Biological Forum – An International Journal **14(4): 1061-1064(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

First Report of Rust Disease on *Dendrocalamus somdevai* in Uttarakhand, India

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(Received 05 September 2022, Accepted 29 October, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Bamboo plants (*Dendrocalamus somdevai*) found in the homestead and hills of Uttarakhand are used for making many household articles and furniture. The nonavailability of seeds and inadequate traditional rhizome propagation methods make it impossible to fulfil the demand of the expanding pulp, paper, furniture, and rayon industries. The optimum propagation technique is being researched to meet this difficulty. *Dendrocalamus somdevai* grown in the Forest Research Institute, Dehradun, displayed symptoms of rust from late February to April 2022. The disease incidence was too high, as more than 90% of the plants were infected. Uredia and telia were observed on the infected leaves. The species was identified through various taxonomical features such as shape, size of urediniospores and teliospores, etc. observed through light microscopy and scanning electron microscopy. Based on symptoms and the morphology of the organism, the pathogen was identified as *Kweilingia divina*. Pathogenicity through urediniospores or sexually reproductive spores has been successfully demonstrated. To our knowledge, this is the first report of the rust fungus *Kweilingia divina* on a new host, *Dendrocalamus somdevai*, in Uttarakhand, India.

Keywords: Urediniospores, rust, scanning electron microscopy.

INTRODUCTION

Bamboo plants are vital for covering 21.1 percent of the Indian subcontinent's forest cover and contributing 12.8 percent of the nation's total forest area (FSI, 2011; Singh *et al.*, 2018). There has previously been evidence of rust on certain bamboo species. Bamboo species have been documented to be infected by more than 29 rust fungi from six different genera. *Dasturella* or *Kweilingia* are the two most prevalent rust fungi in bamboo, and they can be found on both unplanted and planted strands. Mundkur and Kheswalla (1943) reported the first case of *Dasturella*. Both fungi can be distinguished from one another by having varying numbers of teliospores as well as diverse structures that emerge at various phases of the spore life cycle.

Table 1: Records of rust fungal pathogens from different bamboo species.

Species	Host	Location	References
Kweilingia divina (*Dasturella divina*) (*Syd.*)Mundk. & Khesw.	*Bambusa bambos, B. bambos, B. balcooa, B. multiplex, B. tuldoides, B. vulgaris, B. ventricosa, B. arundinacea, B. nutans, Bowsella serrate, Dendroclamus brandisii, D. strictus, D. hamiltonii, D. longispathus, Dendrocalamus* sp., *Ochlandra travancorica, O. scriptoria, O. monostigma, Oxytenanthera abeysannae, Phyllostachys ritcheyi, Thyrsostachys siamensis, T. oliveri, T. siamensis, Catunaregam spinosa.*	Dandeli (Mysore – Karnataka), Dehradun (Uttarakhand), Dharwad (Karnataka), Idukki (Kerala), Majhgwan & Shararanpur (Uttar Pradesh), Mahableshwar & Poona (Maharashtra), Kumarpet (Vishakhapatnam – Aadhra Pradesh), Dharwad (Karnataka), Rajasthan	Bakshi and Singh (1967); Bakshi *et al.* (1972); Bhat (1992); Jamaluddin (1992); Khan *et al.* (1995); Mohanan (1988, 2002, 2006, 2008); Sathe (1965); Patel *et al.* (1949, 51a, 51b); Patil (1966); Rangaswami *et al.* (1970); Tiwari (1992); Tyagi *et al.* (1962); Udayan and Balachandran (2009)
Dasturella oxytenantherae	*Oxyten anthera* sp., *Bambusa* sp.	Mahabaleshwar (Maharashtra)	Sathe (1965)
Dasturella sp.	*Bambusa* sp.	Dandeli (Karnataka)	Rangaswami *et al.* (1970); Mohanan (2002)

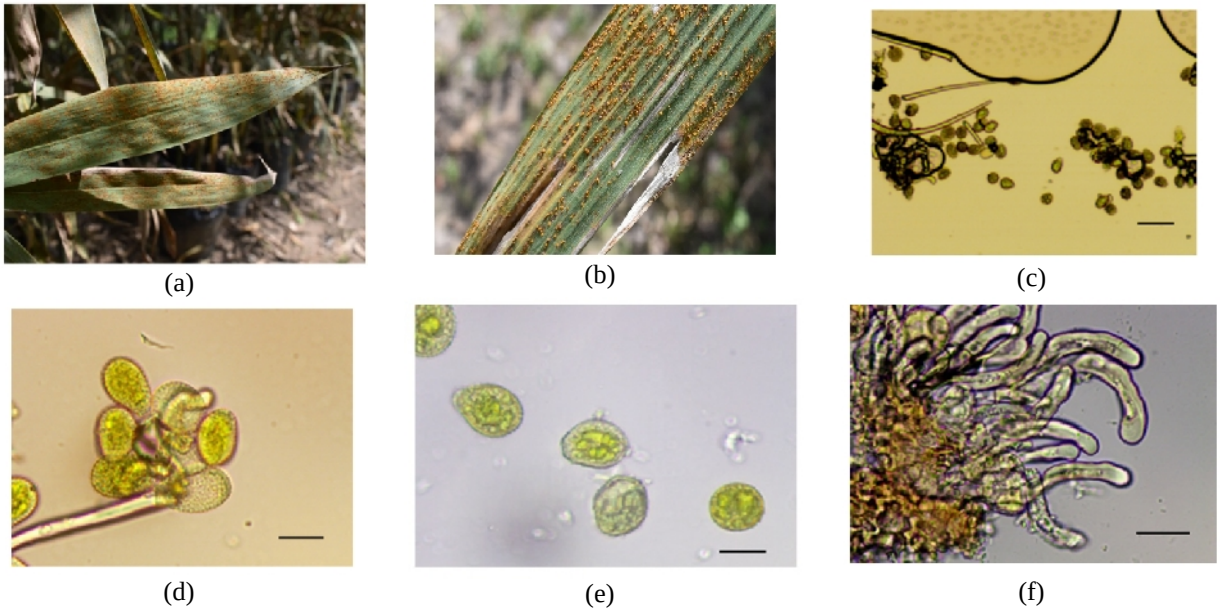
From February to April 2022, rust symptoms were initially found on the upper and lower surfaces of several young leaves of *Dendrocalamus somdevai* culms in Dehradun, India (Fig. 1), which then continued to spread from young leaves at the tips of the stems towards the crown, along stems, and on mature leaves. Matured leaves show more infection compared to juvenile leaves, as mature leaves have a higher density of rust covering their surface. The disease incidence was so high that, based on observations of over 500 culms of *D. somdevai*, approximately 90% of the culms were found to be diseased. Disease symptoms appeared in the Uredia stage, where the rust colour starts to appear on the basal sides of the leaves of bamboo. The rust appears to be of yellow to orange colour and has a raised appearance, as it belongs to the basidiomycetes class of fungi. Finally, infected leaves become discoloured and drop prematurely. The general objective of the present study was to collect disease isolates causing leaf rust, identify them at the species level, and contribute to the prevention of disease spread in *Dendrocalamus somdevai*.

MATERIALS AND METHODS

Rust infected specimens were collected from the nursery of the Division of Plant Genetics and Tree Improvement, Forest Research Institute, Dehradun. A total of 500 culms of *D. somdevai* were observed. Infected leaves were collected in sterile polybags and kept at -20°C while the disease's incidence was recorded. For microscopic characterization, spores of rust fungi were mounted on a sterile glass slide and observed under a light microscope at 4X–40X magnification. A maximum of 30 spores were thoroughly examined for characteristics such as spore size, colour, shape of urediniospores and teliospores, etc. Further, a high-resolution microscopic technique called scanning electron microscopy was used to get high resolution images of the spores. For pathogenicity testing, uredia of rust fungi from infected leaves (n = 10) were collected in a sterile petri-plate to make a spore suspension. Healthy seedlings of *D. somdevai* were obtained, and their leaves were rubbed with 70% ethanol to remove the waxy layer on the leaves so that infection could occur. After that, spores were taken from the suspension and inoculated on healthy leaves of *D. somdevai* with a sterile hairbrush and covered with a sterile polybag. The plants were watered regularly.

RESULTS AND DISCUSSION

Microscopic Examination. Based on the morphological characteristics such as shape, size, colour, presence of echinulate uredinospores and teliospores, etc., it was found that the rust fungus infecting the leaves of *D. somdevai* is *Kweilingia divina* (formerly known as *Dasturella divina*), a fungus known to cause rust infections on the leaves of several bamboo species. This species was described in 1943 as *Bambusa* sp. (Mundkur and Kheswalla 1943). Uredinia and telia were present in the form of pustules on the abaxial surface of the leaves. yellowish to brown-coloured, round to oblong urediniospores having the size range of 20.37–39.18 × 12.49–23.45 µm. Teliospores were septate (2), round, and sessile, with a brownish appearance and a size range of 20.14–31.14 × 21.22–24.36 µm. Incurved paraphyses having lengths of 44.12-110.38 × 7.76–9.90 µm were also observed. Telia sori were also observed.



(a) (b) (c)

(d) (e) (f)

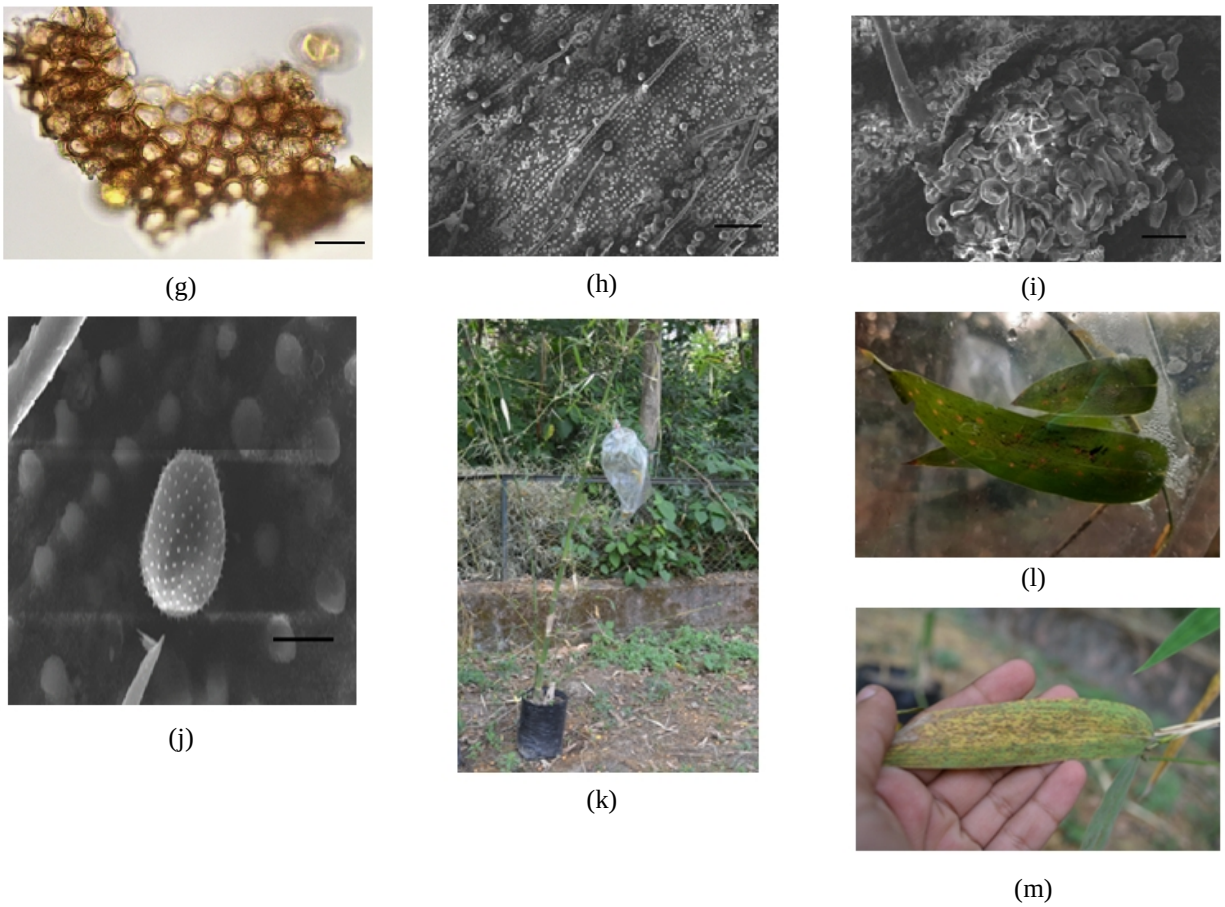


Fig. 1. (a) Rust on leaves of *D. somdevaii*, **(b)** Uredia and telia observed on leaf, **(c)** Urediniospores of *K. divina* seen at 10X magnification, Scale bar = 40 µm, **(d - e)** Urediniospores seen at 40X magnification, Scale bar = 20 µm **(f)** Uredia with paraphyses seen at 40X magnification, Scale bar = 20 µm **(g)** Telial sori of *K.divina* at 40X, Scale Bar = 20µm (**h**) Scanning Electron Micrograph showing spores of *K. divina* on leaves of *D. somdevai*, Scale bar = 100 µm **(i)** Scanning Electron Micrograph of Urediospores of *K. divina* along with paraphyses, Scale bar = 20 µm **(j)** Echinulated Urediospore, Scale bar = 20 µm. **(k)** Pathogenicity test under in-vivo conditions, **(l)** Spore formation after 8 days, **(m)** development of urediniospores after one month.

Pathogenicity Testing. Uredia isolated from infected leaves of *D. somdevaii* was able to infect healthy leaves of *D. somdevaii.* Yellowish-orange pustules with a rusty appearance were observed after 8 days from inoculation. The development of urediniospores was observed one month after inoculation. Hence, proving Koch's postulates.

CONCLUSION

Over 7000 rust fungi species have been reported to be parasitic on plants, including ferns and economically important plants such as cereals, legumes, composites, and agroforestry tree species (Kolmer *et al.,* 2009). Out of these many rust fungi, about 29 rust fungi spanning 6 genera have been known to infect bamboo species. *D. divina, D. bambusina*, *Puccinia* spp., and *Tunicospora bagchi*, are the rust fungi species recorded from bamboo in India. *D. divina* is the most widespread rust fungus in the country (Singh and Bakshi 1964; Nema and Mishra 1965; Bakshi *et al.*, 1972; Mohanan, 1994). The *Kweilingia divina* reported on *Dendrocalamus somdevai* fits the description given by Cummin (1971); Mundkur and Kheswalla (1943) and Nelson and Goo (2011). For the first time, *Kweilingia divina* has been found and is causing a rust infection in *D. somdevai*. We may draw the conclusion that more research is necessary to establish effective remedial strategies to manage the rust disease in *D. somdevai* as well as to identify its optimum growth method. A viable strategy to emphasize its significance and accommodate future demands is the development of rust-resistant species.

Acknowledgement. The funds received for research from the National Authority—Compensatory Afforestation Fund Management and Planning Authority (CAMPA), Ministry of Environment, Forests, and Climate Change, Government of India—are duly acknowledged.
Conflict of Interest. None.

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How to cite this article: R. Juwantha, A. Sharma, J. Saxena, H.S. Ginwal, S. Bhartwal and A. Pandey (2022). First Report of Rust Disease on *Dendrocalamus somdevai* in Uttarakhand, India. *Biological Forum – An International Journal*, *14*(4): 1061-1064.