ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2025): 4.97
IJAFS 2025; 7(9): 177-184
www.agriculturaljournals.com
Received: 12-08-2025
Accepted: 13-09-2025

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Stem end rot of mango: Characterizing disease dynamics and fruit quality deterioration from farm to retail in Saurashtra

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DOI: https://www.doi.org/10.33545/2664844X.2025.v7.i10c.870

Abstract
A roving survey was conducted from May to July 2024 across orchards, wholesale and retail mango markets in Junagadh and Gir Somnath districts of the Saurashtra region of Gujarat. The survey revealed a significant increase in mango stem end rot (SER) severity as fruits moved from field to market. Field incidence ranged from 3.34-30.06% (severity: 1.65-13.6%), escalating to 11.69-28.39% incidence (severity: 7.59-17.82%) in wholesale markets and 15.03-40.08% incidence (severity: 14.19-37.95%) in retail markets. A similar trend was observed for fruit weight loss, which increased from 9.50-15.60% in the field to 11.71-18.13% in wholesale and 13.19-26.35% in retail markets. This progressive escalation in disease prevalence and fruit deterioration highlight the critical post-harvest management challenges posed by stem end rot across the mango supply chain.

Keywords: Mango, stem end rot, post-harvest disease, fruit quality, supply chain, Saurashtra, disease dynamics, retail deterioration

Introduction

Mango (*Mangifera indica* L.) a member of the Anacardiaceae family, is an important fruit crop of India as well as tropical and sub-tropical countries of world. With its rich cultural and religious significance spanning generations, the mango stands as a revered symbol, acclaimed as the "king of tropical fruits" (Yadav *et al*., 2018) [11]. The mango is commercially grown and popular in more than 80 countries worldwide. Among them, India is the largest producer of mango accounting for nearly 50 per cent of the total production of the world (Senjaliya *et al*., 2022) [8]. India occupies top position among mango growing countries of the world with an area of 2.39 million hectares and annual production of 22.66 million tonnes (Anonomous, 2024) [1]. The mango industry faces significant post-harvest losses, with fungal diseases being a primary culprit. These losses can be as high as 50%, particularly impacting perishable fruits like mangoes more severely than other crops (Eckert and Ogawa, 1985) [3]. During transport, storage and sale, on an average of 17.7% of mangoes rot due to fungal infections (Sharma *et al*., 1994) [9]. Among the various post-harvest diseases, stem end rot, caused by *L. theobromae*, is a major concern in India (Johnson *et al*., 1991) [5]. Globally, stem end rot is considered the second most severe post-harvest mango disease after anthracnose (Dodd *et al*., 1997) [2]. Stem end rot initially appears as a small, light brown lesion on the mango's skin around the stem. Which later form a circular snuff brown black patch having fringed margin, under humid condition through which a light brown exudation occurred (Pathak and Srivastava, 1967) [6].

This comprehensive approach aimed to understand the progression of the disease from harvest through to retail sale and to identify potential intervention points for disease management. Additionally, the survey intended to assess the pathogenic diversity of *L. theobromae*, the primary causal agent, across different locations.

Materials and Methods

An intensive roving survey was carried out during the summer season of 2024 (May to July) in major mango-producing regions of Junagadh and Gir Somnath districts to assess the severity of stem end rot diseases of mango. The survey encompassed mango 69 orchards, 14 wholesale and 18 retail mango markets. Naturally infected as well as randomly selected unripe fruits of mango cv. Kesar showing typical symptoms of stem end rot were picked up

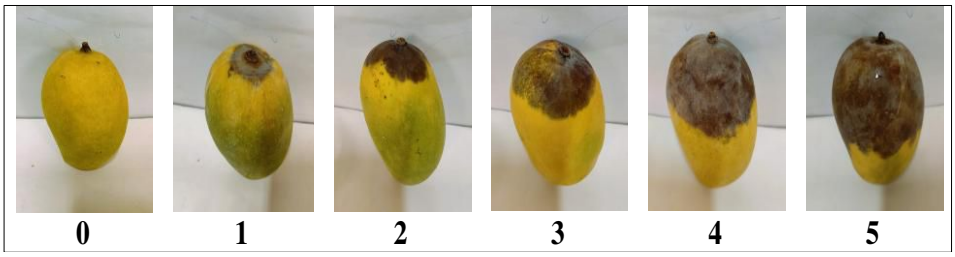
from both the orchards and markets during survey. Each sample containing 60 fruits. It was collected in paper bags then bring to the laboratory and stored at room temperature for 24 hours. Stored samples were examined every day for post-harvest diseases and fruits showing typical stem end tot disease symptoms were sorted out for the isolation and confirmation of the causal agents. The numbers of infected fruits were recorded and per cent disease incidence was calculated by using following standard formula as given by Gupta (2007) [4]. The fruit weight loss was also calculated by using following formula.

$$\text{Disease Incidence (\%)} = \frac{\text{Number of diseased fruits}}{\text{Total number of fruits}} \times 100$$

$$\text{Disease Incidence (\%)} = \frac{\text{Number of diseased fruits}}{\text{Total number of fruits}} \times 100$$

Likewise; to assess the disease severity, observations were taken on area of fruit surface showing symptoms in 0-5 scale as given by Prasannakumar *et al*., (2002) [7].

Grade	Description
0	No symptoms on fruit surface
1	0.1- 5 per cent area covered by lesions
2	5.1-10 per cent area covered by lesions
3	10.1- 25 per cent area covered by lesions
4	25.1-50 per cent area covered by lesions
5	>50 per cent area covered by lesions



Further, per cent disease intensity (PDI) was calculated by using following formula as given by Wheeler, (1969) [10].

$$\text{PDI} = \frac{\text{Sum of all individual rating}}{\text{Total no. of fruits observed} \times \text{Maximum disease grade}} \times 100$$

Results and Discussion

The findings revealed a consistent trend of increasing disease prevalence, severity and fruit weight loss as mango moved from the field to wholesale markets and finally to retail markets in both districts. In Gir Somnath district, the lowest disease levels were recorded at the field level with 10.15% incidence, 4.27% severity and 11.49% fruit weight loss. These parameters increased at the wholesale stage to 19.10% incidence, 14.84% severity and 14.68% fruit weight loss, reaching the highest levels in retail markets with 22.26% incidence, 20.62% severity and 18.38% fruit weight loss.

A similar trend was observed in Junagadh district. At the field level, disease incidence was 9.53%, severity 4.10% and fruit weight loss 11.26%. These levels increased to 17.62% incidence, 11.53% severity and 14.10% fruit weight loss in wholesale markets, peaking in retail markets with 23.99% incidence, 22.51% severity and 19.30% fruit weight loss. Notably, retail market losses in Junagadh district were slightly higher than those recorded in Gir Somnath. This progressive escalation in disease prevalence and fruit deterioration highlights the critical role of post-harvest handling, transportation, storage and market conditions in aggravating stem end rot in mango.

1. Field survey for stem end rot diseases of mango

A detailed field survey covering 69 villages across eight talukas of Junagadh and Gir Somnath districts revealed substantial variation in stem end rot incidence and severity (Table 1 and Plate 1). The highest disease incidence (30.06%) was recorded in Ramrechi village, while the highest severity (14.28%) occurred in Talala village, both located in Gir Somnath district. In contrast, the lowest disease incidence (1.67%) and severity (0.34%) were observed in Ratang village of Junagadh district.

Several villages, including Chhachhar, Ghusiya and Motha in Gir Somnath district and Manpur in Junagadh district, were completely free from the disease during the survey period. Analysis of fruit weight loss data indicated a direct correlation between disease severity and fruit weight reduction. Villages with high disease levels, such as Ramrechi (15.60% fruit weight loss) and Talala (14.93%), recorded significantly greater losses compared to normal physiological levels. Conversely, villages free from stem end rot disease (e.g., Chhachhar - 9.50%, Ghusiya - 9.95%, Motha - 10.05% and Manpur - 9.92%) exhibited fruit weight losses within or near the expected physiological range. These findings demonstrate the localized nature of disease prevalence at the orchard level and highlight the influence of disease-free orchards on minimizing post-harvest losses.

2. Wholesale market survey for stem end rot diseases of mango

The survey of 14 major wholesale mango markets across Junagadh and Gir Somnath districts revealed notable variations in disease incidence, severity and fruit weight loss (Table 2 and Plate 1). Among all the surveyed markets, the highest disease incidence (28.39%) was recorded at APMC Mango Market Yard, Talala, while the highest severity (18.81%) occurred at APMC Market Yard, Kodinar.

The Centre of Excellence for Mango at Talala exhibited the lowest disease incidence (11.69%) and severity (7.59%), demonstrating the potential benefits of improved handling and storage infrastructure in reducing post-harvest losses. In terms of fruit weight loss, the highest percentage (18.13%) was observed at APMC Mango Market Yard, Talala, corresponding with high disease levels. In contrast, the Centre of Excellence for Mango recorded the lowest fruit weight loss of 11.71%. These results emphasize the critical role of post-harvest market practices and infrastructure in either mitigating or exacerbating stem end rot losses at the wholesale level.

3. Retail market survey for stem end rot diseases of mango

Assessed the incidence and severity of mango stem end rot at the retail level (Table 3 and Plate 1). The significant variations were observed in stem end rot prevalence and severity at the retail level. Among the surveyed retail markets, the highest disease incidence (40.08%) and severity (37.95%) were notably recorded in Vegetable Market, Dhal Road (Junagadh), whereas the lowest disease incidence (15.03%) and severity (14.19%) were recorded at Fruits Market, Sakkarbaug (Junagadh).

Furthermore, analysis of fruit weight loss in various retail mango markets as presented in Table 3 revealed that the highest losses were observed at Vegetable Market, Dhal Road (26.35%). The lowest losses were recorded at Fruits Market, Sakkarbaug (13.19%).

Collectively, the surveys demonstrated a clear trend: disease prevalence, encompassing incidence and severity as well as associated fruit weight loss, was minimal at the field level, progressively increasing through the wholesale stage and reaching its maximum at the retail distribution level. This escalating trend is primarily attributed to the cumulative effects of post-harvest handling, transportation stresses, prolonged storage and varying environmental conditions encountered at each stage of the supply chain. These factors collectively favor the development of the pathogen (*L. theobromae*) and subsequent fruit deterioration, leading to significant economic losses highlighted by the increasing fruit weight reduction due to stem end rot of mango.

Conclusion

A roving survey conducted from May to July during the summer seasons of 2024 across 69 orchards, 14 wholesale and 18 retail mango markets in Junagadh and Gir Somnath districts of Saurashtra, revealed widespread stem end rot. Disease severity significantly increased as fruit progressed from fields to markets: field incidence ranged from 3.34-30.06% (1.65-13.6% severity), escalating in wholesale markets (11.69-28.39% incidence and 7.59-17.82% severity) and retail markets (15.03-40.08% incidence and 14.19-37.95% severity). A similar trend was observed in fruit weight loss, emphasizing the intensification of disease during post-harvest stages. Variations are attributed to differences in horticultural practices, environmental conditions and post-harvest handling and storage across various regions and locations.

Conflict of Interest

The authors have no conflict of interest.

Acknowledgement

The authors are highly thankful to the Director of Research and Dean, Faculty of P. G. Studies, Junagadh Agricultural University, Junagadh for providing the necessary facilities to conduct the research work.

Table 1: Field survey for stem end rot diseaseof mango

Sr. No.	Taluka	Village/City	Latitude-Longitude	Disease Incidence (%)	Disease Severity (%)	Fruit weight loss (%)
(1) Junagadh District						
1	Junagadh	Baliyavad	21.583588°N - 70.567981°E	16.7	5.28	11.97
2		Dungarpur I (J K farm)	21.458206°N - 70.490525°E	5.01	3.61	10.72
		Dungarpur II (Shree Hari Farm & Gaushala)	21.456681°N - 70.496975°E	10.02	4.62	11.63
3		Junagadh I (Sakkarbaug Farm)	21.541424°N - 70.467811°E	20.04	9.2	13.88
		Junagadh II (Lalbaug Farm)	21.514820°N - 70.450925°E	18.37	6.64	12.91
		Junagadh III (Sagdividi)	21.484670°N - 70.436421°E	11.69	3.61	10.69
4		Khadiya	21.445119°N - 70.515281°E	6.68	2.67	10.76
Mean				**12.64**	**5.09**	**11.79**
5	Keshod	Magharwada	21.375926°N - 70.287143°E	8.35	5.05	10.69
6		Manekvada	21.385951°N - 70.269381°E	6.68	3.35	10.45
Mean				**7.51**	**4.20**	**10.57**
7	Mendarada	Amargadh	21.310020°N - 70.439080°E	3.34	1.65	10.41
8		Kenedipur	21.275988°N - 70.487028°E	10.02	5.30	11.54
9		Khodiyal Nani	21.291792°N - 70.482689°E	16.7	7.44	12.37
10		Malanka	21.236222°N - 70.508349°E	6.68	2.67	11.39
11		Manpur	21.290304°N - 70.454379°E	0.00	0.00	9.92
12		Najapur	21.330587°N - 70.454253°E	10.02	3.35	12.15
Mean				**7.79**	**3.40**	**11.30**
13	Vanthali	Balot	21.511044°N - 70.342745°E	3.34	2.93	11.02
14		Dhanfuliya	21.450513°N - 70.394115°E	6.68	2.04	10.98
15		Kajaliyala Mota	21.434558°N - 70.344053°E	11.69	3.06	11.23
16		Kajaliyala Nana	21.451319°N - 70.378391°E	16.7	6.26	12.76
17		Kanjha	21.445061°N - 70.298373°E	18.37	7.62	12.97
18		Kanjhadi	21.438974°N - 70.328883°E	8.35	2.72	10.68
19		Santalpur	21.464764°N - 70.279093°E	8.35	4.95	10.72
20		Shapur	21.463342°N - 70.379125°E	21.71	8.84	13.98
21		Tinmas	21.424226°N - 70.269191°E	11.69	3.74	11.21
22		Vanthali	21.481939°N - 70.323712°E	23.38	9.52	14.78
Mean				**13.03**	**5.17**	**12.03**
23	Visavadar	Ishvariya	21.324893°N - 70.637471°E	8.35	3.63	10.69
24		Piyava Gir	21.267330°N - 70.670307°E	11.69	4.08	10.81
25		Rajpara	21.266562°N - 70.782313°E	5.01	2.28	10.69

26		Ratang	21.307517°N - 70.601976°E	1.67	0.34	10.08
27		Visavadar	21.341277°N - 70.741905°E	6.68	3.01	10.79
Mean				**6.68**	**2.67**	**10.61**
District Mean				**9.53**	**4.10**	**11.26**
(2) Gir Somnath District						
28	Gir Gadhada	Babariya	20.970580°N - 70.861403°E	1.67	0.68	10.23
29		Bhakha	20.976649°N - 70.814448°E	18.37	7.38	12.68
30		Gir Gadhada	20.936079°N - 90.908147°E	4.98	1.74	10.54
31		Jamvala Gir	20.979042°N - 70.764687°E	11.67	3.44	10.95
32		Thordi Gir	20.962310°N - 70.849940°E	20.04	9.52	13.57
33		Umedpara	20.910678°N - 70.888208°E	6.68	4.32	10.81
Mean				**10.57**	**4.51**	**11.46**
34	Kodinar	Arnej	20.892096°N - 70.693607°E	5.01	2.95	10.43
35		Chhachhar	20.862337°N - 70.759635°E	0.00	0.00	9.50
36		Dudana	20.804720°N - 70.718877°E	4.96	1.70	10.29
37		Ghantvad	20.926157°N - 70.752069°E	15.03	5.06	12.52
38		Govindpurbhandariya	20.861901°N - 70.751308°E	13.36	3.71	11.94
39		Sugala	20.898305°N - 70.758609°E	10.02	3.40	10.35
40		Vadnagar	20.839359°N - 70.701840°E	18.37	5.44	13.10
Mean				**9.53**	**3.18**	**11.16**
41	Talala	Ankolvadi	21.035751°N - 70.671481°E	20.04	8.25	13.68
42		Bhimdeval	20.962854°N - 70.605108°E	15.03	4.42	12.45
43		Bhojde	21.142919°N - 70.591644°E	10.02	2.64	12.05
44		Borvav	21.093035°N - 70.582900°E	10.02	8.62	11.78
45		Dhava	20.070902°N - 70.600638°E	16.7	5.44	11.89
46		Gabha	21.011351°N - 70.513137°E	21.71	10.23	13.56
47		Ghusiya	21.014164°N - 70.484392°E	0.00	0.00	9.95
48		Gundaran	21.041436°N - 70.570518°E	3.34	2.64	10.45
49		Hadmatiya	21.010435°N - 70.637838°E	15.03	8.16	12.86
50		Jambur	21.033318°N - 70.606521°E	6.68	4.95	11.76
51		Jasapur	21.088958°N - 70.640775°E	1.67	1.32	10.09
52		Mal Jinjava	21.008304°N - 70.469004°E	18.37	3.98	13.22
53		Moruka	21.067597°N - 70.647694°E	8.35	7.26	11.33
54		Pipalava	21.036585°N - 70.528286°E	23.38	11.56	13.78
55		Ramrechi	21.068714°N - 70.533996°E	30.06	13.6	15.60
56		Surva	21.040239°N - 70.636655°E	15.03	6.68	12.88
57		Talala	21.065881°N - 70.537923°E	25.05	14.28	14.93
58		Umrethi	21.024384°N - 70.461598°E	6.68	2.69	10.76
Mean				**13.73**	**6.48**	**12.39**
59	Una	Delwada	20.787505°N - 71.044114°E	3.34	1.7	10.21
60		Kanakbarda	20.839283°N - 71.115082°E	8.35	3.74	11.03
61		Kothari	20.799600°N - 71.060948°E	6.68	2.72	10.78
62		Motha	20.826334°N - 71.139042°E	0.00	0.00	10.05
63		Nathej	20.854910°N - 71.086352°E	10.02	4.12	11.26
64		Sankhada	20.827985°N - 71.158311°E	5.01	2.04	10.63
Mean				**5.57**	**2.38**	**10.66**
65	Veraval	Dabhor	20.941146°N - 70.359892°E	18.37	8.38	13.41
66		Khandheri	20.959670°N - 70.590470°E	6.68	2.72	10.83
67		Moraj	20.983943°N - 70.431815°E	11.67	3.40	11.16
68		Pandava	20.965736°N - 70.507501°E	5.01	2.02	10.68
69		Savni	20.968933°N - 70.465891°E	15.03	7.72	12.92
Mean				**11.35**	**4.84**	**11.80**
District Mean				**10.15**	**4.27**	**11.49**

Table 2: Wholesale market survey for stem end rot disease of mango

Sr. No.	Taluka	Wholesale Market	Latitude-Longitude	Disease Incidence (%)	Disease Severity (%)	Fruit weight loss (%)
(1) Junagadh District						
1	Junagadh	Gujarat Fruits Supplier, Dolatpara	21.547884°N - 70.466259°E	18.37	13.53	14.15
2		Ram Mango Supplier, Vanthali road	21.479147°N - 70.340051°E	15.03	8.25	13.01
3		Sardar Patel Market Yard, Dolatpara	21.549877°N - 70.466103°E	25.05	18.15	17.42
Mean				**19.48**	**13.31**	**14.86**
4	Vanthali	APMC, Mango Market Yard, Vanthali	21.483024°N - 70.355232°E	20.04	13.24	14.78
Mean				**20.04**	**13.24**	**14.78**
5	Visavadar	Keshubhai Patel Market Yard, Visavadar	21.358127°N - 70.747782°E	13.36	8.04	12.65
Mean				**13.36**	**8.04**	**12.65**
District Mean				**17.62**	**11.53**	**14.10**

(1) Gir Somnath District						
6	Kodinar	APMC Market Yard, Kodinar	20.797589°N - 70.697546°E	21.71	18.81	15.97
Mean				**21.71**	**18.81**	**15.97**
7	Talala	Anil Farm - Golden Baug and Nursery, Sasan Gir	21.172676°N - 70.575134°E	20.04	9.56	14.21
8		APMC, Mango Market Yard, Talala	21.073319°N - 70.543962°E	28.39	17.82	18.13
9		Gajera Kesar Mango Supplier - Talala	21.057271°N - 70.634889°E	21.71	13.20	15.49
10		KKM Mango Supplier- Galiyavad	21.047673°N - 70.500257°E	20.4	13.40	14.75
11		Maruti Mango Supplier, Talala	21.035924°N - 70.536443°E	23.38	15.84	16.02
12		Talala (COE for Mango)	21.065455°N - 70.538032°E	11.69	7.59	11.71
13		Talala Gir Mango Supplier, Pipalava	21.036397°N - 70.536456°E	18.37	10.24	14.01
Mean				**20.56**	**12.52**	**14.90**
14	Veraval	APMC Market, Kajli	20.894304°N - 70.419163°E	15.03	13.20	13.19
Mean				**15.03**	**13.20**	**13.19**
District Mean				**19.10**	**14.84**	**14.68**

Table 3: Retail market survey for stem end rot disease of mango

Sr. No.	Taluka	Wholesale Market	Latitude-Longitude	Disease Incidence (%)	Disease Severity (%)	Fruit weight loss (%)
(1) Junagadh District						
1	Junagadh	Fruit Market, Aazad chowk	21.519337°N - 70.461473°E	30.06	27.72	22.87
2		Fruits Market, Sakkarbaug road	21.540518°N - 70.463033°E	15.03	14.19	13.19
3		Joshipara Market, Joshipara	21.530668°N - 70.451905°E	35.07	33.33	23.56
4		Madhuram Vegetable Market, Vanthali Road	21.501165°N - 70.427114°E	28.39	27.37	22.12
5		Moti Baug	21.507804°N - 70.448895°E	20.04	18.46	17.08
6		Reliance Smart Bazaar, Zanzarda	21.524245°N - 70.438624°E	23.38	23.10	21.76
7		Swaminarayan Temple, Vanthali Road	21.504385°N - 70.442199°E	18.37	15.84	16.02
8		The Great Gujri Sunday Market, Gandhigram	21.509586°N - 70.457155°E	33.4	30.36	23.21
9		Vegetable and Fruits Market, Mangnath	21.518899°N - 70.462325°E	25.05	24.75	20.32
10		Vegetable Market, Dhal road	21.522683°N - 70.465263°E	40.08	37.95	26.35
Mean				**26.89**	**25.31**	**20.65**
11	Vanthali	Vegetable and Fruit Market, Vanthali	21.477208°N - 70.334612°E	23.38	22.42	19.54
Mean				**23.38**	**22.42**	**19.54**
12	Visavadar	Vegetable Market, Visavadar	21.341135°N - 70.752239°E	21.71	19.80	17.71
Mean				**21.71**	**19.80**	**17.71**
13	Kodinar	Old Vegetable Market, Pedhavada	20.794359°N - 70.701308°E	23.38	20.46	19.76
14		Vegetable and Fruit Market, Sardarnagar	20.810215°N - 70.688879°E	18.37	16.83	16.19
15	Talala	Vegetable Market, Gayatrinagar	21.056422°N - 70.531996°E	21.71	20.79	17.64
16		Vegetable Market, Talala	21.056676°N - 70.532081°E	26.72	24.75	20.17
Mean				**24.21**	**22.77**	**18.90**
17	Veraval	Main Vegetable Market, Kharakuva	20.905470°N - 70.365033°E	18.37	18.15	16.55
18		Vegetable and Fruit Market, Veraval	20.910375°N - 70.369689°E	25.05	22.73	19.98
Mean				**21.71**	**20.44**	**18.26**
District Mean				**22.26**	**20.62**	**18.38**

Plate 1: Survey for stem end rot disease of mango

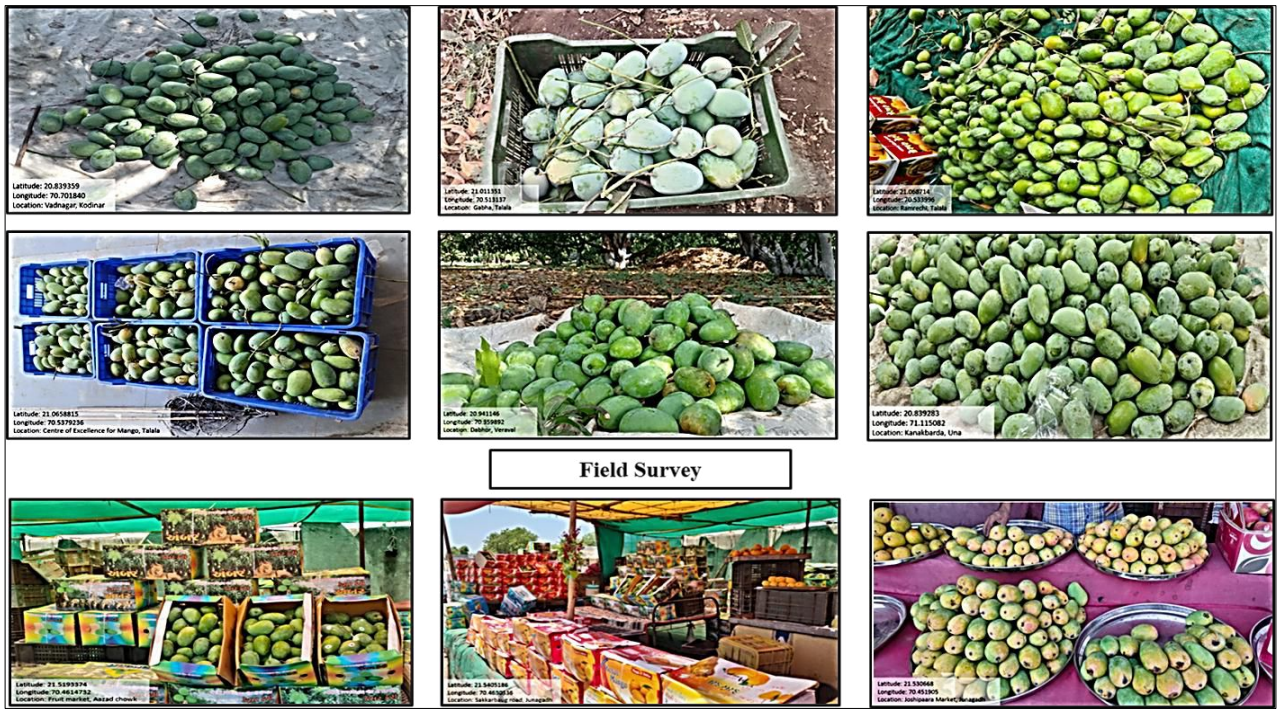


Plate 2: Survey for stem end rot disease of mango

Retail Survey

Plate 3: Survey for stem end rot disease of mango

Wholesale Survey

Plate 4: Survey for stem end rot disease of mango

References

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