



Impact of Integrated Management Practices on Virus Disease Management in Papaya (*Carica papaya* L.) at Farmer's Field Level

D. Vijay Kumar Naik ^{a*}, G. Lalitha Siva Jyothi ^a,
V. Surekha Devi ^b, P. Nagamani ^c, K. Kiran Kumar Reddy ^a,
J. Prasanth ^a and G. Narayanaswamy ^d

^a Krishi Vigyan Kendra, Nellore, India.

^b Agricultural Research Station, Podalakuru, India.

^c Agricultural Research Station, Perumallapalle, India.

^d Sri Mekapati Goutham Reddy Agricultural College, Udayagiri, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Papaya is susceptible to various virus diseases, among these leaf curl and papaya ring spot are major virus diseases in papaya. A total 15 front line demonstrations for virus disease management in papaya were conducted for three years from 2021-2022 to 2023-2024 at farmer's field, Nellore

*Corresponding author: E-mail: dvnaik24@gmail.com;

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district of Andhra Pradesh. The higher incidence of papaya ring spot virus disease was observed during 2022-23 (50.2%) followed by 2021-22 (43.6%) in farmer practice over the demonstration. In 2023-2024, recorded low virus incidence in both farmer and demonstration plot because of unfavorable environmental condition to virus vectors population due to the farmers were planted in August first fortnight. At last stage of harvesting i.e. in May the higher virus disease incidence was observed due to farmers are not followed management practices. The yield and fruit quality was increased in demonstration plot than farmer practice because following and timely application of integrated management practice. An average 13.53% yield was increased in demonstration plot over farmers practice. The average cost of production was less in demonstration (Rs.2,61,800/-) over the farmers practice (Rs.2,76,047/-), gross and net returns were high in demonstration than farmers practice. The higher B:C ration was observed in demonstration plot (3.28) and in farmer's practice it was recorded 2.86. by adopting of demonstration technology the virus diseases were controlled effectively and also yield & gross returns were increased.

Keywords: *Carica papaya* L.; virus diseases; IPM practices; vectors management; fruit quality; higher yield.

1. INTRODUCTION

Papaya (*Carica papaya* L.) belongs to the family Caricaceae, is a popular and economically important edible fruit crop is domesticated in tropical and subtropical countries in the World. The native of papaya is Tropical America and it was introduced in India during 16th century via Malacca by Portuguese. It is a dicotyledonous, polygamous diploid species with a small genome size of 372 Mb (Auxilia et al., 2020). It is also known as, the fruit of angels and poor man's fruit (Nakasone, 1998) and also known as wonder fruit of tropics (Lakshmi Devi et al., 2020). Papaya fruits are rich source for vitamins, macro and micro minerals, bioactive substances and secondary metabolites. Leaves, stems, seeds, and other plant parts of papaya are high in alkaloids and flavonoids, which have antimicrobial and medicinal properties. Endopeptidases, papain, caricain, and proteinase enzymes found in papaya latex are important industrial enzymes used in many commercial applications (Koul et al., 2022).

Papaya crop is affected by many diseases which are caused by fungi, bacteria, viruses and nematodes. Diseases have been shown to be very important factors in reducing yield and market value of papaya. The commercial papaya production has been hampered worldwide due to high susceptibility of the crop to various fungal diseases viz., *Phytophthora* root rot, anthracnose, powdery mildew, stem end rot, black spot disease and virus diseases like papaya ring spot and papaya leaf curl, nematodes and post harvested diseases. Due to the very thin skin of fruit and rough handling

during transport facilitate to a number of rotting of fruits caused by fungi and bacteria (Nagalakshmi et al., 2024). Among them, virus diseases cause significant losses by effecting on fruit production. Viruses spread across the field through its insect vectors, the studies were conducted on virus disease management using different insecticides and bio products for controlling of virus vectors (Premchand et al., 2021).

Plant viruses are often reported in papaya plants, a 22 viral species are known to cause disease in papaya (Alcala-Briseno et al., 2020). Among these *Papaya ringspot virus*, *Papaya leaf curl virus* importance and reported in all the papaya growing countries. *Papaya Ring Spot Virus* (PRSV) belongs to *Potato Virus Y (PoTY)* group of family Potyviridae and virus particles are rod shaped measuring 760 to 800 nm in length and 12 nm in width (Yeh et al., 1984). The nucleic acid of PRSV is positive sense single stranded RNA encapsulated by 30-36 kD coat protein. In India, PRSV is one of the most destructive diseases of papaya, it causing 100% yield losses and it is causes the disease in cucurbits also (Nagalakshmi et al., 2024). PRSV is transmitted by insect vector aphids in a non-persistent manner and spread the disease throughout the field. The PRSV disease is characterized by vein clearing, puckering of the leaf tissues, yellow mosaic on leaves, small shoestring-like new leaves, dark green and slightly sunken rings on the fruit and infected trees shows stunted growth, if young tree is infecting with PRSV never produce any fruit. Second important virus disease in papaya is papaya leaf curl virus (PaLCuV) and in India, the disease was first noticed by Thomas and Krishnaswamy, 1939. PaLCuV is DNA virus of begomoviruses genus

comes under geminiviridae family. It is transmitted through whitefly (*Bemisia tabaci*) vector in persistent-circulative non propagative manner. The diseases symptom of PaLCuV are wrinkled and curled leaves that roll downward or inward and appear as an inverted cup. The leaf becomes leathery, rigid, and reduced in size with thickened vein and zig-zag twisted petioles (Soni et al., 2022).

In papaya, virus diseases management is more important for reducing disease incidence and to minimize the yield loss. Effective vectors management practices, maintaining of fruit quality is important for management of virus diseases and to maximize the fruit yield. Integrated disease management practices including insecticides, biorationals (neem oil, pongamia oil, groundnut oil, and mineral oil), seaweed extract, along with micronutrients, either alone or in combination, were assessed for management of virus disease in papaya (Premchand et al., 2023). Different insecticides, mineral oils, neem oil were evaluated for controlling of virus vectors for management of virus diseases (Kalleswaraswamy et al., 2009). In order to management of virus diseases in papaya, Krishi Vigyan Kendra (KVK), Nellore followed Integrated management practices suggested by DrYSRHU, Andhra Pradesh. In the present study, we conducted front line demonstration on impact of integrated management practices on virus disease management in papaya (*Carica papaya* L.) at farmer's field level.

2. MATERIALS AND METHODS

In Nellore district paddy is the major crop cultivating in two seasons in a year and papaya is second major non perennial horticulture crop in Nellore. Front line demonstration (FLD) was conducted by Krishi Vigyan Kendra, Nellore on to study the impact of integrated management practices for virus disease management in papaya. FLD is one of the powerful tool for technology transfer of new technologies to increase yield and profit (Kumar et al., 2024). In Nellore district, farming situation of papaya was irrigated (drip irrigation) and soils were clay loamy soils. Demonstration was initiated during August and each FLD was setup with 0.4ha demonstration plot and 0.4ha farmer practicing plot. A total 15 FLDs were conducted for three years (2021-22, 2022-23 and 2023-24) at farmer's field.

The experiment was conducted at different locations i.e., 2021-2022: Anantasagaram and Kavali mandals; 2022-2023: Syadapuram, Anantasagaram and Marripadu mandals; 2023-2024: Marripadu and Anantasagaram mandals. These are major papaya growing mandals in Nellore district. The experiment was conducted with 2 treatments & five replications and farmers were practiced with F1 hybrid seeds of papaya Cv. Red Lady.

2.1 Treatments

TO1: Demonstration: Under TO1 (Demonstration) treatment, DrYSRHU Andhra Pradesh suggested Integrated Pest Management practices were followed for demonstration of virus disease management in Papaya. The components of IPM practices are

- i. Sesbania and maize/sorghum has to be planted in two rows as barrier crop for sucking pests 15 days before transplanting of papaya seedlings.
- ii. Erection of 12 to 15 yellow and blue sticky traps for the control of white fly and trips respectively.
- iii. Spraying neem oil @ 2.5 ml along with Thaimethoxam @ 2.5g/l + sticking agent @ 0.5ml/l twice with 15 day's interval.
- iv. To improve fruit quality in plants that are affected with ring spot virus spraying urea 10 g + zinc sulphate 1.5 g + boron 1 g/l once in a month upto 8 months is recommended.
- v. Plants that are affected with virus has to be uprooted and burnt immediately.

TO2 (Farmers practice): Spraying Monocrotophos 1.6 ml per liter and Acetamiprid 1g/l of water.

The data related to The percent disease incidence (PDI), cost of production, yield and returns was recorded from demonstration and farmer practice fields through repeated field visits during 2021-22, 2022-23 & 2023-24 and analyzed using statistical techniques. The observations of virus diseases were recorded after application of treatments and PDI of diseases were recoded using below formula.

The average yield, extension gap, technology gap, technology index, cost of cultivation, gross returns, net returns, and benefit-cost ratio (Yadav et al., 2004) and PDI (Vijay Kumar Naik et al., 2024) were calculated using following formula's as given below.

$$\text{Percent Diseases Incidence (PDI)} = \frac{\text{Total Number of infected Plants per sq.m}}{\text{Total number of plants per sq.m}} \times 100$$

$$\text{Extension gap} = \text{Demonstration yield} - \text{Farmer practice yield}$$

$$\text{Technology gap} = \text{Potential yield} - \text{Demonstration yield}$$

$$\text{Technology index (\%)} = \text{Potential yield} - \frac{\text{Demonstration yield}}{\text{Potential yield}} \times 100$$

$$B:C \text{ ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

3. RESULTS AND DISCUSSION

3.1 Virus Diseases Incidence

A total 15 front line demonstrations were conducted for three years from 2021-2022 to 2023-2024 at major papaya growing mandals of Nellore district, Andhra Pradesh. Three years' data regarding Papaya ring spot virus (PRSV) and papaya leaf curl virus (PaLCuV) disease incidences were recorded. Higher incidence of PRSV disease was recorded in farmer practice during two years i.e. 2021-2022 (43.6%) and 2022-2023 (50.2%) over demonstration plot. During 2023-2024 season, very less virus disease incidence was recorded in both demonstration and farmers practice. The average low PRSV disease incidence was recorded for three years in demonstration plot (10.4%) whereas in farmer practice it was recorded 32.07% of PRSV disease incidence. During the year 2023-2024, no PaLCuV disease incidence was recorded, but in the year 2021-2022 and 2022-2023 less leaf curl virus disease incidence was recorded in demonstration plot than farmer practice plot. An average three-year data of leaf curl virus disease was recorded 2.13% in demonstration plot where as in farmer practice 6.27% incidence was recorded (Table 1). Singh et al., 2019 conducted survey regarding virus diseases in papaya during Kharif, rabi and summer seasons in Begusarai district of north Bihar, he observed no virus disease incidence at nursery stage but in transplanted field recorded mosaic, leaf curl and ring spot diseases in all three seasons.

Table 1. the details of virus disease incidence of papaya in demonstration and farmer's fields

Season	Papaya ring spot virus (%)		Leaf curl virus (%)	
	TO1	TO2	TO1	TO2
2021-2022	14.6	43.6	0.6	6.4
2022-2023	15.6	50.2	0.6	6.4
2023-2024	1	2.4	0	0
Average	10.4	32.07	0.4	4.27

*TO1-Demonstration plot; TO2-Farmer practiced plot

Table 2. The yield data, extension gap, technology gap and technology index comparative studies between demonstration and farmer's practice

Years	Demonstration Yield (t/ha)			Farmer practice average yield (t/ha)	Increased in yield (%)	Extension gap (t/ha)	Technology gap (t/ha)	Technology index (%)
	Highest	Lowest	Average					
2021-2022	50	40	45	37.3	20.64	7.7	55	55
2022-2023	78	73	75.5	66.42	13.67	9.08	24.5	24.5
2023-2024	91	85	88	82.8	6.28	5.2	12	12
Average	73	66.00	69.50	62.17	13.53	7.33	30.50	30.50

*Papaya potential yield is 100 tonnes/ha

Table 3. Comparative economics studies of papaya production between demonstration and farmer's practice

Years	Gross return (Rs./ha)		Cost of cultivation (Rs./ha)		Net return (Rs./ha)		B:C Ratio	
	TO1	TO2	TO1	TO2	TO1	TO2	TO1	TO2
2021-2022	637000	588000	255150	274850	381850	313150	2.50	2.14
2022-2023	902400	797040	253250	264640	649150	532400	3.56	3.01
2023-2024	1050000	993600	277000	288650	773000	704950	3.79	3.44
Average	863133	792880	261800	276047	601333.3	516833.3	3.28	2.86

*TO1-Demonstration plot; TO2-Farmer practiced plot; B:C ratio- Benefit: Cost ratio

The reasons for low virus disease incidence in demonstration plot was timely application of plant protection measures (IPM practice) for control of virus vectors and nutrient management for improving and maintaining fruit quality up to 8 months of crop stage. The virus disease management is mainly depending on its vector control i.e. aphids (PRSV) and whitefly (PaLCuV). For management of virus diseases, several research works' conducted using different insecticides and bio rationales (Premchand et al., 2021), demonstration of new varieties (Kumar et al., 2024), transgenic papaya varieties (Tripathi et al., 2008), mineral and neem oils (Kalleswaraswamy et al., 2009) for aphid management in papaya. Premchand et al., 2023 conducted field experiments over two years for management of PRSV disease using insecticides, biorationals, and a seaweed extract with micronutrients, alone or in combination. He was recorded 100% PRSV disease incidence during his survey in farmer field.

Yield: The yield data from both demonstration and farmer practice plots over three years was recorded and extension gap, technology gap & technology index was calculated based on yield data obtained from demonstration and farmer practice plot (Table. 2). An average 69.50 t/ha yield was produced in demonstration plot and it was 13.53% increased yield over farmer practice (62.17 t/ha). Based on these results concluded that, demonstration practice is better than farmer practice in order to control of virus diseases and improvement of yield quality. The yield was increased in demonstration plot because of not only virus disease control but also use of high yielding varieties, improved production technologies, irrigation and nutrient management. Kumar et al., 2024 (6) observed an average higher yield (64.37% and 71.05 t/ha) as compared to farmers' existing practices (43.25 t/ha) in 36 FLDs over three years.

The potential yield of papaya is 100 t/ha. Technology gap was calculated using

demonstration yield and potential yield and also calculated extension gap. An average 7.33 t/ha extension gap was observed over three years i.e. 2021-22, 2022-23 and 2023-24. High technology gap was observed during 2021-2022 (55 t/ha) followed by 2022-2023 (24.5 t/ha). Technology gap over three years was observed 30. 50 t/ha. Similar results were observed by Kumar et al., 2024.

Economics of papaya:The economics data like cost of cultivation, gross and net return, B:C ration of demonstration, farmers practice over three years were calculated (Table.3). The average cost of cultivation of papaya was Rs. 2,61,800/- per ha against an average of Rs. 2,76,047/- per ha in farmer practice. Based on three years' average data, comparatively higher gross return (Rs. 8,63,133/- per ha) and net return (Rs. 6,01,333/- per ha) was observed in demonstration plot over farmer practice. Also higher B:C ratio was observed in demonstration plot (3.28) than farmer practice (2.86). Under papaya plantation mission ran by KVK, Sirohi similar results, recorded 4.77 B:C ratio during experimentation period (2008- 2011) in Sirohi district of Rajasthan. Economics of papaya i.e. yield, cost of production, gross and net returns were studied by Javed et al., 2017 at Bidar district of Karnataka and he was noticed during his study (2016-2017), the farmers were invested low cost of cultivation (Rs. 1,22,978/- per ha) papaya production and also earned low gross return (Rs. 3,72,638/- per ha).

4. CONCLUSION

The main objective of our study is to demonstrate the integrated management practice for virus disease management in papaya at Nellore district, Andhra Pradesh. In our study, we observed higher PRSV incidence during 2021-22 and 2022-23 because of high virus vector populations and late planting (1st fortnight of October). Over three year's average, less PRSV disease incidence (10.4%) and PaLCuV

incidence (0.4%) was recorded in demonstration plot over farmer practice. Based on these result concluded that IPM practices play important role in management of virus diseases and its vector. By adopting of good management practice like nutrient and water management could increase the yield. An average of three years, 13.53% of higher yield was recorded in demonstration plot over farmer practice. The economics study of papaya revealed that, adopting of demonstrated practices is more profitable than farmer practice.

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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