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Research article

Effect of fungal inoculants on growth and establishment of *Gmelina arborea* Roxb. in transplantation conditions

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Abstract: To evaluate the effect of fungal inoculants, a pot experiment was carried out on 30 days old transplanted seedlings of *Gmelina arborea* under nursery condition. Transplants were inoculated with seven day old liquid culture of *Aspergillus ellipticus*, *Fusarium incarnatum*, *Aspergillus aculeatus*, *Aspergillus candidus*, *Penicillium species*, *Alternaria alternata*, *Penicillium species*, *Fusarium javanicum*, *Penicillium cyclopium*, *Aspergillus flavus* separately. Growth of plants were measured in terms of plant height, leaf no, leaf size, biomass, NAR, RGR, LAR after 120 days. Data recorded on growth performance of *Gmelina arborea* plant exhibited the positive impact of fungal inoculation especially in case of *Fusarium incarnatum*, *Penicillium species*, *Penicillium cyclopium* and *Aspergillus flavus* over un-inoculated control. Successful establishment after transplantation and improvement in growth over control has been demonstrated well when plants were treated with *Aspergillus flavus*.

Keywords: *Gmelina arborea* - Phosphate solublization - Transplantation - Growth.

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INTRODUCTION

Filamentous fungi are widely used as production of organic acid and are capable of solubilising the insoluble form of phosphate, make them available to the plant root system indirectly (Manoharachary *et al.* 2005, Richa *et al.* 2007, Pandey *et al.* 2008, Yadav *et al.* 2011). It is important to note that sufficient and balanced quantities of nutrients needed for optimal growth of plants. Most of the nutritional contents in soil are present in bonded form and released only through biological and/or chemical activity. In such circumstances supplementation of chemical fertilizers is the only alternative to enrich the soil. But organic fertilizers are not the long term nutrient supplier (Pascual *et al.* 1997, Patil *et al.* 2002, Mehrvarz & Chaichi 2008, Reis *et al.* 2008). In such cases, bioinoculation of mineral solubilisers have shown a vital role in growth and development of plants especially forest tree species (Pascual *et al.* 1997, Sahgal *et al.* 2004, Thatoi *et al.* 2005). The development of proper soil mixture for use in the nursery may be the cost effective process to attain better growth and production of tree species (Dash *et al.* 2013). Many such uses of biofertilizer for the production of quality planting material of forest trees are well reported (Barua *et al.* 2010, Dhar & Mridha 2012). *Gmelina arborea* Roxb. is a large, tropical, evergreen perennial tree, an important medicinal plant and preferred in afforestation programs because of its unique timber (Orwa *et al.* 2009). It is reported that in poor soil, plantation of the tree may suffer from nutrient disorder (Sturmann *et al.* 1994). The importance of fungal inoculation in *Gmelina arborea* under heavy metal stress condition has also been reported (Barua *et al.* 2010). Under nutrient depletion condition, the inoculation of mineral solubilising fungi play a vital role in growth and establishment of forest tree seedlings. In view, an experiment under nursery condition has been carried out along with fungal inoculation in transplanted seedlings of *G. arborea* and growth performance was evaluated.

MATERIALS AND METHODS

The pot experiment was carried out in poly bags (size: 12×16 cm containing 5.5 kg red laterite soil) received average 35±2ºC temperature & 60–80 % relative humidity. The soil contains a high amount of iron, manganese

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and copper. Textural class of the soil was loamy sand the soil pH was 5.61. Average nitrogen (N), average phosphate (P_2O_5) and average potassium (K_2O) of the soil was 232.0 kg.Ha^{-1}, 25.2 kg.Ha^{-1} and 99.12 kg.Ha^{-1} respectively. The soil was fumigated with 1% formalin (25 ml per pot) for 48 hrs prior to the experiment.

The seeds were collected from native plant and were treated with organic manure water for 72 hrs to depulp. After drying at room temperature, seeds were sown in experimental poly bags 1 inch below the upper surface. The seedlings were transplanted after 30 days from DAS (days of sowing) to other polypots of the similar capacity and filled with the same type of soil. Seven days after the transplantation, 25 ml of 7 days old fungal culture (prepared in Czapek dox medium pH 4.5) of 10 different fungi were added separately in 20 replications to the polybags contain *Gmelina arborea* Roxb. seedlings. Fungal inoculations were repeated thrice in one month's interval of the experiment duration of 120 days. Observations after 4 months from DAS (date of sowing) were recorded for shoot height, a number of leaves, leaflets, branches, the fresh and dry biomass of leaves and stem (Leopold & Kriedemann 1975). The data were evaluated for RGR (Relative growth rate), NAR (Net Assimilation Rate) and LAR (Leaf area ratio) and quality index (Dickson *et al*. 1960, Basak *et al*. 2004, Tewari *et al*. 2006).

RESULT AND DISCUSSION

Fungal inoculation exhibited the improved shoot height as compare to uninoculated control. *Penicillium species* and *Aspergillus flavus* both fungi had shown enhancement in shoot and root as well (Table 1). Treated and transplanted plants had developed 3–4 branches under fungal inoculation of *Fusarium javanicum*, *Penicillium cyclopium* and *Fusarium incarnatum*. The highest no of leaves were found in plants treated with *Fusarium incarnatum* followed by *Aspergillus aculeatus*, *Penicillium* species and *Fusarium javanicum*. Only these fungal inoculations *i.e. Penicillium species*, *Penicillium cyclopium*, *Aspergillus flavus* have shown the highest no of leaf area as compared to uninoculated control.

Table 1. Growth performance of *Gmelina arborea* at transplantation stage and inoculated condition.

Treatments	Growth Parameters								
	Shoot Height (cm)	Root Length (cm)	No. of Branch	No. of Leaves	Leaf Area (mm^2)	Initial Biomass (g)		Dry Biomass (g)	
						Shoot	Root	Shoot	Root
Control	58.8±4.1	22.2±3.2	2±1.0	35.1±8.6	8296.4±800.5	32.1±7.7	17.7±5.6	15.3±4.3	9.1±2.2
Aspergillus ellipticus	52.0±8.6	25.2±3.9	2±0.5	30.5±13.6	6124.0±1067.4	20.3±3.9	19.9±3.3	13.4±3.5	11.3±3.4
Fusarium incarnatum	63.0±8.1	27.2±2.9	3±1.4	55.0±11.2	7425.0±828.9	50.9±5.2	39.4±13.3	22.7±7.3	17.0±6.7
Aspergillus aculeatus	57.2±6.7	22.2±3.9	2±1.4	46.8±7.1	8107.0±882.6	31.8±17.2	26.7±9.7	17.6±3.2	11.9±3.4
Aspergillus candidus	61.3±7.7	26.3±6.6	2±1.7	41.3±13.0	5727.4±80.7	43.8±13.1	25.2±8.6	20.0±5.0	12.7±3.8
Penicillium species	70.7±14.3	27.5±4.2	2±1.6	52.3±8.6	11995.8±1321.9	50.7±6.9	49.7±11.0	21.6±5.5	20.2±6.5
Alternaria alternata	46.5±10.8	29.8±4.7	1±1.3	32.2±11.9	4255.8±70.8	22.0±5.1	17.2±4.4	10.9±3.2	7.0±1.5
Penicillium species	54.7±6.2	31.2±2.9	2±0.6	42.5±11.5	4469.4±185.7	33.2±10.1	32.2±9.3	15.0±5.0	12.4±4.6
Fusarium javanicum	52.2±1.1	33.2±3.1	4±1.5	48.8±4.8	4714.8±96.7	37.1±8.0	30.3±3.8	19.3±2.4	15.2±2.3
Penicillium cyclopium	63.0±3.7	25.3±2.8	3±1.0	42.2±10.1	15982.6±699.0	43.8±4.5	33.9±7.9	19.3±3.7	13.9±1.7
Aspergillus flavus	75.7±12.5	28.7±2.4	2±0.8	36.2±7.6	14228.0±923.0	59.1±6.0	38.0±6.2	23.8±4.3	16.9±1.4

Note: RGR= Relative Growth Rate; QI= Quality Index; NAR= Net Assimilation Rate; RSR= Root Shoot Ratio; LAR= Leaf Area Ratio.

In general, biomass in seedlings was higher under inoculated conditions as compared to control. Seedlings exhibited maximum biomass production when inoculated with fungal strains *Fusarium incarnatum*, *Penicillium species*, *Penicillium cyclopium*, *Aspergillus flavus*. Mean Biomass (fresh and Dry) measured after four months indicated the maximum increment in growth of plants inoculated with this fungi. It is apparent that, in the term of biomass, the seedlings inoculated with different fungi showed a higher production and superiority over control. *Fusarium incarnatum*, *Penicillium species*, *Penicillium cyclopium*, *Aspergillus flavus* inoculated plants attained maximum biomass with respect to control. Except for *Aspergillus ellipticus*, almost all other inoculants resulted increased in biomass in comparison to control. Relative growth rate (RGR) was also changed due to the enhancement in dry biomass, stem height and leaf area in transplanted conditions (Table 2). However, transplanted seedlings of *Fusarium incarnatum*, *Penicillium species, and Aspergillus flavus* showed higher RGR as well as Net assimilation rate. Growth analysis revealed that NAR (net assimilation rate), and LAR (leaf area ratio) accounted for the differences in RGR (relative growth rate) in the treatments. Data recorded for the quality index of *Gmelina arborea* Roxb. grown with selected fungal isolates in non transplanted and transplanted conditions showed better quality and comparatively more growth than the un-inoculated control. Application of

selected fungal cultures resulted in an increase of biomass as compared to control, which leads to the successful establishment of *Gmelina arborea*.

Table 2. Physiological growth performance of *Gmelina arborea* under transplanted and inoculated condition.

Treatments	Wet RGR (d^{-1})	Dry RGR (d^{-1})	NAR ($g.m^{-2}.d^{-1}$)	LAR ($m^2.g^{-1}$)	QI	RSR
Control	0.161	0.107	0.30	0.657	0.402	0.377
Aspergillus ellipticus	0.030	0.085	0.06	0.609	0.465	0.485
Fusarium incarnatum	0.370	0.189	0.37	0.455	0.617	0.432
Aspergillus aculeatus	0.158	0.133	0.35	0.583	0.504	0.388
Aspergillus candidus	0.291	0.160	0.04	0.436	0.520	0.429
Penicillium species	0.368	0.177	1.15	0.640	0.587	0.392
Alternaria alternata	0.049	0.058	0.07	0.587	0.371	0.641
Penicillium species	0.174	0.104	0.10	0.480	0.491	0.571
Fusarium javanicum	0.217	0.151	0.11	0.409	0.644	0.636
Penicillium cyclopium	0.291	0.151	1.59	0.860	0.514	0.402
Aspergillus flavus	0.461	0.202	1.77	0.667	0.530	0.379

Note: RGR= Relative Growth Rate; QI= Quality Index; NAR= Net Assimilation Rate; RSR= Root Shoot Ratio; LAR= Leaf Area Ratio.

Application of liquid inoculants to seedlings was better than seed inoculation. It is recommended that seedlings raised in the nursery should be inoculated with liquid inoculants immediately or soon after germination (Odee *et al.* 2002). Organic and inorganic fertilizers are not only supply limited amount of nutrients to the plants but also needed in huge quantity. As *Gmelina arborea* is a forest grown plant, regular organic manure supplement is not possible. So it is an ideal choice to develop microbial consortia which help the plant root system to grow and absorb nutrients. It also improves the physiochemical and biological properties of soil. It has been reported that *Gmelina arborea* has weak establishment property but once it establishes in an environment, it grows quickly (Lamb 1968). In this regard, the supplementation of fungal cultures having phosphate solubilising potential to the transplanted seedlings may be the better option to overcome the transplantation and establishment problems. This process can also be applied to another forestry plant, those who has weak establishment property.

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