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A Review on Mango Gummosis Incited by *Lasiodiplodia theobromae*

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Authors' contributions

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

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Review Article

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ABSTRACT

Mango gummosis caused by *Lasiodiplodia theobromae* (Pat.) Griffon & Moube [synonym: *Botryodiplodia theobromae]* is a serious disease in India especially on popular varieties of mango during monsoon and post-monsoon periods. Severe infection with pathogen causes up to 30- 100 % yield losses in mango. Gummosis infected orchards shows abundant gum secretion from branches, stem and main trunk and also Vascular discoloration. In severe cases infected mango trees may die. The pathogen produces grey-brown to black colonies with dense aerial mycelia on the PDA medium. Pycnidia were separate or aggregated, dark brown, thick or thin-walled. Conidiophores were hyaline, cylindrical to sub-obpyriform, with oblong, straight and hyaline single celled conidia andinitially. Gradually the conidia became dark brown and produced one septum with longitudinal striations. The pathogen has wide host range so difficult to manage the disease at field level. There are sevral Management strategies for mango gummosis like resistant or tolerant varieties, effective fungicides, botanicals and effective biological control agents role in disease management. This review attempts to summarize the Knowledge on mango gummosis, symptomotology, pathogen host range, morphological and cultural characters of *Lasiodiplodia* and management of the disease.

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1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the world's most important and popular delicious fruit of the tropical and subtropical world. It probably originated in Indo-Burma region and has been cultivated for the last 4000 years with the existence of more than 1000 varieties in Indian subcontinent. Mango fruit is very delicious taste and it has superb flavor, very high nutritive and medicinal value. Mango is being called as the "King of fruits" [1]. Most common mango diseases are anthracnose, powdery mildew, die back, malformation, sooty mould, red rust and gummosis etc. Gummosis incited by *Lasiodiplodia theobromae* (Pat.) Griffon & Moube [synonym: *Botryodiplodia theobromae*] is becoming a serious disease in India especially on popular varieties of mango [2]. In major mango growing areas mango gummosis disease incidence and severity recorded was 20-83.3 percent and 62.5-85 per cent respectively. The incidence of gummosis was reported to be 20 and 60 percent in Punjab and Sindh Provinces of Pakistan, respectively and 60 percent in Al Batinah region of Oman [3,4].

In India, Mango dieback disease was first reported by Das-Gupta and Zachariah in 1945 [5] from Uttar Pradesh and also they were the first to emphasize the importance of die back of mango caused by *B.theobromae.* In Allahabad Isolated *B. theobromae* from dead roots of mango seedlings [6]. Mango gummosis as a serious disease in Jaipur district [7],which was affected with 30-40 per cent of the plantations in the Mora bad region of Uttar Pradesh [8]. mango dieback Incidence 0 to 40 per cent [9] and 2-13.33% [10] mango gummosis incidence recorded in major mango growing areas of Andra Pradesh.

2. SYMPTOMATOLOGY

The symptoms of gummosis are dieback, twig-blight, bark splitting or cracks on bark and exudation of gum was severe in advanced conditions [10]. Infected plant secretes gum and longitudinal crack of infected stem. In severe cases, the mango trees die due to cracking, rotting and girdling [11]. Drying, dieback of twigs and darkening of the bark [12]. Later, infection moves downward effects bigger branches as well and that leads to exudation of gum from the diseased portions. In severely infected branches shows bark splitting or cracking [13] infected twigs die from the tips to back into old wood, which gives a scorched appearance to limb [14]. The affected leaves turn brown and rolls upward. In severe cases, the entire plants killed. Vascular discoloration: Infected twigs, plants and branches shows internal discolouration. Brown streaks visible in vascular region and these are severe in water stress conditions [15-18].

2.1 Mango Gummosis Symptoms

(A) Die back

B) Gummosis

C) Bark Splitting **D) Vascular Discolouration**

Fig. 1. A) Die back B) Gummosis C) Bark Splitting D) Vascular Discolouration

3. MORPHOLOGICAL AND CULTURAL CHARACTERISTICS OF THE TEST PATHOGEN

Lasiodiplodia theobromae is belongs to Ascomycota in the order Botryosphaeriales and the family *Botryosphaeriaceae* [19,20]. The sexual stage (teleomorph) *Botryosphaeria rhodina*; Morphological variation among *B. theobromae (L. theobromae)* isolates causing mango twig-blight/die-back. The size of the immature and mature pycnidia varied greatly with the substrate. The pycnidia were smallest in naturally infected twigs and biggest in nutritionally rich medium such as oatmeal agar. No such distinct variation was observed in the size of immature and mature conidia. The measurement range of mature pycnidia (189-886 x 154-704 4m) should be taken into account for identification of a species [21]. The pycnidia are mostly aggregated, spherical and dark brown in colour with thick walls; the conidia are two celled, oval and dark brown in colour produced on Potato Dextrose Agar (PDA) [22]. Pycnidia are uniloculate, dark brown to black, immersed in the host becoming erumpent when mature [23,24].

4. MORPHOLOGY OF PATHOGEN

Botryodiplodia theobromae found that 25-30^{o}C temperature optimum [25] for the pathogen. And also reported highest sporulation occurred at 30^{o}C. Mycelium growth was higher in glucose and Sucrose contain [26] media because of contain more presence of 'Carbon' sources [27] reported that lactose and glucose had similar effect on growth of *B. theobromae.* Optimum temperature of *L. theobromae* was 28^{o}C [29] and also reported PDA and PSA were most suitable for vegetative growth. Corn meal agar (CMDA), Potato sucrose agar (PSA), and Yeast extract manitol agar (YEMA) were most suitable for mycelial growth but Potato carrot agar (PCA) was not suitable for either mycelial growth or pycnidia production. The YEMA found best medium for pycnidial formation as well as maximum numbers of pycnidia were produced at 35-40ºC. Glucose and sucrose were found superior for growth. maximum growth of the pathogen amongst the tested inorganic nitrogen sources was observed on Potassium nitrate supplemented media while peptone produced maximum growth among the tested organic nitrogen sources [30]. *L. theobromae g*rows at pH 5.0-9.0 and optimum growth was observed at pH 7.0 [31].

5. HOST RANGE OF THE PATHOGEN

L. theobromae causes different diseases viz., Gummosis, rots, dieback, blights canker and root rot in a variety of different hosts in tropical and subtropical regions.

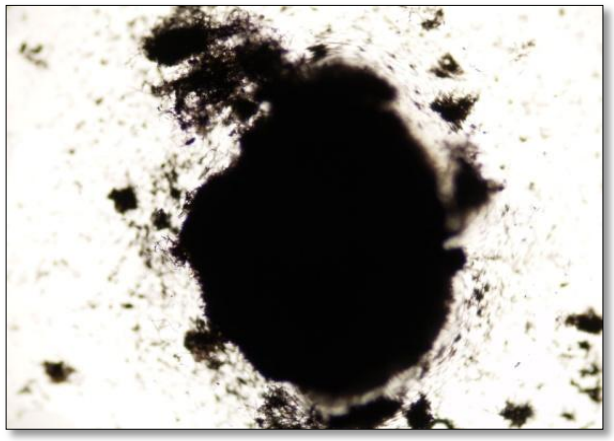
6. MANAGEMENT STUDIES ON *L. theobromae*

This Pathogen is one of the significant constraints in mango cultivation, the management of the disease is very essential.

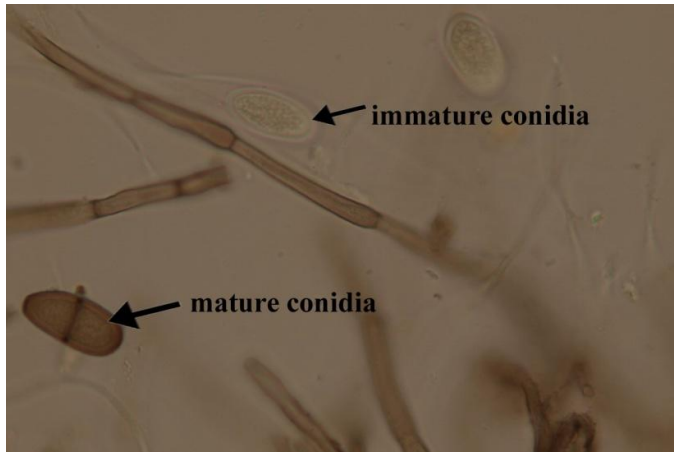
6.1 Effect of Fungicides on *L. theobromae*

Many workers have used different chemicals to control *Lasiodiplodia sp.*

(a) Pure Culture of *Lasiodiplodia theobromae*



(b) Pycnidia of Lasiodiplodia



(c) Mature and Immature Conidia

Fig. 2. (a) Pure Culture of *Lasiodiplodia theobromae* (b) Pycnidia of Lasiodiplodia (c) Mature and immature Conidia

Table 1. Summery of host range of the pathogen

S. No.	Host	Disease	Scientific name	Reference
1	Papaya	Fruit rot	*Carica papaya*	[32]
2	Horsegram	Seed rot	*Dolicus biflorus*	[33]
3	Pyrussps.	Seed rot and sedling rot	*Pyrus calleryana*	[33]
4	Dates	Decaying disease	*Delonix regia*	[34]
5	Pigeon pea	Seed rot	*Cajanus cajan*	[35]
6	Mango	Dieback	*Mangifera indica*	[36]
7	Dogwoods	Canker	*Cornus florida*	[37]
8	Lemon	Fruit rot	*Citrus aurantifolia*	[38]
9	Guava	Fruit rot	*Psidium guava*	[39]
10	Coconut	Fruit rot	*Cocus nusifera*	[40]
11	Yellow passion fruits	Black rot	*Passiflora edulies f.sp. flavicarpa*	[41]
12	Sweet potato	Java black rot	*Ipomoea batatas*	[42]
13	Shisham	Decline	*Dalbergia sissoo*	[43]
14	Kumquat	Decline	*Fortunella margarita*	[44]
15	Cashew	Gummosis	*Anacardium occidentale*	[45]
16	Jackfruit	Leaf blight	*Artocarpus heterophyllus*	[46]
17	Guava	Wilt	*Psidium guava*	[47]
18	Aubergine	Fruit rot	*Solanum melongena*	[48]
19	Banana	Crown rot	*Musa paradisiaca*	[49]
20	Jatropha	Gummosis	*Jatropha podagrica*	[50]
21	Pawpaw	Stem-end rot	*Asiminatribola*	[51]
22	Grapevine	Dieback	*Vitis vinifera*	[52]
23	Cattleya	Necrotic spots on stem	*Cattleya labiata*	[53]
24	Ballon plants	Dark necrosis	*Asclepias physocarpa*	[54]
25	Pummelo	Fruit rot	*Citrus maxima*	[55]
26	Jute	Stem end rot	*Corchorus olitorus*	[56]
27	Cocoa	Dieback	*Theobromae cocoa*	[57]
28	Mamey trees	Dieback	*Pouteria sapota*	[58]
29	Nutmeg	Fruit rot	*Myristica fragrans*	[59]
30	Eucalyptus	Gummosis	*Eucalyptus citriodora*	[60]
31	Peach	Gummosis	*Prunas percisa*	[61]

S. No.	Host	Disease	Scientific name	Reference
32	Bottle guard	Seed rot	*Lagenaria siceraria*	[62]
33	Cycas	Dieback	*Cycas circinalis*	[63]
34	Cassava	Rot	*Manihot esculenta*	[64]
35	Mulberry	stemcanker	*Morus alba*	[65]
36	Euphorbia	Decline	*Euphorbia ingens*	[66]
37	Kinnow fruits	Stem end rot	*Citrus reticulata*	[67]
38	Avacado	Fruit rot	*Persea americana*	[68]
39	Mangosteen	Decline	*Garcinia mangostana*	[69]
40	Parthenium	Foliar pathogen	*Parthenium hysterophorus*	[70]
41	Tuberose	Peduncle blight	*Polianthes tuberose*	[71]
42	Sapota	Dieback	*Achras sapota*	[72]
43	Ficus	Dieback	*Ficus carica*	[73]
44	Elephant tree	Canker	*Boswellia papyrifera*	[74]
45	Mara Manjal	Leaf spot	*Coscinium fenestratum*	[75]

Table 2. Summery of different chemicals to control *Lasiodiplodia sp.*

S. No.	Chemical management of *L. theobromae*	References
1	Mixture of oil and 5 per cent phenol	[76]
2	Copper oxychloride sulphate	[77]
3	Carbendazim and Bordeaux mixture	[78]
4	Carbendazim (0.1%) or Topsin M (0.1%) or Chlorothalonil (0.2%).	[79]
5	Topsin-M (20 ppm) and Benlate (100 ppm)	[80]
6	Topsin M and Score (100 ppm)	[81]
7	Mancozeb (3g a.i./l) and Iprodione (0.5 - 0.75g (a.i./l))	[82]
8	Carbendazim @ 1 ppm, Thiophanate-methyl@1 ppm, Allite@ 1000 ppm	[83]
9	Acrobat MZ, Dithane M-45, Mancozeb, Metalaxyl+Mancozeb@ 0.1%, 0.75% and 0.50%	[84]
10	Carbendazim (0.1%) and Thiabendazole (0.2 %)	[85]
11	Difenoconazole(75; 100; 125 L.ha-1)	[86]
12	Spergon,Propiconazole, Flusilazole, Prochloraz, Iprodione, Difenoconazole, Tebuconazole, Myclobutanil, Pyraclostrobin, Validamycin, Carbendazim, Chlorothalonil and Mancozeb	[87]
13	Thiophanate-methyl, Carbendazim and Precure @ 50 ppm and 100 ppm	[88]

S. No.	Chemical management of *L. theobromae*	References
14	Topsin-M (Thiophanate-Methyl) and Carbendazim (25-200 ppm)	[89]
15	Carbendazim @0.1%	[90]
16	Carbendazim and Topsin-M	[91]
17	Topsin M and Daconil	[92]
18	Difenaconazole	[86]
19	Carbendazim, Carbendazim + Mancozeb and Propiconazole @ 250 &500 PPM	[93]
20	Carbendazim@0.5%	[94]
21	Flutriafol@0.75%	[95]

6.2 Effect of Botanicals on *L. theobromae*

Table 3. Summery of effect of botanicals on *L. theobromae*

S. No.	Botanicals	References
1	*Acorus calamus*@1 %	[96]
2	*Cymbopogon citrates*	[97]
3.	Garlic @1 %	[98]
4	Neem extract	[99]
5	*Amomum subulatum* @ 500 µL/L	[100]
6	*Ocimum gratissimum*	[101]
7	*Allium sativum*	[102]
8	*Azaderecta indica* and *Eucalyptus camaldulensis*	[103]
9	*Alpinia galangal*	[104]
10	*Zingiber officinale*	[105]
11	Zimmu, *Zehneria scabra*	[106]
12	Garlic and neem	[93]
13	*Chromolaena odorata*	[94]

6.3 Biological Control

Various biological control stategies have been used to reduced the mango gummosis disease.

Table 4. Summery of efficacy various biological control agents against mango gummosis pathogen

S. No.	Bio control agent	References
1	*T. virens and T. hamatum*	[107]
2	*T. pseudokoningii*	[108,109]
3	*T. viridae sps*	[93]
4	*T. asperellum*	[110]
5	T*. hematum*	[111]

6.4 Host Plant Resistance

Table 5. List of Screening of cultivars against *L. theobromae*

S. No.	Resistant/ Tolerant varieties	References
1	Dosehri,	[112]
2	Willard, 'Rata' and 'Kohu'	[113]
3	Baneshan, Alphonso, Imam pasand and Pandurivari mamidi	[93]
4	Langra and Desi	[115]
5	S13, M5	[116]
6	Dosehri	[117]
7	Dasheri, Mahmooda, Neeleshan, Baneshan	[114]

7. CONCLUSION

Mango gummosis is caused by *Lasiodiplodia theobromae,* becoming a serious problem in India on many popular varieties of mango. Mango gummosis is reported from major mango growing areas and observed high disease severity and disease become threaten disease in mango due to the death of the trees with high disease severity. The pathogen have wide host range and the large potential for transmission, make it difficult to control the disease and also very meager data available on gummosis. The effective fungicides, botanicals, fungicides, and cultivars against *Lasiodiplodia theobromae* from various sources is mentioned in this review. So the future research approach is to develop new resistant varieties through a breeding selection program, studies to develop epidemiological prediction models, host pathogen interactions, molecular, cultural and biochemical characterarization, develop integrated disease management programme *viz.,* Chemical, Biological and other ecological models for disease management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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