2013:46:581-584.
18. Singh S, Awasthi LP. Survey, diagnosis and identification of resistant source of leaf curl virus infecting papaya (*Carica papaya* L.) in India. Virology: Research & Reviews,2017:1:1-4.
19. Srivastava A, Jaidi M, Kumar S, Raj SK, Shukla S. Association of papaya leaf curl virus with the leaf curl disease of grain amaranth (*Amaranthus cruentus* L.) in India. Phytoparasitica,2015:43:97-101.
20. Srivastava A, Pandey V, Al-Sadi AM, Shahid MS, Gaur RK. An insight into emerging begomoviruses and their satellite complex causing papaya leaf curl disease. Current Genomics,2023:24(1):2-17.
21. Srivastava A, Pandey V, Sahu AK, Yadav D, Al-Sadi AM, Shahid MS, *et al*. Evolutionary Dynamics of Begomoviruses and Its Satellites Infecting Papaya in India. Frontiers in Microbiology,2022:13:879413.
22. Srivastava A, Raj SK, Kumar S, Snehi SK. New record of papaya leaf curl virus and ageratum leaf curl beta-satellite associated with yellow vein disease of aster in India. New Disease Reports,2013:28:6.
23. Srivastava A, Raj SK, Kumar S, Snehi SK. New record of papaya leaf curl virus and ageratum leaf curl beta-satellite associated with yellow vein disease of aster in India. New Disease Reports,2013:28:6.
24. Srivastava A, Vineeta P, Gupta R, Gaur RK. Molecular characterization of bipartite begomovirus associated with papaya leaf curl disease in Chhattisgarh, India. Indian Phytopathology,2024:77:859-864.
25. Srivastava A, Vineeta P, Gupta R, Gaur RK. Molecular characterization of bipartite begomovirus associated with papaya leaf curl disease in Chhattisgarh, India. Indian Phytopathology,2024:77:859-864.
26. Udavatha P, Mesta RK, Basavarajappa MP, Venkataravanappa V, Devappa V, Narasimha Reddy LRC, *et al*. Identification of Novel Begomoviruses Associated with Leaf Curl Disease of Papaya (*Carica papaya* L.) in India. Agronomy,2023:13:3.
27. Varun P, Saxena S. Association of tomato leaf curl Gujarat virus and tomato leaf curl Bangladesh betasatellite on papaya showing typical leaf curl symptoms in North India. 3 Biotech,2018:8:243.
28. Varun P, Saxena S. Leaf Curl Disease of *Carica papaya*. Springer Singapore, 2017, 111-135.
29. Wang X, Xie Y, Zhou X. Molecular characterization of two distinct begomoviruses from papaya in China. Virus Genes,2004:29:303-309.
30. Yang CX, Luo JS, Zheng LM, Wu ZJ, Xie LH. Mixed infection of papaya leaf curl China virus and *Siegesbeckia yellow vein virus* in *Siegesbeckia orientalis* in China. Journal of Plant Pathology,2011:93:4-81.
31. Zhang H, Ma XY, Qian YJ, Zhou XP. Molecular characterization and infectivity of Papaya leaf curl China virus infecting tomato in China. Journal of Zhejiang University: Science B – Biomedicine & Biotechnology,2010:11:109-114.