Review Article

A review on Mango gummosis incited by *Lasiodiplodia theobromae*

Abstract:

Mango gummosis caused by *Lasiodiplodia theobromae* (Pat.) Griffon & Moube [synonym: *Botryodiplodia theobromae]* is becoming a serious problem in India on many popular varieties of mango particularly 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; 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.

Key words: Gummosis, *Lasiodiplodia theobromae,* Conidia, Pycnidia, *Trichoderma etc.*

1.Introduction

Mango (*Mangifera indica* L.) is one of the world's most important and esteemed fruit of the tropical and subtropical world and is cultivated extensively as a commercial fruit crop in India. 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. By virtue of wide range delicious taste superb flavor, very high nutritive and medicinal value as well as great religio-histolorical significance, it is being called the "King of fruits"(1).

The mango crop is susceptible to various diseases like powdery mildew, anthracnose, die back, blight, red rust, gummosis and sooty mould etc. Gummosis incited by *Lasiodiplodia theobromae* (Pat.) Griffon & Moube [synonym: *Botryodiplodia theobromae*] is becoming a serious problem in India on many popular varieties of mango particularly during monsoon and post-monsoon periods(2). Severe mango gummosis 20-83.3 percent mango gummosis incidence with a severity of 62.5-85 per cent recorded in Major mango growing areas. 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.

Comment [jofil1]: The paper addressed mango gummosis, its morphological characterization, and potential disease management. However, the authors are requested to review the paper completely for typos, misspelled words, and minor grammatical problems.

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Comment [jofil4]: Check spelling and correct spacing.

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Try to add "Mango"
The keywords are used for indexing so that the article may be found more easily when searched. I suggest selecting keywords that complement the article but are not featured in the title. Only a few words from the title may be included. The title contains all of the keywords used in this paper.

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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 of tip, discoloration and darkening of bark some distance from the tip are common symptoms(12). Later, it moves downward involving bigger branches as well. As a result, the leaves are shed followed by exudation of gum from the diseased portions. In severe cases, bark splitting or cracking has also been noticed. (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. Gummosis: the infected plants show abundant gum secretion from branches, stem and main trunk. Vascular discoloration: Infected twigs, plants and branches shows internal discolouration. Brown streaks visible in vascular region and these are severe in water stress conditions.(15,16, 17, 18)

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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 bigget 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

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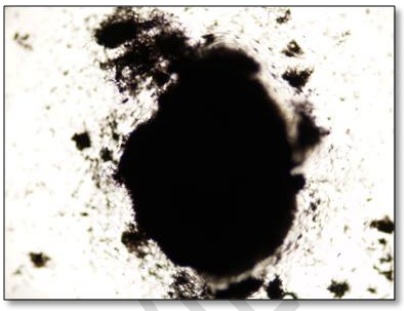
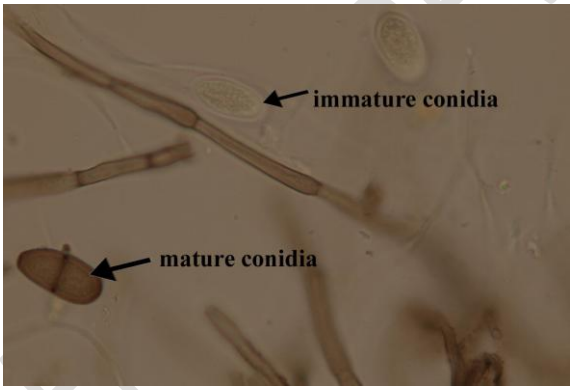
brown in colour produced on Potato Dextrose Agar (PDA). (22). Pycnidia are uniloculate, dark brown to black, immersed in the host becoming erumpent when mature.(23, 24).

(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

4.Physiology

B.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. Potato sucrose agar (PSA), Corn meal agar (CMDA) and Yeast extract

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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. Potassium nitrate supplemented media showed maximum growth amongst the tested inorganic nitrogen sources while peptone produced maximum growth among the tested organic nitrogen sources(30). *L. theobromae* grows 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.

Table 1 : Hosts and their disease with scientific name.

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

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Comment [jofil14]: Provide "Table 1 ". E.g "In table 1 summarizes...."
and so on, as per the table provided below

Comment [jofil15]: Just a thought: might we do this in alphabetical order?

Comment [jofil16]: Check spelling

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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

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31	Peach	Gummosis	*Prunas percisa*	61
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

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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.*

*Table 2 : D*ifferent 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*

Comment [jofil17]: Create a summary that corresponds to the table you provided. Also, kindly include the management options, such as cultural and physical/mechanical practices.

Comment [jofil18]: Isn't it a different species than *L. theobromae*?

Comment [jofil19]: What are the most common chemicals used to control this pathogen? Kindly provide in this statement.

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
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

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20	Carbendazim@0.5%	94
21	Flutriafol@0.75%	95

6.2 Effect of botanicals on *L. theobromae*

Table 3:* 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: Various biological control stategies

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 Screening of varieties against *L. theobromae*

Table 5 :* Screening of varieties against *L. theobromae

Comment [jofil20]: Provide a summary of assertions about the effects of botanicals on *L. theobromae*

Comment [jofil21]: Consider including the common name of each botanical used.

Comment [jofil22]: Since *Trichoderma* is often utilized, try to revise your statement

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Comment [jofil25]: List of resistant/tolerant varieties? Make a statement/s here, such as what resistant varieties are typically utilized in the area.

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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 is gaining importance 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. 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 characters, develop integrated disease management programme *viz.,* Chemical, Biological and other ecological models for disease management.

Comment [jofil26]:

8. Reference:

Comment [jofil27]: Check the journal reference format again. Take note of the "," and "." following each author's name. Some scientific names were not italicized.

1. Hayes, W. B. 1953. Fruit growing in India, Kitabistan, Allahabad, India.
2. Leghari, T. N. 2005. Epidemiology and yield losses by sudden death syndrome in mango orchards of Sindh and its possible control. *M. Sc. Thesis*. Sindh Agriculture University, Tandojam, Pakistan.
3. Al Adawi, A. O., Deadman, M. L., Al Rawahi, A. K., Al Maqbali, Y. M., Al Jahwari, A. A., Al Saadi, B. A., Al Amri, I. S and Wing field, M. J. 2006. Etiology and causal agents of mango sudden decline disease in the Sultanate of Oman. *European Journal of Plant Pathology.* 116: 247–254.
4. Saeed, S., Ijaz Khan, M and Masood, A. 2011. Symptom development after artificial inoculation of *Botryodiplodia theobromae*, a possible causal organism quick decline in mango trees. *Pakistan Journal of Agriculture Science*. 48 (4): 289-294.
5. Das-Gupta, S.N. and A.T. Zachariah. 1945. Dieback of mango. A new disease in India. Ind. J. Bot. Sci., 24(1): 101-108.

UNDER PEER REVIEW

6. Edward, J.C. 1954. *Macrophomina* and *Botrydiplodia,* two distinct genera of aphneropaidaceae. *Allahabad farmer*. 28: 3.

7. Verma, O.P and Singh, R.D. 1970. Epidemology of mango dieback caused by *B. Theobromae* pat. 40: 813.

8. Prakash, O and Srivastava, K.C. 1987. *Mango diseases and their management*. A world review (book). Today and tomorrow Printer and Publishers, Karal Bagh, New Delhi. 175.

9. Maduleti MC. 1989. Studies on die back and death of mango trees (*Mangifera indica* L.)M.sc.Thesis.Acharya N.G. Ranga Agricultural University, Hyderabad, India.

10. Suresh,V., Vidya Sagar,B., Kishore Varma, P and Koteswara Rao, SR. 2017. Mango gummosis disease incidence studies under natural and artificial conditions. *Journal of Entomology and Zoology Studies.* 5(5): 1037-1041.

11. Prakash, O and Singh, U.N. 1976. New disease of mango. In *Proceedings of Fruit Research workshop*. 24-28 May, 1976, Nyderabad, India. 300-302

12. Prakash, O and Srivastava, K.C. 1987. *Mango diseases and their management*. A world review (book). Today and tomorrow Printer and Publishers, Karal Bagh, New Delhi. 175.

13. Ploetz, R.C. 1999. Malformation: A unique and important disease of Mango, *Mangifera indica* L. In B.A. Summerell (ed.) *Paul E. Nelson Memorial Symposium*. APS Press, St. Paul, 1-8

14. Khanzada, M. A., Lodhi, A. M and Shahzad, S. 2004. Mango dieback and gummosis in Sindh Pakistan caused by *Lasiodiplodia theobromae*. *Plant Pathology*. 57: 381.

15. Malik, A.H., Khan, S. M., Iqbal, Z., Malik, M.T., Saleem, A and Haq, I. 2005. Histological and control studies on *Botryodiplodia theobromae*, the cause of mango decline in the Punjab. *Pakistan Journal of Botany*. 17: 18-21

16. Shahbaz, M., Khan, S.M., Iqbal, Z., Rehman, A., Muhammad, F and Saleem, A. 2005. Etiological studies to explore the causal agent of mango decline in the Punjab, Pakistan. Pakistan Journal of Phytopathology.17: 33-35.

17. Al Adawi, A. O., Deadman, M. L., Al Rawahi, A. K., Al Maqbali, Y. M., Al Jahwari, A. A., Al Saadi, B. A., Al Amri, I. S and Wing field, M. J. 2006. Etiology and causal agents of mango sudden decline disease in the Sultanate of Oman. European Journal of Plant Pathology. 116: 247–254.

18. Iqbal, Z., Valeem, E.E., Shahbaz, M., Ahmad, K., Khan, Malik, T and Danish, M. 2007. Determination of different decline disorders in mango orchards of the Punjab. *Pakistan journal of Botany*. 39(4): 1313-1318

UNDER PEER REVIEW

19. Schoch CL, Shoemaker R, Seifert K, Hambleton S, Spatafora JW, Crous PW. (2006). A multigene phylogeny of the *Dothideomycetes* using four nuclear loci. *Mycologia* 98: 1041–52

20. Slippers B, Roux J, Wingfield MJ, Walt FJJ van der, Jami F, Mehl JWM, Marais GJ. (2014). Confronting the constraints of morphological taxonomy in the fungi: A *Botryosphaeriaceae* case study. *Persoonia*

21. Sabalpara, A.N., Vala, D.G and Solanky, K.U. 1991. Morphological variation in *Botryodiplodia theobromae* pat. Causing twig-blight and die-back of mango. *Acta Horticulture.* 291 : 312-316.

22. Mirzaee, M. R., Azadvar, M and Ershad, D. 2002. The incidence of *Lasiodiplodia theobromae* the cause of fruit and stem-end rot of mango in Iran. *Iranian Journal of Plant Pathology.* 38(1/2): 62-65, 148-149.

23. Celiker, N. M and Michailides, T. J. 2012. First report of *Lasiodiplodia theobromae* causing canker and shoot blight of fig in Turkey. *New Disease Reports.* 25: 12.

24. Twumasi, P., Ohene-Mensah, G and Moses. 2014. The rot fungus *Botryodiplodia theobromae* strains cross infect cocoa, mango, banana and yam with significant tissue damage and economic losses. *African Journal of Agricultural Research.* 6(9): 613-619.

25. Alam, M. S., Begum, M.F., Sarkar, M.A., Islam, M.R and Alam, M.S. 2001. Effect of temperature, light and media on growth, sporulation, formation of pigments and pycnidia of *Botryodiplodia theobromae* Pat. *Pakistan Jounal of Biological Sciences*. 4: 1224-1227.

26. Eng, F., Gutierrez-Rojas, M and Favela-Torres, E. 2003. A survey of temperature and pH effect on colonial growth of *Botryodiplodia theobromae* RC1. *Revista Iberoamericana de Micologia*. 20: 172-

27. Ray, R. C. 2004. Extra cellular amylase (production by fungi) *Botryodiplodia theobromae* and *Rhizopus oryzae* grown on cassava starch residue. *Journal of Environmental Biolology*. 25: 489-495.

28. Fu, G., Huang, S. L., Wei, J. G., Yuan, G. Q., Ren, J. G., Yan, W. H and Cen, Z. L. 2007. First record of *Jatropha podagrica* gummosis caused by *Botryodiplodia theobromae* in China. *Australasian Plant Disease Notes.* 2: 75–76.

29. Khanzada, M. A., Rajput, A. Q and Shahzad, S. 2006. Effect of medium, temperature, light and inorganic fertilizers on *in vitro* growth and sporulation of *L. theobromae* isolated from mango. *Pakistan Journal of Botany.* 38(3): 885-889.

30. Saha, A., Mandal, P., Dasgupta, S and Saha, D. 2008. Influence of culture media and environmental factors on mycelial growth and sporulation of *Lasiodiplodia theobromae* (Pat.) Griffon and Maubl. *Journal of Environmental Biology*. 29(3): 407-410.1

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31. Latha, P., Prakasham, V., Jonathan, E.J., Samiyappan, R and Natarajan, C. 2013. Effect of culture media & environmental factors on mycelial growth and pycnidial production of *L.theobromae* in Physic nut (*Jatropa curcas*). *Journal of environmental biology*. 34 : 683-687.

32. Hunter, J. E., Buddenhagen, I. W and Kojima, E. S. 1969. Efficiency of fungicides, hot water and gamma radiation for control of postharvest fruit rots of papaya. *Plant disease reports.* 53: 279-284.

33. Maholay, M.N and Sihi, H.S. 1977. Studies on Botrydiplodia rot of *Dolichus biflorus*. *Review of plant pathology.* 57: 1927.

34. Omamor, I. B. 1988. Black rot of date fruit: a new post-harvest decay caused by *Botryodiplodia theobromae*. *Date Palm Journal.* 6(1):299-305.

35. Jagdish, C and Adekunle, F. 1989. Studies on the stem end rot (*Diplodia natalensis* pole Evans) disease of post-harvest mango (*Mangifera indica* L.). *Review of plant pathology.* 70: 5797.

36. Simone, G.W. 1999. Diseases control in Mango *(Mangifera indica).* Plant Pathology Department Document *PDMG-V3-*22 document, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

37. Mullen, J. M., Gilliam, C. H., Hagan, A. K and Morgan-Jones, G. 1991. Canker of dogwood caused by *Lasiodiplodia theobromae*, a disease influenced by drought stress or cultivar selection. *Plant Disease.* 75: 886-889.

38. Cedeno, L and Palacios-Pru, E. 1992. Identificacion of *Botryodiploida theobromae* as the cause of lesions and gummosis in citrus. *Revista Fitopatogia Venezola*. 5: 10-13.

39. Patel, K. D and Pathak, V. N. 1993. Incidence of guava fruit rots and losses due to Rhizopus and Botryodiplodia in Udaipur and Ahmedabad markets. *Indian Journal of Mycology and Plant Pathology*. 23(3): 273-277.

40. Gunasekaran, M and Srinivasan, N. 2000. Involvement of *Lasiodiplodia theobromae* (Pat.) Griffon and Maubl. in fruit rot of coconut in India. *Tropical Agriculture*. 77(2): 123-125

41. Viana, F. M. P., Santos, A. A., dos Sobrinho, C. A., Freire F. C. O and Cardoso, J. E. 2000. Black rot: a new disease of passion fruit caused by *Lasiodiplodia theobromae* in the northeastern region. *Fitopatologia Brasileira*. 25(4): 671.

42. Pati, S. P., Maheswari, S. K and Ray, R. C. 2001. Effect of culture media, temperature, pH, carbon and nitrogen sources on growth of *Botryodiplodia theobromae* causing Java black rot of sweet potato tubers. *Journal of Mycopathological Research*. 39(1): 15-19

UNDER PEER REVIEW

43. Khan, S. H., Idrees, M., Muhammad, F., Mahmood, A and Zaidi, S. H. 2004. Incidence of shisham (*Dalbergia sissoo* Roxb.) decline and *in vitro* response of isolated fungus spp. to various fungicides. *International Journal of Agriculture and Biology.* 6(4): 611-614.

44. Ko, W. H., Wang, I. T and Ann, P. J. 2004. *Lasiodiplodia theobromae* as a causal agent of kumquat dieback in Taiwan. *Plant Disease*. 88(12): 1383.

45. Cardoso JE, Paiva JR, Cavalcanti JJV, Santos AA, Vidal JC. 2006. Evaluation of resistance in dwarf cashew to gummosis in north-eastern Brazil. *Crop Prot* 25: 855– 859

46. Haqueet, M. M., Mridha, M. A., Bhuiyan, M. K., Huda, S. M. S and Uddin, M. B. 2005. Studies on the occurrence and severity of leaf blight of Jack fruit (*Artocarpus heterophyllus* Lam.) Caused by *Botrydiplodia theobromae* pat. *Journal of Mycopathological Research.* 43(1): 91-94.

47. Pandit, P. K and Samajpati, N. 2005. Wilt disease of guava caused by *Botryodiplodia theobromae* Pat. *Journal of Mycopathological Research.* 43(1): 41-43

48. Woodward, J. E., Langston, D. B., Jr. Brock, J. H., Kemerait, R. C., Jr. Brenneman, T. B and Beard, G. H. 2005. First demonstration of Koch's postulates for *Lasiodiplodia theobromae* fruit spot on eggplant (*Solanum melongena*). *Plant Disease.* 89(6): 687.

49. Alvindia, D.G and Natsuaki, K.T. 2007. Control of crown rot-causing fungal pathogens of banana by inorganic salts and a surfactant. *Crop Protection. 26(11): 1667–1673.*

50. Fu, G., Huang, S. L., Wei, J. G., Yuan, G. Q., Ren, J. G., Yan, W. H and Cen, Z. L. 2007. First record of *Jatropha podagrica* gummosis caused by *Botryodiplodia theobromae* in China. *Australasian Plant Disease Notes.* 2: 75–76.

51. Wang, H. L., Chen, P. H., Ni, H. F and Chen, R. S. 2007. Physiological characterization and screen of control chemicals for *Lasiodiplodia theobromae* of papaya. *Plant Pathology Bulletin.* 16(2): 71-77

52. Burruano, S., Mondello, V., Conigliaro, G., Alfonzo, A., Spagnolo, A and Mugnai, L. 2008. Grapevine decline in Italy caused by *Lasiodiplodia theobromae*. *Phytopathologia Mediterranea*. 47(2): 132-136

53. Cabrera, M. G and Cudom, M. A. 2013. Occurrence of *Lasiodiplodia theobromae* in Cattleya spp. in Corrientes, Argentina. *Summa Phytopathologica*. 39 (2):143.

54. Fischer, I. H., Almeida, A. M., Garcia, M. J. M., Bertani, R. M. A and Bueno, C. J. 2008. First report of *Lasiodiplodia theobromae* on *Asclepias physocarpa* in Brazil. *Australasian Plant Disease Notes*. 3: 116-117.

55. Luo, M., Dong, Z. Y., Bin, S. Y and Lin, J. T. 2011. First report of fruit rot disease on pomelo caused by *Lasiodiplodia theobromae* in China. *Plant Disease*. 95(9): 1190.

UNDER PEER REVIEW

56. Sato, T., Iwamoto, Y., Tomioka, K. *2008.* Black band of Jew's marrow caused by *Lasiodiplodia theobromae* . *J Gen Plant Pathol* 74, 91–93 (2008).

57. Kannan, C., Karthik, M and Priya, K. 2009. *Lasiodiplodia theobromae* causes a damaging diebackof cocoa in India. *New Disease Reports*.19: 63.

58. López, A.F., Aguilera, J.M.A., Cárdenas–Soriano and Téliz–Ortiz, E.D. 2009. Etiology and histopathology of dieback disease on mamey trees (*Pouteria sapota* (Jacq.) H. E. Moore and Stearn) in Guerrero, Mexico. *Agrociencia.* 43: 717-728

59. Attah, A.I and Ahiatsi, E. N. 2010. Causal agent of premature fruit rot of nutmeg (*Myristica fragrans* Houtt.) and its mycelial growth inhibition with some fungicides. *Ghana Journal of Horticulture*. 8: 71-77.

60. Khalil, O. 2010. *Lasiodiplodia theobromae* Associated with Gummosis in Eucalyptus spp. in the Sudan. *Journal of Science*. 1(1): 27-34.

61. Simas-Tosin, F. F., Barrzaz, R. R., Petkowicz, C. L. O., Silveira, J. L. M., Sassaki, G. L and Santos, E. M. R. (2010). Rheological and structural characteristics of peach tree gum exudate. *Food Hydrocolloids*. 24: 486–493.

62. Sultana, N and Ghaffar, A. 2010. Effect of fungicides and microbial antagonists in the control of *Lasiodiplodia theobromae*, the cause of seed rot, seedling and root infection of bottle gourd. *Pakistan Journal of Agricultural Research*. 23(1/2): 46-52.

63. Chakraborty, M. R., Ojha, S and Chatterjee, N. C. 2011. Die-back disease of Cycas - a new record from Burdwan, West Bengal. *Journal of Mycopathological Research.* 49(1): 195-196.

64. Bua, B and Okello, C. 2011. Isolation and identification of cassava root rot disease causal pathogens from Lira district, Uganda. *In proceedings of 10th African crop science workshop on cassava rot*, African crop science society Maputo, Mozambique.10: 183-186.

65. Kumari, G. B. G and Govindaiah Sukumar, J. 2011. Incidence of stemcanker (*Lasiodiplodia theobromae*) in mulberry nurseries of Kolar district. *Indian Journal of Sericulture.* 50(1): 78-81.

66. Van der Linde, J. A., Six, D. L., Wingfield, M. J and Roux, J. 2011. *Lasiodiplodia* species associated with dying *Euphorbia ingens* in South Africa. *Southern Forests.* 73(3&4): 165–173.

67. Sharma, R. N., Maharshi, R. P and Gaur, R. B. 2011. Prevalance of newly recorded pre-harvest stem-end rot of kinnow (*Citrus reticulata*) fruits from Rajasthan and its management. *Indian Phytopathology*. 64(3): 296-298.

UNDER PEER REVIEW

68. Bertetti, D., Amatulli, M. T., Cardinale, J., Gullino, M. L and Garibaldi, A. 2012. First report of stem-end rot caused by *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. on avocado (*Persea americana* Mill.) fruits in Italy. *Protezione delle Colture*. 3: 49-51.

69. Paim, E. C. A., Silveira, A. J., Bezerra, J. L., Newman luz, E. D. M and Sacramento, C. K. 2012. Etiology of the decline of mangosteen in the southern Bahia*. Brazilian Journal of Tropical Fruits*. 34(4): 1074-1083

70. Kumar, P.S and Singh. 2000 First Report of *Lasiodiplodia theobromae* as a Foliar Pathogen of *Parthenium hysterophorus.* Plant Disease.84(12):1343-1343.

71. Durgadevi, D and Sankaralingam, A. 2012. First report of peduncle blight of tuberose caused by *Lasiodiplodia theobromae* in India. *New disease reports.* 26: 5.

72. Tovar Pedraza, J. M., Mora Aguilera, J. A., Nava Diaz, C., Teliz Ortiz, D.,Valdovinos, P.G., A Villegas M. G and Hernández, M. J. (2012). Identification, pathogenicity, and histopathology of *Lasiodiplodia theobromae* on mamey sapote grafts in Guerrero, Mexico. *Agrociencia*. 46: 146-161.

73. Rehab, M. E. A. A., Rashed, M. F., Ammar, M. I and El-Morsy, S. A. 2014. Dieback and sooty canker of Ficus trees in Egypt and its control. *Pakistan Journal of Biological Sciences.* 17(3): 364-371.

74. Gezahgne, A., Yirgu, A and Kassa, H. 2014. First report of *Lasiodiplodia theobromae* causing canker on tapped *Boswellia papyrifera* trees in Ethiopia. *New Disease Reports.* 29: 11.

75. Jose, JM., Kumar, S., Johnson, M., Mufeeda, K T, Kripa, T S and Mahadevakumar S.2023. *Letters in Applied Microbiology*.76:4.

76. Batista, A.C. 1947. A serious disease of mango. *Thesis*, Pemambuco College of Agriculture, Pemambuco. 19:212-215.

77. Alvarez-Garcia, L.A. & Lopez-Gracia, J., 1971. Gummosis, dieback, and fruit rot disease of mango(*Mangifera indica* L.) caused by *Physalospora rhodina* (B. and C.) Cke. in Puerto Rico. *Journal of Agriculture.* 55: 435–450.

78. Sharma, I. M and Badiyala, S. D. 1994. Effect of pre-harvest fungicidal sprays against stem end rot of mango fruits in storage caused by *Botryodiplodia theobromae* Pat. in Himachal Pradesh. *Indian Journal of Mycology and Plant Pathology*. 24(2): 141-142.

79. Saxena, A. K. and R. D. Rawal (1989). Wilt of mango - a new disease. Plant Disease Research, 4: 89.

80. Mahmood, A. and Gill, A.M. (2002). Quick decline of mango and in-vitro response of fungicides against the disease. *Int.J. Agric. Bio.* 4: 39-40

UNDER PEER REVIEW

81. Khan, S. H., Idrees, M., Muhammad, F., Mahmood, A and Zaidi, S. H. 2004. Incidence of shisham (*Dalbergia sissoo* Roxb.) decline and *in vitro* response of isolated fungus spp. to various fungicides. *International Journal of Agriculture and Biology.* 6(4): 611-614.

82. Meah M. B., Plumbley, R. A., Jeger, M. J. (1991) Growth and infectivity of *Botryodiplodia theobromae* causing stem end rot of mango. *Mycological Research*. 95: 405-408.

83. Khanzada, M. A., Lodhi, A. M and Shahzad, S. 2005. Chemical control of *L. theobromae*, the causal agent of mango decline in Sindh. *Pakistan Journal of Botany*. 37(4): 1023-1030.

84. Javaid, A., Javaid, A and Akhtar, N. 2008. *In vitro* chemical control of *Botryodiplodia theobromae*, the cause of dying back disease of mango. *Pakistan journal of plant pathology.* 20(2): 195-199.

85. Renganathan, P. 2008. Efficacy of fungicides against mycelial growth and spore germination of *Colletotrichum musae*, *Botryodiplodia theobromae* and *Fusarium solani* in banana. 8(2): 959-961.

86. Júnior, R.S., Nunes, GHS, Lima, LL., Guimarães, Morais, I M. 2009. Chemical control stem rot caused by Lasiodiplodia theobromae on mangoes fruits. Rev. Bras. Frutic. 31 (3).

87. MeiJiao, H., Chao, S., Yong, A., Min, L., FengZhen, Y and Yin, G.Z. 2009. Resistance of *Botryodiplodia theobromae* to carbendazim and the fungicides screening using stem end rot of mango fruit as a control. *Journal of Fruit Science. 26 (5): 671-677.*

88. Shahbaz, M., Iqbal, Z and Saleem and Anjum, M.A. 2009. Association of *Lasiodiplodia theobromae* with different decline disorders in mango (*Mangifera indica* L.). *Pakistan journal of botany.* 41(1): 359-368.

89. Attah, A.I and Ahiatsi, E. N. 2010. Causal agent of premature fruit rot of nutmeg (*Myristica fragrans* Houtt.) and its mycelial growth inhibition with some fungicides. *Ghana Journal of Horticulture*. 8: 71-77.

90. Ojha, S., Khatun, S., Chakraborty, M. R and Chatterjee, N. C. 2010. Occurrence of die-back of *Dalbergia sissoo* in West Bengal and evaluation of fungicidal control of its pathogen. *International Journal of Plant Protection*. 3(1): 17-19.

91. Sultana, N and Ghaffar, A. 2010. Effect of fungicides and microbial antagonists in the control of *Lasiodiplodia theobromae*, the cause of seed rot, seedling and root infection of bottle gourd. *Pakistan Journal of Agricultural Research*. 23(1/2): 46-52.

92. Sahi, S. T., Habib, A., Ghazanfar, M. U and Badar, A. 2012. *In vitro* evaluation of different fungicides and plant extracts against *Botryodiplodia theobromae*, the causal agent of quick decline of mango. *Pakistan Journal of Phytopathology.* 24(2): 137-142.

UNDER PEER REVIEW

93. Suresh,V., Vidya Sagar,B., Kishore Varma, P and Koteswara Rao, SR. 2016. In vitro Evaluation of Certain Fungicides, Botanicals and Bio control Agents against *Lasiodiplodia theobroma*. *Research Journal of Agricultural Sciences*. 7(4/5): 747-750.

94. Ablormeti, F.K., Coleman, S.R., Honger, J.O., Owusu, E., Bedu, I. Aidoo, O.F., Cornelius, E.W. And Odamtten, G.T. 2021. Management Of *Lasiodiplodia theobromae*, The Causal Agent Of Mango Tree Decline Disease In Ghana. Vol. 29, No. 2, Pp. 193 – 207.

95. DeSilva L.A.B., Leite M. D and Capucho A.S. 2022. Chemical control of dieback and mango malformation in a semiarid region. (Agricultural Parasitology) Arq. Inst. Biol., 89: 1-5.

96. Sardsud, U., Sardsud, V., Sittigul, C and Chaiwangsri, T. 1994. Effects of plant extracts on the *in vitro* and *in vivo* development of fruit pathogens. *In Development of postharvest handling technology for tropical tree fruits*: a workshop held in Bangkok, Thailand, 16-18 July 1992-1994. 60-62.

97. Bankole, S. A and Adebanjo, A. 1995. Inhibition of growth of some plant pathogenic fungi using from some Nigerian plants. *International Journal of Tropical Plant Diseases*. 13(1): 91-95.

98. Lima, G. S.A., de Lima, N. M. F and Lopez, A. M. Q. 1996. Effect of aqueous extracts from garlic bulbs (*Allium sativum)* on germination and mycelial growth of *Botryodiplodia theobromae* Pat. *in vitro*. *Ciencia Agricola*. 4:7-15.

99. Nwachukwu, E. O and Umechuruba, C. I. 2001. Antifungal activities of some leaf extracts on seed-borne fungi of African yam bean seeds, seed germination and seedling emergence. *Journal of Applied Science & Environmental Management*. 5(1): 29-32.

100. Dubey, R. K., Kumar, R., Jaya., Chansouria, J. P. N and Dubey, N. K. 2008. Evaluation of *Amomum subulatum* roxb oil as a source of botanical fungitoxicant for the protection of mango fruits from fungal rotting. *Journal of Food Safety.* 28(3): 400-412.

101. Okigbo, R. N., Okorie, R. E and Putheti, R. R. 2009. *In vitro* effects of garlic (*Allium sativum* L.) and African basil (*Ocimum gratissimum* L.) on pathogens isolated from rotted cassava roots. *Interciencia.* 34(10): 742-747.

102. Sharma, R. N., Maharshi, R. P and Gaur, R. B. 2011. Prevalance of newly recorded pre-harvest stem-end rot of kinnow (*Citrus reticulata*) fruits from Rajasthan and its management. *Indian Phytopathology*. 64(3): 296-298.

103. Sahi, S. T., Habib, A., Ghazanfar, M. U and Badar, A. 2012. *In vitro* evaluation of different fungicides and plant extracts against *Botryodiplodia theobromae*, the causal agent of quick decline of mango. *Pakistan Journal of Phytopathology.* 24(2): 137-142.

UNDER PEER REVIEW

104. Khewkhom, N., Sangchote, S and Sungsiri, T. 2013. Postharvest control of fruit rot of mangosteen by plant extracts from Zingiberaceae family. *Acta Horticulturae*. 973: 119-124.

105. Kumah, P., Ampomah, E.O., Olympio, N.S. and Moses, E. 2013. efficacy of four botanicals and two chemical fungicides in the control of crown rot disease of banana (*Musa* spp. AAA) 'medium cavendish'. *Acta Horticulture*.1007: 385-392.

106. Sangeetha, G., Thangavelu, R., Rani, S. U and Muthukumar, A. 2013. Antimicrobial activity of medicinal plants and induction of defense related compounds in banana fruits cv. Robusta against crown rot pathogens. *Biological Control*. 64(1): 16-25.

107. Suhannaa A Y, Aifaa N H and Shazalwardi S. 2013. Trichoderma sp. as a biological control agent in the postharvest treatment of mango stem end rot. Journal of Tropical Agriculture and Food Science 41: 159-168.

108. Priya K S and Nagaveni H C. 2009. Screening of Trichoderma spp against Lasiodiplodia theobromae causing fruit rot of Elaeocarpus munronii. Indian Journal of Plant Protection 37: 166-169.

109. Sangeetha G, Usharani S and Muthukumar M. 2009. Biocontrol with Trichoderma species for the management of postharvest crown rot of banana. Phytopathologia Mediterranea 48: 214-225.

110. Borges, R C F. , Marques, E., Macedo, M A., Martins,I., Filho, JGS and Mello, S C M.2018. Control of teak canker caused by *Lasiodiplodia theobromae. Revista Árvore*. 2018;42(3):420304

111. Li, X., Leng, J., Yu, L, Bai, H., Li X., , Wisniewski , M., Liu, J and Sui, Y. 2022.Efficacy of the biocontrol agent *Trichoderma hamatum* against *Lasiodiplodia theobromae* on macadamia. Frointers in microbiology. Front.13:994422.

112. Khan, S.S and Asad Masood, M. I. 2011. Symptom development after artificial inoculation of *Botryodiplodia theobromae*, a possible causal organism to quick decline in mango trees. *Pakistan Journal of Agricultural Sciences*. 48(4): 289-294.

113. Karunanayake, K. O. L. C., Sinniah, G. D., Adikaram, N. K. B and Abayasekara, C. L. 2014. Cultivar differences in antifungal activity and the resistance to postharvest anthracnose and stem-end rot in mango (*Mangifera indica* L.). *Australasian Plant Pathology*. 43(2): 151-159.

114. Reddy, T. N., Chaturvedi, A and Babu, J. D. 2005. Screening of mango cultivars against important post-harvest diseases in Andhra Pradesh. *Journal of Research ANGRAU*. 33(3): 71-73.

UNDER PEER REVIEW

115. Mahmood, A., Khan, S.N and Ali, S. (2007). Screening of genetic source against sudden death / quick decline *Lasiodiplodia theobromae* of mango. November 19-21, 3rd International phytopathology conference, University of the Punjab, Lahore.

116. Uma, M and Thirupathaiah, V. 2009. Reaction of three genotypes of mulberry (*Morus alba* L.) to *B. theobromae. Agricultural Science Digest*. 29(3): 228-229.

117. Saeed, S., Ijaz Khan, M and Masood, A. 2011. Symptom development after artificial inoculation of *Botryodiplodia theobromae*, a possible causal organism quick decline in mango trees. *Pakistan Journal of Agriculture Science*. 48 (4): 289-294.

UNDER PEER REVIEW