

Revision and Compilation of Health Management Plan of Khair (*Acacia catechu*)

Rajeev Bhattarai*¹, Puja Sharma², Bishnu Wagle¹, Angel Adhikari³, Suman Acharya⁴

¹University of Maine, School of Forest Resources, Orono, Maine, USA

²Georg-August-Universität Göttingen, Department of Silviculture and Forest Ecology of the Temperate Zones, Göttingen, Germany

³University of Tokyo, Tokyo, Japan

⁴University of Maine, Department of Anthropology, Orono, Maine, USA

*Corresponding Author (Email: rajeev.bhattarai@maine.edu)

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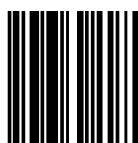
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Abstract

Acacia catechu (Khair) is one of the significant tree species evolved together with Nepali communities. The tree is widely used for medicinal purposes, feeding the livestock, fulfilling the structural needs, and satisfying religious and spiritual needs. Despite the wide use and importance of this tree, the available publications have failed to address the risks the tree is vulnerable to, and develop a management design to overcome these threats. Due to these reasons, the people are growing the Khair trees without any robust health management plan. The abundance and overall importance of this tree in the South Asian region strongly demands an interpretative and comprehensive way of its cultivation. This study is aimed towards bringing together the available information on Khair and finally coming up with an advantageous management plan that can deal with all the hazards the tree is prone to, and help in the production of healthy and of economically high-value timber. This study only deals with two of the several prevalent fungal stresses- *Ganoderma lucidum* and *Fomes badius*, causing root rot and heart rot, respectively, putting the tree under risk. The heart rot and root rot are capable of destroying the whole site rendering the trees useless for consumption. The findings from this study can help cultivators know the nature of the diseases and their occurrences and improve the way of cultivating the tree and take prompt actions on the syndromes.

Keywords

Ganoderma lucidum, *Fomes badius*, Health management plan, Syndromes

Introduction

Acacia catechu is one of the important plant species of Indian subcontinent commonly known with the name of Khair. It is a deciduous and gregarious tree with a light feathery crown. It is found mostly associated with *Bombax ceiba*, *Butea monosperma* and *Dalbergia sissoo*. Although the tree is considered very important from the ecological and socio-economic point of view, unavailability of a proper health management plan is always a point of concern. The whole tree is used for commercial purpose, and its uses vary from locality to locality and the need of a particular place. It is found as native species in Nepal, India, Pakistan and Thailand, and as exotic species in Indonesia, Kenya and Mozambique. Distribution of this species can be seen in Figure 1.

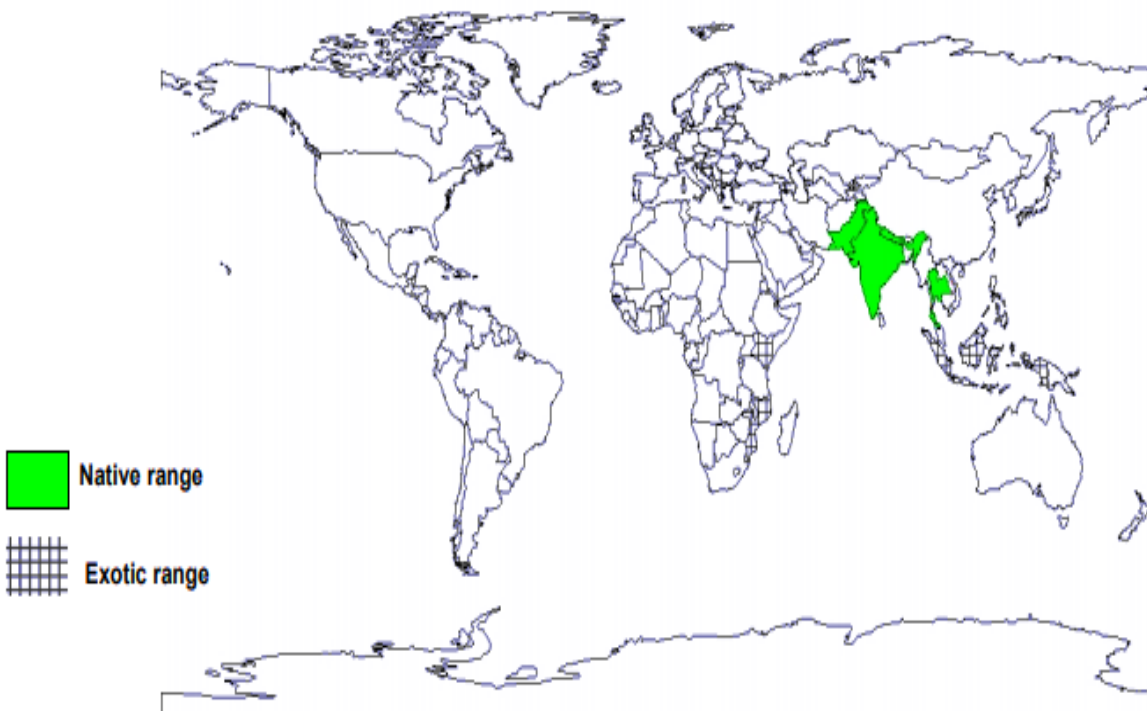


Figure 1: Native and exotic range of *A. catechu* (Orwa *et al.*, 2009)

A wealth of unpublished and informal knowledge and some written documents about the use and management of this particular species can be found in the locality with its prevalence. Furthermore, there are several published articles on this species about the diseases affecting it; however, all-inclusive health management plan of this tree with a great value is still missing. Therefore, this study attempts to address the lacunae between the scattered pieces of literature out there in the academic and non-academic world and bring them together so that we can come up with a comprehensive health management plan of *A. catechu*.

Methods

The whole management plan as the output of our study was produced by reviewing the literature on *A. catechu*. The databases used to search for the literature were Google Scholar, websites of

forestry institutions of Nepal and India that could be of help for this study on the internet. With an initial one month of literature search and review from starting of 2019 with "Acacia catechu", "Khair" and "Diseases" as keywords, we again went for the search with additional keywords such as "Ganoderma lucidum", "Fomes badius" and "fungal diseases in Khair". Finally, we found several works of literature thought to be ample for the development of a comprehensive health management plan. Among them, the articles with no open access were accessed through the Raymond H. Foglar Library, University of Maine.

Results

From the set of available literature, the information on *A. catechu* leading to its health management plan is compiled in such a way that the flow starts from its vernacular names to the management of two fungal diseases, *Ganoderma lucidum* and *Fomes badius*.

Table 1: Vernacular names of *A. catechu* (Singh and Lal, 2006; Orwa *et al.*, 2009).

Nepali	Khair and Khaira
Sanskrit	Khadir, Payor, Gayatrin, Pathidrum
Hindi	Khair, sundra, supari, tallatuma, koir
Tamil	Kamugu, Paku, Buga, Karungali
Burmese	Sha
Malayalam	Karingal, Karintaali
French	Acacia au cachou
Thai	Sa-che, seesiat, sisiatnua
English	Betel-nut palm, black cutch, catechu tree, cutch tree and heartwood
Trade name	Kherson, Katha, Kath, cutch tree, Pegu cutch

Table 2: Taxonomy of *A. catechu*

Kingdom	Plantae
Order	Fabales
Family	Fabaceae/Leguminosae
Genus	<i>Acacia</i>
Species	<i>catechu</i>

Botanical descriptions and species adaptation:

The tree is a small to medium-sized tree up to 15 m tall (Sasidharan, 2019). The bark looks dark grey or dark brown, which is 12-15mm in thickness. It can be seen rough and exfoliating in long narrow rectangular flakes which can also be seen hanging on the tree trunk (Orwa *et al.*, 2009). The trunk is generally crooked and forked. The leaves are bi-pinnately compound with 9-30 pairs of pinnae and glandular rachis; each pinna has 16-50 pairs of leaflets. The leaflets are oblong, glabrous. Pubescent length of the leaflets ranges from 2-6mm, whereas at the base of each petiole, it has a pair of curved prickles (Orwa *et al.*, 2009; Sasidharan, 2019).

Flowers are borne on 5-10 cm long axillary spikes, which are white to pale yellow with a campanulate calyx. The calyx and corolla are about 1.5 and 2.5 mm, respectively, with numerous stamens having white to yellowish-white filaments (Troups, 1921; Orwa *et al.*, 2009).

The fruit is a flat pod tapering on both the sides, greenish-red when raw, and shiny brown when ripe. The pod is dehiscent with 3-10 ovoid seeds inside (Troup, 1921). The seeds are stored in the orthodox manner (15,000-40,000 seeds kg⁻¹) and viability is preserved till nine months in room temperature, which can be prolonged by storing it in a controlled environment (Troups, 1921; Orwa *et al.*, 2009).

The tree grows at an elevation of 1500 m from sea level as a mixed deciduous forest. In Nepal, it grows together with *Saccharum spontaneum* on the floodplains of terai¹ (Sharma *et al.*, 2019). Generally, its site competitors are *Bombax ceiba*, *Butea monosperma* and *Dalbergia sissoo* (McNeil, 2016; Orwa *et al.*, 2009).

The tree grows in a wide range of soil with preference to porous soil with sufficient subsoil moisture and drainage. It is also mostly seen growing in dry as well as shallow soil, including riverine deposits of sand (McNeill, 2016; Singh and Raizada, 2010).

Acacia is a high light-demanding species which needs an open and clean area for establishment since the seedlings can not tolerate the suppression by weeds. The tree should be protected against parasitic plants like *Cuscuta*, *Loranthus* and other competing weeds, especially during the young age (McNeill, 2016), and from grazing as well as waterlogging conditions. It can moderately tolerate fire and frost. It grows in xerophytic conditions but can survive in high rainfall areas with 3800 mm (McNeill, 2016). It can also be seen in moist tropical conditions, tropical dry conditions and subtropical climate. The temperature ranging from 2.5°C in winter to 40°C in summer are tolerable for Khair (McNeil, 2016; Orwa *et al.*, 2009).

Importance of the tree:

Since *A. catechu* takes over the preliminary stages of succession and helps in making up the eroded areas, it has a vital role in making up the soil and nutrient enrichment. Furthermore, it protects the soil on the floodplains from being washed away and leads the succession in these areas (Raizada and Juyal, 2012). Being a member of the Leguminosae family, the root nodules sheltering *Rhizobium* helps to fix atmospheric nitrogen making the soil rich in essential nutrients (Parkash and Aggarwal, 2009). Further, as all the trees do, it also shelters various birds, insects, and various known and unknown microorganisms sustaining food chain cycle.

Katha (Catechin) is obtained by boiling small chips of heartwood in specially designed pitchers and allowing the concentrate to cool and crystalize. Katha is used as a significant ingredient in chewing beetle leaf (widely sold locally) and cutch (byproduct during Katha production) is used locally for tanning leather and as a dye. Cutch is also used as an adhesive in plywood industry and the preparation of polishes and paints. Its heartwood is comparatively expensive than other species

¹Terai is the lowland region of southern part of Nepal, covering about 23.1% of Nepal's land area. Its altitudinal range starts from 67 m to 300 m from sea level (Johnsingh *et al.*, 2004).

(\$4-6 per kg in the local market) and usually not used as timber. It can also be used as structural timber because of its naturally durable wood.

Flower extract is used to treat gonorrhoea. Katha and cutch are used to treat different types of digestive disorders (chronic diarrhoea, and piles), uterine haemorrhages, chronic bronchitis, leucorrhoea, cough, asthma, sore throat, pain related to osteoarthritis (McNeil, 2016; Jayasekhar, Mohanan and Rathinam, 1997; Saini *et al.*, 2008; Verma and Pandey, 2014; Stohs and Bagchi, 2015). *A. catechu* also possesses anti-microbial and anti-viral properties (Gupta and Chaphalkar, 2016). Katha is believed to enhance strength, prevent from cold, and fetch milk in women after childbirth.

The tree is considered sacred according to Hindu culture, and the wood is used during various religious ceremonies. During the funeral, if the dead one is burnt with the wood from this tree, it is believed that the soul of dead one will rest in peace.

Problems to the tree and need of health management plan:

The tree is heavily lopped and felled during the maturity stage and grazed by herbivores during the early stage. Stem- and root-associated fungal diseases are prevalent in this species. Severe mortality (up to 55%) is found in young and mature *Acacia* stands. Plantations are affected by *Ganoderma lucidum* (Bakshi, Reddy and Singh, 1976). *Ganoderma* attacks the root causing severe necrosis and finally, death of the tree (Bakshi, Reddy and Singh, 1976). Likewise, *Fomes badius* attacks the heartwood making it unfit for the commercial purpose. Thus, this study aims to protect the trees from pathogens (*Ganoderma* and *Fomes*) and devise a management plan for the production of healthy and high-volume wood.

Risk factors for the tree:

A. Ganoderma root rot:

Ganoderma lucidum is the fungus of division Basidiomycota. It causes complex disease called *Ganoderma* root rot. The fungus attacks the cambium of the tree leading to its decay and death finally, interrupting the nutrient and water supply in the tree. Figure 2 shows the life cycle of this fungus.

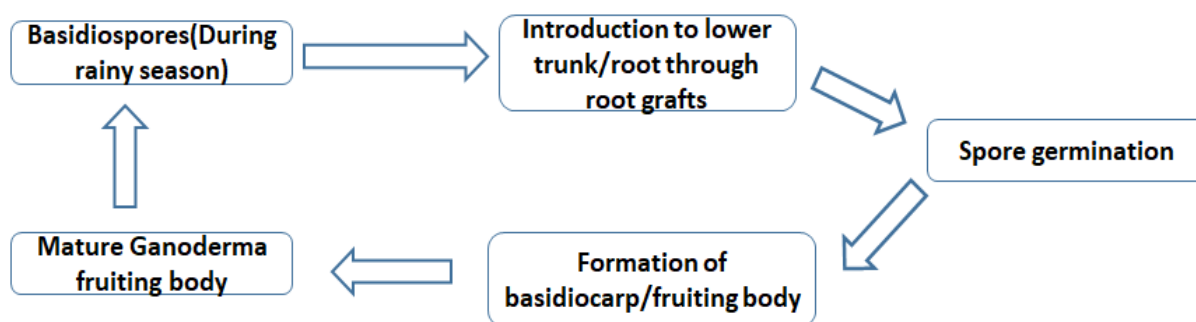


Figure 2: The life cycle of *Ganoderma lucidum*

The *Ganoderma* basidiocarp (a sign of the disease complex) is annual, hard and brittle, which is seen in the rainy season. It is 10-12 cm broad and 3-4 cm thick. It is borne on a brown stalk, laterally stipitate. It is found in collar/basal region of the tree (Bakshi, 1957; Verma, 2014; Zhou *et al.*, 2015). Its upper surface is yellow-brown and lower surface white. The fungus produces a white mycelial mat between the bark and wood (Verma, 2014).



Figure 3. *Ganoderma* basidiocarp (©Eric Steinert)

When an *Acacia* tree gets infected by *Ganoderma*, peculiar symptoms are root decay (sapwood and heartwood both) with conspicuous white spongy rot in the sapwood, necrosis on the lower trunk of the tree stem bleeding from the base, defoliation from the top, stag headed condition, and snapping of the tree due to overeating of roots (Bakshi, 1957; Bakshi, 1963; Bakshi, 1974; Bakshi, Reddy and Singh, 1976; Verma, 2014). Young trees are killed soon after the infection, while mature trees need most of its roots to be eaten. Epicormic branching is also very common during *Ganoderma* infection.

In the cycle of disease development and establishment, predisposing factors are those which increase the chance for a host tree to get the disease. In this study, predisposing factors are categorized into four types: (i) degree of adaptations of the tree towards the disease, (ii) factors increasing or decreasing the degree of stress (disease-causing agents), (iii) event that incites the disease in host, and (iv) secondary factors that come after the tree is weakened. The interrelationships of predisposing factors can be seen in figure 4.

The health management plans are designed based on the prevalent predisposing factors and are broken into three working units. 1. Preemptive measures: they are applied to tackle the predisposing factors and are the prevention against the disease; 2. Regular monitoring and survey of the signs and symptoms: this step is targeted towards the identification and prevention of disease from disseminating from an infected tree to other healthy ones and; 3. Reactive measures, which will help to prevent further loss and the disease from being an epidemic. The detailed health management plan against *Ganoderma* is shown in figure 5.

B. Heart rot in Khair:

Fomes badius is the fungus of division Basidiomycota, causing disease complex heart rot in *Acacia*. The fungus attacks xylem of the tree undermining the strength and usability of the tree heartwood. figure 7 shows the life cycle of this fungus.

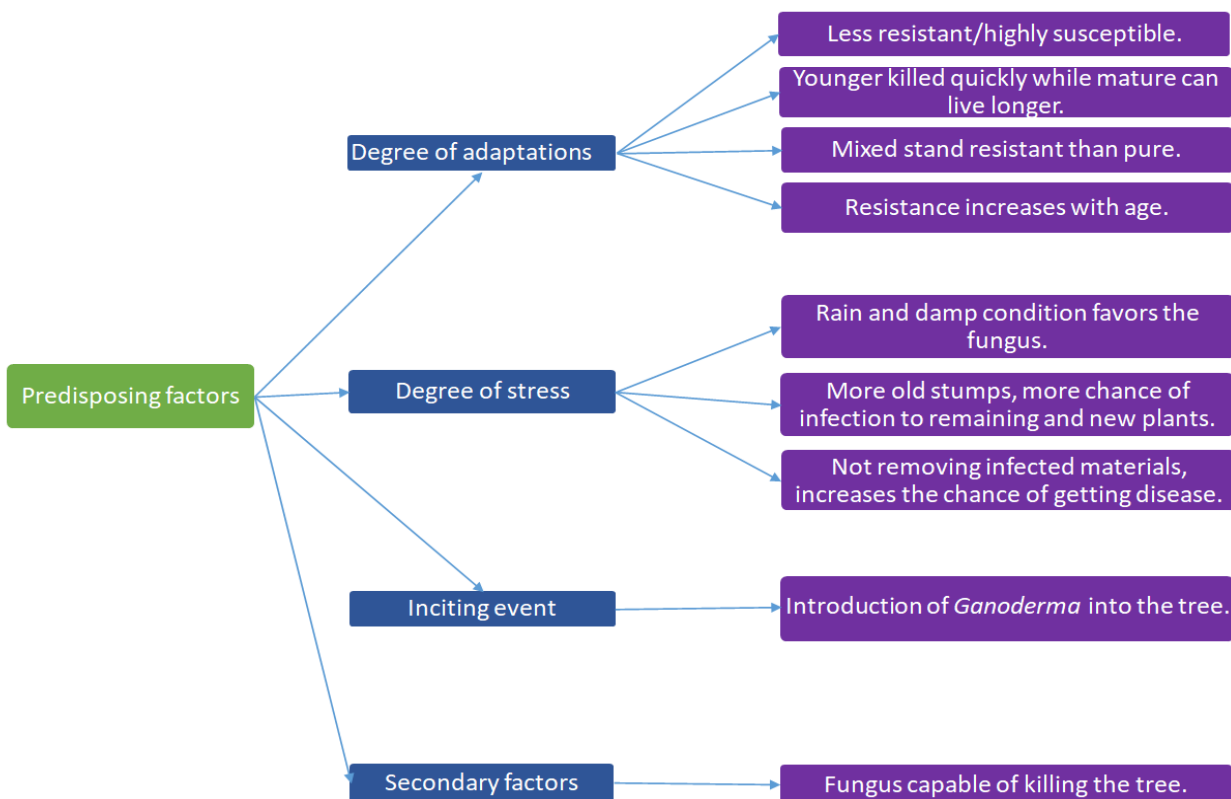


Figure 4: Development of *Ganoderma lucidum* (Bakshi, 1957; Bakshi, 1963; Bakshi, 1974; Bakshi, Reddy and Singh, 1976; Sankaran, Bridge and Gokulapalan, 2005; Verma, 2014)

The *Fomes* basidiocarp (the sign of the disease complex) is seen in the rainy season. Basidiocarp is hard, woody, perineal, hoof-shaped and easily detachable from the tree trunk. It has a dull brown lower surface containing minute pores (0.2 mm diameter) (Bagchee and Bakshi, 1950; Bakshi 1957; Bakshi, 1963). During each growing season, a layer develops on the lower side of the fruiting body of the tree and takes over the reproductive function in the tree. The basidiocarps can be seen on the different heights of the tree stem (figure 6).

This fungus is tough to identify during the incipient stage. The decay is not associated with external symptoms since a diseased tree is not killed and does not lose the growth vigour. The decay of the tree becomes visible when the wood splits or tree weakens or breaks (Bagchee and Bakshi, 1950; Bakshi, 1957; Bakshi, 1963). An infected *Acacia* tree shows its sapwood free from infection, while the heartwood is attacked. Trees are wind broken only after the fungus destroys most of the heartwood. Reddish-brown heartwood changes to a deeper brownish shade during the initial stages of infection. On the other hand, hard heartwood changes into yellow and spongy mottled during the advanced stages of infection (Bagchee and Bakshi, 1950; Bakshi 1957; Bakshi, 1963).

The development of *Fomes* is shown in figure 8, and detailed health management plan is shown in figure 9. The best way to protect the tree from infection is the prevention of injury from where the spores of fungus enter the tree. Sanitizing the forest from infectious spores can also control the sources of spores. The plantation area should be thoroughly monitored for the signs and symptoms

of *Fomes*. If the tree is infected once, the only solution is to detach the fruiting bodies, collect them and destroy.

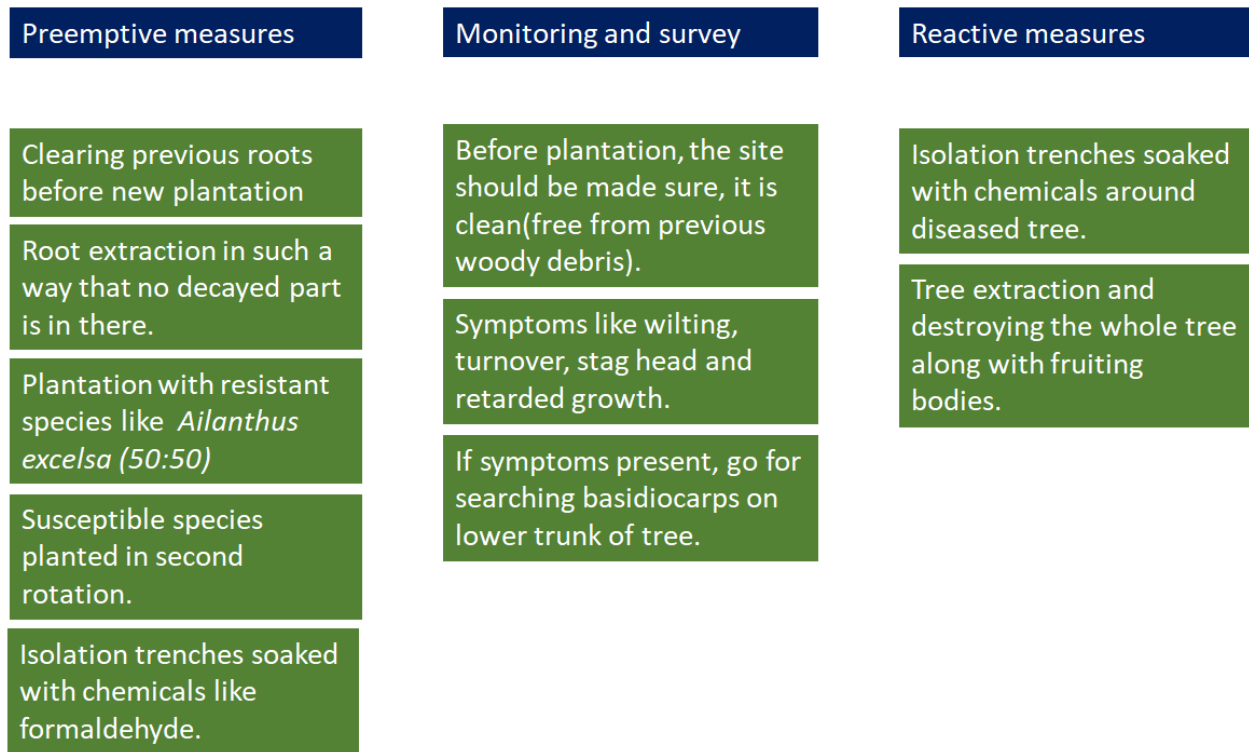


Figure 5: Health management plan against *Ganoderma lucidum* (Bakshi, Reddy and Singh, 1976; Bakshi, 1957; Bakshi, 1963; Sankaran, Bridge and Gokulapalan, 2005; Verma, 2014).

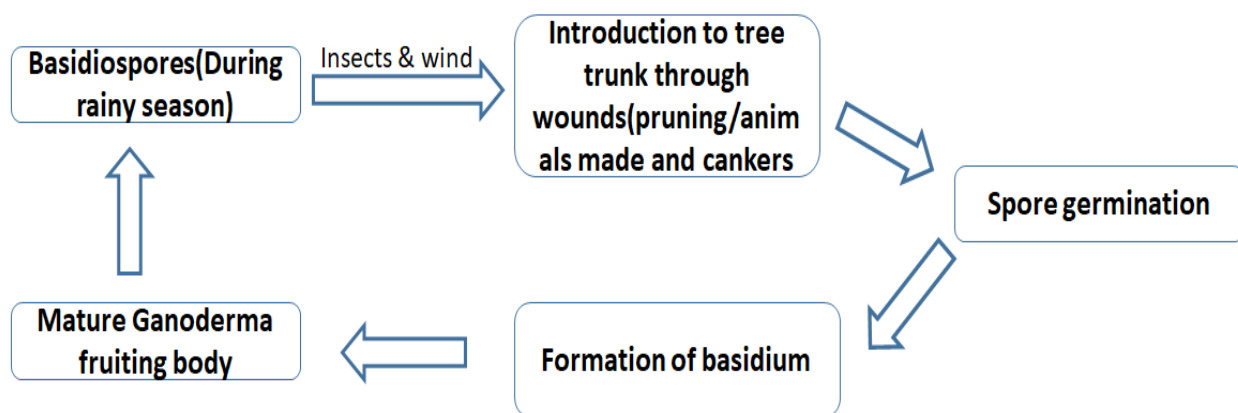


Figure 7: The life cycle of *Fomes badius*

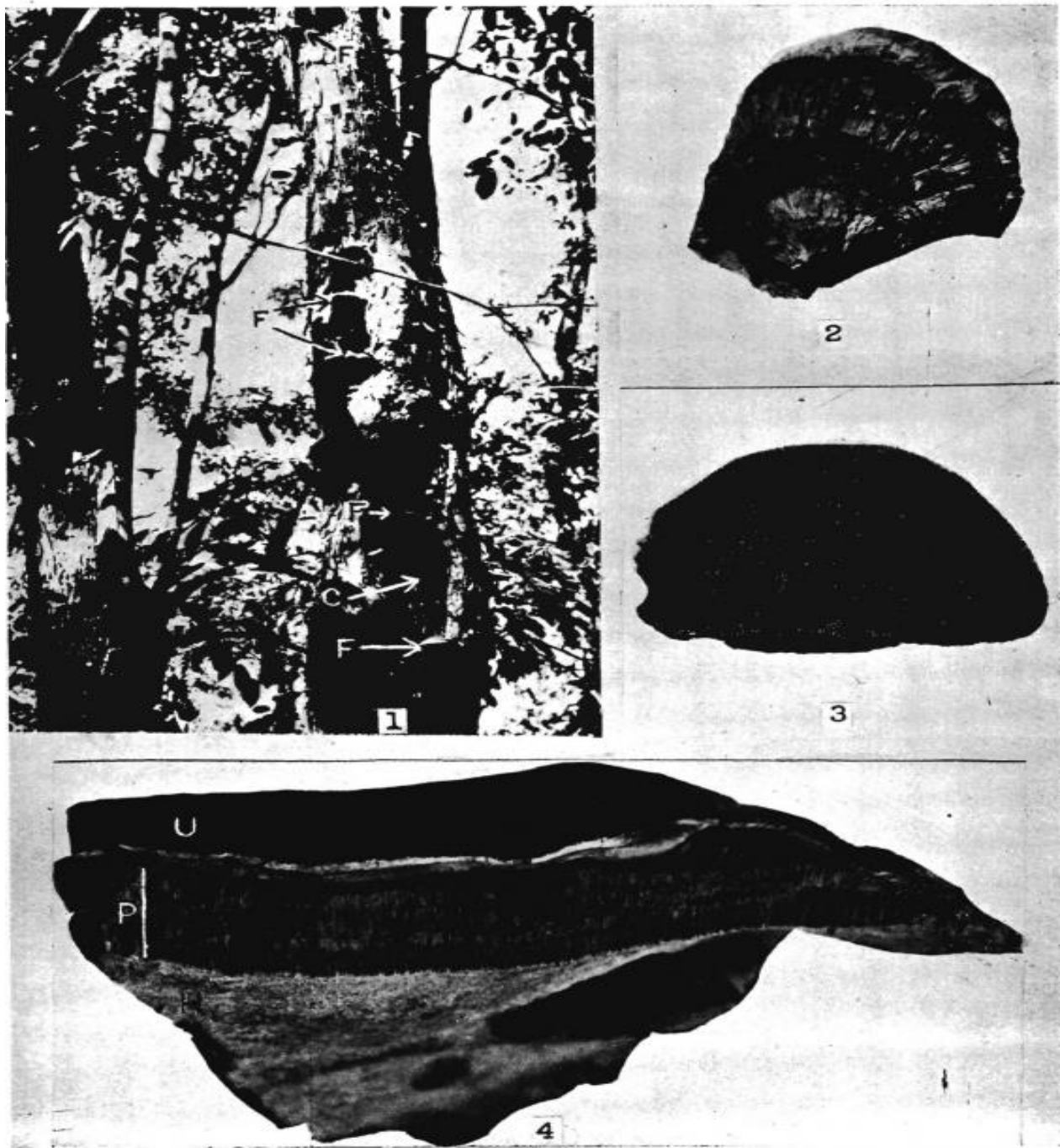


Figure 6: Panel 1 shows *Fomes* basidiocarps at different tree heights; panel 2 shows the fruiting from above; panel 3 shows the same from below; and panel 4 shows upside down view of fruiting body (Bakshi, 1957).

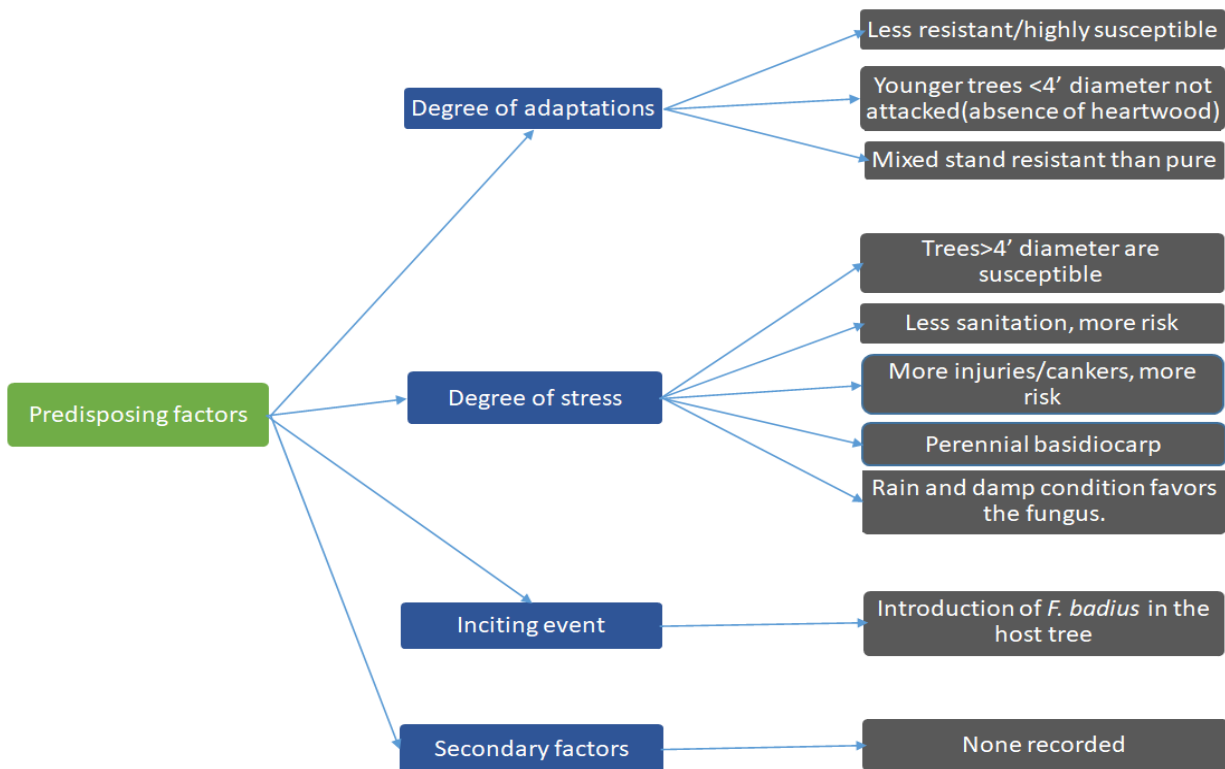


Figure 6: Development of *Fomes badius* (Bagchee and Bakshi, 1950; Bakshi 1957; Bakshi, 1963)

Preemptive measures	Monitoring and survey	Reactive measures
Prevention of injury: minimizing entry point for the spores.	Before plantation, the site should be made sure, it is clean (free from previous woody debris).	Fungus once injected, no solution.
Sanitation of the forest : getting rid of diseased woody particles.	Heartwood analysis if broken trees are seen.	Fruiting bodies detached, collected and destroyed.
Plantation with resistant/mixed species.	Fruiting bodies on tree trunk.	Infected tree (fruiting bodies present) extraction and destruction.
Susceptible species planted in second rotation.		

Figure 7: Health management plan against *Fomes badius* (Bagchee and Bakshi, 1950; Bakshi 1957; Bakshi, 1963)

Conclusion and Recommendations

Acacia catechu is very popular in the Southern part of Asia and holds a high social, economic and ecological value over the areas where it grows. As a solution for the prevalent fungal stresses on *A. catechu*, a comprehensive health management plan we suggested for both of the fungal stresses can be a strong reference plan for the cultivation of this tree. From the reviewed literature, variable management plans are found to be opted by different researchers/cultivators against the fungal diseases occurring in *A. catechu*. Since prevention is always the best option, preemptive measures should be taken seriously. Wound prevention helps prevent especially basidiospore of *Fomes* to get inside the host.

Similarly, site sanitation restricts the spread of *Ganoderma*. Regular monitoring for the early detection of the fungal pathogens will be very beneficial to prevent the disease from outbreaking as an epidemic. Previous stumps and debris should be cleaned before new plantations so that we can reduce the risk of disease transfer to the remaining and regenerating trees. Soil treatment with neem cake/farm manure and chemicals like copper oxychloride, hexaconazole, tridemorph and formaldehyde to sterilize the soil can be recommended to discourage the spread of the fungi. Avoidance of close planting and mixed plantation will help in retarding the speed of the disease spread. Further, *Acacia* plantation should be done in the second generation to build the resistance of the site against the disease.

References

- Bagchee, K. and Bakshi, B. (1950). Some fungi as wound parasites on Indian trees. *Indian Forester*, 76(6).
- Bakshi, B. (1963). *Dangerous forest diseases in India*. In *Internationally dangerous forest tree diseases*. US Dep. Agric. Misc. Plbl. 939. ... Saccardo, P. A. 1888. *Sylloge fungorum omnium hucusque cognitorum*. Vol. VII.
- Bakshi, B. (1974). Control of root disease in plantations in reforested stands (with special reference to Khair, Sissoo, Eucalyptus, etc.). *Indian Forester*, 100(1).
- Bakshi, B.K. (1957). Fungal diseases of Khair (*Acacia catechu* Willd.) and their prevention. *Indian Forester*, 83(1): 41-46.
- Bakshi, B., Reddy, M. and Singh, S. (1976). *Ganoderma* root rot mortality in Khair (*Acacia catechu* Willd.) in reforested stands. *European Journal of Forest Pathology*, 6(1): 30-38.
- Gupta, A. and Chaphalkar, S.R. (2016). Cytotoxic and anti-viral activity of *Acacia catechu* on human peripheral blood mononuclear cells. *Indonesian Journal of Pharmacy*, 27(2): 111-116.
- Jayasekhar, P., Mohanan, P. and Rathinam, K. (1997). Hepatoprotective activity of ethyl acetate extract of *Acacia catechu*. *Indian Journal of Pharmacology*, 29(6): 426-428.
- Johnsingh, A.J.T., Ramesh, K., Qureshi, Q., David, A., Goyal, S.P., Rawat, G.S., Rajapandian, K. and Prasad, S. (2004). *Conservation status of tiger and associated species in the Terai Arc Landscape, India* (pp. viii+-110). Dehradun: Wildlife Institute of India.
- McNeill, L. (2016). *Acacia catechu: Nepal Export*. Plant Agriculture International Development. University of Guelph, Canada.
- Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). Agroforestry Database: a tree reference and selection guide version 4.0 (<http://www.worldagroforestry.org/af/treedb/>)

- Parkash, V. and Aggarwal, A. (2009). Diversity of endomycorrhizal fungi and their synergistic effect on the growth of *Acacia catechu* Willd. *Journal of Forest Science*, 55(10): 461-468.
- Raizada, A., and Juyal, G. (2012). Tree species diversity, species regeneration and biological productivity of seeded *Acacia catechu* Willd. In rehabilitated limestone mines in the North West Indian Himalayas. *Land Degradation and Development*, 23(2): 167-174.
- Saini, M.L., Saini, R., Roy, S. and Kumar, A. (2008). Comparative pharmacognostical and antimicrobial studies of *Acacia* species (Mimosaceae). *Journal of Medicinal Plants Research*, 2(12): 378-386.
- Sankaran, K., Bridge, P. and Gokulapalan, C. (2005). Ganoderma diseases of perennial crops in India – an overview. *Mycopathologia*, 159(1): 143-152.
- Sasidharan, N. (2019). India Biodiversity Portal. Retrieved from <https://indiabiodiversity.org/species/show/228563?pos=>.
- Sharma, P., Adhikari, H., Tripathi, S., Ram, A.K. and Bhattarai, R. (2019). Habitat suitability modelling of Asian Elephant *Elephas maximus* (Mammalia: Proboscidea: Elephantidae) in Parsa National Park, Nepal and its buffer zone. *Journal of Threatened Taxa*, 11(13): 14643-14654.
- Singh, A. and Raizada, P. (2010). Seed germination of selected dry deciduous trees in response to fire and smoke. *Journal of Tropical Forest Science*, 22(4): 465-468.
- Singh, K. and Lal, B. (2006). Notes on traditional uses of Khair (*Acacia catechu* Willd.) by inhabitants of Shivalik range in Western Himalaya. *Ethnobotanical Leaflets*, 10: 109-112.
- Stohs, S.J. and Bagchi, D. (2015). Antioxidant, anti-inflammatory and chemoprotective properties of *Acacia catechu* heartwood extracts. *Phytotherapy Research*, 29(6): 818-824.
- Troup, R.S. (1921). *The silviculture of Indian trees* (Vol. 1). Oxford: Clarendon, 1195.
- Verma, K.S. and Pandey, R. (2014). Antioxidant potential of young pods of *Acacia catechu* wild collected from Jabalpur region. *Journal of Pharmacognosy Phytochemistry*, 2(6): 68-73.
- Verma, R. (2014). Biodiversity and conservation of forest fungi of Central India. *Microbial Diversity and Biotechnology in Food Security* (543-559). New Delhi: Springer.
- Zhou, L.W., Cao, Y., Wu, S.H., Vlasák, J., Li, D.W., Li, M.J. and Dai, Y.C. (2015). Global diversity of the *Ganoderma lucidum* complex (Ganodermataceae, Polyporales) inferred from morphology and multilocus phylogeny. *Phytochemistry*, 114: 7-15.

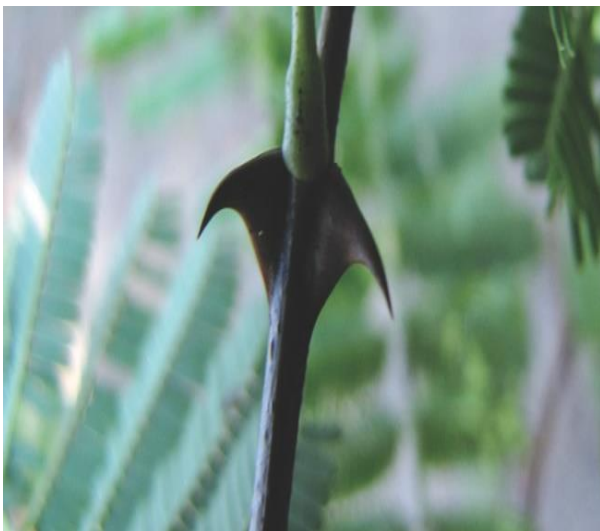
Appendix 1: Some photo plates of *Acacia catechu* (©Puran Dev Mishra; India Biodiversity Portal; Verma 2014; Zhou *et al.*, 2015).



Medium sized tree up to 15m tall



Bipinnately compound leaf



Two spines at each petiole base



Unripe Fruit (pods)



Forked and exfoliating stem



Flowers in 5-10cm long spikes



Ganoderma basidiocarps on soil around the tree base



Acacia catechu seeds