Occurrence and Impact of Papaya ring spot virus in the Marathwada region of Maharashtra, India

ABSTRACT

Papaya ring spot virus (PRSV) is a major challenge to global papaya cultivation, including in the Marathwada region of Maharashtra, India. This study aimed to survey the prevalence of PRSV disease across three agroclimatic zones of Marathwada during, 2022. Infected plants exhibited various symptoms on leaves such as vein clearing, chlorosis, mosaic, blistering, leaf curling, puckering and shoestring appearance. Other symptoms such as, ringspots on leaves, fruits and stems, oily streaks on petioles and stems, malformed fruits, stunted growth of plants. Depending on the stage of infection, diseased plants produced few or no fruits. The survey revealed that, an average PRSV incidence ranging from 0.03% to 100%.

Further analysis examined the influence of PRSV incidence on papaya cultivar, crop age and agroclimatic zones. Results indicated that older plants were more susceptible to PRSV than younger ones. Among the cultivars studied, the Red Lady cultivar demonstrated high susceptibility to the virus. However, there were no significant differences in the percent disease index (PDI) across the agroclimatic zones. These findings highlight the need for targeted management strategies, including the development of resistant cultivars and region wise disease control measures, to reduce the impact of PRSV on papaya production.

Keywords: Agroclimatic zone impact, Papaya ring spot virus, disease incidence, Red lady cultivar.

1. Introduction

Papaya (*Carica papaya* L.), a member of the family Caricaceae, is recognized as one of the most economically important fruit crops in tropical and subtropical regions of world (Mishra *et al*., 2007). India is the leading global producer of papaya, accounting for 43% of the world's production and ranking first among papaya-producing nations (Anonymous, 2020). Between 2019 and 2022, the estimated global production of papaya reached 13,894,705 metric tons (MT), reflecting a 1.9% increase from 13,641,294 MT in 2019. In India, papaya is cultivated on an average area of 148.8 thousand hectares, yielding approximately 5,341.8 thousand MT annually, with a productivity rate of 35.9 MT per hectare. Among different states, Maharashtra ranks second in cultivation area (17.62 thousand

hectares), production (642.29 thousand MT) and productivity (36.45 MT per hectare) (Anonymous, 2024).

Papaya is a highly significant fruit crop, renowned for its exceptional nutritional, medicinal, and industrial value. It ranks third as the richest source of vitamin C, following amla and citrus fruits. However, despite its economic and nutritional importance, pest and diseases are major threats to papaya cultivation worldwide. Of these fungal and viral diseases are of global significance, causing serious damage to fruit production and devastating the entire crop (Akhter and Akanda, 2008). Among the viral diseases, Papaya ringspot virus (PRSV), Papaya leaf curl virus (PaLCuV) and Papaya mosaic virus (PMV) are more prevalent. In India, PRSV is most devastating disease affecting papaya production in almost every region where it is grown and have potential to cause 100% yield loss (Sharma and Tripathi, 2014).

The symptoms produced by PRSV on leaves includes vein clearing, chlorosis, intense yellow mosaic, blistering, leaf curling, puckering, distortion and shoestring appearance was observed. On fruits, small lichen like lesions, uneven ring spots, distortions and unpleasant taste was observed. Other symptoms such as dark green sunken rings on leaves, petioles, stem and fruit, oily streaks on leaves, petioles and stem and stunted growth of plants. Trees infected at an early stage remain stunted and fail to produce any fruit (Kunkalikar *et al*., 2006; Reddy *et al.*, 2007).

In addition, PRSV is naturally transmitted by aphids in a non-persistent manner and mechanically transmitted under laboratory conditions. (Purcifull *et al*., 1984). However, under experimental conditions, PRSV isolates exhibited very limited host range it infects only to the members of the Caricaceae, Chenopodiaceae and Cucurbitaceae families (Tripathi *et al.,* 2008) PRSV is classified into two biotypes: type-P (PRSV-P), which infects both cucurbits and papaya, and type-W (PRSV-W), which infects only cucurbits (Purcifull *et al*., 1984). Papaya ring spot virus (PRSV) belongs to the genus Potyvirus and family Potyviridae.

Despite advancements in managing papaya ringspot disease in papaya and other crops, there is still a need to address various aspects of PRSV management, particularly in the Marathwada region. Therefore, a survey was conducted during 2022-23 to assess the incidence of PRSV across Marathwada, Maharashtra.

2. MATERIALS AND METHODS

2.1. Survey of PRSV in various agroclimatic zones of Marathwada.

A survey was conducted during, year 2022 in 20 major papaya growing regions of different agroclimatic zones *viz*., assured rainfall zone, moderate rainfall zone and scarcity

rainfall zone of Marathwada region of Maharashtra, India to determine the incidence Papaya ring spot virus disease. Major papaya fields were identified from the records available at the office of Sub-Divisional Agriculture Officers, of respective districts. The disease incidence was estimated by counting the number of infected plants visually by the total number of plants in a random selected plot area in each field. While survey, the observations on incidence of PRSV and different cultivar was recorded and the percent disease incidence (PDI) was calculated by using the following formula. (reference for PDI is not available)

$$\text{PDI (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

2.2. Symptomatology of PRSV

During survey, the PRSV infected plants in various locations were observed carefully and data were recorded on visual appearance of symptoms on different plant parts from each location and the PRSV symptoms were identified based on symptoms of Papaya ring spot virus was first time reported by Jensen (1949).

3. RESULTS AND DISCUSSION

3.1. Survey and incidence of PRSV disease

A total of 20 farmers' fields were surveyed across different agroclimatic zones *viz*., assured rainfall zone, moderate rainfall zone and scarcity rainfall zone of Marathwada region of Maharashtra, India, recorded the incidence of PRSV was presented in Table 1. The average disease incidence ranged from 0.03 to 100 per cent in the surveyed fields. The findings of this study align with Priya *et al*. (2020) documented PRSV incidence between 49.00% and 75.30% across three experimental plots in Bhagalpur, Bihar and Premchand *et al.* (2023) surveyed 10 major papaya growing districts in Karnataka during, 2019-2021 and recorded disease incidence rates of 50.50% to 100.00%.

During survey, the relation of papaya varieties/cultivars, papaya crop age and agro-climatic zone with PRSV incidence were studied and resulted in following sub-heads.

3.1.1. Effect of papaya varieties/ cultivars on PRSV disease incidence

The results of Papaya ringspot disease incidence recorded on papaya varieties/cultivar, during survey were presented in Table 2 and Fig. 1 indicate that, the three papaya varieties/cultivars namely Red Lady, Local 15 no and Iceberg were grown by farmers in the Marathwada region, among them, the highest incidence of PRSD was observed in the

Cv. Red Lady is 93.62 per cent. This was followed by Cv. Local 15 no., which had an incidence of 19.20 per cent, while Cv. Iceberg showed the lowest incidence of PRSV at 4.99 per cent.

A similar observation was recorded by Lokhande *et al.*, (1992) reported that, the incidence of PRSV is widespread in different parts of Vidarbha region of Maharashtra it may be due to continuously growing susceptible cultivars of papaya such as Red Lady, Sunrise Solo and Arka Surya. Chavan *et al*. (2010) conducted a screening of eight commercial papaya cultivars and resulted that, among all cultivars Red Lady was widely grown and showed the highest percentage of disease incidence (86.00%), followed by Cv. Pusa Nanha (44.80%) and the Cv. Madhubala exhibited the lowest disease incidence (13.20%). Pushpa *et al.,* (2018) reported that, the Red Lady, Sunrise Solo and Arka Surya were found highly susceptible to PRSV in south Karnataka, and Khaire *et al*. (2024) conducted a survey across five major papaya growing districts of western Maharashtra and reported that the Cv. Taiwan-786 was widely grown in these regions, exhibited an incidence ranging from 10.41% to 87.50%.

3.1.2. Effect of papaya crop age on PRSV disease incidence

The results of survey revealed that, the papaya ring spot incidence was influenced by the age of the crop, the differences in the per cent disease incidence of PRSV among various papaya varieties/cultivars grown by farmers was observed and the results are presented in (Table 3 and Fig. 2) indicated that, the highest incidence of papaya ringspot disease (PRSV) was found in 18-24 month old papaya fields and it was reached to 100 per cent. This was followed by 12-18 month old fields with an incidence of 77.51 per cent and 6-12 month-old fields with 31.43 per cent. These findings indicate that as the crop age increases, the incidence of PRSV also increases.

Similar findings were reported by several earlier workers. Noshad *et al.* (2015), who surveyed various regions in Pakistan and reported PRSV incidence ranging from 0% to 100%, with the highest incidence in plants aged 1–2 years compared to those under 1 year old. Similarly, Selangga *et al.* (2020) studied the impact of crop age on PRSV incidence in Gianyar, Bali and reported that, the highest per cent disease incidence in 35-42 days old cucumber plants in Ubud (66.87%), followed by 30-43 days old plants in Blahbatuh (63.80%).

3.1.3. Effect of agroclimatic zones on PRSD incidence

The agro-climatic zone wise incidence of papaya ring spot disease recorded on papaya during survey and results were presented in (Table 4 and Fig. 3) revealed that, among the three agro-climatic zones surveyed *viz*., scarcity rainfall zone, assured rainfall zone and

moderate rainfall zone. The highest PRSV disease incidence was observed in the scarcity rainfall zone with 68.34 per cent. This was followed by the moderate rainfall zone, with an incidence of 68.09 per cent, and the assured rainfall zone, which had the lowest incidence at 53.80 per cent. From these observations, it can be concluded that there is no significant variation in the incidence of PRSV disease was observed across different agroclimatic zones of Marathwada regions of Maharashtra. This suggests that the spread and impact of the disease are not influenced by variations in agroclimatic conditions within this area. These results highlight the uniform vulnerability of papaya crops to the disease across different zones, underscoring the need for region wise preventive and management strategies.

3.2. Symptomatology

The papaya plants infected with PRSV exhibited various type of symptoms during the survey were presented in the Plate 1. The symptoms were on leaves such as vein clearing, chlorosis, mild mosaic, mosaic, blistering on leaves, leaf curling, leaf distortion, puckering and shoestring. On fruits, small regular to irregular ring spots observed, distortions of fruits and unpleasant taste was observed. Other symptoms such as dark green sunken rings on leaves, petioles, stem and fruit, oily streaks on leaves, petioles and stem and stunted growth of plants were observed. Depending on the stage of the crop and infection, the infected plants produced few or no fruits.

Similar symptoms of Papaya ring spot virus disease have been documented by several earlier researchers. Tripathi *et al.* (2008) described PRSV symptoms as leaf mosaic, chlorosis, oily streaks on petioles and the upper trunk, leaf distortion, and stunted growth with flower abortion. Kshirsagar (2014) reported vein clearing, yellow mosaic, blistering, necrotic spots, and shoestring-shaped leaves, leading to severe stunting and wilting. Singh *et al*. (2017) noted mild to severe mosaic, chlorotic mottling, puckering, curling, and stunted growth. Premchand *et al*. (2023) investigated the impact of crop age on symptom development caused by PRSV. Their study revealed that the green mosaic symptom was consistently observed across all surveyed locations, irrespective of plant age. In younger plants (below five months) at the pre-vegetative stage, only green mosaic symptoms were recorded. However, plants in the pre-reproductive stage (above five months) exhibited additional symptoms, including yellow mosaic, leaf curling, stunted growth, puckering, mottling, blistering on leaves, and shoestring symptoms. Symptoms became more severe during the reproductive stage, with severely infected plants showing pronounced leaf distortion. Khaire *et al.* (2024) detailed symptoms such as light discoloration, mottling, blisters, and fruit distortion, with plants often producing few or no fruits

CONCLUSION

From the present study, it can be concluded that a widespread occurrence of Papaya ring spot virus (PRSV) was observed during the survey. The findings indicated that the incidence of PRSV was notably higher in older crops compared to those at the younger growth stage. Additionally, the Red Lady cultivar was found to be particularly susceptible to PRSV, highlighting its vulnerability to the disease. These results emphasize the need for targeted management strategies and the development of resistant cultivars to mitigate the impact of PRSV on papaya production.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

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Table 1. Collection of PRSV Infected Samples from Agroclimatic Zones of Marathwada Region, Maharashtra

Sr. no.	Place of survey	Taluka	District	Name of variety	Area (Acre)	Crop stage (Month)	Previous crop	No. of plants		Percent disease incidence (PDI)	Symptoms
								Observed	Infected		
I.	**Assured Rainfall zone**										
1.	Parbhani-1	Parbhani	Parbhani	Red lady	2.0	24	Cucumber	70	70	100.00%	Vc, Mo, Bl, Ld, Ss, Osf, Stp, Sts
2.	Parbhani-2	Parbhani	Parbhani	Local 15 no	1.2	09	Turmeric	30	04	13.33%	GM, LR
3.	Pathari-1	Pathari	Parbhani	Ice Berg	2.0	12	Soybean	30	02	6.66%	GM, Yel
4.	Pathari-2	Pathari	Parbhani	Red lady	1.5	18	Watermelon	70	70	100.00%	Vc, Mmo, Mmot, Stp, Sts
5.	Hatkarwadi	Manwat	Parbhani	Red lady	1.5	15	Cotton	70	62	88.57%	Vc, Mo, Bl, Ld, Ss, Osf, Stp, Sts
6.	Osmanabad	Osmanabad	Osmanabad	Red lady	1.0	18	Cucumber	70	70	100.00%	Vc, YMo, Yel, Osf, Stp, Sts
7.	Latur	Latur	Latur	Local 15 no	1.5	10	Chilli	70	20	28.57 %	GM, LR
8.	Biloli	Biloli	Nanded	Iceberg	2.0	15	Turmeric	30	08	3.33%	GM, Yel
II.	**Moderate Rainfall zone**										
9.	Basmat	Basmat	Hingoli	Local 15 no	1.2	18	Soybean	70	18	25.71%	GM, LR
10.	Kalamba-1	Basmat	Hingoli	Local 15 no	1.2	12	Soybean	70	09	12.85%	GM, LR
11.	Kalamba-2	Basmat	Hingoli	Red lady	1.5	24	Watermelon	70	70	100.00%	Vc, Mmo, Mmot, Stp, Sts
12.	Dongarkada phata	Kalamnuri	Nanded	Red lady	2.0	17	Watermelon	70	68	97.14%	Vc, Mo, Bl, Ld, Ss, Osf, Stp, Sts
13.	Adgaon	Loha	Nanded	Red lady	1.0	12	Soybean	70	51	72.85%	Vc, Mo, Bl, Ld, Ss, Osf, Stp, Sts
14.	Nanded	Nanded	Nanded	Red lady	1.5	20	Watermelon	70	70	100.00%	Vc, Mmo, Mmot, Stp, Sts
III.	**Scarcity Rainfall zone**										
15.	Rohatwadi	Patoda	Beed	Local 15 no	2.5	10	Capsicum	30	06	16.66%	GM, LR
16.	Chakarwadi	Beed	Beed	Red lady	1.5	18	Bitter gourd	70	70	100.00%	Vc, Mmo, Mmot, Stp, Sts
17.	Beed	Beed	Beed	Red lady	2.0	15	Soybean	70	61	92.85%	Vc, Mmo, Mmot, Stp, Sts
18.	Ralesangavi	Shirur	Beed	Local 15 no	1.2	09	Soybean	30	01	3.33%	GM, LR
19.	Naliwadgaon	Bhum	Osmanabad	Red lady	1.5	12	Soybean	50	41	82.00%	Vc, Ym, Yel, Osf, Stp, Sts
20.	Pimpalgaon lingi	Washi	Osmanabad	Red lady	1.0	15	Soybean	70	63	90.00%	Vc, Ym, Yel, Osf, Stp, Sts

*Vc-Vein clearing, Mo=Mosaic, Bl=Blistering, Mmo=Mild mosaic, MMot=Mild Mottle, Ld=Leaf distortion, Ss-Shoestring symptom, Osf- Oily spots on fruit, Stp- Streaks on petioles, Sts- Streaks on stem, GM- green mosaic, Yel = Yellowing, Ym = Yellow mosaic.

Table 2. Papaya ringspot disease incidence on papaya varieties/cultivar during , 2022-23

Sr. no.	Papaya Varieties/Cultivar	No. of locations	% PRSV Incidence
1.	Red Lady	12	93.62 %
2.	Local 15 no.	06	19.28 %
3.	Iceberg	02	4.99 %

Table 3. Crop age-wise incidence of papaya ring spot disease on papaya during, 2022-23

Sr. no.	Papaya Crop age (Month)	No. of locations	% PRSV Incidence
1.	6-12	08	31.43 %
2.	12-18	09	77.51 %
3.	18-24	03	100.00 %

Table 4. Agro-climatic zone wise incidence of papaya ring spot disease on papaya During, 2022-23

Sr. no.	Agro-climatic zone	No. of locations	% PRSV Incidence
1.	Assured rainfall zone	08	53.80 %
2.	Moderate rainfall zone	06	68.09 %
3.	Scarcity rainfall zone	06	68.34 %

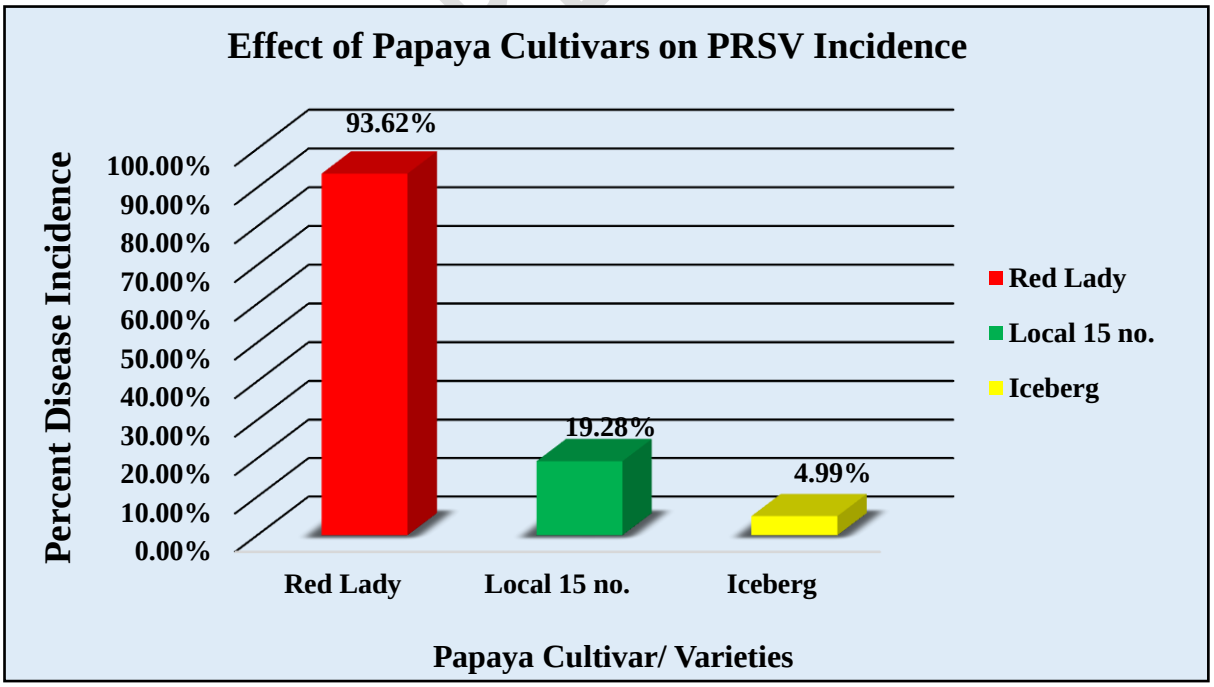

Fig. 1. Effect of papaya varieties/cultivar on Papaya ringspot disease incidence during, 2022-23

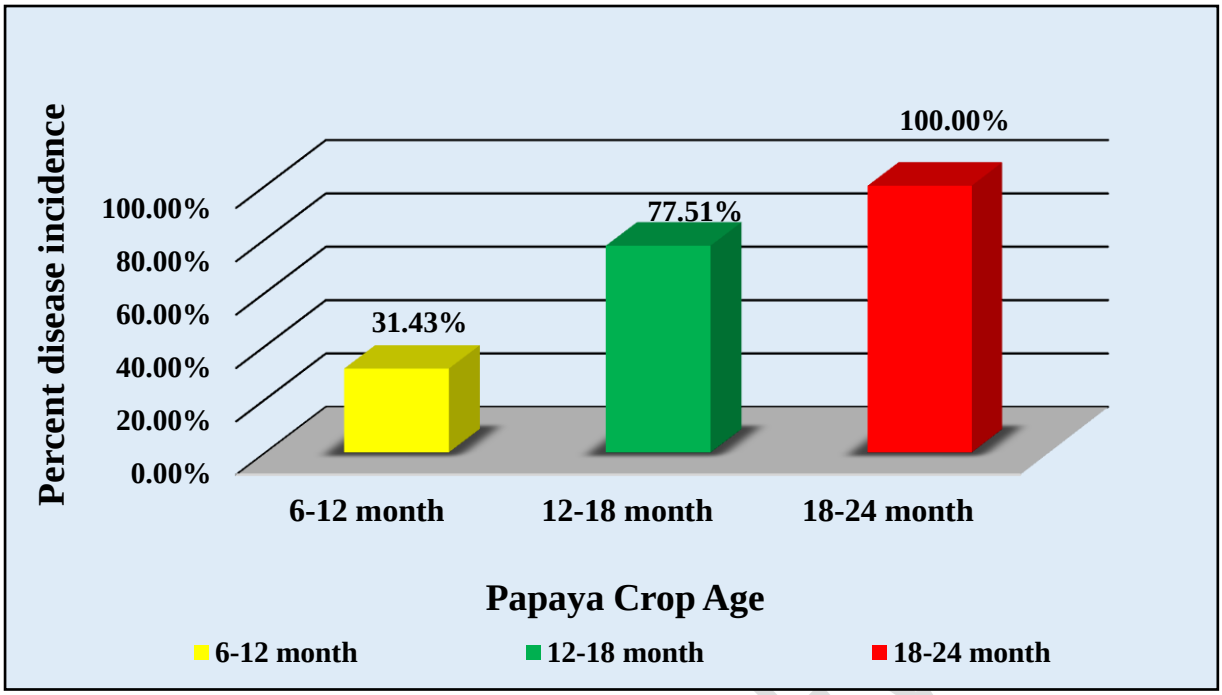

Fig. 2. Effect of crop age on Papaya ringspot disease incidence in papaya plant during, 2022-23

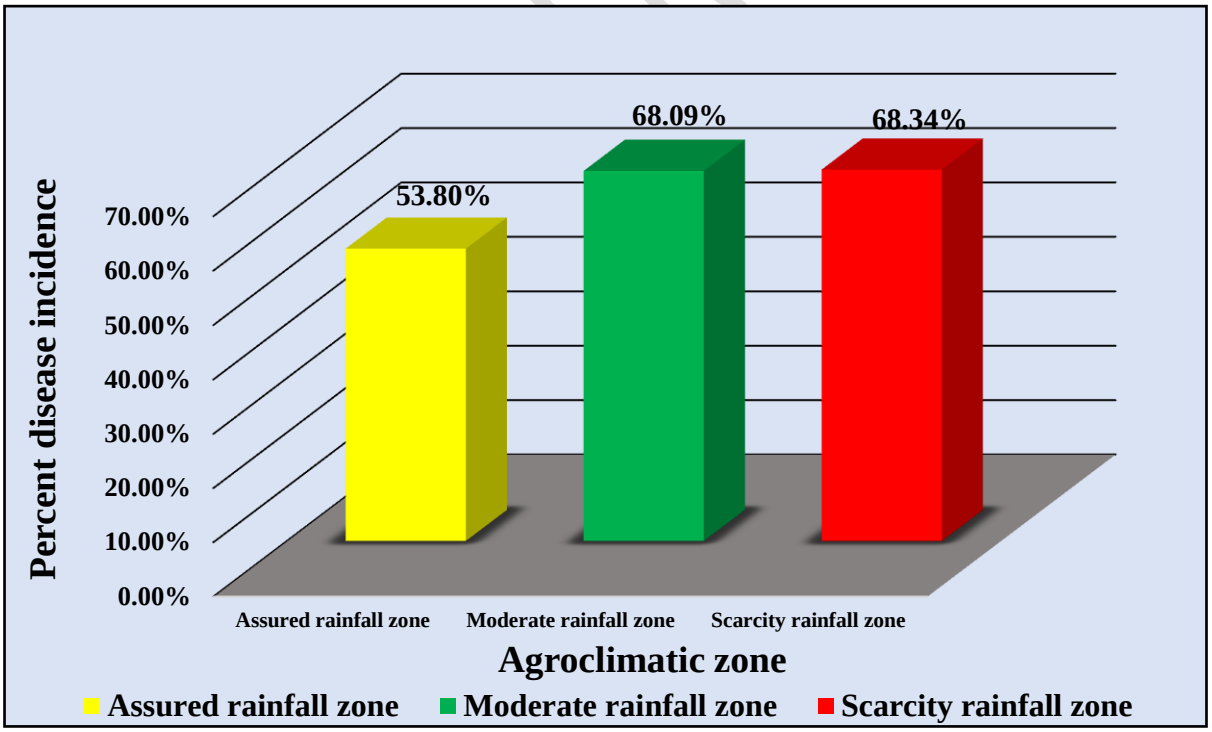

Fig. 3. Effect of agro-climatic zone on papaya ringspot disease on percent disease incidence in papaya during, 2022-23

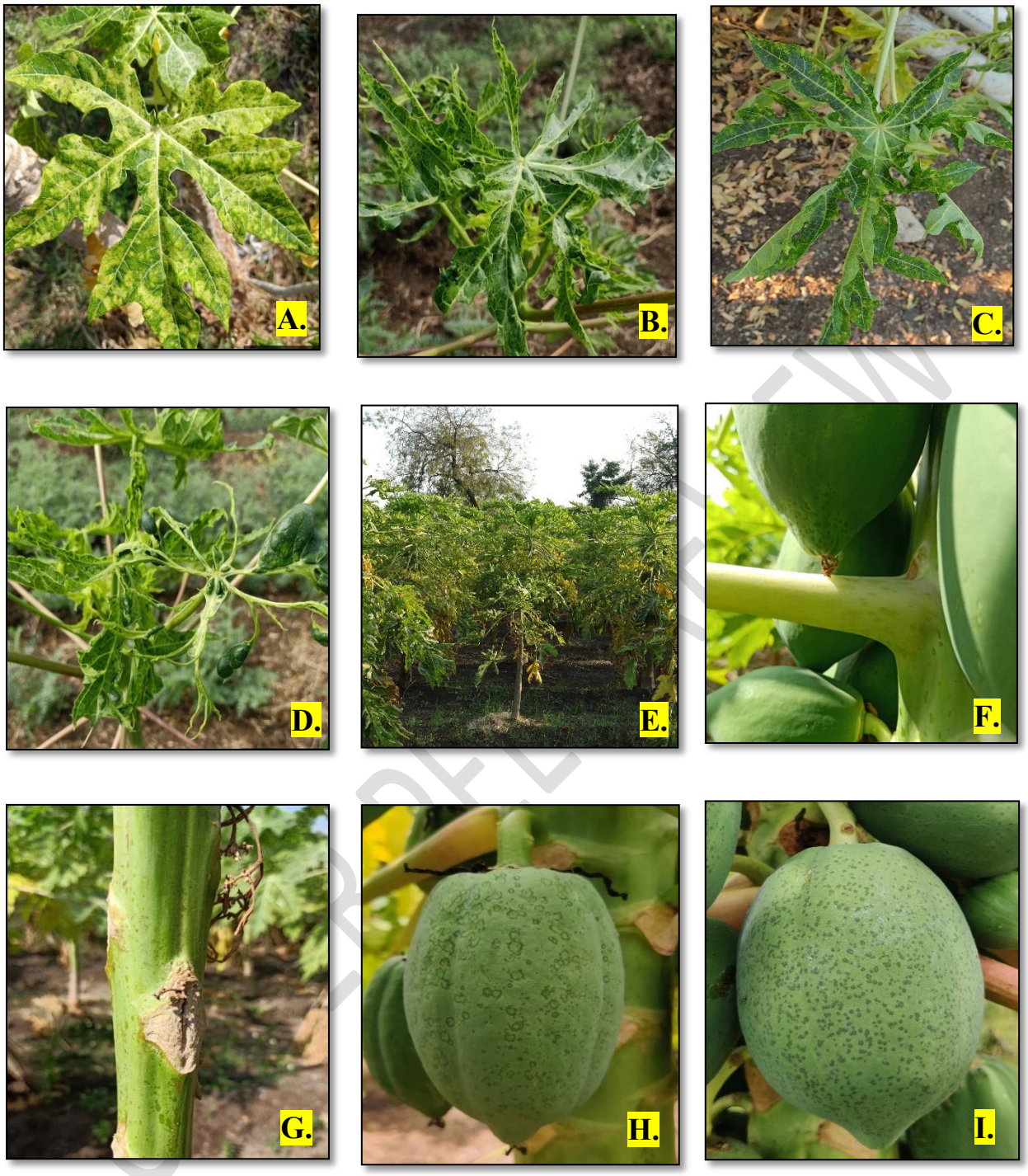

PLATE 1: Symptoms of PRSV observed under natural conditions during survey
A. Mosaic, B. Blistering on leaves, C. Leaf rolling, D. Shoestring, E. Stunted growth of plant, F. Oily streaks on petioles, G. Oily streaks on stems, H. Irregular ringspots on fruit and I. Circular ringspot on fruit.