Botanical Leaf Packing as a Green Strategy to Manage Stem End Rot Caused by *Lasiodiplodia theobromae* in Mango cv. Kesar

Abstract

Mango (*Mangifera indica* L.) is one of the most important tropical fruit crops of India; however, its production and market value are severely affected by post-harvest diseases, particularly stem end rot (SER). During storage and ripening, stem end rot caused by latent fungal infections such as *Lasiodiplodia theobromae* causes large post-harvest losses. Concerns about fungicide resistance, chemical residues, environmental contamination, and hazards to human health have been brought up by the overuse of synthetic fungicides for disease management. Thus, there is an immediate need for sustainable and eco-friendly alternatives. The current study was conducted to assess the effectiveness of various plant leaf treatments for the management of stem end rot disease in the mango variety Kesar. Plant-derived antifungal compounds such as flavonoids, phenolic acids, alkaloids, isothiocyanates, tannins, saponins, aliphatic aldehydes and terpenoids exhibit strong antimicrobial activity**,** effectively reducing disease severity, delaying fruit ripening, and enhancing shelf life without leaving hazardous residues**.** Healthy, uniform mango fruits were packed with fresh leaves of tulsi, karanja, curry leaf, neem, lantana, eucalyptus, and drumstick at 25 g kg^{-1} fruit and stored at room temperature under a completely randomized design. Disease incidence and shelf life observations were noted. In comparison to the control (70.00%), the results showed that fruits packed with karanja leaves had the lowest disease incidence (20.00%), which was at par with neem leaves (23.33%). Fruits treated with neem leaves (12.67 days) and karanja leaves (14.67 days) had far longer shelf lives than control fruits (7.00 days). The study showed that plant leaf treatments—specifically, karanja and neem leaves—are safe, efficient, and eco-friendly substitutes for controlling stem end rot disease and extending the shelf life of mango fruits.

Keywords: Mango, Stem end rot, Leaves, Per cent disease incidence, Shelf life

1. Introduction

One of India's most significant tropical fruit crops, the mango (*Mangifera indica* L.) is referred to as the "King of Fruits" because of its superior flavor, abundance of nutrients, and versatility (Mayani *et al.*, 2017). Mango, *Mangifera indica* L., a member of the Anacardiaceae family and order Sapindales (Anusha *et al*., 2023). Fundamental chromosomal number of mango is 10 (2n = 4x = 40) (Hassan Zai, 2024). It is frequently grown in tropical and subtropical regions of Southeast Asia. It is believed that mangoes originated in India, Burma (Myanmar) and even the Malay region. In the sixteenth century, it started to spread to other continents (Anusha *et al.*, 2023).

"Alphonso" and "Kesar" in western India, "Banganpalli," "Totapuri," and "Neelum" in southern states, "Bombai," "Gulabkhas," "Malda," "Zardalu," and "Fazli" in eastern states,

and "Dashehari," "Langra," and "Chausa" in northern states are popular varieties grown throughout the nation (Singh *et al*., 2017). Kesar, Alphonso, Rajapuri, Totapuri, Dadamiyo, Jamadar, Dashehari, Langra, Karanjiyo, Sardar, and Neelum are among the commercial mango varieties planted in Gujarat (Noorullah, 2018).

Gujarat is one of the top mango-producing states due to its advantageous agro-climatic conditions and India leads the globe in mango production, accounting for a significant portion of worldwide production (Anon., 2013; Bhagwat *et al.*, 2016). Mango production and marketing are significantly hampered by post-harvest diseases, which result in significant qualitative and quantitative losses during storage, transportation and ripening, despite the fruit's economic significance (Dodd *et al*., 1997; Haggag, 2010)

Stem end rot (SER) is one of the most severe post-harvest diseases that affect mango quality, shelf life, and marketability (Johnson *et al.*, 1992). Latent fungal pathogens such as *Lasiodiplodia theobromae*, *Dothiorella* spp., *Phomopsis mangiferae*, and *Pestalotiopsis* spp., which infect fruit throughout flowering and fruit development stages and remain dormant until ripening, are the primary cause of the disease (Johnson *et al*., 1992; Galsurker, 2018). Mango fruit undergoes physiological and biochemical changes during ripening, including ethylene generation, increased sugar content, cell wall disintegration, and decreased defense chemicals, which encourage the activation of these pathogens and cause severe decay at stem end (Galsurker, 2018).

Microbial degradation is responsible for 17.0–26.9% of fresh mango post-harvest losses in Asian nations, which are estimated to be between 25 and 40% in India (Diedhiou *et al.*, 2007; Vahia, 2021). Synthetic fungicides are traditionally used to control stem end rot before or after harvest; however, their irresponsible application has led to fungicide resistance, chemical residues, environmental contamination, and possible health risks (Bally, 2006; Zhan *et al.*, 2023). These restrictions have made it necessary to create safe, environmentally acceptable, and sustainable options for the control of mango post-harvest diseases.

Because of their innate antifungal qualities, non-toxicity, and safety for both people and the environment, plant extracts have drawn interest as a potential solution for postharvest disease management (Obagwu & Korsten, 2003).

By serving as an antifungal include flavonoids, phenolic acids, alkaloids, isothiocyanates, tannins, saponins, aliphatic aldehydes, and terpenoids, are responsible for their antimicrobial effectiveness. It has been discovered that using plant extracts can decrease the severity of diseases, postpone fruit ripening, and increase fruit shelf life without producing hazardous residues.

By lowering dependence on chemical fungicides and protecting human health and the environment, eco-friendly management techniques not only reduce post-harvest losses but also support sustainable agriculture (Perrenoud, 1994; Vahia, 2021). However, systematic studies on the use of different plant leaves for the management of mango stem end rot disease are limited, particularly under Indian conditions.

With the goal of reducing post-harvest losses while establishing grower-friendly, sustainable disease management techniques, the current study was conducted to assess the effectiveness of various plant leaf extracts as environmentally sound treatments for the management of mango stem end rot disease.

2. Materials and methods

Ten healthy, uniform in size (average size) and shape, free from any bruising and mechanical injured fruits of mango of Kesar variety were collected from farm and each was cleaned by washing under cold tap water then wiped with muslin cloth. Fruits were packed in cardboard boxes by making a layer of fresh leaves (25g Kg^{-1} fruits) of each treatment along with the control and kept at room temperature (27°C ± 2). Each fruit amongst the different treatments were thoroughly scrutinized for any visible symptoms of stem end rot disease and end of shelf life was considered when 30 per cent fruits were show over ripen.

3. Observations recorded

- Shelf life
- Number of infected fruits were recorded and per cent disease incidence was calculated by using following standard formulae (Mamatha and Rai, 2000):

$$\mathrm{DI}(\%) = \frac{Do}{D} \times 100$$

Where, DI = Disease incidence

Do = Number of infected fruit

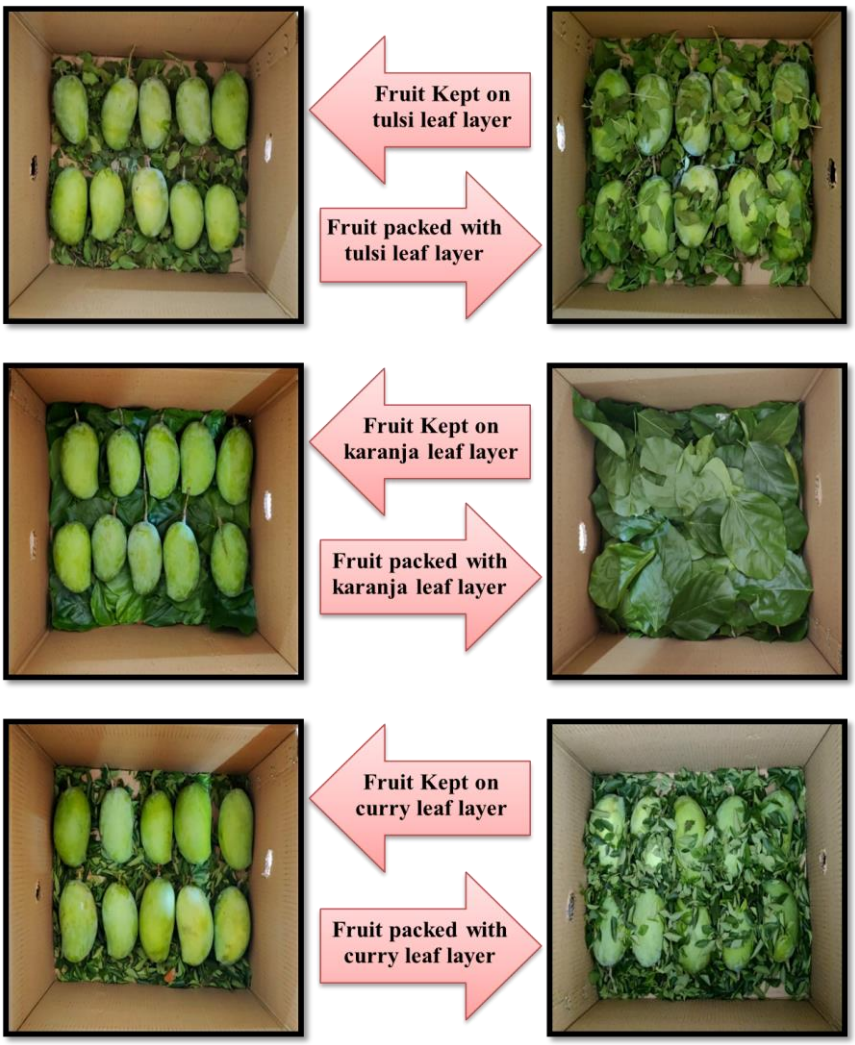
D = Total number of fruit

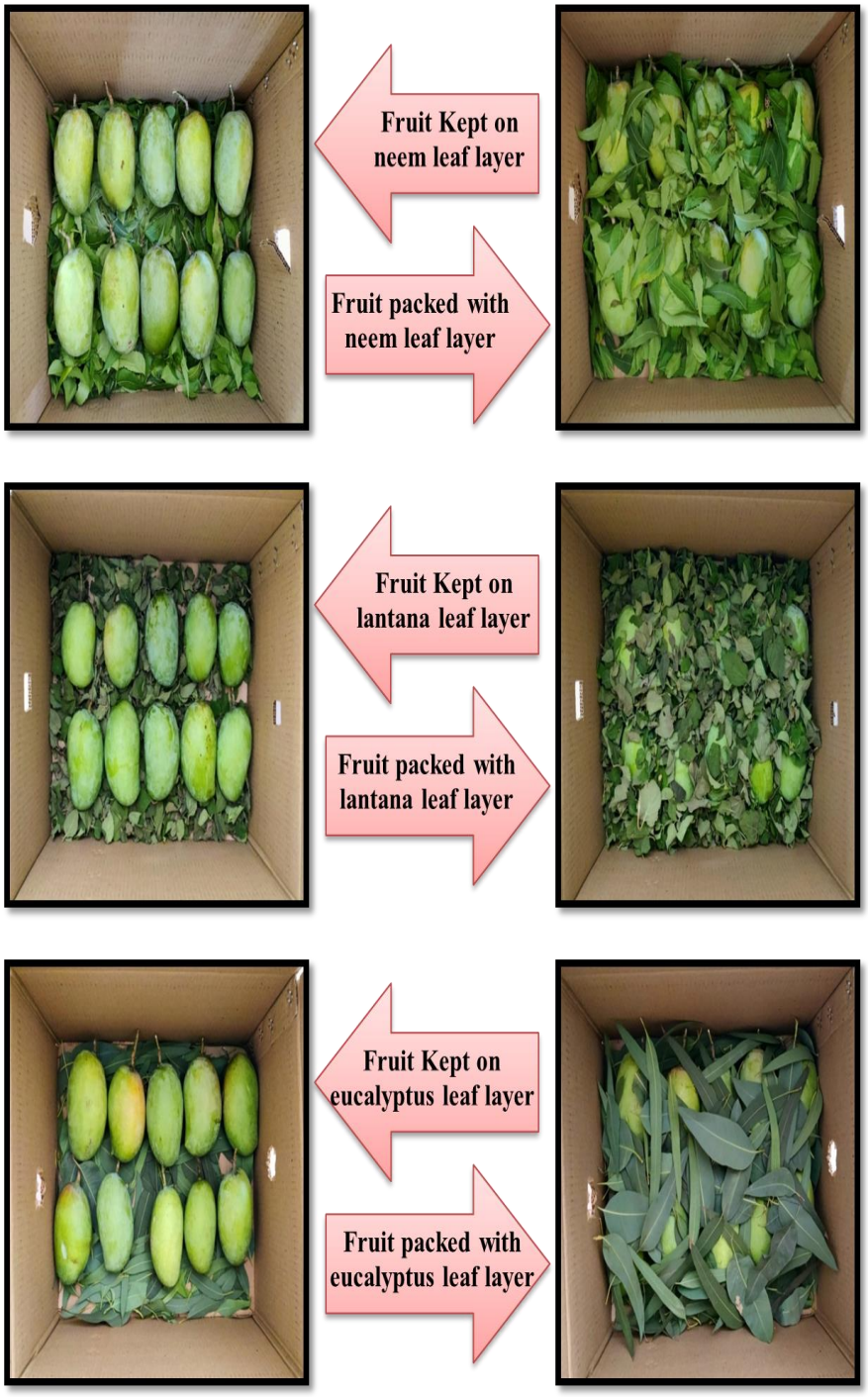
4. Statistical analysis

For the experiment CRD (Completely Randomized Design) design was done through statistical packages. The replicate fruits were used to assess disease incidence and shelf life. Data were subjected to analysis of variance (ANOVA) and disease incidence were arc sine transformed before analysis.

Table 1. Different botanicals used in experiment

Tr. No.	Name	Scientific name	Family	Chemical Compounds
T_1	Tulsi	*Ocimum tenuiflorum* L.	Lamiaceae	Eugenol
T_2	Karanja	*Millettia pinnata* L.	Febaceae	Karanjin
T_3	Curry tree	*Murraya koenigii* (L.) Sprengel	Rutaceae	Murrayacine, Murrayanine
T_4	Neem	*Azadirachta indica* A. Juss	Meliaceae	Nimbicidin, Azadirachtin
T_5	Lantana	*Lantana camera* L.	Verbenaceae	Sesquiterpenes
T_6	Eucalyptus	*Eucalyptus camaldulensis* L.	Myrtaceae	Eucalyptol
T_7	Drumstick	*Moringa oleifera* L.	Moringaceae	Niazirin
T_8	Control			


Fruit Kept on tulsi leaf layer
Fruit packed with tulsi leaf layer
Fruit Kept on karanja leaf layer
Fruit packed with karanja leaf layer
Fruit Kept on curry leaf layer
Fruit packed with curry leaf layer


Fruit Kept on neem leaf layer
Fruit packed with neem leaf layer
Fruit Kept on lantana leaf layer
Fruit packed with lantana leaf layer
Fruit Kept on eucalyptus leaf layer
Fruit packed with eucalyptus leaf layer

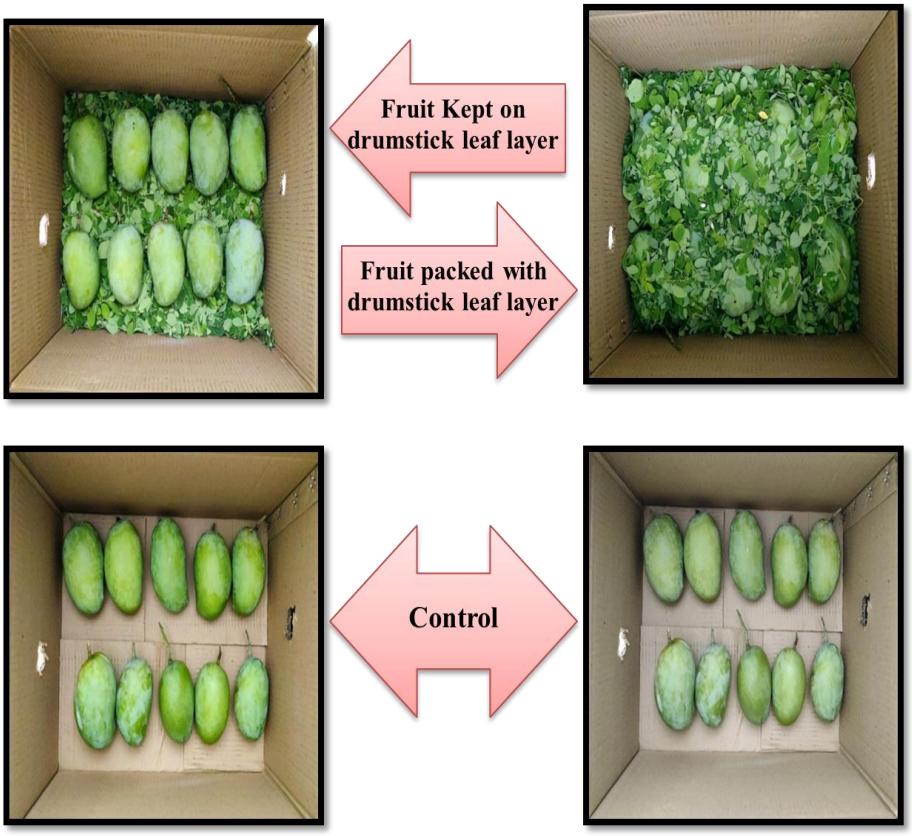


Photo 1 : Mango fruits packed with different botanical leaves in cardboard box (10 kg) with making layer of leave on fruit

5. Results and Discussion

The data presented in table 1 showed that fruit packed with karanja leaves show minimum disease incidence (20.00%) which is at par with neem leaves (23.00%) followed by tulsi leaves (30.00%), eucalyptus leaves (30.00%), curry leaves (50.00%), lantana leaves (50.00%), drumstick leaves (53.00%) as compared to control (70.00%). Shelf life of fruit found to be higher in fruits covered by karanja leaves (14.67 days) followed by neem leaves (12.67 days) as compared to control (7 days) (Table 4.5 and Photo 4.12).

This, result was in accordance with, Tandel (2017) discovered that mango fruits treated with a 10 per cent solution of neem leaf extract exhibited a notable decrease (88.30%) in the occurrence of stem end rot disease. Additionally, these treated fruits demonstrated an extended shelf life of 11.17 days which was comparable to the shelf life achieved 7.00 days in control fruits.

Suresh and Sagar (2016) who reported that fruit treated with neem and karanj leaf extract (10%) showed significant percent inhibition 8.15 per cent and 5.93 per cent respectively in disease incidence of mango stem end rot disease. The fruits treated with neem leaf extract showed higher shelf life (11.17 days).

These studies support the use of *P. pinnata* extracts as natural antimicrobial agents with potential applications in plant and human disease management. Azadirachtin is considered the most active substance in neem, which has growth-regulating, fungicidal and insecticidal properties (Khan *et al.*, 2021). The aroma and volatile compound of different leaves form a thin film around the fruit that works as an anti-repellent and antifungal. Therefore, it prevents the entry, penetration and attack of pathogens.

Karanjin and pongamol interfere with chitin and β-glucan synthesis**,** weakening the fungal cell wall and restricting hyphal growth of *L. theobromae*. Karanja leaf extract reduces **spore viability**, abnormal hyphal branching, and distorted mycelial growth, leading to reduced pathogenicity. Phenolics and tannins present in karanja cause protein precipitation. Neem phytochemicals interact with ergosterol in the fungal cell membrane, causing increased membrane permeability**,** leakage of cellular contents, and eventual cell lysis of *L. theobromae*. This extract enhances defense-related enzymes in mango fruits, such as peroxidase (PO), polyphenol oxidase (PPO), and phenylalanine ammonia lyase (PAL)**,** leading to increased phenolic accumulation and resistance against infection.

Table 2. Eco-friendly management of stem end rot disease of mango cv. Kesar

Tr. no	Treatment	Plant part used	PDI (%)	Reduction in incidence (%)	Shelf life (days)
1	Tulsi	Leaves	(30.00) 33.21	57.14	10.67
2	Karanja	Leaves	(20.00) 26.57	71.42	14.67
3	Curry tree	Leaves	(40.00) 39.23	42.85	9.00
4	Neem	Leaves	(23.33) 28.78	66.67	12.67
5	Lantana	Leaves	(40.00) 39.23	42.85	9.00
6	Eucalyptus	Leaves	(30.00) 33.21	57.14	9.67
7	Drumstick	Leaves	(53.33) 46.92	23.81	7.67
8	Control	-	(70.00) 56.79	00.00	7.00
	SEm±		1.04	-	0.31
	CD (%)		3.11	-	0.93
	CV (0.05%)		4.73	-	2.92

*Figures in parenthesis are original value and those outside are arcsine transformation value

6. Conclusion

Mango fruits were packed in various types of fresh plant leaves when they were at the green ripe stage in order to evaluate the effect of different leaf treatments on the development of stem end rot disease. Our results revealed that fruit packed with karanj leaves showed the lowest incidence (20.00%), which was at par to neem leaves (23.33%), followed by tulsi leaves (30.00%) and eucalyptus leaves (30.00%) in comparison to the control (70.00%).

Fruits covered with karanja leaves (14.67 days) and neem leaves (12.67 days) had longer shelf lives than the control (7.00 days).

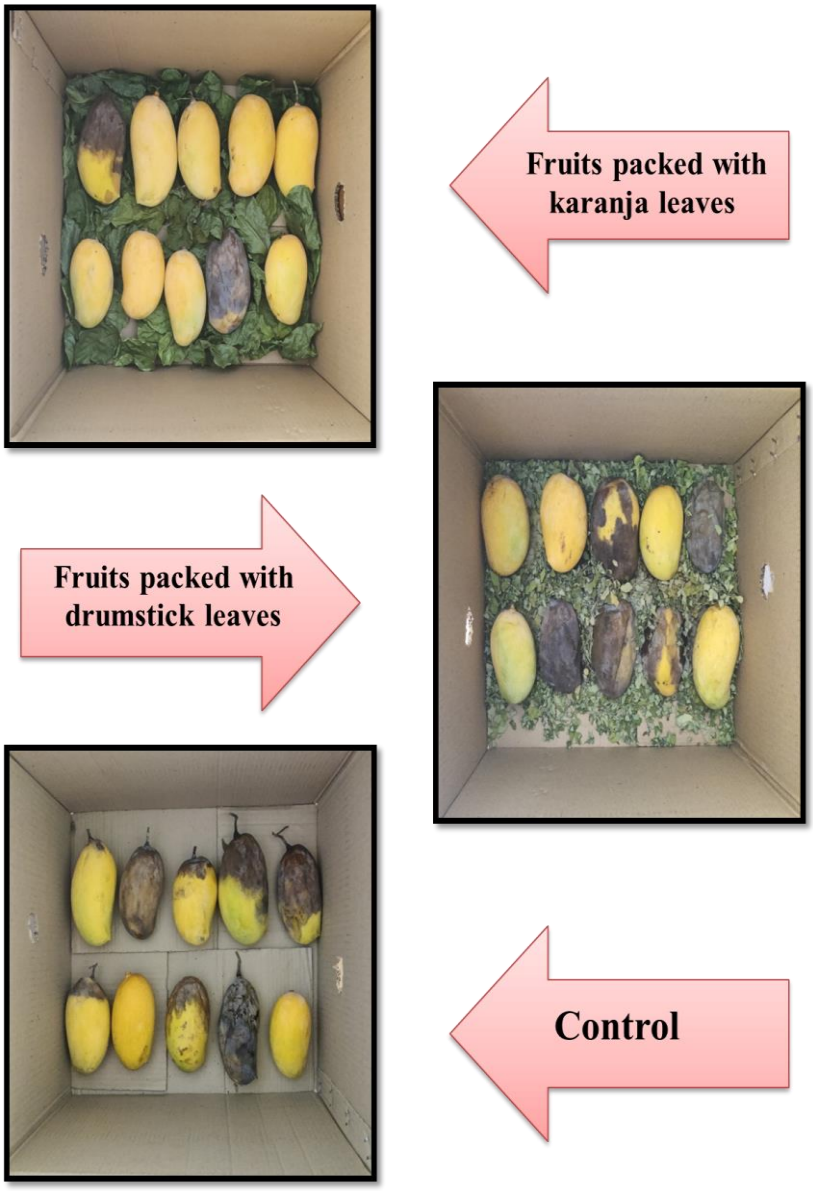


Photo 4 : Most superior and inferior botanicals against mango stem end rot disease

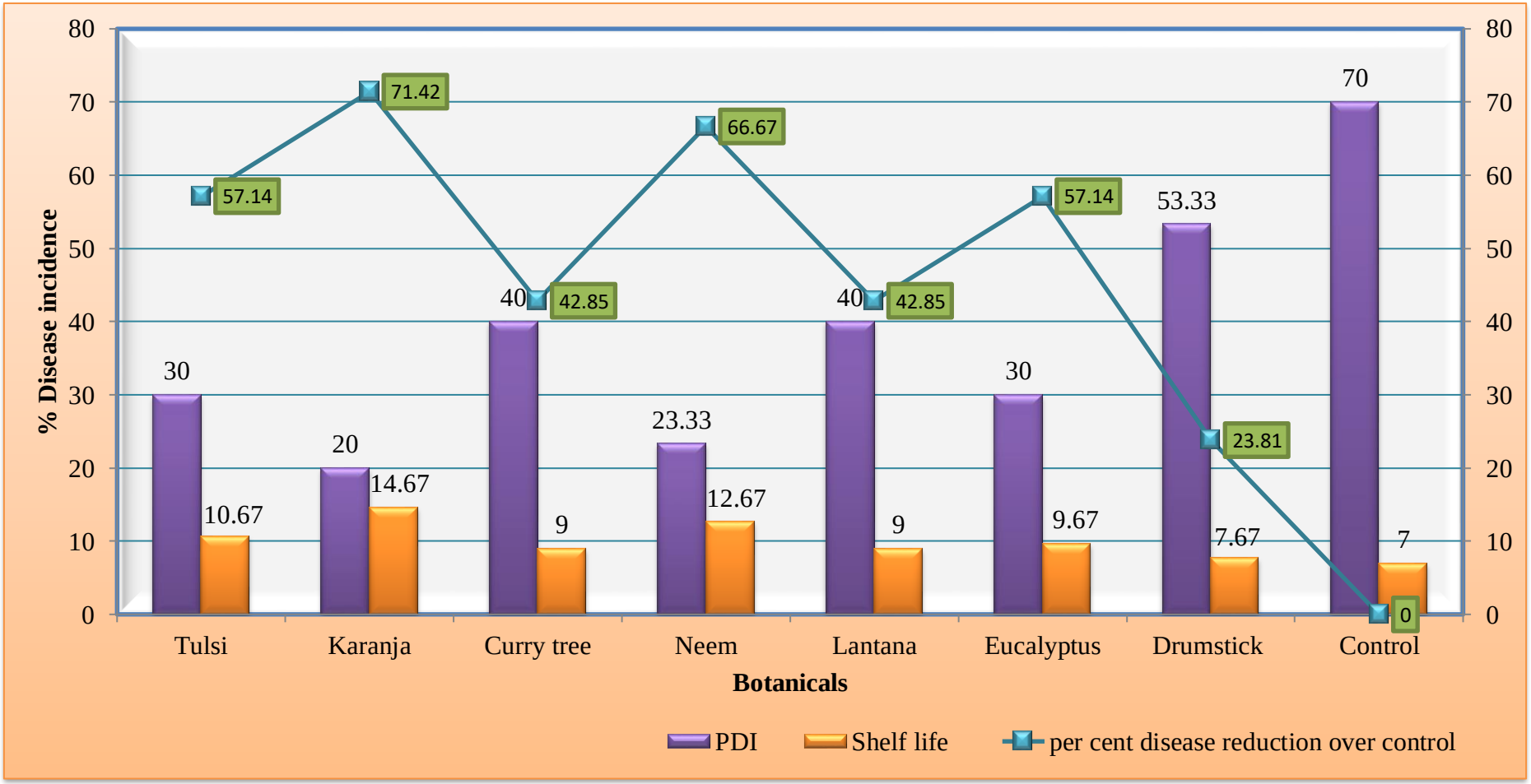


Fig. 1: Eco friendly management of stem end rot disease of mango cv. Kesar

8. References

Anonymous (2013). Post-harvest profile of mango, Directorate of Marketing and Inspection Branch, Ministry of Agriculture, Government of India, Nagpur.

Anusha, S.; Indra, N.; Kannan, R.; Geetha, P. and Rahale, C. S. (2023). Morphological and Molecular Characterization of Major Postharvest Diseases of Mango. *International Journal of Plant & Soil Science*, **35**(19): 1291-1299.

Bally, I. S. (2006). Mangifera indica (mango). *Species profiles for pacific island agroforestry*, 3: 1-25.

Bhagwat, R. G.; Mehta, B. P. and Patil, V. A. (2016). Survey and occurrence of mango anthracnose disease under south gujrat condition. *AGRES – An Int. e-J.*, **5**(2): 132–136.

Diedhiou, P. M.; Mbaye, N.; Drame, A. and Samb, P. I. (2007). Alteration of post-harvest diseases of mango (*Mangifera indica* L.) through production practices and climatic factors. *Afr. J. Biotechnol.*, **6**(9): 1087-1094.

Dodd, J. C.; Prusky, D. and Jeffries, P. (1997). Fruit diseases: Litz, R. E. (ed.) the mango: botany, production and uses. *CAB International*, UK. pp. 257-280.

Galsurker, O.; Diskin, S.; Maurer, D.; Feygenberg, O. and Alkan, N. (2018). Fruit stem-end rot. *Hortic.*, **4**(4): 50.

Haggag, W. M. (2010). Mango diseases in Egypt. *Agric. Biol. J. N. Am.*, **1**(3): 285-289.

Hassanzai, R. G.; Pratap, B.; Sonkar, A. and Jain, S. (2024). Studies on effect of bagging and foliar application of different chemicals on physico-chemical characteristics and post-harvest quality of mango fruits (*Mangifera indica* L.) Cv. Amrapali. *Plant Archives*., **24**(01): 620-624.

Johnson, G. I.; Mead, A. J.; Cooke, A. W. and Dean, J. R. (1992). Mango stem end rot pathogens-Fruit infection by endophytic colonisation of the inflorescence and pedicel. *Ann. Appl. Biol.*, **120**(2): 225-234.

Joshi, R. L. (2022). Prevalence, loss assessment and management of mango (*Mangifera indica* L.) Anthracnose disease. *Thesis M.Sc.(Agri.)*, Navsari Agricultural University, Navsari.

Khan, M. R.; Chonhenchob, V.; Huang, C. and Suwanamornlert, P. (2021). Antifungal activity of propyl disulfide from neem (Azadirachta indica) in vapor and agar

diffusion assays against anthracnose pathogens (Colletotrichum gloeosporioides and Colletotrichum acutatum) in mango fruit. Microorganisms, 9(4): 839.

Mamatha, T.; Lokesh, S. and Rai, V. R. (2000). Impact of seed mycoflora of forest tree seeds on seed quality and their management. *Seed res.*, **28**(1): 59-67.

Mayani, J.; Patel, N.; Dev Raj, P. B.; Tandel, Y. and Chhatrola, H. (2017). Effect of hot water dip treatment physico-chemical and sensory quality of Mango (CV. Kesar). *Int. J. Chem. Stud.*, **5**(6): 220-227.

Noorullah, R. (2018). Effects of silicon sources and salicylic acid on quality and shelf life of mango fruits (*Mangifera indica* L.) cv. Kesar. *Int. J. Agric. Sci.,* **10**(5): 5360-5364.

Obagwu, J. and L. Korsten. (2003). Control of citrus green and blue molds with garlic extracts. *Eur. J. Plant Pathol.*, **109**: 221-225.

Perrenoud S. (1994). Potassium and plant health. Bern: International Potash Institute. pp. 218.

Singh, A.; Tyagi, M. and Singh, C. P. (2017). Studies on morphology and physical attributes of mango varieties. *Int. J. Curr. Microbiol. Appl. Sci.,* **6**(10): 2324-2330.

Suresh, V.; Sagar, B. V.; Varma, P. K.; Sumalatha, N. and Prasad, M. R. (2016). In vitro Evaluation of Certain Fungicides, Botanicals and Bio control Agents against *Lasiodiplodia theobromae*. Res. *J. Agric. Sci.,* **7**(4): 747-750.

Tandel, D. H. (2017). Prevalence, loss assessment and management of mango (*Mangifera indica* L.) post-harvest fungal diseases. *Thesis Ph. D.*, Navsari Agricultural University, Navsari.

Vahia, C. G. (2021). Prevalence, loss assessment and management of stem end rot disease of mango (*Mangifera indica* L.). *Thesis M.Sc.(Agri.)*, Navsari Agricultural University, Navsari.

Zhan, X.; Khan, R. A. A.; Zhang, J.; Chen, J.; Yin, Y.; Tang, Z. and Liu, T. (2023). Control of postharvest stem-end rot on mango by antifungal metabolites of *Trichoderma pinnatum* LS029-3. *Scientia Horticulturae,* **310**: 111696.