Effect of Lead and Cadmium on the Fungal Population in Rhizosphere Soils of Eucalyptus species

Article · February 2019

CITATIONS
0

READS
51

4 authors, including:

Gunjan Patil
Guru Ghasidas University
9 PUBLICATIONS **22** CITATIONS

SEE PROFILE

Environment & Ecology 35 (4A) : 2965—2970, October—December 2017
Website : environmentandecology.com ISNN 0970-0420

Effect of Lead and Cadmium on the Fungal Population in Rhizosphere Soils of *Eucalyptus species*

Gunjan Patil, Mohammad Faizan

Received 12 January 2017; Accepted 14 February 2017; Published online 4 March 2017

Abstract High concentrations of heavy metals in soil have an adverse effect on micro-organisms and microbial processes. Among different types of microorganisms of soil fungi are the only ones providing a direct link between soil and roots and can therefore be of great importance in heavy metal availability and toxicity to plants. In paper dicusses the interactions between heavy metals and fungi. Effects of heavy metals on the occurrence of fungi, heavy metal tolerance in these micro-organisms and their effect on different *Eucalyptus species*. Toxic effect of heavy metals on the the population of fungi from rhizospheric and non-rhizospheric soils of for *Eucalyptus species* are discussed . The possible use of mycorrhizal fungi as bioremediation agents in polluted soils or as bioindicators of pollution is also discussed.

Keywords Fungal population, Heavy metals, Rhizosphere, Non-rhizosphere.

Gunjap Patil*, Mohammad Faizen
Assistant Professor,
Department of Forestry, Wildlife and Environmntal Sciences
Guru Ghasidas Viswavidyalaya, Bilaspur 495009, CG, India
e-mail : gurju-20072yahoo.com
*Correspondence

Introduction

Pollutants permitted to the biosphere including heavy metals due to industrial and agricultural and domestic activities has created a serious problem for the safe utilizes of sod soils [1]. Toxic effect of heavy metals on fungal population is already known by world [2]. The influence of heavy metals on fungal activities was studied at 30 DAS and 180 DAS in microbiology laboratory. Pot culture experiment was conducted in two types of forest soil clay loam and sandy loam. three different comcentrations of metals lead and cadmium were imposed in both soils. The fungal activity decreased with increased metal condcentrations. Fungal activity initially increased with the level of metal contamination, being up to 3 and 7 times higher than that in the control samples during the first week t the highest levels of Zn and Cu addition, respectively. This is the first direct evidence that activities in soil are differently affected by heavy metals. The different responses of fungi to metals were reflected in an increase in the relative fungal.

Materials and Methods

The experiment was conducted at the nursery of Forest College and Research Institute, Mettupalayam. Air dried red sandy loam anbd black clayey loam soils were spiked with respective metal levels up to saturated condition and about 6 kg of spiked soil is into plastic pots of (17 cm in diameter and 15 cm iin length) dimensions. The good quality seeds of *E. tereticornis, E. camaldulensis, E. globulus and E. citriodora* were directly sown (10 seeds pot) on

plastic pots. the seedings were thinned after 30 days by keeping uniform sized seedling (3 seedlings pot). In the pot culture experiment no recommended fertilizers were applied for the plants. three replications were fixed for each for each treatment in a factorial completerly randomized design (FCRD). Soil samples rhizosphere and non- rhizosphere soil were recorded in two intervals 30 and 180 DAS.

The microbial load were analyzed in rhizosphere and non-rhizosphere soils. The enumeration of microbes was carried out on solid media using the serial dilution and plating technique, one gram of soil samples was taken and serial dilutions were carried out in sterile water. seven dilutions viz 10^{-2}, 10^{-3} 10^{-4}, 10^{-5} 10^{-6} and 10-7 were prepared and used for the isolation of microorganisms 10^{-6} for fungi [3].

Rose bengal agar (RBA) medium were used to isolate fungi. Three replications were maintained for each isolation. The petri plates were incubated at room temperature and colonies of different microorganisms enumerated after appropriate time interval 2-3 days for fungi.

Factor	Particulars		Details
Factor 1	Soil types	2	S_1-Sandy loam S_2- Clay loam
Factor 2	tree species	4	E_1-Eucalyptus tereticornis E_2-E. camaldulensis E_3-E. globulus E_4-E.citriodora
Factor 3	Treatments	7	T_0-Control M_1T_1-Cadmium 25 ppm M_1T_2-Cadmium 50 ppm M_1T_3-Cadmium 100 ppm M_2T_1-Lead 100 ppm M_2T_2- Lead125 ppm M_2T_3-Lead 250 ppm
	Replications design	3	FCRD

Results and Discussion

The data on the heavy metals viz., cadmium and lead in the fungal population of rhizosphere and non-rhizosphere sandy and clay loam soil of four *Eucalptus species* at 30 DAS was given in Table 1. The results showed that the fungal population in the four *Eucalptus species* was significantly affected due to the application of heavy metals in different concentrations in the rhizosphere and non-rhizosphere soils when compared to control. The fungal population significantly reduced due to the toxicity of different metal concentrations. The rhizosphere is considered a major niche for microbial activity, where a substantial number of microorganisms may exert a beneficial effect on plant fitness and development, particularly phosphate solubilisation, which is considered to be one of the most important features associated with plant nutrition.

The fungal population in the rhizosphere soil of *E. tereticornis, E. camaldulensis, E. globulu*s and *E. citriodora* decreased under cadmium treated sandy loam soil and it was 8.22 CFU g-l,6.22 CFU g-l, 7.56 CFU g-l and 9.89 CFU g-l respectively. In lead treated sandy loam soil, it was 10.55 CFU g-l, 6.67 CFU g-l, 8.00 CFU g-l and 10.67 CFU g-l respectively. In cadmium treated clay loam soil, the fungal population in the rhizosphere soil *E. tereticornis, E. camaldulensis, E. globulus* and *E. citridora* was 7.00 CFU g-l, 5.33 CFU g-l, 6.33 CFU g-l and 9.00 CFU g-l respectively and it was 9.00 CFU g-l, 5.89 CFU g-l, 7.22 CFU g-l and 9.44 CFU g-l respectively in lead treated clay loam soil.

The fungal population in the non-rhizossphere soil of *E. tereticornis, E. camaldulensis, E. globulus* and *E. citriodora* decreased under cadmium treated sandy loam soil and it was 4.22 CFU g-l, 3.44 CFU g-l, 3.89 CFU g-l and 7.00 CFU g-l respectively. In lead treated sandy loam soil, it was 5.89 CFU g-l, 4.33 CFU g-l, 5.11 CFU g-l and 7.67 g-l respectively. In cadmium treated clay loam soil, the fungal population in non rhizosphere soil of *E. tereticornis , E. camaldulensis, E. globulus* and *E. citriodora* was 4.00 CFU g-l, 2.55 CFU g-l, 3.33 CFU g-l and 6.33 CFU g-l. respectively and itwas 5.11 CFU g-l, 3.56 CFU g-l, 4.89 CFU g-l and 6.89 CFU g-l respectively in lead tresated clay loam soil. The fungi population was significantly varied with soil types, toxic metals level and species. The fungi were showed sensitivity towards toxic metals. The toxic effect of metals reduced the activity of the fungi. It showed decreasing trend with increasing metal concentration [4]. The sandy loam soil was

Table 1. Total counts of fungi as influenced by cadmium and lead at 30 DAS (CFU g^{-1}).

		Fungi 180 DAs (CFU g^{-1})									
		Rhizosphere					Non-rhizosphere				
Soil type	Treatment	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean
	To	12.33	11.67	11.33	11.00	11.58	7.67	8.00	8.33	8.00	8.00
S_1	M_1T_1	10.33	7.67	9.33	11.00	9.58	5.67	5.00	5.33	8.00	6.00
	M_1T_2	8.33	6.00	7.67	10.00	8.00	3.67	3.00	3.33	7.00	4.25
	M_1T_3	6.00	5.00	5.67	8.67	6.34	3.33	2.33	3.00	6.00	3.67
	Mean	8.22	6.22	7.56	9.89	7.97	4.22	3.44	3.89	7.00	4.64
	M_2T_1	11.33	8.00	9.33	11.67	10.08	6.67	5.67	6.00	8.33	6.67
	M_2T_2	11.00	6.67	8.00	10.67	9.09	6.00	4.00	5.00	7.67	5.67
	M_2T_3	9.33	5.33	6.67	9.67	7.75	5.00	3.33	4.33	7.00	4.92
	Mean	10.55	6.67	8.00	10.67	8.97	5.89	4.33	5.11	7.67	5.75
	To	10.33	10.33	10.00	9.67	10.08	7.00	7.00	7.33	7.33	7.17
	M_1T_1	9.00	6.33	8.00	10.00	8.33	5.00	4.00	4.67	7.33	5.25
	M_1T_2	7.00	5.33	6.00	9.00	6.83	4.00	2.33	3.00	6.33	3.92
	M_1T_3	5.00	4.33	5.00	8.00	5.58	3.00	1.33	2.33	5.33	3.00
S_2	Mean	7.00	5.33	6.33	9.00	6.92	4.00	2.55	3.33	6.33	4.05
	M_2T_1	9.67	7.00	8.67	10.33	8.92	6.00	5.00	5.67	7.67	6.09
	M_2T_2	9.00	6.00	7.00	9.33	7.83	5.00	3.00	5.00	7.00	5.00
	M_2T_3	8.33	4.67	6.00	8.67	6.92	4.33	2.67	4.00	6.00	4.25
	Mean	9.00	5.89	7.22	9.44	7.89	5.11	3.56	4.89	6.89	5.11

Table 1. Continued.

	Rhizosphere	
	SEd	CD (0.05)
S	1.27	2.51
E	1.79	3.55
M	1.27	2.51
T	1.54	3.08
S × E	2.53	5.02
S × M	1.79	3.55
S × T	2.19	4.35
E × M	2.53	5.02
E × T	3.09	6.15
M × T	2.19	4.35
S × E × M	3.58	7.10
S × E × T	4.38	8.70
S × M × T	3.09	6.15
E × M × T	4.38	8.70
S × E × M × T	6.19	12.30

Table 1. Continued.

	Non-rhizosphere	
	SEd	CD (0.05)
S	0.07	0.14
E	0.09	0.19
M	0.07	0.14
T	0.08	0.17
S × E	0.14	0.27
S × M	0.09	0.19
S × T	0.11	0.24
E × M	0.14	0.27
E × T	0.17	0.33
M × T	0.12	0.24
S × E × M	0.19	0.39
S × E × T	0.24	0.47
S × M × T	0.17	0.33
E × M × T	0.24	0.47
S × E × M × T	0.34	0.67

Table 1. Continued.

	Rhizosphere				
	E_1	E_2	E_3	E_4	Mean
S_1	9.39	6.45	7.78	10.28	8.47
S_2	8.00	5.61	6.78	9.22	7.41
Mean	8.70	6.03	7.28	9.75	7.94
M_1	7.61	5.78	6.95	9.45	7.45
M_2	9.78	6.28	7.61	10.06	8.43

Table 1. Continued.

	Non-rhizosphere				
	E_1	E_2	E_3	E_4	Mean
S_1	5.06	3.89	4.50	7.34	5.20
S_2	4.56	3.06	4.11	6.61	4.58
Mean	5.06	3.89	4.50	7.34	5.20
M_1	4.11	3.00	3.61	6.67	4.35
M_2	5.50	3.95	5.00	7.28	5.43

showed higher fungal growth (8.47 CFU g-l) as compared to clay loam soil (7.41 CFU g-l) in rhizosphere soil. In case of non-rhizosphere soil similar results was found. The fungal growth was counted more in rhizosphere soil as compared to non-rhizosphere soil at the early stage (30 DAS). Some ions of heavy elements necessary for the growth of fungi, wnen added low concentrations fall within the limits of carrying fungus, but increased concentrations of ions limits of carrying fungus adversely affect the growth and reproduction, have been observed this phenomeonn when exposing fungi under study todifferent concentration of heavy metals [5]. Among all species the fyungi colonies were in E. citriodora seedling (9.75 CFU g-l) over the other species in rhizosphere soil at 30 DAS.

The data on the heavy metals viz., cadmium and lead in the fungal population of the rhizosphere and non rhizosphere sandy and clay loam soil of four eucalyptus species at 180 DAs was given in Table 2. The results showed that the fungal population in the four eucalyptus species was significantly affected due to the application of heavy metals in different concentrations in the rhizosphere and non-rhizosphere soils when compared to control. The fungal population significantly reduced due to the toxicity of different metal concentrations.

The fungal population in the rhizosphere soil of *E. terticornis, E. camaldulensis, E. globulus* and *E. citriodora* decreased under cadmium treated sandy loam soil and it was 15.22 CFU g-l, 9.22CFU g-l, 14.33 CFU g-l and 17.56 CFU g-l respectively. in lead treated sandy loam soil, it was 17.78 CFU g-l, 12.00 CFU g-l, 16.44 CFU g-l and 18.44 CFU g-l respectively. In cadmium treated clay loam soil, the fungal population in the rhizosphere soil of *E. tereticornis, E. camaldulensis, E. globulus* and *E. citriodora* was 13.33 CFU g-l, 8.67 g-l, 11.78 CFU g-l and 14.67 CFU g-l respectively and it was 14.22 CFU g-l, 9.56 CFU g-l, 123.44 CFU g-l and 15.56 g-l respectively in leadtreated clay loam soil.

The fungal population in the non-rhizosphere soil of *E. tereticornis, E. camaldulensis, E. globulus* and *E. citriodora* decreased under cadmium treated sandy loam soil it was 10.44 CFU g-l, 6.56 CFU g-l,

Table 2. Total count of fungi as influenced by cadmium and lead at 180 DAS (CFU g^{-1}).

		Fungi 180 DAS (CFU g^{-1})									
		Rhizosphere					Non-rhizosphere				
Soil type	Treatment	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean
	To	19.33	18.67	21.00	19.33	19.58	13.67	12.67	13.67	12.67	13.17
	M_1T_1	18.67	12.33	17.00	19.67	16.92	12.33	7.67	11.00	12.67	10.92
	M_1T_2	15.33	8.33	14.67	17.67	14.00	10.33	7.00	9.00	10.67	9.25
	M_1T_3	11.67	7.00	11.33	15.33	11.33	8.67	5.00	7.67	9.00	7.59
S_1	Mean	15.22	9.22	14.33	17.56	14.08	10.44	6.56	9.22	10.78	9.25
	M_2T_1	19.00	13.67	17.67	20.00	17.59	13.00	11.33	11.67	13.00	12.25
	M_2T_2	17.67	11.67	16.33	18.33	16.00	11.33	9.67	10.00	13.00	11.00
	M_2T_3	16.67	10.67	15.33	17.00	14.92	10.67	8.33	9.00	11.00	9.75
	Mean	17.78	12.00	16.44	18.44	16.17	11.67	9.78	10.22	12.33	11.00
	To	16.00	16.33	16.00	16.00	16.08	11.00	10.33	10.67	11.33	10.83
	M_1T_1	15.33	11.00	14.33	16.33	14.25	10.67	7.00	9.33	11.33	9.58
	M_1T_2	14.00	9.00	12.00	15.00	12.50	9.33	6.00	8.33	10.00	8.42
	M_1T_3	10.67	6.00	9.00	12.67	9.59	7.33	4.00	6.67	8.00	6.50
S_2	Mean	13.33	8.67	11.78	14.67	12.11	9.11	5.67	8.11	9.78	8.17
	M_2T_1	15.33	11.67	15.00	17.00	14.75	11.00	8.00	10.00	11.67	10.17
	M_2T_2	14.33	10.00	13.33	15.67	13.33	10.00	6.67	9.00	11.00	9.17
	M_2T_3	13.00	7.00	12.00	14.00	11.50	9.00	5.33	8.00	10.00	8.08
	Mean	14.22	9.56	13.44	15.56	13.19	10.00	6.67	9.00	10.89	9.14

Table 2. Continued.

Rhizosphere		
	SEd	CD (0.05)
S	0.09	0.19
E	0.14	0.28
M	0.09	0.19
T	0.12	0.24
S × E	0.19	0.39
S × M	0.14	0.27
S × T	0.17	0.34
E × M	0.19	0.39
E × T	0.24	0.48
M × T	0.17	0.34
S × E × M	0.28	0.55
S × E × T	0.34	0.68
S × M × T	0.24	0.48
E × M × T	0.34	0.68
S × E × M × T	0.48	0.96

Table 2. Continued.

Non-rhizosphere		
S	SEd	CD (0.05)
S	0.09	0.18
E	0.13	0.26
M	0.09	0.18
T	0.11	0.23
S × E	0.18	0.37
S × M	0.13	0.26
S × T	0.16	0.32
E × M	0.19	0.37
E × T	0.23	0.45
M × T	0.16	0.32
S × E × M	0.26	0.52
S × E × T	0.32	0.64
S × M × T	0.23	0.45
E × M × T	0.32	0.64
S × E × M × T	0.46	0.9

Table 2. Continued.

Rhizosphere					
	E_1	E_2	E_3	E_4	Mean
S_1	16.50	10.61	15.39	18.00	15.13
S_2	13.78	9.12	12.61	15.12	12.65
Mean	15.14	9.87	14.00	16.56	13.89
M_1	14.28	8.95	13.06	16.12	13.10
M_2	16.00	10.78	14.94	17.00	14.68

Table 2. Continued.

Non-rhizosphere					
	E_1	E_2	E_3	E_4	Mean
S_1	11.06	8.17	9.72	11.56	10.13
S_2	9.56	6.17	8.56	10.34	8.66
Mean	10.31	7.17	9.14	10.95	9.40
M_1	9.78	6.12	8.67	10.28	8.71
M_2	10.84	8.23	9.61	11.61	10.07

9.22 CFU g-l, and 10.78 CFU g-l respectively. In lead treated sandy loam soil, it was 11.67 CFU g-l, 9.78 CFU g-l, 10.22 CFU g-l and 12.33 CFU g-l respectively. In cadmium treated clay loam soil, the fungal population in the non-rhizosphere soil of *E.tereticornis, E. camaldulensis, E. globulus* and *E. citriodora* was 9.11 CFU g-l, 5.67 CFU g-l, 8.11 CFu g-l and 9.78 CFU g-l respectively and it was 10.00 CFU g-l, 6.67 CFU g-l, 9.00 CFU g-l and 10.89 CFU g-l respectively in lead treated clay loam soil.

Similarly at 180 DAS, the fungal growth was found to be higher in sandy loam soil (15.13 CFU g-l) compared to clay loam (12.65 CFU g-l) rhizosphere soil. In non-rhizospheric soil. In non-rhizosphere soil, the fungal colonies were less as compare to rhizosphere (10.13 CFU g-l) in sandy loam soil and (8.66 CFU g-l) in clay loam soil. The fungi must be able to sequester essential trace metal ions from various sources, where the metals can be present in concentrations ranging from trace to toxic levels. Theconcentration of heavy metal ions in their main source, wood, is usually low. in beech (*Fagus syvatica*), Cd and Pb concentrations are usually below 1 ppm, Zn concentrationcan reach tens of parts per million[6]. At 180 DAS, the fungal population was increased in *E. citriodora* 916.56 CFU g-l) over the other *Eucalyptus* spp.

References

1. Igwe J C, Nnorom IC, gbaruk BCG (2005) Kinetics of radionu clides and heavy metals behavior in soils, Implications for plant growth afri J Biotech 4 : 1541—1547.
2. Anahida S, Yaghmaeia S, Ghobadinejadb Z, (2011) Heavy metal tolerance of fungi. scientia Iranica 18 : 502—508.
3. Pennanen T, Frosetgard A, Fritze H, Baath E (1996) Phspholipid fatty acid composition and heavy metal toler

ance of soil microbial communities along two heavy metal polluted gradients in coniferous forests. Appl Environ Microbio 62 : 420—428.

4. Zuniga-Silva J R, Wilberth CC, Octavio L, Aguilar-Lopez R, Xoconostle-Cazares B, vazquez RR (2015) In vitro toxic effects of heavy metals on fungal growth and phosphate solubilising abilities of isolates obtained from phragmites australis rhizosphere. J Chem and Ecol 32 : 49—67.
5. Baldrian P (2003) Interactions of heavy metals with white-rot fungi. Enzyme and Microbial Technol 32 : 78—91.
6. Najwa M, Jameel A, Mejdad A (2013) Response of some fungal species to the effect of copper, magnesium and zinc under the laboratory condition. European J Exptl Bio 3 : 535—540.