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## Biocontrol of Timber Decaying Fungi by Botanical Pesticides an Ecofriendly Technology

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### ABSTRACT

Timber is one of the longest-used building materials for various types of structures, and has been used in the construction of both historical and modern structures. Timber decay is caused by primarily enzymatic activities of microorganisms. The eco-friendly management of timber degrading fungi is tried by using plant extracts, oils and gels. In most of the fungi 25% methanolic extract was more effective than 5 and 10% concentrations. *Lenzites sterioides* was completely inhibited by 5% leaf extract of *P. Juliflora* and 10% leaf extracts of *Prosopis*, *Cymbopogon* and *Datura* at 25% concentration. Oils and gels of *Cymbopogon citrates*, *Anacardium occidentale* L., *Gossypium barbadensis* L., *Linum usitatissimum* L., *Aloe vera* L., and *Aloe ferox* Mill. were used to control the timber degrading fungi. Out of four oils cashew nut shell oil was most effective followed by cotton seed oil. Of the two *Aloe* gels tried the *A. ferox* gel showed better results than *A. vera*. For the first time the biocontrol of *L. sterioides* T. *pini* and *S. commune*, by botanical pesticides was reported. For the first time the biocontrol of *L. sterioides* T. *pini* *S. commune*, *G. lucidum*, and *S. hirsutum* by Oils and gels was reported.

**Keywords:** Timber decay; Biocontrol; Plant Extracts; Ecofriendly Technology; *Lenzites* rot; *Ganoderma* rot; *Schizophyllum* rot

## 1. INTRODUCTION

Nowadays, pesticides of synthetic origin have been widely used, producing a strong impact on the environment with the emergence of resistant strains of microbes and insects to these types of compounds. New plant protection chemicals are needed for modern pest management due to insect resistance and ecological disorders associated with numerous currently used pesticides [1]. Several higher plants and their constituents have shown success in plant disease control and are proved to be harmless and non-phytotoxic, unlike chemical fungicides. To control damages by fungi scientists have suggested use of chemicals, fumigants, use of  $\gamma$  irradiations and application of UV rays, heat treatments etc. Use of creosote oil to prevent rail, roads and telephone poles and sodium fluoride and zinc chloride (Wolman salts) to treat the wood used in mines had been tried. Turpentine, varnishes and paints provide a protective coating and seal the pores present in wood to imbibe water and this protects wood from decay caused by fungi.

During recent years use of plant secondary metabolites for the control of fungi is gaining importance. There is a widespread effort to find new pesticides, and currently it is focused on natural compounds such as flavonoids, coumarins, terpenoids, and phenolics from diverse botanical families from India, Mexico and Americas. Biofungicidal properties of different plant extracts on the growth of *S. commune* were evaluated by Singh and Basu [2]. The effect of heartwood extracts from *Acacia mangium* (heartrot susceptible) and *A. auriculiformis* (heartrot-resistant) was examined on the growth of wood rotting fungi was tested by Mihara *et al.* [3]. *A. auriculiformis* heartwood extracts had higher antifungal activity than *A. mangium*. Wood biodeterioration control potential of *Acalypha hispida* leaf phenolic extract in combination with *Trichoderma viride* culture filtrate was studied by Ejechi [4]. The phenolic extracts of *Acalypha* leaves inhibited growth of *Gleophyllum sepiarum* and *pleurotus* sp. In potato dextrose agar, starch agar, starch glucose agar, carboxy methyl cellulose agar and carboxy methyl cellulose glucose agar.

The phenolic extract of *A. hispida* may prove useful in an integrated chemical and biological approach to wood treatment [4]. *Trichoderma lignorum* is used to control a wood decaying fungi *Lenzites sepiaria* (*Gleophyllum sepiarium*) [5]. Spencer *et al.* [6] made pioneering efforts to suggest use of harmless non phytotoxic and biodegradable plant extracts to be used as antifungal agents. Neem leaves possess bioactive compounds like Meliantriol [7] and Azadirachtin [8], which have antifungal and feeding deterrent property for insects. A large number of plants like *A. indica* A. Juss., *Melia tosendens* L., *M. azadirach* L., *Swtenia mahogani*, *Annona squamosa* L., *Tagetes erecta* L., *T. tatula* L. and *Tripterygium wilfordii* Hook are reported by numerous investigators as botanical pesticides. Lal and Srivastva [9] found 51 plants as effective biopesticides.

Use of fixed oils [10] and essential oils [11-13] is reported to control fungal growth. Volatile oils are sweet-smelling lipids synthesized and stored in various plant parts. These oils are essentially mixtures of two classes of terpenoids *i.e.* the monoterpenes and the sesquiterpenes, the former predominating in most cases. It has been found that D- limonene and Cineole present in *Cymbopogon martini* [14] and Eugenol present in *Ocimum gratissimum* inhibited the radial colony diameter of *Alternaria alternata*, *Rhizoctonia* sp. and *Sclerotium rolfsii* [15]. Garlic (*Allium sativum* L.) cloves and *Bignonia alliciverum* leaves may be effective due to the presence of sulphur compound Allicin in them (16). Leaf extract of *Strichnos nux vomica* was effective against *Phomopsis psidii* [10].

## 2. MATERIALS AND METHODS

### Sample collection and isolation

The young fruit bodies of timber decaying fungi were collected from timbers of Gujarat, India. Fungal samples measuring 5 mm × 5 mm × 2 mm were aseptically removed from the fruit bodies and transferred to petriplates containing cultural media: 2% malt extract agar amended with 250 µg Streptomycin sulphate per ml. Eight pieces were removed from each sample and placed in 2 petriplates. These plates were incubated at 25 ±2 °C for 7 days. Once fungal colonies were formed in the agar plates, each colony was transferred to a new agar slant to obtain a pure culture.

### Bio-control studies

On the basis of field survey of forests and saw mills certain preventive methods are suggested for proper storage. *In vitro* studies were undertaken to control certain wood rotting fungi by using different leaf explants. That is leaf extracts of *Thevetia peruviana* (Pers.) Schum., *Tagetes erecta* L., *Eucalyptus globulus* Labill., *Azadirachta indica* A. Juss., *Prosopis juliflora* (Sw.) DC., *Saraca indica* L., *Lantana camara* L., *Biota sinensis* L., *Cimnopogon citrates* (Nees) Stapf., *Datura metel* L., *Callistemon linearis* DC., and *Parthenium hysterophorus* L. (Table. 1). Fresh leaves of different plants were washed with running tap water and dried at 60 °C in oven, and powdered. To prepare stock solution the 25 g of powdered plant material was Soxhlet extracted with methanol for 8 h. After extraction the methanol was removed by distillation. The obtained plant extract was dissolved in 100 ml of 20% ethanol. In case of water extract the 25 g of powdered plant material was dissolved in 150 ml of distilled water and extracted in a water bath for 2 h and the solution was filtered with muslin cloth and then through the Whatman filter paper no.1. Extract thus obtained was utilized for the experiment.

Fresh *Aloe vera* leaves were taken to extract the gel from them. An incision was on leaves of Aloe and collected the gel releasing from them. After collecting the gel it is mixed in a mixer and whole content was made into different concentration like 5%, 10% and 25%.

**Table 1.** Plants used as botanical pesticides and their active ingredients.

S. No	Plant	Family	Active ingredient
1	<i>Thevetia peruviana</i> (Pers.) Schum. (Pili kaner)	Apocynaceae	Peruvoside cannogenin
2	<i>Tagetes erecta</i> L. (Merigold)	Asteraceae	L- thevetoside Trimer of thiophene
3	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Cineole , α – inene limonene
4	<i>Azadirachta indica</i> A. Juss	Meliaceae	Azadirachtin
5	<i>Prosopis juliflora</i> (Sw.) DC.	Mimosaceae	

6	<i>Saraca indica</i> L. (Sita Ashoka)	Caesalpiniaceae	
7	<i>Lantana camara</i> L.	Verbenaceae	Because of its antifungal property Ocean Agro Ltd has produced a biofungicide Ovis.
8	<i>Biota sinensis</i> L. (Thuja)	Cupressaceae	B lincins a group of tropolon monoterpenoids
9	<i>Cymbopogon citrates</i> (Nees) Stapf. (Citronella)	Poaceae	Citronellal Geraniol, Eugenol Borneol
10	<i>Datura metel</i> L.	Myrtaceae	
11	<i>Callistemon linearis</i> DC.	Solanaceae	
12	<i>Parthenium hysterophorus</i> L.	Asteraceae	Sesquiterpene parthenin

### Poisoned food technique

The leaf extracts were taken and appropriate volume was mixed with medium (PDA) to obtain concentrations ranging from 2.0 to 10.0% in the final volume of 100 ml of medium. This 100 ml medium was dispensed into 10 cm petriplates. Fungal isolates of selected fungi were placed in the centre of each plate. Control sets were also prepared without plant extract. The plates were incubated at  $25 \pm 2$  °C and growth of colony was measured after 7 days of inoculation. The radial growth of mycelium was measured at two points along the diameter of the plate and the mean of these two readings was taken as the diameter of the colony. The growth of the colony in control sets was compared with that of various treatments and the difference was converted into percent inhibition by following formula

$$\text{Percent inhibition} = \frac{\text{Diameter of control set} - \text{diameter of treated set}}{\text{Diameter of control set}} \times 100$$

## 3. RESULTS AND DISCUSSION

### Bio-control by Botanicals

The timber decaying fungi like *L. sterioides*, *T. pini*, *S. commune*, *G. lucidum*, and *S. hirsutum* were isolated and pure cultures were maintained on Potato Dextrose agar medium. It is evident from Table 3. that leaf extracts of 10 dicots, 1 monocot and 1 gymnospermous plant was tested against 5 wood degrading fungi *in vitro*. In most of the fungi 25% methanolic extract was more effective than 5 and 10% concentrations. *L. sterioides*, was completely inhibited by 5% leaf extract of *Prosopis Juliflora* and 10% leaf extracts of *Prosopis*, *Cymbopogon* (Plate III, IV Fig. A to C) and *Callistemon*, *Datura* at 25% concentration (Plate I Fig. A), *T. pini*, *S. commune* completely inhibited by 25% leaf extract of *Callistemon*, *Datura* (Plate I Fig. B, C). *Tagetes*, *Eucalyptus*, *Azadirachta*, and *Prosopis* controlled all the 5 test fungi completely. Extract of *P. juliflora* and *A. indica* were more effective than other plants.

**Table 3.** Effect of methanolic and aqueous plant extracts on 5 wood decay fungi by Poisoned food technique.

<b><i>Thevetia peruviana</i> (Pers.) Schum.</b>						
	<b>Methanolic</b>			<b>Aqueous</b>		
<b>Fungi</b>	<b>5%</b>	<b>10%</b>	<b>25%</b>	<b>5%</b>	<b>10%</b>	<b>25%</b>
<i>Lenzites strioides</i>	35.13	81.56	93.04	34.37	65.0	78.75
<i>Trametes pini</i>	66.76	90.76	96.92	31.42	57.14	71.42
<i>Schizophyllum commune</i>	41.52	69.55	93.35	29.52	48.57	61.90
<i>Ganoderma lucidum</i>	36.09	54.88	94.58	19.11	36.76	48.52
<i>Sterium hirsutum</i>	62.77	79.44	100	0	0	0
<b><i>Tagetes erecta</i> L.</b>						
<i>Lenzites strioides</i>	25.42	68.92	100	35.83	50.0	68.33
<i>Trametes pini</i>	36.92	70.76	100	49.03	60.57	66.34
<i>Schizophyllum commune</i>	14.06	64.84	100	50.0	58.33	66.66
<i>Ganoderma leucidum</i>	40.0	81.37	100	49.09	63.63	74.54
<i>Sterium hirsutum</i>	83.88	90.55	100	27.77	63.88	88.88
<b><i>Eucalyptus globulus</i> Labill.</b>						
<i>Lenzites strioides</i>	61.66	75.0	100	11.58	28.39	40.24
<i>Trametes pini</i>	62.37	79.20	100	40.14	47.88	57.74
<i>Schizophyllum commune</i>	35.83	56.66	100	18.11	29.13	37.0
<i>Ganoderma leucidum</i>	51.81	77.27	100	32.0	42.4	53.6
<i>Sterium hirsutum</i>	27.77	100	100	11.11	16.66	27.77
<b><i>Azadirachta indica</i> A. Juss</b>						
<i>Lenzites sterioides</i>	61.98	94.15	100	69.90	100	100
<i>Trametes pini</i>	41.42	87.14	100	85.91	90.14	94.36
<i>Schizophyllum commune</i>	21.42	60.0	100	35.77	48.62	63.30
<i>Ganoderma lucidum</i>	45.45	77.27	100	67.27	81.81	90.90

<i>Sterium hirsutum</i>	27.77	100	100	11.11	55.55	100
<b><i>Prosopis juliflora</i> (Sw.) DC.</b>						
<i>Lenzites sterioides</i>	100	100	100	47.05	52.94	69.93
<i>Trametes pini</i>	46.51	100	100	63.41	74.79	82.92
<i>Schizophyllum commune</i>	78.33	100	100	57.98	68.42	72.92
<i>Ganoderma lucidum</i>	73.77	100	100	85.87	93.22	97.74
<i>Sterium hirsutum</i>	100	100	100	81.11	94.44	97.77
<b><i>Saraca indica</i> L.</b>						
<i>Lenzites sterioides</i>	53.29	85.02	100	5.55	46.66	76.66
<i>Trametes pini</i>	67.21	96.72	100	15.58	59.74	77.92
<i>Schizophyllum commune</i>	13.63	81.81	90.9	21.17	58.82	85.88
<i>Ganoderma lucidum</i>	47.91	86.11	100	8.88	32.22	55.55
<i>Sterium hirsutum</i>	3.33	16.66	70.0	11.11	33.33	75.55
<b><i>Lantana camara</i> L.</b>						
<i>Lenzites sterioides</i>	13.25	26.34	30.68	18.89	29.56	60.00
<i>Trametes pini</i>	40.24	48.45	62.46	20.25	30.65	48.28
<i>Schizophyllum commune</i>	50.00	82.34	100.00	23.25	50.26	55.68
<i>Ganoderma lucidum</i>	44.35	68.24	100.00	24.86	42.46	63.34
<i>Sterium hirsutum</i>	41.24	53.25	85.68	15.80	28.05	58.25
<b><i>Biota sinensis</i> L.</b>						
<i>Lenzites sterioides</i>	50.00	55.34	65.24	10.00	15.00	50.00
<i>Trametes pini</i>	18.50	25.56	54.89	48.89	60.25	65.34
<i>Schizophyllum commune</i>	10.00	20.00	60.00	15.00	40.00	45.00
<i>Ganoderma lucidum</i>	44.00	53.00	80.00	15.00	50.00	68.00
<i>Sterium hirsutum</i>	35.00	50.00	55.00	6.00	15.00	20.00
<b><i>Cimbapogan citrates</i> (Nees) Stapf.</b>						
<i>Lenzites sterioides</i>	53.94	100	100	48.36	69.93	84.96

<i>Trametes pini</i>	44.0	87.84	100	37.30	78.57	85.71
<i>Schizophyllum commune</i>	18.75	53.75	97.65	34.67	48.38	58.06
<i>Ganoderma lucidum</i>	53.54	85.16	100	0	46.66	63.33
<i>Sterium hirsutum</i>	49.44	72.77	100	0	0	0
<b><i>Datura metel L.</i></b>						
<i>Lenzites sterioides</i>	74.25	100	100	15.55	33.33	76.66
<i>Trametes pini</i>	65.42	83.56	99.5	26.12	44.18	62.79
<i>Schizophyllum commune</i>	35.27	70.83	100	6.06	22.72	65.15
<i>Ganoderma lucidum</i>	65.39	80.25	98.06	22.12	44.50	65.25
<i>Sterium hirsutum</i>	23.50	48.24	80.44	15.25	24.56	60.87
<b><i>Callistemon linearis DC.</i></b>						
<i>Lenzites sterioides</i>	73.41	89.24	100	-9.29	-16.90	-19.71
<i>Trametes pini</i>	45.52	80.95	100	19.40	38.80	67.14
<i>Schizophyllum commune</i>	26.66	82.96	88.14	38.96	57.14	77.92
<i>Ganoderma lucidum</i>	42.91	81.11	100	15.88	42.22	75.55
<i>Sterium hirsutum</i>	13.33	46.66	80.0	21.11	53.33	89.55
<b><i>Parthenium hysterophorus L.</i></b>						
<i>Lenzites sterioides</i>	26.66	50.00	90.00	38.40	58.00	70.00
<i>Trametes pini</i>	15.00	59.00	88.78	20.00	75.80	100.00
<i>Schizophyllum commune</i>	25.23	38.57	50.45	36.24	58.85	100.00
<i>Ganoderma lucidum</i>	27.91	46.11	89.05	27.88	62.22	95.55
<i>Sterium hirsutum</i>	34.33	68.66	92.00	21.11	43.33	85.55

Methanolic extract of *Cymbopogon* showed 100% inhibition of *S. hirsutum*, while its aqueous extracts was ineffective in all the concentrations tried. Variation in activity observed in methnolic and aqueous extract may be due to presence of different inhibitory compounds in these extracts. Aqueous extracts of *A. indica* *P. Juliflora* and *P. hysterophorus* may be further tried *in vivo* against all the 5 wood decay fungi. Extracts of *Tagetus*, *Eucalyptus*, *Azadirachta*, *Saraca*, *Cymbopogon*, *Datura* and *Callistemon* were 100% effective at 25% concentration to all test fungi (Plate II Fig A to C).

Bio-control of wood rotting fungi includes antibiosis and mycoparasitism, the two direct mechanisms of antagonism have been proposed to explain the inhibition of fungal pathogen in the rhizosphere by biocontrol agents. The biocontrol agents used for inhibition of wood rotting fungi includes phenolic compounds catechol, quinines, vanillin, Aromatic compounds, micro fungi like *Trichoderma polysporum*, *T. Harzianum*, *Penicillium* sp. *Aspergillus* sp. Bacteria like *Pseudomonas*, *Streptomyces*, *Streptovercillium*, *Xenorhabdus* and *Actinomycetes* like *Streptomyces*, *Micromonospora*, *Microbispora*, *Thormomonospora*, *Norcadia* and *Arthrobacter* were studied [17]. But in the present study for the first time the botanical pesticides were used to control timber decaying fungi. Biological control has also tried as a mean of perverting establishment of wood decay fungi in wounds caused by pruning. Here antagonistic non wood decay organism eg. *Trichoderma* sp have been applied [18]. But in present study the application of Botanical pesticides may show better alternative to antagonistic.

The ever-increasing public concern and the new environmental regulations on the use of chemicals have created the need for the development and the use of alternative methods for wood protection. Biological wood protection by antagonistic microbes alone or in combination with biochemicals, is one of the most promising ways for the environmentally sound wood protection. The best preventive method for storage of wood was storing them in a dry atmosphere. The most effective biocontrol antagonists belong to genera *Trichoderma*, *Gliocladium*, *Bacillus*, *Pseudomonas* and *Streptomyces* [19]. But in present study the Botanical pesticides like 5% leaf extract of *Prosopis Juliflora* completely inhibited *L. sterioides* decay. Arya [10] found leaf extract of *E. globulus* against styler end rot pathogen of guava (*Phomopsis psidii* Nagaraj and Ponappa). Pandey *et al.* [20] reported control of *Pestalotia* rot of guava by application of Neem (*Azadirachta indica*) and Tulsi (*Ocimum sanctum*) but in the present study the timber decaying fungi were controlled with different Botanical pesticides.

Basal stem rot (Ganoderma) disease which is posing a potential threat to coconut cultivation is wide spread in India. Twenty-nine plant products were evaluated in vitro and in vivo on the management of BSR of coconut. Ten percent leaf extracts of *Pongamia pinnata*, *Azadirachta indica* and *Prosopis juliflora* were effective in suppressing the mycelia growth of *G. lucidum* in vitro [21]. But in the present study the Methanol extracts of *Thevetia peruviana* (Pers.) Schum., *Tagetes erecta* L., *Eucalyptus globulus* Labill., *Azadirachta indica* A. Juss., *Prosopis juliflora* (Sw.) DC., *Saraca indica* L., *Lantana camara* L., *Biota sinensis* L., *Cimbopogan citrates* (Nees) Stapf., *Datura metel* L., *Callistemon linearis* DC., and *Parthenium hysterophorus* L. showed almost 100% inhibition. The heartwood extracts of *Platymiscium yucatanum*, a tropical wood highly resistant to the fungi *L. trabea* and *C. versicolor*, showed varying degrees of inhibitory activity against these two organisms in vitro. Medicarpin was the most active and was inhibitory than phenol against *C. versicolor* [22]. But in the present study the *L. sterioides* was 100% inhibition by all the Botanicals used except *L. camara* L.

This conifer *Araucaria araucana* (Mol.) K. Koch is endemic to rain forest of southern Chile and Argentina. It has high commercial, ethnobotanical, taxonomic, and ecological value derived from its long biogeographical and remote occurrence. the antifungal activity against *Trichophyton mentagrophytes*, *Ceratocystis pirifera*, *T. versicolor* these lignans exhibited antifungal and antibacterial activities [23] and antifeedant and insect growth regulator activities on FAW [24], in the range between 1.0 and 50.0 ppm. But in the present study the

*T. pini* was 100% inhibition by all the Botanicals used except *L. camara* L. and *Biota sinensis* L.,

### Bio-control by Oils and Gels

It is evident from Table 3, Lemon grass oil, cashew nut shell oil, Cotton Seed oil, Alsi oil, *Aloe vera*, *A. ferox* gels were used to control the timber decaying fungi. Out of 4 oils tested cashew nut shell oil was most effective followed by cotton seed oil. The timber decaying fungi like *L. sterioides*, *T. pini*, *S. commune*, *G. lucidum*, and *S. hirsutum* was controlled up to 80%, 78%, 60%, 50%, and 70% by 10% of cashew nut shell oil respectively (Table 4). In two *Aloe* gels tried the *A. ferox* gel showed better results than *A. vera*. The timber decaying fungi like *L. sterioides*, *T. pini*, *S. commune*, *G. lucidum*, and *S. hirsutum* was controlled up to 55%, 35%, 45%, 46%, 35% by 10% of *A. ferox* gel respectively (Table 4). In the future the use of pesticides will be tightly regulated because of well-documented environmental risks in the use of synthetic chemicals. This may lead to a growing demand for biological plant protection agents including use of botanicals. Use of oils prevents infection in plants or wooden planks by making their surface water repellent. Su et al. (25) demonstrated the antifungal activity of essential oils from *Eucalyptus grandis*, *E. camaldulensis*, and *E. citriodora* against wood rot fungi. *T. versicolor*, *P. chrysosporium*, *Phaeolus schweinitzii* and *L. sulphureus*. Based on the study, the authors opined that essential oil from *E. citriodora* could be an excellent choice as a wood preservative and preservation of leather goods and wood artifacts. But in present study the oils and gels were used to control the timber decaying fungi like *L. sterioides*, *T. pini*, and *S. commune*, for the first time. Chang et al. [26] reported antifungal activity against plant pathogenic fungi of essential oil and its constituents from *Calocedrus macrolepis* var. *formosana* Florin leaf. These compounds also efficiently inhibited the mycelia growth of *G. australe*, but in present paper the use of oils and gels for the first time to control *G. lucidum*.

**Table 3.** Oils and gels used as antifungal agents to control fungal organisms.

S. No.	Plant	Family	Active ingredients
1	<i>Cymbopogon citrates</i> (Lemon grass oil)	Poaceae	Citral, citronellol, Geraniol and Myrcene
2	<i>Anacardium occidentale</i> L. (Cashewnut shell oil)	Anacardiaceae	Anacardic acid and Cardol
3	<i>Gossypium barbadensis</i> L. (Cotton Seed oil)	Malvaceae	Gossypol
4	<i>Linum usitatissimum</i> L. (Alsi oil)	Linaceae	Cyanogenetic glycoside linamarin (used for making paints Varnishes) and Linoleum
5	<i>Aloe vera</i> L. Gel (Ghrat kumari)	Liliaceae	Barbaloin, Iobarbaloin, Aloinoside
6	<i>Aloe ferox</i> Mill. (Gel)	“	Lesser amount of Aloe-emodin Beta barbaloin

**Table 4.** Effect of 3 different concentrations of oils and gels on 5 wood decay fungi *in vitro*.

S. No	Oils and gel	Fungi	1%	5%	10%
1	<i>Cymbopogon</i>	<i>L. sterioides</i>	10.10	12.5	15.25
		<i>T. pini</i>	20.20	26.80	32.50
		<i>S. commune</i>	20.00	22,50	40.00
		<i>G. lucidum</i>	7.50	10.00	12.50
		<i>S. hirsutum</i>	20.25	30.50	40.00
2	<i>Anacardium occidentale</i>	<i>L. sterioides</i>	50.00	65.00	80.00
		<i>T. pini</i>	30.00	50.80	78.00
		<i>S. commune</i>	38.00	54.30	60.00
		<i>G. lucidum</i>	20.00	35.00	50.50
		<i>S. hirsutum</i>	20.50	45.20	70.80
3	<i>Gossypium barbadensis</i>	<i>L. sterioides</i>	27.70	45.45	52.25
		<i>T. pini</i>	30.00	46.10	60.10
		<i>S. commune</i>	35.25	58.25	72.85
		<i>G. lucidum</i>	20.25	50.00	50.00
		<i>S. hirsutum</i>	15.00	28.00	35.25
4	<i>Linum usitassim</i>	<i>L. sterioides</i>	10.00	18.12	20.25
		<i>T. pini</i>	15.00	20.10	15.20
		<i>S. commune</i>	20.00	22.10	30.34
		<i>G. lucidum</i>	10.15	15.80	40.45
		<i>S. hirsutum</i>	20.50	24.43	25.00
5	<i>Aloe vera</i>	<i>L. sterioides</i>	2.00	15.50	25.10
		<i>T. pini</i>	5.00	10.00	30.00
		<i>S. commune</i>	2.24	12.54	24.89
		<i>G. lucidum</i>	10.15	18.25	32.50
		<i>S. hirsutum</i>	10.10	15.25	20.25

6	<i>Aloe ferox</i>	<i>L. sterioides</i>	10.00	21.70	55.59
		<i>T. pini</i>	2.25	11.58	35.58
		<i>S. commune</i>	5.50	11.11	45.80
		<i>G. lucidum</i>	2.50	34.25	46.66
		<i>S. hirsutum</i>	10.25	10.25	35.58

Local resources must be utilized in wood preservation and thus also recentralized production of biopesticides should become a common practice. The development of organic farming as predicted by FAO (2009) may boost the use of botanical pesticides and biological pest control globally. Formulation of slow-release products will increase the efficacy of botanicals such as wood vinegar [27]. Scientific evidence has proved that birch tar oil is an environmentally friendly product [28,29]. Similarly, it has been shown that essential oils do not pose any threat to the environment [30]. So in present study different oils and gel was used to control timer decaying fungi. Maruzzella et al. [31] reported the toxicity of the oil of *Cassia* sp. against *Lentinus lepideus*, *L. trabea*, and *Polyporus versicolor*. But in present paper the oils of *Cymbopogon citrates* *Gossypium barbadensis* L. *Linum usitatissimum* L. were studied against *L. sterioides*. Antifungal activities of essential oil from *Litsea cubeba* Pers. fruits against wood decay fungi. The antifungal tests revealed that the antifungal indices of the fruit essential oil at 300 µg/ml against two strains of white rot fungi, *L. betulina* and *T. versicolor*, were both 100%, while at 200 µg/ml its antifungal indices against two strains of brown rot fungi, *Laetiporus sulphureus* and *Fomitopsis pinicola*, and were also 100%. The fruit oil processed the strongest antifungal activity against *F. pinicola* among the tested wood decay fungi [32]. But in present paper the Cashewnut shell oil (*Anacardium occidentale* L.) showed 80%, 78% inhibition of *L. sterioides*, and *T. pini*, at 100 µg/ml

#### 4. CONCLUSIONS

Preliminary studies are indicative of great potential for production, commercialization and the use of botanical pesticides in fungal pest control. Plant extracts are biodegradable and thus will not cause similar environmental risks. Uses of ecofriendly alternative like botanical pesticides and gels may be helpful to control the wood damage in forests and in different wood deposes. The leaf extracts, oils and gels were tried as ecofriendly management of certain Timber decaying fungi. For the first time the biocontrol of *L. sterioides* *T. pini* and *S. commune*, by botanical pesticides was reported. For the first time the biocontrol of *L. sterioides* *T. pini* *S. commune*, *G. lucidum*, and *S. hirsutum* by Oils and gels was reported.

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### Illustration of figures

Plate I. Fig. A. Biocontrol of *L. sterioides* by methanolic extract of *Callistemon linearis*  
a) control, b) 5% c) 10% d) 25%

Fig. B. Biocontrol of *S. commune* by methanolic extract of *Callistemon linearis*  
a) control, b) 5% c) 10% d) 25%

Fig. C. Biocontrol of *Trametes pini* by methanolic extract of *Callistemon linearis*  
a) control, b) 5% c) 10% d) 25%

Plate II. Fig. A. Biocontrol of *L. sterioides* by aqueous extract of *C. linearis*  
a) control b) 5% c) 10% d) 25%

Fig. B. Biocontrol of *S. commune* by aqueous extract of *C. linearis*  
a) control b) 5% c) 10% d) 25%

Fig. C. Biocontrol of *T. pini* by aqueous extract of *C. linearis*  
a) control b) 5% c) 10% d) 25%

Plate III. Fig. A. Biocontrol of *L. sterioides* by methanolic extract of *Cimbopogon citrates*  
a) control b) 5% c) 10% d) 25%

Fig. B. Biocontrol of *S. commune* by methanolic extract of *Cimbopogon citrates*  
a) control b) 5% c) 10% d) 25%

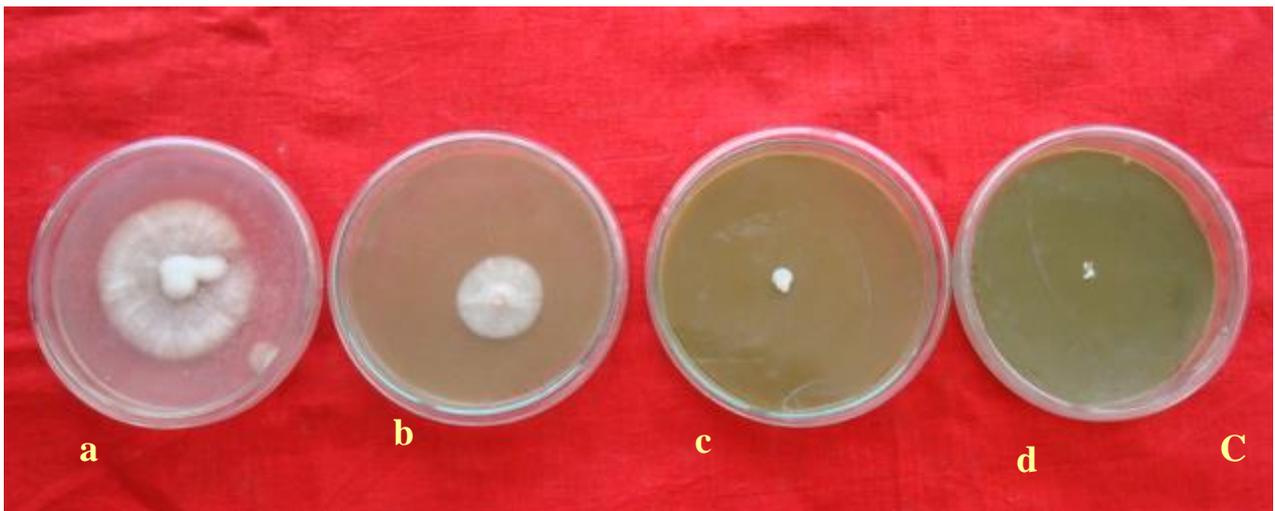
Fig. C. Biocontrol of *T. pini* by methanolic extract of *Cimbopogon citrates*  
a) control b) 5% c) 10% d) 25%

Plate IV. Fig. A. Biocontrol of *L. sterioides* by methanolic extract of *Prosopis juliflora*  
a) control b) 5% c) 10% d) 25%

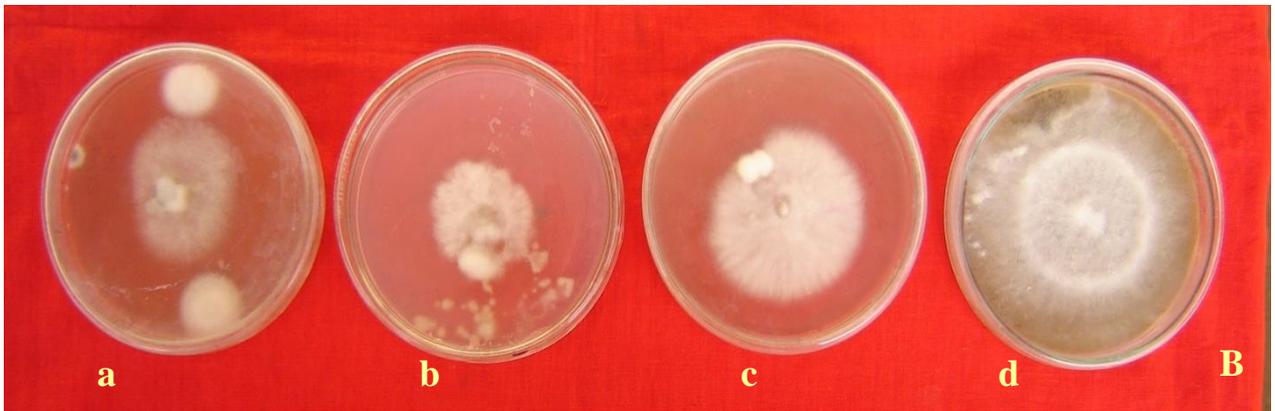
Fig. B. Biocontrol of *S. commune* by methanolic extract of *Prosopis juliflora*  
a) control b) 5% c) 10% d) 25%

Fig. C. Biocontrol of *T. pini* by methanolic extract of *Prosopis juliflora*  
a) control b) 5% c) 10% d) 25%

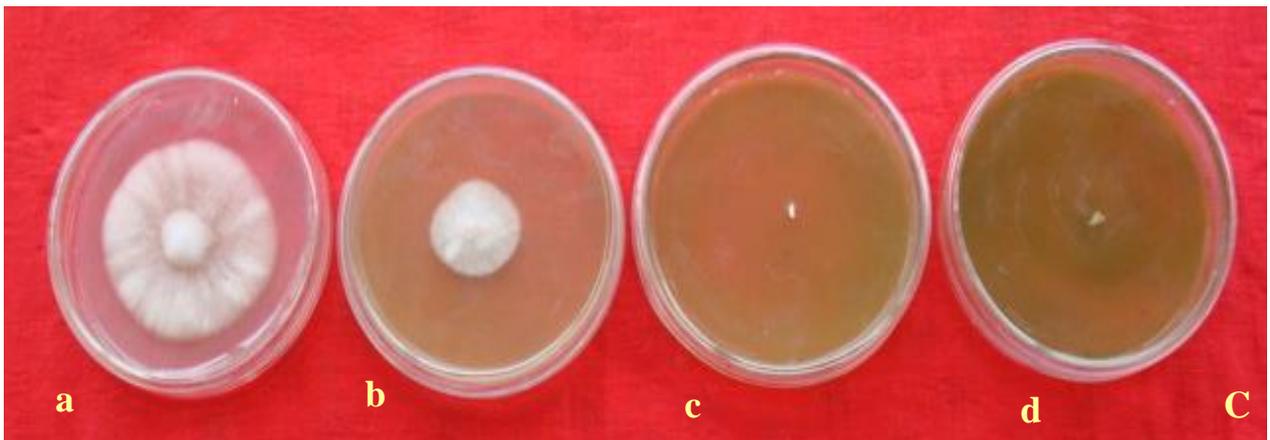
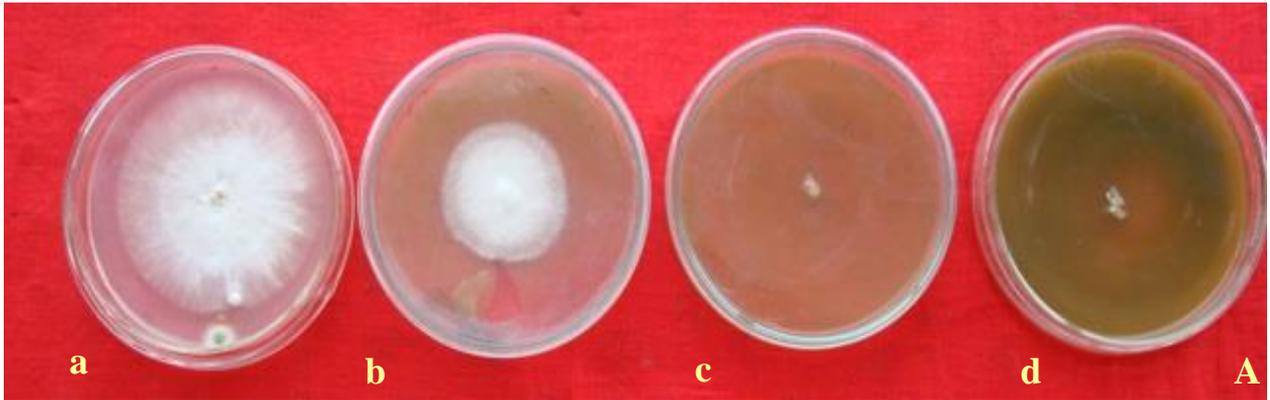
**Plate I**



**Plate II**



**Plate III**



**Plate IV**

