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Ganoderma Association with the Mortality of *Acacia auriculiformis*, Susceptibility to Different Hosts and Its Controls

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Abstract

An investigation was conducted to find out the association of *Ganoderma* spp. with the mortality of *Acacia auriculiformis* at Jahangirnagar University Campus, Bangladesh. Diseases severity of the tree was calculated where the highest (52.2 %) incidence was recorded in site-1 of the study area. Isolation and identification of the *Ganoderma* spp. and *Trichoderma* spp. were carried out. A total of 11 hosts were examined for examine the susceptibility of *Ganoderma* on host. All of the wild *Ganoderma* spp. viz., *G. lucidum*-1, *G. lucidum*-2, *G. lucidum*-3 and *G. applanatum* preferred to use saw dust of *Mangifera indica* followed by *Ceriops decandra* whereas the least performance recorded in *Albizia procera* and *Dipterocarpus turbinatus*. *Trichoderma* isolates found effective to control *Ganoderma* infestation under field conditions.

Keywords: *Ganoderma*; *Acacia auriculiformis*; *Trichoderma*; Disease severity; Biological control

Introduction

The genus *Ganoderma* includes several wood decaying fungi on living trees as well as dead trunks and stumps, and has been recorded mostly in tropical and temperate countries. Generally, *Ganoderma* spp. cause extensive heart rots of standing trees by growing in the central, non-living woody tissues. Several studies have been carried out on *Ganoderma* diseases focusing on economic damage, severity of the disease and host range in many regions such as America, Asia, the Middle East and Europe [1]. *Ganoderma lucidum* has been reported as the causal organism of the heart rot disease of 91 hosts species *Quercus* spp. [2], *Cocos nucifera* [3], *Camellia sinensis* [4], *Prunus persica* [5], *Vitis vinifera* [6], *Delonix regia* and *Cassia fistula*. According to previous studies, several *G. lucidum* strains have been identified in the *G. lucidum* complex [7] having different host specificity. Control of root rot diseases is difficult as the pathogens survive on woody material in the soil. Green mould disease caused by *Trichoderma* spp. one of the serious problem of oyster mushroom and white button mushroom. It causes large economic losses to the mushroom growers. This was agreed by [8-11]. But this *Trichoderma* spp. has ability to control various plant diseases. This study was undertaken to examine the spread of root and stem rot disease in a particular study area, identify the causal agent of the disease and control the disease by means of biocontrol agent, *Trichoderma*. So, we can use this spent mushroom compost as a biofertilizer.

Materials and Methods

A study was carried out to calculate disease prevalence of *Acacia auriculiformis* at four selected different sites of Jahangirnagar University Campus, Bangladesh. *Acacia auriculiformis* are the dominant trees in every site of the campus. A total of fifty trees were randomly selected in each study area. *Ganoderma* spp. viz *G. lucidum*-1, *G. lucidum*-2, and *G. lucidum*-3 were collected from fully dead plants where as *G. applanatum* from partially dead trees. Symptomatology of infected trees due to *Ganoderma* was studied carefully.

Identification of *Ganoderma* spp. and *Trichoderma* spp.

In the present study, *Ganoderma* spp. was classified according to Corner [12] and Steyaert [13]. All of mycelium of four *Ganoderma* was hyaline, hyphae aseptate, basidiospores were thick walled, bitunicate, golden brown in color and ovate in shape. Colors of the colony of all wild *Ganoderma* were white (Figure 1) The morphological, microscopic and cultural characteristic features of *Ganoderma lucidum* found more or less similar with previous researchers [1,14]. There was no chlamydospore found during present study as described by previous workers.

Disease severity index

The trees were scored for disease classes on a scale of 0 to 4 (Table 1). The Disease Severity Index (DSI) was calculated using a modified method of Abdullah et al. [15] and Ilias [16].

Isolation of wild *Ganoderma* spp.

Both the pathogens and infested wood chips were cultured on PDA medium. Pieces (1 cm × 1 cm) of pileus and wood chips (1 cm × 1 cm) were placed at the center of the plate separately. Three replications for each isolate were maintained and incubated at 32 ± 2°C. All of the isolates were pure cultured on PDA plates and stored at 4°C until further use.

Morphological and cultural characteristics

Morphological Characterization of *Ganoderma* such as shape, size, thickness, margin, color, texture of pileus was examined. Microscopic studies were done by stereoscopic binocular microscope (OLYMPUS SZ 61, magnification 40X with Camera DP20, Japan). Hyphal features, colony characteristics were recorded.

Isolation of antagonist

A total of four species of *Trichoderma* i.e., *Trichoderma harzianum*,

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Figure 1: Photographs showing basidiocarps of studied *Ganoderma* spp.

- **a.** *Ganoderma lucidum* 1 (wild)
- **b.** *Ganoderma lucidum* 2 (wild)
- **c.** *Ganoderma lucidum* 3 (wild)
- **d.** *Ganoderma applanatum* (wild)

Disease Classes	Range	Severity of infection
0	0	Healthy plants
1	25 >	Initial development of pinheads of *Ganoderma* spp.
2	26-50	Appearance of *Ganoderma* on the tree trunk but no remarkable damage observed in plants.
3	50-75	Partially top dying
4	>75	Fully top dying of plants and plants dried.

Formula used to calculate disease severity index (DSI) % = Σ (A × B) × 100/ ΣB × 4
where:
A – Disease classes (0, 1, 2, 3, 4 and so on)
B – Number of plants showing that disease classes per treatment

Table 1: Parameters used to calculate disease severity in the study area.

T. koningii, *T. viride* (green strain), and *T. viride* (yellow strain) were collected from infected spent mushroom spawn packets of *Pleurotus ostreatus*, during December'2010 to February'2011. Antagonists *Trichoderma harzianum* was characterized according to Barnett [17] and Choi et al. [18] and. Others strain of *Trichoderma* were characterized as described by Barnett [17].

Assessment of *Ganoderma* susceptibility to different host range

Sawdust of 11 randomly selected hosts viz., *Acacia auriculiformis* (L), *Ceriops decandra* (Griff.) Ding Hou, *Tectona grandis* L. f., *Delonix regia* (Bof.)Raf. *Mangifera indica* L., *Dipterocarpus turbinatus* Gaertn., *Artocarpus chaplasha* Roxb., *Albizia procera* Benth., *Albizia lebbeck* (L.) Benth., *Artocarpus heterophyllus* Lamk. were collected from Barisal Timbers & Saw mills, Kazi Timbers & Saw mills, M/S. N.S. Timbers etc. of Savar Bazar, Dhaka. Sawdusts were put in broad mouth test tubes (20 cm) and autoclaved (121°C temperature, 15 atm pressure for 20 minutes) for two times (a modified method of Fernando, 2008). Four treatments combinations were used to assess susceptibility of *Ganoderma*. After cooling of saw dusts, fungal block each of 8 mm in size was inoculated into the test tubes containing sawdust under aseptic condition and cotton plugged. Test tubes were incubated at 32 ± 2°C temperature. Radial growth of *Ganoderma* spp. on the test tube was measured at 10 days intervals and was analyzed statistically by MSTAT-C program.

Treatment T_1 (Control) comprised of 70% Sawdust+65% moisture+ inoculums (*Ganoderma*-1,2,3,4 separately); treatment T_2 of 70% Sawdust+65% moisture+ 0.5% $CaCO_3$ +inoculums (*Ganoderma*-1,2,3,4 separately); thus Treatment T_3 and T_4 made up of 70% Sawdust+65% moisture+ 30% wheat bran+2% sucrose+0.5% $CaCO_3$ +inoculums (*Ganoderma*-1,2,3,4 separately) and 70% Sawdust+65% moisture+ 30% rice bran+2% sucrose+0.5% $CaCO_3$ +inoculums (*Ganoderma*-1,2,3,4 separately) respectively.

Field trial

A field experiments were also conducted at Jahangirnagar University Campus during April to August 2011. A total of eight treatment combinations were used in field experiments (Table 2). A total of fifty non infected plants were randomly selected in these purpose to inoculate the isolated *Ganoderma* to examine the capacity to infest on living host and the control of diseases prevalence using antagonists.

Mass culture of four *Ganoderma* isolates

The bamboo chips (3 cm) were sun dried for 10 days after cutting. Then these chips were mixed with wheat bran (30%), rice bean (30%) and 2% sugar solution with maintained 65% moisture. Then, these substrates were put into broad mouth test tubes (20 cm) and plugged with cotton. These test tubes were autoclaved for two times and waited until cooled. Test tubes were inoculated with each of four *Ganoderma* species. Data was collected until test tubes were filled with *Ganoderma* mycelium.

Preparation of *Trichoderma* spore suspension

At first, 20 ml of double distilled water was poured in each Petri dish having *Trichoderma* isolates. Then, each plate was scrapped to separate out mycelium of *Trichoderma* by using inoculating needle as mycelium of antagonist separated out. Then this solution was taken in plastic pot and covered with sterilized aluminum foil.

The stump or trunk region of *Acacia* sp. plants were holed by hammer and auger. Bamboo chips were inoculated into the plant by

Treatments no.	Description
Control	No inoculation of *Ganoderma*
T_1	Inoculation of G-1.
T_2	Inoculation of G-2
T_3	Inoculation of G-3
T_4	Inoculation of G-4
T_5	Inoculation of G-1+addition of *T. harzianum* suspension
T_6	Inoculation of G-2+addition of *T. koningii* suspension
T_7	Inoculation of G-3+addition of *T. viride* (green strain) suspension
T_8	Inoculation of G-3+addition of *T. viride* (yellow strain) suspension

Here, G1-*Ganoderma lucidum*-1, G2-*Ganoderma lucidum*-2, G3-*Ganoderma lucidum*-3, G4-*Ganoderma applanatum*.

- 5 replication in each treatment except control where 10 replications were used.

Table 2: Treatments used to assesses the pathogenecity of *Ganoderma* spp. and its control using antagonistic potentiality of *Trichoderma* spp. at field condition.

hammer and covered with adhesive tape. The mycelial run rate per bamboo chip was observed.

Result and Discussion

Symptomatological study

Ganoderma infected plants showed symptoms with initially a bleached zone appeared in the wood which results delignification, drying of apical meristem or top dying of plants was the common symptoms on plants, wilting of plants, stem blackening, defoliation, white rot and root rot, loss of stiffness and finally, death of tree plants. All of the *Ganoderma* infected plants consisted at least 5 to 7 fruit bodies except *Ganoderma applanatum* where infected plants contained one fruit body and plant was defoliated. The symptoms recorded during study are in conformity with some researchers [14,19,20]. Dysfunctional xylem associated with large wounds on the roots which were thought to be due to delignification; caused by *Ganoderma applanatum* [21].

Calculation of Disease Severity Index (DSI)

The DSI value of *Ganoderma* at four selected sites of Jahangirnagar University Campus revealed that the highest disease incidence was found in site-1 (55.2%) in *Acacia auriculiformis* followed by site-2 (47.5%), site-4 (45%) and site-3 (36%) (Table 3). Such findings partially supported by Nur and Abdullah [22] who cited the highest DSI (70.0%) due to *Ganoderma* infected oil palm seedlings. Disease progression of basal stem rot symptoms caused by *Ganoderma boninense* was recorded 100% in oil palm seedlings [23].

Assessment of wild *Ganoderma* (four) susceptibility to different host range

Ganoderma lucidum-1 was susceptible *Acacia auriculiformis* due to treatment T_2 which is statistically identical to T_4 followed by T_3 at 10 days (Table 4) but treatment T_4 exhibited more susceptible at 30 days. More or less similar results found in case of *Ganoderma lucidum*-2 and *Ganoderma lucidum*-3. *Ganoderma applanatum* showed no significant differences at 10 days but at 20 and 30 days only saw dusts showed more susceptible. In case of *Artocarpus chaplasha*, *Ganoderma lucidum*-1 was susceptible to treatment T_4 at 10, 20, 30 days respectively (Table 4). More or less similar patern recorded in case of *Delonix regia* (Table 5). *Ganoderma applanatum* showed better growth in sole saw dust of *Delonix regia*.

Disease Class	Range	No. of infected plants			
		Site 1	Site 2	Site 3	Site 4
0	0	7	10	15	10
1	25 >	10	10	13	10
2	26-50	8	10	12	15
3	50-75	15	15	5	10
4	>75	10	5	5	5
DSI (%)		55.2	47.5	36	45

Table 3: Disease severity index (DSI) of site -1, 2, 3, 4 at Jahangirnagar University Campus.

There was no clear pattern found in case of *Albizia lebbeck* for its growth (Table 4).

In case of *Dipterocarpus turbinatus*, *Ganoderma lucidum*-1 and 2 showed better growth in the treatment T4 during entire incubation period (Table 5). *Ganoderma applanatum* preferred to grow where $CaCO_3$ was added up to 20 days but treatment T_4 showed better performance at 30 days of inoculation. All of the *Ganoderma* spp. showed better growth performance in sole saw dust of *Ceriops decandra* (Table 5). In case of *Artocarpus heterophyllus*, *Ganoderma lucidum*-1 and 3 showed better performance in treatment T_4 at

	Treatments	*Ganoderma lucidum* 1			*Ganoderma lucidum* 2			*Ganoderma lucidum* 3			*Ganoderma applanatum*		
		10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)
Acacia auriculiormis	T_1(control)	1.93 ab	6.0 b	9.00 d	2.00 c	6.20 c	9.60 c	2.70 b	6.20 c	9.50 c	1.50 a	3.80 a	5.80 a
	T_2	2.60 a	7.0 a	10.10 c	3.30 a	7.20 b	11.27 b	3.10 a	7.20 b	11.00 b	1.50 a	3.60 b	5.20 b
	T_3	1.87 b	6.20 ab	11.30 b	3.03 b	8.20 a	13.50 a	0.00 c	0.00 d	0.00 d	1.40 a	3.20 c	0.00 c
	T_4	2.57 a	6.20 ab	13.30 a	0.00 d	0.00 d	0.00 d	2.70 b	7.50 a	12.30 a	1.47 a	3.30 c	5.13 b
	CV (%)	14.94	7.39	3.96	5.54	2.07	1.54	6.51	2.28	1.17	8.80	2.88	2.48
Artocarpus chaplasha	T_1(control)	1.40 b	2.80 b	4.20 b	0.00 c	0.00 c	0.00 c	2.00 b	4.00 b	6.00 b	1.40 b	2.80 b	4.20 b
	T_2	1.67b	2.37 c	3.57 c	1.60 b	3.20 b	4.80 b	2.00 b	4.00 b	6.00 b	1.40 b	2.80 b	4.20 b
	T_3	1.40 b	2.80 b	4.20 b	2.00 a	3.97 a	6.00 a	3.00 a	6.00 a	9.00 a	2.17 a	4.367 a	6.57 a
	T_4	2.20 a	4.40 a	6.60 a	1.57 b	3.17 b	4.77 b	3.00 a	6.00 a	9.00 a	1.40 b	2.80 b	4.20 b
	CV (%)	7.72	3.85	2.56	5.00	2.58	1.66	4.00	2.00	1.33	6.02	3.00	2.00
Delonix regia	T_1(control)	1.87 b	5.87 c	8.87 d	1.97 c	6.10 c	9.50 c	2.60 b	6.10 c	9.47 c	1.42a	2.43a	5.70 a
	T_2	2.60 a	6.87 a	10.27 c	3.20 a	7.10 b	11.17 b	2.97 a	7.07 b	10.90 b	1.05b	2.07c	5.10 b
	T_3	2.60 a	6.10 b	11.20 b	2.87 b	8.10 a	13.57 a	0.00 c	0.00 d	0.00 d	1.00b	2.10b	4.70 c
	T_4	2.56 a	6.10 b	13.20 a	0.00 d	0.00 d	0.00 d	2.60 b	7.40 a	12.20 a	1.00b	2.30b	4.97 b
	CV (%)	3.66	1.34	3.05	3.62	0.94	1.28	5.48	0.97	0.94	1.01	1.15	1.49
Albizia lebbeck	T_1(control)	1.80 b	5.60 c	8.90 d	1.87 d	5.87 d	9.47 c	2.50 b	5.20 c	9.30 c	1.40 a	4.10 a	5.60 a
	T_2	2.50 a	6.70 a	9.77 c	3.06 a	6.67 b	10.87 b	2.97 a	6.77 b	10.87 b	1.30 b	3.20 b	4.97 b
	T_3	1.87 b	4.77 d	10.07 b	2.80 b	7.90 a	13.50 a	0.00 c	0.00 d	0.00 d	1.17 c	2.97 d	2.97 c
	T_4	2.40 a	5.80 b	13.10 a	2.10 c	6.10 c	9.20 d	2.50 b	7.30 a	12.10 a	1.20 c	3.10 c	5.00 b
	CV (%)	3.57	1.34	0.80	3.59	1.33	0.82	3.83	1.59	0.95	2.28	0.86	0.72

✓Means in a column followed by the same letter do not differ significantly at 5% level of significance (DMRT)
✓Treatment 1(Control) = only saw dusts+ inocula (*Ganoderma*-1,2,3,4 separately), Treatment 2 (T_2) = 70% Sawdust+65% moisture+ 0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately), Treatment 3 (T_3) = 70% Sawdust+65% moisture+ 30% wheat bran+2% sucrose+0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately), Treatment 4 (T_4) = 70% Sawdust+65% moisture + 30% rice bran+2% sucrose+0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately).

Table 4: Susceptibility of *Ganoderma* spp. to *Acacia auriculiormis*, *Artocarpus chaplasha, Delonix regia and Albizia lebbeck* at different days of inoculation.

	Treatments	*Ganoderma lucidum* 1			*Ganoderma lucidum* 2			*Ganoderma lucidum* 3			*Ganoderma applanatum*		
		10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)
Dipterocarpus turbinatus	T_1(control)	0.97 c	2.10 c	3.20 c	1.27 b	1.27 d	1.27 d	1.30 b	3.27 b	4.87 b	1.20 b	2.70 c	4.10 b
	T_2	1.17 bc	2.40 b	3.60 b	1.20 b	2.40 b	3.60 b	0.60 c	2.70 c	4.20 c	1.87 a	3.87 a	3.87 c
	T_3	1.17 b	1.67 d	1.67 d	1.87 a	1.87 c	1.87 c	2.20 a	4.40 a	6.60 a	1.00 c	2.10 d	3.20 d
	T_4	1.30 a	3.80 a	6.50 a	1.77 a	4.10 a	7.60 a	0.00 d	0.00 d	0.00 d	0.97 c	3.57 b	5.67 a
	CV (%)	9.87	5.05	3.36	5.35	3.85	2.46	9.34	3.34	2.21	7.37	3.03	2.21
Ceriops decandra	T_1(control)	5.00 a	12.40 a	17.00 a	4.50 a	12.40 a	16.80 a	5.00 a	13.10 a	17.30 a	2.00 a	4.50 a	6.80 a
	T_2	3.10 b	10.57 b	16.00 b	1.80 d	12.40 a	16.00 b	4.70 a	11.80 b	16.00 b	1.80 b	4.00 b	6.30 b
	T_3	2.70 c	6.60 d	11.30 d	2.40 c	4.80 c	1.50 d	3.20 b	8.30 c	13.40 c	0.00 c	0.00 c	0.00 d
	T_4	3.20 b	8.50 c	13.80c	3.40 b	9.00 b	14.60 c	3.30 b	8.20 c	13.60 c	1.90 ab	3.93 b	5.10 c
	CV (%)	1.65	1.63	0.44	1.65	1.50	0.42	3.70	1.22	0.83	6.72	4.15	2.10
Artocarpus heterophyllus	T_1(control)	1.70 b	3.40 b	5.30 b	0.00 c	0.00 c	0.00 c	2.27 b	4.57 b	7.17 b	1.67 b	3.37 b	5.27 b
	T_2	1.50 c	2.97 c	4.70 c	1.80 b	3.60 b	5.70 b	2.30 b	4.60 b	7.20 b	1.70 b	3.40 b	5.30 b
	T_3	1.67 b	3.37 b	5.27 b	2.30 a	4.60 a	7.20 a	3.17 a	6.37 a	9.80 a	2.50 a	5.00 a	7.70 a
	T_4	2.50 a	5.00 a	7.70 a	1.80 b	3.63 b	5.70 b	3.20 a	6.40 a	9.80 a	1.70 b	3.40 b	5.30 b
	CV (%)	4.15	1.97	1.33	3.39	2.18	1.08	4.52	2.25	1.23	4.04	2.01	1.30
Mangifera indica	T_1(control)	3.70 c	9.30 d	16.00 a	3.20 d	9.47 a	16.00 a	5.20 a	11.97 a	16.00 a	2.30 c	4.70 c	7.00 c
	T_2	3.97 b	11.60 b	16.00 a	4.30 b	11.80 a	16.00 a	4.50 b	11.50 b	16.00 a	2.30 c	5.20 b	7.77 b
	T_3	4.20 a	10.10 c	16.00 a	5.27 a	43.17 a	16.00 a	4.97 a	10.97 c	16.00 a	4.50 a	9.50 a	16.00 a
	T_4	3.80 c	12.50 a	16.00 a	4.07 c	11.57 a	16.00 a	3.77 c	9.867 d	16.00 a	3.97 b	9.20 a	16.00 a
	CV (%)	1.95	0.46	0.00	2.10	47.86	0.00	4.62	1.14	0.00	2.93	2.10	0.25

✓Means in a column followed by the same letter do not differ significantly at 5% level of significance (DMRT)
✓Treatment 1(Control) = only saw dusts+ inocula (*Ganoderma*-1,2,3,4 separately), Treatment 2 (T_2) = 70% Sawdust+65% moisture+ 0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately), Treatment 3 (T_3) = 70% Sawdust+65% moisture+ 30% wheat bran+2% sucrose+0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately), Treatment 4 (T_4) = 70% Sawdust+65% moisture + 30% rice bran+2% sucrose+0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately).

Table 5: Susceptibility of *Ganoderma* spp. to *Dipterocarpus turbinatus, Ceriops decandra, Artocarpus heterophyllus and Mangifera indica* at different days of inoculation.

	Treatments	*Ganoderma lucidum* 1			*Ganoderma lucidum* 2			*Ganoderma lucidum* 3			*Ganoderma applanatum*		
		10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)	10 days (cm)	20 days (cm)	30 days (cm)
Mixed saw dust	T_1(control)	2.07 d	8.57 c	16.00 a	2.50 c	7.30 c	14.20 c	4.60 a	11.30 a	16.00 a	2.70 a	5.70 a	8.50 a
	T_2	3.80 a	10.00 a	16.00 a	2.87 b	7.97 b	15.27 b	2.60 b	8.00 b	14.80 b	2.20 b	5.20 b	8.00 b
	T_3	3.27 b	10.00 a	16.00 a	5.00 a	9.97 a	16.00 a	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
	T_4	2.80 c	9.30 b	16.00 a	2.77 b	5.57 d	5.57 d	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
	CV (%)	2.01	0.53	0.00	2.21	1.06	0.57	3.21	1.20	0.65	4.71	2.12	1.40
Tectona grandis	T_1(control)	3.37 c	7.30 c	10.20 c	2.20 b	7.30 c	12.87 c	2.17 a	7.17 a	13.30 b	1.97 a	4.60 a	7.07 a
	T_2	3.60 b	7.70 b	10.77 b	2.30 b	7.70 b	14.30 a	2.00 a	7.10 ab	13.50 a	1.90 a	4.30 b	6.97 b
	T_3	3.80 a	6.00 d	11.40 a	3.00 a	6.00 d	9.07 d	0.00 c	0.00 c	0.00 d	0.00 c	0.00 d	0.00 d
	T_4	1.30 d	8.10 a	10.97 b	2.97 a	8.10 a	13.90 b	1.80 b	6.97 b	12.10 c	1.20 b	3.30 c	5.00 c
	CV (%)	2.14	0.69	1.34	3.98	0.69	0.99	6.70	1.37	0.84	6.45	1.64	0.70
Albizia procera	T_1(control)	0.80 b	1.80 b	3.70 b	0.90 c	1.80 d	4.10 b	1.30 a	3.50 b	5.00 b	Not detected		
	T_2	0.00 c	0.00 c	0.00 c	1.27 b	2.97 b	4.27 b	1.40 a	3.06 c	4.47 c			
	T_3	0.00 c	0.00 c	0.00 c	1.80 a	2.27 c	2.27 c	0.00 b	0.00 d	0.00 d			
	T_4	1.08 a	3.60 a	6.30 a	1.70 a	4.70 a	8.50 a	1.60 a	4.20 a	7.40 a			
	CV (%)	8.88	4.28	2.31	7.35	3.16	1.94	21.98	3.03	1.94			

✓Means in a column followed by the same letter do not differ significantly at 5% level of significance (DMRT)
✓Treatment 1(Control) = only saw dusts+ inocula (*Ganoderma*-1,2,3,4 separately), Treatment 2 (T_2) = 70% Sawdust+65% moisture+ 0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately), Treatment 3 (T_3) = 70% Sawdust+65% moisture+ 30% wheat bran+2% sucrose+0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately), Treatment 4 (T_4) = 70% Sawdust+65% moisture + 30% rice bran+2% sucrose+0.5% $CaCO_3$ + inocula (*Ganoderma*-1,2,3,4 separately)

Table 6: Susceptibility of *Ganoderma* spp. to mixed saw dust*, Tectona grandi,* and *Albizia procera* at different days of inoculation.

10, 20, 30 days respectively. Whereas, *Ganoderma lucidum*-2 and *Ganoderma applanatum* showed better growth in treatment T_3 during entire period of study (Table 5). *Ganoderma lucidum*-1, 2, 3 showed better performances to all of the treatments at 30 days. *Ganoderma applanatum* preferred to use best performance in treatment T_3 and T_4 at 20, 30 days respectively (Table 5).

In case of mixed saw dust, *Ganoderma lucidum*-1 was susceptible to treatment T_2 showed significant difference at 10 days but *G. lucidum*-1, 2 showed better performances in treatment T_3 at 30 days. *G. lucidum*-3 and *Ganoderma applanatum* were prone to sole saw dust at 10, 20, 30 days respectively upto entire study (Table 6) *G. lucidum*-1 and 2 were commonly susceptible to *Tectona grandis* due to the treatment T_3 at

10 days and treatment T_4 at 20 days. But at 30 days *G. lucidum*-1 and 2 showed better growth in treatment T_3 and T_2 respectively. *G. lucidum*-3 and *G. applanatum* showed more growth performance in treatment T_2 at 30 days (Table 6). In case of *G. lucidum*-1, 2, 3 showed better performances in the treatment T_4 at 30 days whereas *G. applanatum* showed no run rate in any treatments at any days (Table 6).

All of the *Ganoderma* spp. i.e., *G. lucidum*-1, *G. lucidum*-2, *G. lucidum*-3 and *G. applanatum* preferred to use saw dust of *Mangifera indica* followed by *Ceriops decandra*. This might be due to the presence of readily usable materials for its growth. In most of the cases, the least performance showed in *Albizia procera* and *Dipterocarpus turbinatus* might be the presence of secondary metabolites such as tannin, resins, and gums in wood. Root diseases caused by *Ganoderma* spp. seriously affected growth of *Acacia* spp. [24], *Acacia auriculiformis* and *Acacia nilotica* in India and Pakistan [25], Red rot disease of *Acacia mangium* caused by *Ganoderma* sp. reported in Malaysia [26]. *Acacia auriculiformis* affected by root rot disease caused by *Ganoderma* and Phellinus spp. in Papua New Guinea [27], heart rot disease caused by *Ganoderma lucidum* recorded in *Quercus* spp., *Cocos nucifera*, *Camellia sinensis*, *Prunus persica*, *Vitis vinifera*, *Cassia nodosa*, *Casia fistula*, *Delonix regia*, others 144 hosts in India [1].

Figure 2: Photographs showing *in vivo* potentiality of *Trichoderma* and pathogenecity of *Ganoderma* spp.

a. Sporulation of *Trichoderma* over *Ganoderma* inoculated area

b. Colonization of *Ganoderma* mycelia

c. Colonization of *Ganoderma lucidum*-1 mycelia on the inoculated area

d. Colonization of *Ganoderma lucidum*-2 mycelia on the inoculated area

e. Colonization of *Ganoderma lucidum*-3 mycelia on the inoculated area

f. Colonization of *Ganoderma applanatum mycelia* mycelia on the inoculated area (just initiated).

Pathogenecity of *Ganoderma* spp. and antagonistic potentiality of *Trichoderma* spp.

In vivo pathogenecity of four *Ganoderma* spp. showed colonization of mycelium within 5 months, that means trees inoculated with bamboo chips of *Ganoderma lucidum*-1, *G. lucidum*-2, *G. lucidum*-3, *G. applanatum* showed mycelial run rate in the surroundings of inoculated area. In case of *Ganoderma applanatum*, mycelial run rate was just initiated (Figure 2). *In vivo* evaluation of potentiality of *Trichoderma* against *Ganoderma* spp. also studied. Bamboo chips of four *Ganoderma* spp. were inoculated with four selected *Trichoderma* spp. showed no mycelial run rate of *Ganoderma* spp., even *Trichoderma* spp. was sporulated over the inoculated area. *Ganoderma applanatum* as the most degradative wood colonizer [14]. The pathogenicity of *Ganoderma* spp. and the inhibitory effect of *Trichoderma* on *Ganoderma* spp. was followed earlier research [28].

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