नागालैण्ड विश्वविद्यालय
NAGALAND UNIVERSITY

(संसद द्वारा पारित अधिनियम 1989, क्रमांक 35 के अंतर्गत स्थापित केन्द्रीय विश्वविद्यालय)
(A Central University Established by the Act of Parliament No.35 of 1989)

मुख्यालय : लुमामी, जिला : जुन्हेबोटो (नागालैण्ड), पिन कोड - 798 627

Headquarters: Lumami, District: Zunheboto (Nagaland), Pin Code - 798 627

No. NU/PF/P-44/12 - 8124

Dated: 04.04.2019

To

The Under Secretary (FD-III)
University Grants Commission
Bahadurshah Zafar Marg
New Delhi – 110 002

Sub: **Forwarding of Utilization Certificate, Mandate Form, HRA Certificate and details of field work certificate**

Madam,

With reference to the subject cited above, I am directed to forward herewith duly signed Utilization Certificate, mandate Form, HRA Certificate and details of field work certificate of the project entitled "Isolation, identification and characterization of Ectomycorrhizal fungi and their application in forestry" of Dr. Talijungla, PI, Department of Botany, Nagaland University, Lumami.

This is for your kind information and necessary action.

Yours faithfully,

Encl: As stated

(Utpal Duwarah)
Assistant Registrar (RDC)

No. NU/PF/P-44/12 -

Dated: 04.04.2019

Copy to:

1. The Finance Officer, Nagaland University, Lumami for kind information
2. The Head, Department of Botany, Nagaland University, Lumami for kind information
3. Dr. Talijungla, PI, Department of Botany, Nagaland University, Lumami for information
4. Office file

5/4/19
Assistant Registrar (RDC)

Annexure - III

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR RESEARCH PROJECT

1. Name of Principal Investigator : Dr. Talijungla

2. Deptt. of Principal Investigator : Botany

   University/College : Nagaland University

3. UGC approval Letter No. and Date: No. F 41-437/2012 (SR) Dated July, 2012

4. Title of the Research Project: Isolation, identification. Characterization of ectomycorrhizae and its application in forestry.

5. Effective date of starting the project : August 01, 2012

6. a. Period of Expenditure: From 01.07.2012 to 01.06.2015

b. Details of Expenditure from 01.07.2012 to 01.06.2015

S.No.	Item	Amount Approved (Rs.)	Amount released (Rs.)	Expenditure Incurred (from 01.07.2012 to 01.06.2015) (Rs.)	Bank interest earned in three years (Rs.)	Grant to be released
i. Books & Journals		Nil	Nil	Nil		Nil
ii. Equipment	Equipments 1.Horizontal Laminar Flow Cabinet (IK137), 2. BOD Incubator (BDI-55)	1,50,000.00	1,50,000.00	1,49,934		Nil
iii. Contingency	Stationeries, lab wares, tools etc.	30,000.00	27,000.00	30,058.00		3058.00
iv. Field Work/Travel (Give details in the proforma at Annexure- IV).	Details given in Annex. IV)	30,000.00	27,000.00	30,138.00		3158.00
v. Hiring Services		Nil		Nil		nil
vi. Chemicals & Glassware		40,000.00	36,000.00	39,996.00		3,996.00
vii. Overhead	Computer HP core i5	59,800.00	59,800.00	59,800.00		Nil
viii. Any other items (Please specify) **Bank interest earned in three years**					**8298.00**	
Total		**3,09,800.00**	**2,99,800.00**	**3,09,926.00**	**8298.00**	**12,196.00**

c . Staff

Date of Appointment August 01. 2012.

S.No.	Item	From	To	Amount Approved (Rs.)	Amount released (Rs.)	Expenditure Incurred (Rs.)	Grant to be released
1.	Honorarium to PI (Retired Teachers) @ Rs. 18,000/- p.m.	Nil	Nil	Nil		Nil	Nil
2.	Project fellow: i) NET/GATE qualified- Rs. 16,000/- p.m. for initial 2 years and Rs. 18,000/- p.m. for the third year. ii) Non-GATE/Non -NET- Rs. 14,000/- p.m. for initial 2 years and Rs. 16,000/- p.m. for the third year.	August 01, 2012	March 31, 2015	**5,28,00.00**	**4,51,509.00**	**4,64,000.00**	**12,491.00**
Total b & c					**7,51,309.00**	**7,73,926**	**24687**

1. It is certified that the appointment(s) have been made in accordance with the terms and conditions laid down by the Commission.

2. If as a result of check or audit objection some irregularly is noticed at later date, action will be taken to refund, adjust or regularize the objected amounts.

3. Payment @ revised rates shall be made with arrears on the availability of additional funds.

It is certified that the grant of **Rs. _7,51,309.00 (Rupees Seven lakh fifty one thousand three hundred and nine only)** received from the University Grants Commission out of which the total expenditure incurred was **Rs. 7,73,926 (Rupees Seven lakh seventy three thousand nine hundred twenty six only)** under the scheme of support for Major Research Project entitled **"Isolation, identification and characterization of ectomycorrhizae and their application in forestry"** vide UGC letter **No. F. 41-437/2012 (SR) dated July 16, 2012**.has been fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.

- **Total amount to be released by UGC- Rs. 24,468.00**
- **Interest amount earned in three years Rs. 8298.00**

SIGNATURE OF PRINCIPAL INVESTIGATOR

P.I. UGC Project
Nagaland University
Lumami

02.04.19

REGISTRAR/PRINCIPAL

(Seal)

कुलसचिव / Registrar
नागालैण्ड विश्वविद्यालय / Nagaland University
लुमामी / Lumami- 798 627

SIGNATURE OF THE CO-INVESTIGATOR

Annexure - V

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

Utilization certificate

Certified that the grant of Rs. 7,51,309.00 (Rupees Seven lakh fifty one thousand three hundred and nine only) received from the University Grants Commission out of which the total expenditure incurred was **Rs. 7,73,926 (Rupees Seven lakh seventy three thousand nine hundred twenty six only) under the scheme of support for Major Research Project entitled "Isolation, identification and characterization of ectomycorrhizae and their application in forestry" vide UGC letter No. F. 41-437/2012 (SR) dated July 16, 2012 has been fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.**

- **Total amount to be released by UGC- Rs. 24,468.00**
- **Interest amount earned in three years Rs. 8298.00**

02.4.19

SIGNATURE OF THE PRINCIPAL INVESTIGATOR	**REGISTRAR/PRINCIPAL**	**STATUTORY AUDITOR**
P.I. UGC Project Nagaland University Lumami	**(Seal)** कुलसचिव / Registrar नागालैण्ड विश्वविद्यालय / Nagaland University लुमामी / Lumami- 798 627	**(Seal)** वित्त अधिकारी / Finance Officer I/c नागालैण्ड विश्वविद्यालय / Nagaland University लुमामी / Lumami- 798 627

Annexure – X

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

MAJOR RESEARCH PROJECT COPY OF THE SPECIMEN OF HOUSE RENT FOR POST-DOCTORAL FELLOW / PROJECT ASSOCIATE / PROJECT FELLOW

Certified that Shri/Dr.____________________ is paying House Rent of Rs. ______________ and is eligible to draw House Rent Allowances @ ______________ as per University Rules.

Registrar/Principal
(Signature with Seal)

Certified that Shri/Dr. ____________________ is not staying independently and therefore is eligible to draw House Rent @ of Rs. __________ p.m. minimum admissible to a Lecturer as per University Rules.

Registrar/Principal
(Signature with Seal)

Certified that Shri/Dr. Smt. S. Arenla has been provided accommodation in the Hostel. But he/she could not be provided with single seated flat type accommodation as recommended by the Commission, Hostel fee @ Rs. 416.66 per month w.e.f. 1.7.2012 – 31.3.15 is being charged from him/her.

02.4.19

Registrar/Principal
(Signature with Seal)

कुलसचिव / Registrar
नागालैण्ड विश्वविद्यालय / Nagaland University
लुमामी / Lumami- 798 627

Annexure-IV

UNIVERSITY GRANT COMMISSION

BAHADUR SHAH ZAFAR MARG

NEW DELHI-110 002

STATEMENT OF EXPENDITURE INCURRED ON FIELD WORK

Name of the Principal Investigator: Dr. Talijungla

Name of the Place visited	Duration of the visit		Mode of Journey	Expenditure Incurred (Rs.)
	From	To		
1. Primary reserved forests of Zunheboto, Mokokchung and Tuensang districts of Nagaland for collection ectomycorrhizal forming fungi. 2. Tuli area for collection of *Dipterocarpus* seedlings	01.07.2012	30.06.2015	By hired taxi (as the field collection was performed on remote areas where public transport was not available).	30,138.00

Certified that the above expenditure is in accordance with the UGC norms for Major Research Projects.

SIGNATURE OF PRINCIPAL INVESTIGATOR

P.I. UGC Project
Nagaland University
Lumami

REGISTRAR/PRINCIPAL

(Seal) कुलसचिव / Registrar
नागालैण्ड विश्वविद्यालय / Nagaland University
लुमामी / Lumami- 798 627

SIGNATURE OF THE CO-INVESTIGATOR

SIGNATURE OF THE GOVERNMENT AUDITOR/CHARTERED ACCOUNTANT

/ Finance Officer
नागालैण्ड विश्वविद्यालय / Nagaland University
लुमामी / Lumami- 798 627

Scanned with CamScanner

Potassium content of rhizospheric soil and seedlings root of *Dipterocapus retusus*

Seedlings root of *R. rosea* inoculated was found higher content of potassium (122.6mg/100g) but rhizospheric soil of *S. citrinum* inoculated found higher content of soil potassium (44.5mg/100g) as compared to *R. rosea* inoculated and control seedlings. There was not much variation was found between the available potassium content of *R. rosea* and *S. citrinum* inoculated seedlings rhizospheric soil (Table 25).

Potassium content of rhizospheric soil and seedlings root of *Corymbia citriodora*

Seedlings root and rhizospheric soil of *R. rosea* inoculated was found higher content of potassium (Table 26).

Potassium content of rhizospheric soil and seedlings root of *Cryptomeria japonica*

Seedlings root of *S. citrinum* inoculated was found higher content of potassium (136.6mg/100g). *R. rosea* inoculated seedlings root showed higher potassium content (41.1mg/100g). However, there was not much variation on average mean value between both the fungal inoculated seedlings root and rhizospheric soil of potassium content (Table 27).

***Dipterocarpus retusus* seedlings growth**

Seedlings growth viz. shoot height, leaf length, root length and root collar diameter at the interval of every 4th month showed variation and significantly better growth of both the ECM inoculated seedlings as compared to control seedlings. At the 24th month the growth *R. rosea* inoculated seedlings (SH=90.6cm) showed better growth than the *S. citrinum* inoculated seedlings (Table 28).

***Corymbia citriodora* seedlings growth**

Seedlings growth for 2 years such as shoot height, leaf length, roots length and root collar diameter showed significantly better growth of both the fungal inoculated treatment. *R. rosea* inoculated seedlings growth was found successively better growth till the 24th month. Significant means difference was between the ECM colonization at different month and seedlings growth (Table 29).

Attachment 1

11. Brief objectives of the project:

The main objective of the study is to conduct a survey of native strains of ectomycorrhizal fungi, their functioning in the ecosystem and the effect of forest management. For this periodic collections was made from the forest parts of Lumami, Nagaland and all collections was studied systematically, identified and characterized.

1. Isolated and maintained ectomycorrhizae using pure culture technique.
2. Isolated ectomycorrhizae were inocukated to the seedlings and study the ectomycorrhizal colonization in field condition
3. Growth of the seedlings was monitored periodically and analyzed nutrients (NPK) in soil and in seedlings roots.
4. Soil pH, soil organic carbon and moisture content on the soil were determined.
5. Metabolic activity of the rhizospheric soil and root of seedlings was studied.

Methodology:

1. Isolation of ectomycorrhizal fungi from the sporocarp using MMN agar medium (Marx, 1969).
2. Inoculation of this culture near the seedlings roots.
3. Establishment, growth and survival of the ectomycorrhizal seedlings will be evaluated by studying different parameters every four months.
4. Determination of soil pH using digital pH meter following the method of Allen *et al.*, (1974).
5. Seasonal determination of Soil moisture content by gravimetric method.
6. To evaluate the percentage of ectomycorrhizal colonization every four month as outlined by Sharma (1981).
7. To determined the carbon content in the soil by Wet digestion method (Walkey and Black, 1934).
8. Analysis of nitrogen content by Kjeldahl's distillation method (Mishra, 1968).
9. Estimation of phosphorus and potassium content.
10. Estimation of urease enzyme of soil and root of seedlings by Mc Garity and Meyers method (1967).

12. Whether objectives were achieved (Give details): Yes

(a) Field work done

The sporocarps of the fungus were collected and isolated. The degraded land sites were selected and weeds were cleared prior to plantation. Three economically important plants such as *Cryptomeria japonica* (thumb.ex.L.f) D. Don., *Dipterocarpus retusus* Blume and *Corymbia citriodora* (Hook) K. D. Hill and L.A.S. Johnson which form ectomycorrhizal associations were selected. Seedlings were then transplanted in the field and allowed to establish for 1 month. The seedlings were then inoculated with *Russula rosea* and *Scleroderma citrinum* and studied their association with the seedlings root. 20 seedlings were maintained for each fungus and 20 control seedlings were also maintained without the inoculation of fungi. The growth parameters of the seedlings such as shoot height, root length, root collar diameter and leaf/ needle length was measured every 4^{th} month. Growth of the seedlings has observed for two years. Soil samples were collected for soil analysis.

(b) Laboratory work done

The ectomycorrhiza colonized roots of the seedlings were collected from the field and identified based on their morphology. Ectomycorrhizal roots showed dichotomous branching types of roots. Rhizospheric soil moisture and soil pH was determined for different seasons for two years. Soil organic carbon was analyzed of different seasons for two years. Ectomycorrhizal colonization percentage of the inoculated seedlings with two ectomycorrhizal fungi and control seedlings was calculated at the interval of 4^{th} month till 24^{th} month. Seedlings roots and rhizospheric soil urease activity was determine for summer, autumn, winter and spring season. Nutrient analyses of seedlings root and rhizospheric soil was analyzed i.e. nitrogen, phosphorus and potassium.

13. Achievements from the project:

Seedlings of *Cryptomeria japonica*, *Corymbia citriodora* and *Dipterocarpus retusus* were planted in barren field. Ectomycorrhizal fungi *Russula rosea* and *Scleroderma citrinum* isolated and cultured were submitted to Nagaland University. Seedlings growth of ectomycorrhizal inoculated showed better growth than the control seedlings. Inoculation of native ectomycorrhiza fungi in exotic seedlings were found beneficial in survival of seedlings. Ectomycorrhizal technology in forest nursery plantation is the cheapest method for the productivity in afforestation programmes. Selection of effective mycorrhizae is essential to enhance growth and in nutrient uptake.

14. Summary of the findings

Ectomycorrhizal fungi are important component of terrestrial ecosystem. They receive a net primary productivity of plant photosynthesis, in return help in uptake of nutrient from soil and helps in plant survivability and growth. In the present study seedlings of *Dipterocarpus retusus*, *Cryptomeria japonica* and *Corymbia citridora* were inoculated with two indigenous fungi *Russula rosea* and *Scleroderma citrinum* (2.2×10^5 and 2.7×10^5 spores/ ml). Colonization of the inoculated ectomycorrhiza in all the three seedlings showed variation in their degree of colonization at different months. Ectomycorrhizal formation on the inoculated seedlings was observed only after 6th month of inoculation. Colonization level of inoculated ectomycorrhiza and their activity was found higher during the autumn and summer season i.e. between May-October. Control season was colonized by the ectomycorrhiza because the experiment was conducted in unsterile substrate the soil borne fungus might colonized the seedlings root. *R. rosea* colonization percentage was found higher at different months than *S. citrinum*.

Soil pH was found lower during summer season. Decreasing in pH level of rhizospheric soil was found to increase in the colonization of the fungus in the inoculated seedlings. pH level between 4.7-5.5 was found to be favourable for the colonization and increasing in fungal activity. Increase in moisture level of rhizospheric soil was found to increase in colonization of ectomycorrhiza, during winter season and dry period (December-March) colonization percentage of ectomycorrhiza was found low. Ectomycorrhiza was also found to be sink of carbon and helps in sequestration of carbon in the soil. Seedlings inoculated with ectomycorrhiza showed higher content of rhizospheric soil organic. Increase in ectomycorrhizal colonization was found in relation with increase in carbon demand

and sequestration carbon in soil. Carbon enters into the soil through fine roots of plant, through fungal mycelia or saprotrophic organism. In the present study increase in *R. rosea* colonization was found to increase in carbon content of rhizospheric soil. Seasonal variation did not showed much affect on soil organic carbon content. This could be due to, during dry season when the photosynthate activity of host plant is low ectomycorrhizal fungi live as saprotrophs depending on the resource available in soil.

Seedlings growth of the inoculated showed better growth of shoot height, root length as compared to control seedlings. In *D. retusus* and *C. citriodora* seedlings, *R. rosea* inoculated showed better growth till 24th month as compared to *S. citrinum* and control seedlings. But in *C. japonica* seedlings growth of *S. citrinum* inoculated showed better growth. This could due to host specificity which showed variation on effect of seedlings growth of different host with different fungus.

Urease activity was found to affect by seasonal variation. During summer and autumn season urease activity in both rhizospheric soil and seedlings root was showed higher in all three seedlings. Urease activity of rhizospheric soil and seedlings root tips did not showed much variation, this shows that ectomycorrhizal fungi contribute a labile amount of enzyme in soil and helps in decomposition of organic matter. Both the fungal inoculated treatment showed variation in urease activity at different season. Thus, ectomycorrhizal activity in soil affect in urease activity. Considerable amount of nitrogen, potassium and phosphorus was found in seedlings roots. Uptake of nitrogen from soil and content of total nitrogen in seedlings root tips was showed better of *S. citrinum* inoculated seedlings. Available phosphorus of seedlings root tips was showed better content of *S. citrinum* inoculated but rhizospheric soil phosphorus content did not showed much variation between inoculated treatment and control seedlings.

Artificial inoculation of ectomycorrhiza to the seedlings helps in establishment and restoration of forest. In the present study *R. rosea* was found to be effective fungi in all the seedlings growth. Ectomycorrhizal species varies in their activity with different host plant. Ability of ectomycorrhizal fungi varies in nutrient uptake, *S. citrinum* was found to be effective fungi in nutrient uptake at the present study field.

15. Contribution to the society (Give details): Artificial inoculation of ectomycorrhiza to the seedlings root planted in the barren field was found to benefit in seedlings survival, growth and also in forest reclamation practices. 200 seedlings viz. *Cryptomeria japonica*, *Corymbia citriodora* and *Dipterocarpus retusus* were planted in the present study area. Economically important seedlings *D. retusus* which mostly found in low plain areas, was should better survival and growth even at the higher altitude at the present study area. Reconition, utilization and management of mycorrhizae are very necessary for the skilful production of resilent planting stock. Ectomycorrhizal application in reforestation and agroforestry practices should be adapted without using chemical fertilizers.

17. Details of publication resulting from the project work (please attach reprints) letter of acceptance of paper communicated:

a. Published research paper, 'Effect of soil moisture and soil pH of ectomycorrhizal colonization on *Dipterocarpus retusus* Blume seedlings', *Int. Jour. of Life Sci., Biotech and Pharma research*, 3(2):102-107

b. Published research paper, 'Influence of soil organic carbon on ectomycorrhizal colonization of *Cryptomeria japonica* (Thunb. Ex. L.f.) D. Don., *Int. Jou. Recent Biotech.*, 2(2): 40-45.

c. Published research paper, "Role of soil moisture in ectomycorrhizae formation and growth of Eucalyptus [*Corymbia citriodora* (Hook.) K. D. Hill and L. A. S. Johnson] seedlings", The Fazl Ali College Journal, 65-71.

d. Titled "Impact of carbohydrate in ectomycorrhizal colonization and establishment of *Dipterocarpus retusus* Blume seedlings" (Under communication).

Seminar and conference paper presented:

a. Poster presentation at the National Conference on Plant Biology 'Plant, People and Planet', Dept. Of Bot., Bangalore University, Sep. 24-27, 2013.

b. Presented paper at the National Symposium on "Unravelling Plant Microbe Interaction for Supporting Plant Health" & Annual General Meeting of Indian Society of Mycology and Plant Pathology (East Zone), 2014, Dept. of Bot., Gauhati University, Oct. 27-28, 2014.

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UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG, NEW DELHI- 110 002.

Consolidated Statement of Expenditure for the period 2012 to 2015 in the Department of Botany, Nagaland University under UGC MRP. Sanctioned letter NO F 41-437/2012 (SR) Dated July 16,, 2012

Items of Expenditure	Total grant approved by the UGC (Rs. In lakhs)	Total grant released by the UGC so far	Actual Expenditure Incurred			Total Expenditure Incurred	Grant to be released by UGC
			Year 1	year 2	year 3		
A. Non-Recurring							
1. Equipments Horizontal Laminar Flow Cabinet (IK137), BOD incubator (BDI-55)	**1,50,000**	**1,50,000**	**1,50,000**	**nil**	**nil**	1,49,934	nil
Total of Non-Recurring							
Recurring							
1.Project Fellow	5,28,000	4,51,509	2,64,000	1,87,509	nil	4,64,000	76,491
2.Travel/field work	30,000	27,000	15,000	12,000	nil	30,138	3000
3.Chemicals & Glasswares	40,000	36,000	20,000	16,000	nil	39,996	4000
4..Contingency	30,000	27,000	15,000	12,000	nil	30,058	3000
5.Overhead charges	59,800	59,800				59,800	nil
Total	**8,37,800**	**7,51,309**	**314000**	**227509**		**773926**	**86,491***

*An amount of **Rs 86,491.00** (Rupees eighty six thousand four hundred ninety one only) is yet to be released by UGC as per the UGC sanctioned letter **No.F 41-437/2012 (SR) Dated July 16,, 2012 & No.F 41-437/2012 (SR) Dated November 25,, 2014**

Details of Expenditure Statement of Project Fellow salary

Sl No.	**Months**	**Amount/month (Rs.)**	**Total Amount (Rs.)**
1	August, 2012-July, 2013	14,000 (JRF)	1,68,000
2	August, 2013- July, 2014	14,000 (JRF)	1,68,000
3	August, 2014- March, 2015	16,000 (SRF)	1,28,000
Total Amount of expenditures			**4,64,000**

26.4.16

Principal Investigator

P.I. UGC Project
Nagaland University
Lumami

Registrar/Principal

कुलसचिव / Registrar
नागालैण्ड विश्वविद्यालय
Nagaland University
लुमामी / Lumami - 798627

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Final Project Report of the Work Done

on

"Isolation, Identification and Characterization of Ectomycorrhizal and its Application in Forestry"

Under UGC-MRP in the Department of Botany

Achievements of work in details

Result:

Fig 1: Basidiocarp of a) *Scleroderma citrinum* b) *Russula rosea*

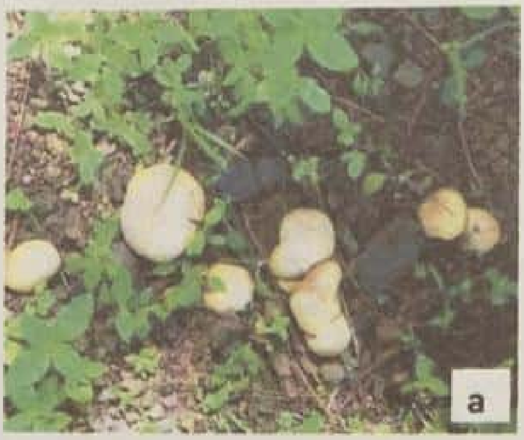

Fig 2.1 Culture of Scleroderma citrinum in MMN

Fig 2.2: Culture of *Russula rosea* in MMN

Figure 3: ***Crptomeria japonica*** **growth in field a) 2 year b) 12th month c) 4th month**

Figure 4: ***Corymbia citriodora*** **growth in field a) 2 year b) 12th month c) 4th month**

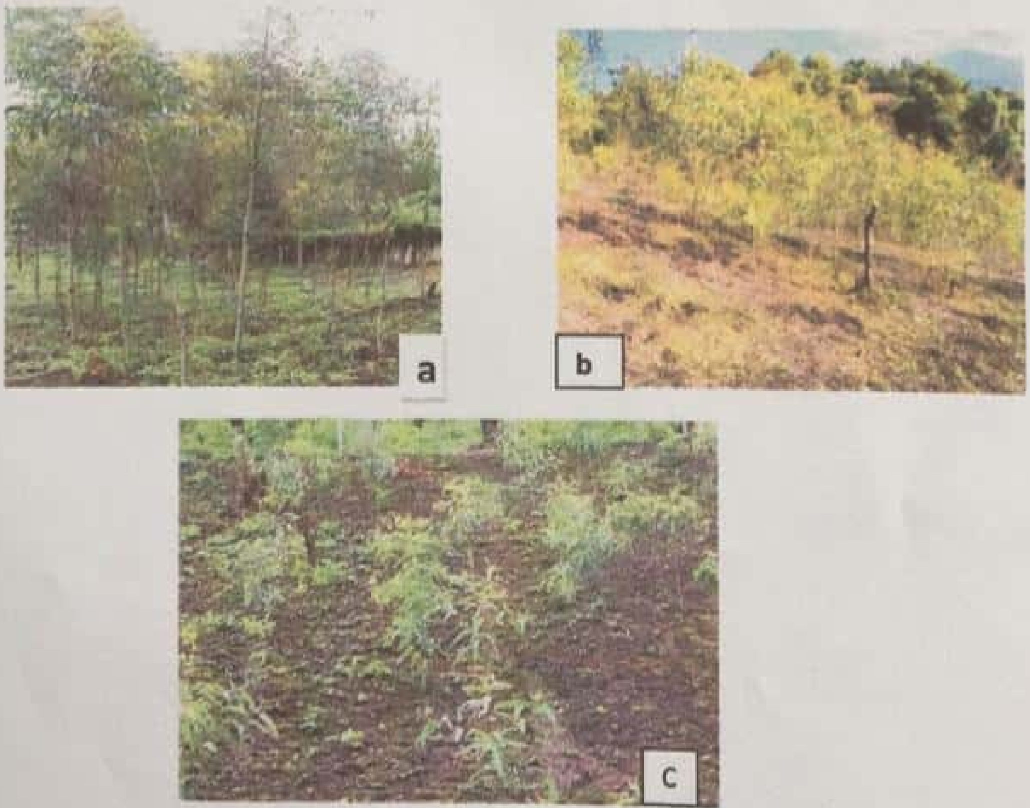

Figure 5: ***Dipterocarpus retusus*** **growth in field a) 2 year b) 12th month c) 4th month**

Ectomycorrhizal fungi fruiting body

Scleroderma citrinum Pers., fruit body 3-6 cm tall and 4-10 cm across rounded stemless, tough skin, initially white, cream and turn to ochre brown. Sporemass white at first but soon turns to brown and to purple brown. Spore prints are brown and average size of 9.5μm. Hyphae granular, clamp abundant, intercalary and multiple branched junctions (Fig. 1a).

Occurrence between July- November.

Position in Classification

Phylum	-	Basidiomycota
Class	-	Basidiomycetes
Order	-	Scleromatales
Family	-	Sclerodermacae
Genus	-	*Scleroderma*
Species	-	*citrinum*

Russula rosea Pers. fruit body red or pink often cream towards the centre and turn to brown, shiny or matt, 5- 12 cm diameter cap, convex later flattening or slight depression, gills pale cream. Stipe - brittle white flesh, especially on the upper part, cylindrical, swollen at the lower part. Spore prints are pale cream (Fig. 1b).

Occurrence between August to November

Spores - 9.0× 7.5 μm, ovoid.

Position in Classification

Phylum	-	Basidiomycota
Class	-	Basidiomycetes
Order	-	Agaricales
Family	-	Russulaceae
Genus	-	*Russula*

Ectomycorrhizal colonized roots of the seedlings

Ectomycorrhizal colonized roots were identified based on their morphology. *R. rosea* were unramified to monopodial pinnate, dark yellow to brown color and often had a distinctive layer of cystidia covering the mantle. The inner mantle was composed of non- interlocking, irregular pseudoparenchyma.

S. citrinum were monopodially branched and the branches short, hirsute, white morphotype, clamps were present. Emanating hyphae were abundant, simple septate. Control seedlings were also found to be colonized by ECM fungi.

ECM colonization to the seedlings roots were confirmed only after the 6th month of inoculation during the summer season. The non inoculated seedlings was also found to be colonized by the ECM fungi because the experiment was conducted in unsterile substrate under field condition, some air borne fungi or indigenous fungi present in the soil result in ECM formation to seedlings root

Ectomycorrhizal colonization percentage to the seedlings roots of *Dipterocarpus retusus*

Colonization of ECM fungi to the seedlings roots was found variation at different months. At the 12th and 20th month colonization of *R. rosea* was found higher but at the 6th, 8th and 24th month *S. citrinum* colonization was found higher after inoculation to the seedlings root.

Ectomycorrhizal colonization percentage to the seedlings roots of *Corymbia citriodora*

R. rosea colonization was found higher at the 6th, 8th, 12th and 20th month. At the 16th and 24th month *S. citrinum* colonization was found. Variation of ECM colonization at different season could be due to seasonal variation of ECM colonization and activity.

Ectomycorrhizal colonization percentage to the seedlings roots of *Cryptomeria japonica.*

ECM colonization was confirmed after 6th month of inoculation to the seedlings root. At the 6th (43.6%), 8th (43%) and 12th month (86.3%) *R. rosea* colonization was found higher than *S. citrinum* and control to the seedlings root per centimeter of the root length. At the 16th, 20th and 24th month *S. citrinum* colonization was consistently found higher.

Rhizospheric soil organic carbon

Soil organic carbon of rhizospheric soil was determined every season for two years i.e. at the interval of every four months. Statistical analyses were done comparing with different season of rhizospheric SOC and different months of ectomycorrhizal colonization percentage to the seedlings root.

Rhizospheric soil organic carbon of *Dipterocarpus retusus.*

In the 1st year, rhizospheric SOC *Scleroderma citrinum* inoculated seedlings was found higher at the summer and autumn season, but at the winter and spring season *R. rosea* inoculated was found higher. In the 2nd year, rhizospheric SOC of summer season of both the fungal inoculated seedlings was consistently found higher. In all the four seasons, *R. rosea* inoculated seedlings SOC percentage of rhizospheric soil was shown higher as compared to *S. citrinum* inoculated seedlings and control seedlings.

In the 1st year, increase of SOC percentage of *S. citrinum* inoculated seedlings at the summer season was found in consistent with the result of increase in colonization of *S. citrinum* at the 6th month and at the spring season increase in *R. rosea* SOC was found in increase *R. rosea* colonization to the seedlings root at the 12th month after inoculation. Similarly, significant relation was showed between increased in the rhizospheric SOC of *R. rosea* inoculated seedlings at the summer, autumn and winter season of 2nd year was found consistent with the result of increase in colonization of *R. rosea* at the 16th, 20th and 24th month after inoculation (Table 1).

Rhizospheric soil organic carbon of *Corymbia citriodora*

In the 1st year, rhizospheric SOC of summer, autumn and winter was found higher of *S. citrinum* inoculated seedlings, but spring season was found higher of *R. rosea* inoculated seedlings. In the 2nd year, rhizospheric SOC of *S. citrinum* inoculated seedlings was found higher at the spring season but at the autumn, winter and summer season *R. rosea* inoculated seedlings was found higher.

In the winter season of 1st year SOC of *R. rosea* (0.8%) and *S. citrinum* (0.9%) inoculated does not showed much variation, which showed similar results with colonization of both fungal to the seedlings root at the 12th month. Rhizospheric SOC of autumn season of 2nd year was found higher of *R. rosea* inoculated seedlings which shows in consistent with the result of increase colonization of *R. rosea* at the 20th month after inoculation to the seedlings root and increase of SOC at the spring season of *S. citrinum* was found in increase of colonization of *S. citrinum* to the root length at the 24th month (Table 2).

Rhizospheric soil organic carbon of *Cryptomeria japonica*

In the 1st and 2nd year rhizospheric SOC was found to be higher at the winter season. 1st year, summer, autumn and spring season was found higher of *R. rosea* inoculated seedlings but at the winter season *S. citrinum* inoculated seedlings was found higher. In the 2nd year, at the summer season rhizospheric SOC of was found higher of *S. citrinum* inoculated seedlings, but at the autumn, winter and spring season *R. rosea* inoculated seedlings was higher.

SOC of rhizospheric soil at the summer and autumn season of the 1st year was showed in consistent with the result of *R. rosea* colonization to the seedlings roots which was higher at the 6th and 8th month. In the 2nd year, autumn season SOC of *R. rosea* inoculated seedlings was in consistent with *R. rosea* colonization which was shown higher at the 16th month and at summer season *S. citrinum* SOC of rhizospheric soil was higher and are in consistent with increase in colonization of *S. citrinum* (87.5%) at the 16th month (Table 3).

Soil pH of rhizospheric soil of fungal inoculated seedlings

Seasonal soil pH was tested for two years i.e. at the interval of every 4th month of the 4 different seasons.

Rhizospheric soil pH of *Dipterocarpus retusus.*

Rhizospheric soil pH of summer, autumn, winter and spring season was found lower of *R. rosea* inoculated seedlings (4.5–5.0) at the 1st year as compared to *S. citrnum* and control seedlings. In the 2nd year, spring and autumn season was found lower of *R. rosea* inoculated seedlings, winter and summer was found lower of *S. citrinum* inoculated seedlings (4.5- 5.0). During the rainy season i.e. summer season pH value was found to be lower. Lower in soil pH during autumn, winter and spring season of

R. rosea inculated seedlings of 1st year was found in increase ECM colonization to the seedlings root at the 8th and 12th month. Increase of *R. rosea* colonization to the seedlings root at the 20th month was in relevant to the lower soil pH of autumn (5.3) and summer (4.6) in the 2nd year of *R. rosea* inoculated seedlings (Table 7).

Rhizospheric soil pH of *Corymbia citriodora*

Soil pH of summer, autumn, winter and spring season was lower of *R. rosea* inoculated rhizospheric soil in the 1st year. In the winter season of the 1st year control seedlings rhizospheric soil was also found to be lower (5.0) as compared to *S. citrinum* inoculated seedlings rhizospheric soil. In the 2nd year, there was not much variation in soil pH. Winter and summer season of *R. rosea* was found lower but at the spring season *S. citrinum* inoculated and control seedlings was found lower (Table 8). Lower of soil pH of *S. citrinum* during the winter and spring of 2nd year (4.9) was found increase in *S. citrinum* colonization at the 24th month (70%) as compared to *R. rosea* (40%) inoculated seedlings. Similarly, rhizospheric soil pH at the autumn season of 2nd year of *R. rosea* and *S. citrinum* does not showed much variation which was in consistent with ECM colonization at the 20th month of both the fungal inoculated (*R. rosea*= 50%, *S. citrinum* =20%).

Rhizospheric soil pH of *Cryptomeria japonica*

In the 1st year of spring season soil pH did not showed variation among the fungal inoculated and control seedlings. During the summer season *R. rosea* inoculated seedlings showed lower soil pH of rhizospheric soil (4.3). But during the autumn and winter season *S. citrinum* inoculated showed lower soil pH. In the 2nd year autumn, winter and spring season showed *S. citrimm* inoculated seedlings lower soil pH (Table 9). The results are in consistent with the increase in colonization of *S. citrinum* at 24th month and lower soil pH of *S. citrinum* during the winter and spring season. At the summer season of 2nd year soil pH of both the fungal inoculated viz. *R. rosea* and *S. citrinum* was same, which also found relevant with results of colonization of both the fungal at the 16th month (*R. rosea*=77%, *S. citrinum*=87.5%).

Soil moisture content of rhizospheric soil

Rhizospheric soil moisture of *Dipterocarpus retusus*

Rhizospheric soil moisture of summer season during the 1st year was found higher of *R. rosea* (28%) and *S. citrinum* (27%) inoculated seedlings did not show much variation in the rhizospheric soil moisture content. But autumn, winter and spring season was found higher of *S. citrnum* (21%, 22% and 16%) inoculated seedlings. During the 2nd year summer, autumn, winter and spring season was found of *S. citrinum* inoculated seedlings. In the summer season of 2nd year control seedlings rhizospheric soil moisture was higher as compared to *R. rosea* inoculated seedlings. Results did not show much variation because the experiment was conducted under same soil type condition (Table 10).

Increase of soil moisture was found to increase in ECM colonization percentage. ECM colonization percentage of *S. citrinum* and *R. rosea* at the 16th month was found which was in consistent with the result of soil moisture content of both the fungal inoculated seedlings (*R. rosea* =25.7%, *S. citrinum*=25.8%) during the summer season of 2nd year.

Rhizospheric soil moisture of *Corymbia citriodora*

Summer, autumn, and winter season of *R. rosea* (27%, 21% and 22%) inoculated seedlings showed higher rhizospheric soil moisture during the 1st year. But at the spring season *S. citrinum* inoculated seedlings soil moisture was higher than *R. rosea* inoculated and control seedlings. In the 2nd year, *R. rosea* inoculated seedlings showed higher soil moisture content at the spring, autumn and winter season. But at the summer season *S. citrinum* (25.5%) inoculated seedlings showed higher soil moisture content. Soil moisture content was higher during the summer season. Subsequently, which showed increased in soil moisture increase in ECM colonization to the seedlings roots (Table 11). Increase of soil moisture content at the summer, autumn and winter season in the 1st year of *R. rosea* seedlings rhizospheric soil also showed in increasing the colonization of *R. rosea* to the seedlings at the 6th, 8th and 12th month. Autumn season of 2nd year showed *R. rosea* inoculated seedlings higher and also the colonization of *R. rosea* at the 20th month.

Rhizospheric soil moisture of *Cryptomeria japonica*

Soil moisture of summer, autumn, winter and spring season during the 1st year was found higher of *S. citrinum* inoculated seedlings as compared to *R. rosea* and control. During the 2nd year of the summer, winter and spring season was higher of *S. citrinum* inoculated seedlings but at the autumn season *R. rosea* (17%) inoculated seedlings was found higher In *C. japonica* seedlings also increase in soil moisture was found to increase in ECM colonization to the seedlings root of both the fungal inoculated. Increase in colonization to the seedlings root length of *R. rosea* at the 20th month was found in consistent with the increase in soil moisture of *R. rosea* inoculated seedlings at the autumn season during the 2nd year and in winter season increase of soil moisture of *S. citrinum* inoculated was found to increase in *S. citrinum* colonization (Table 12).

Urease activity of rhizospheric soil and root

Urease activity of rhizospheric soil and root was determined. The result did not show much variation at different season.

Rhizospheric soil urease activity of *Dipterocarpus retusus*

Urease activity of the rhizospheric soil was found higher at the summer and autumn season i.e during the rainy season. Urease soil activity of *S. citrinum* was found higher during the summer, winter and spring season as compared to *R. rosea* and control inoculated seedlings. But at the autumn season *R. rosea* inoculated seedlings urease activity of rhizospheric soil was higher (Table 13).

Seedlings root tips urease activity of *Dipterocarpus retusus*

Root urease activity was high at the summer season of both the fungal inoculated and control seedlings. Summer, winter and spring season was found higher of *R. rosea* fungal inoculated seedlings but at the autumn season *S. citrinum* inoculated seedlings was found higher (Table 14).

Rhizospheric soil urease activity of *Corymbia japonica*

Rhizospheric soil urease activity was high at the autumn season of both the fungal inoculated and control seedlings. Summer, autumn, winter and spring season was found of *R. rosea* inoculated seedlings as compared to *S. citrinum* inoculated seedlings (Table 15).

Seedlings root tips urease activity of *Corymbia citriodora*

Summer and autumn season was found higher root tips urease activity. During the summer, autumn and spring season was higher of *S. citrinum* inoculated seedlings. But *R. rosea* inoculated root tips showed higher urease activity at the winter season (Table 16).

Rhizospheric soil urease activity of *Cryptomeria japonica*

Summer and autumn season was found higher of both the fungal inoculated seedlings. During the autumn season *S. citrinum* inoculated seedlings was found higher urease activity of rhizospheric soil but at the summer, winter and spring season both *R. rosea* and *S. citrinum* inoculated seedlings did not show much variation of urease activity. At the 8th month and 12th month *S. citrinum* inoculated seedlings did showed any significant relation. Control seedlings rhizospheric soil urease activity showed less significant relation (Table 17).

Seedlings root tips urease activity of *Cryptomeria japonica*

Urease activity of seedlings root was also found higher during the autumn and winter season. During the autumn season *S. citrinum* inoculated seedlings was higher. During the autumn season control seedlings root was also showed higher than R. rosea. In the spring season both the fungal inoculated seedlings showed same root urease content (0.3μg/gm). There was not much variation in the urease activity of ECM inoculated and the control seedlings (Table 18).

Total nitrogen content of rhizospheric soil and seedlings root total of *Dipterocarpus retusus*

S. citrinum inoculated seedlings root was found higher content of nitrogen (0.82%) as compared to *R. rosea* inoculated seedlings root and control seedlings. Rhizospheric soil of *R. rosea* inoculated seedlings was found higher, but there was not much variation was showed between the other seedlings rhizospheric soil (Table 19).

Total nitrogen content of rhizospheric soil and seedlings root of *Corymbia citriodora*

Rhizospheric soil and seedlings root nitrogen content of *S. citrinum* inoculated seedlings was showed significantly higher as compared to *R. rosea* inoculated and control seedlings (Table 20).

Total Nitrogen content of rhizospheric soil and seedlings root of *Cryptomeria japonica*

Rhizospheric soil of *S. citrinum* inoculated seedlings was found significantly higher total nitrogen content. Control seedlings rhizospheric soil was found higher percentage content of total nitrogen as compared to *R. rosea* inoculated. Seedlings roots nitrogen content of *R. rosea* seedlings root found higher (Table 21).

Available phosphorus content of rhizospheric soil and seedlings root of *Dipterocarpus retusus*

Seedlings root of *R. rosea* inoculated was found higher content of phosphorus (33.3mg/100g) as compared to *S. citrinum* inoculated and control seedlings. *S. citrinum* (8.6mg/ 100g) inoculated seedlings rhizospheric soil was found higher content of available phosphorus (Table 22).

Available phosphorus content of rhizospheric soil and seedlings root of *Corymbia citriodora*

S. citrinum inoculated seedlings found higher content of phosphorus of seedlings root (31.1mg/100g). Rhizospheric soil of *S. citrinum* showed higher content of phosphorus (2.4mg/100g) as compared to *R. rosea* inoculated and control seedlings (Table 23).

Available phosphorus content of rhizospheric soil and seedlings root of *Cryptomeria japonica*

Rhizospheric soil of *S. citrinum* inoculated found higher content of phosphorus (12.1mg/100g) as compared to *R. rosea* and control seedlings. Seedlings root of *S. citrinum* inoculated found higher content of phosphorus (Table 24).

Potassium content of rhizospheric soil and seedlings root of *Dipterocapus retusus*

Seedlings root of *R. rosea* inoculated was found higher content of potassium (122.6mg/100g) but rhizospheric soil of *S. citrinum* inoculated found higher content of soil potassium (44.5mg/100g) as compared to *R. rosea* inoculated and control seedlings. There was not much variation was found between the available potassium content of *R. rosea* and *S. citrinum* inoculated seedlings rhizospheric soil (Table 25).

Potassium content of rhizospheric soil and seedlings root of *Corymbia citriodora*

Seedlings root and rhizospheric soil of *R. rosea* inoculated was found higher content of potassium (Table 26).

Potassium content of rhizospheric soil and seedlings root of *Cryptomeria japonica*

Seedlings root of *S. citrinum* inoculated was found higher content of potassium (136.6mg/100g). *R. rosea* inoculated seedlings root showed higher potassium content (41.1mg/100g). However, there was not much variation on average mean value between both the fungal inoculated seedlings root and rhizospheric soil of potassium content (Table 27).

***Dipterocarpus retusus* seedlings growth**

Seedlings growth viz. shoot height, leaf length, root length and root collar diameter at the interval of every 4th month showed variation and significantly better growth of both the ECM inoculated seedlings as compared to control seedlings. At the 24th month the growth *R. rosea* inoculated seedlings (SH=90.6cm) showed better growth than the *S. citrinum* inoculated seedlings (Table 28).

***Corymbia citriodora* seedlings growth**

Seedlings growth for 2 years such as shoot height, leaf length, roots length and root collar diameter showed significantly better growth of both the fungal inoculated treatment. *R. rosea* inoculated seedlings growth was found successively better growth till the 24th month. Significant means difference was between the ECM colonization at different month and seedlings growth (Table 29).

Cryptomeria japonica **seedlings growth**

Growth of the seedlings at the 24th month was significantly showed better of *S. citrinum* (SH=375cm) inoculated seedlings (Table 30).

Table 1: Ectomycorrhizal colonization percentage of *Dipterocarpus retusus*

ECM treatment	6th Month	8th month	12th month	16th month	20th month	24th month
R. rosea	73±6.8	62±6.2	58.6±14.5	85±15	60±8.7	55±10
S. citrinum	88±6..9	66±4.3	51.4±4.3	85±10	50±18.4	63.3±18.5
Control	30±5.7	25.3±2.8	46.6±21.3	61.3±10.5	21±8.7	34.6±18.3

Mean±SE. Each mean is mean of five replicate of percentage of colonization/ cm to the root length

Table 2: Ectomycorrhizal colonization percentage of *Corymbia citriodora*

ECM treatment	6th Month	8th month	12th month	16th month	20th month	24th month
R. rosea	59.3±9.1	70±9.01	56.6±23	74.3±13	50±2	52±18.7
S. citrinum	46.1±4.2	60±15.3	50±22.3	80±12.2	30±7	60±12.2
Control	19.6±5.4	39.2±10.3	33.3±18.2	65.3±18.3	16±8.7	13.3±8.2

Mean±SE. Each mean is mean of five replicate of percentage of colonization/ cm to the root length

Table 3: Ectomycorrhizal colonization percentage of *Cryptomeria japonica*

ECM treatment	6th month	8th month	12th month	16th month	20th month	24th month
R. rosea	43.6±1.8	43±2.02	86.33±6.3	77±10.1	70±20	43.3±12
S. citrinum	40.2±4.6	41.6±3.3	70±14.5	87.5±12.5	43.3±19.4	70±20
Control	19±1.8	39.2±10	33.3±18.2	65.3±18.3	16±8.7	40±8.7

Mean±SE. Each mean is mean of five replicate of percentage of colonization/ cm to the root length.

Table 4: Rhizospheric soil organic carbon percentage of *Dipterocarpus retusus* of different seasons

ECM treatment	1st year				2nd year			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
R. rosea	1.03±0.1	0.71±0.2	1.58±0.1	1.5±0.1	3.15±0.3	0.8±0.2	2.1±0.8	2.9±0.3
S. citrinum	2.1±0.5	1.2±0.5	1.5±0.5	0.9±0.4	2.5±0.13	0.5±0.1	1.9±0.12	1.7±0.6
Control	1.9±0.2	0.9±0.4	1.3±0.4	0.8±0.4	2.3±0.1	0.6±0.02	0.53±0.1	1.9±0.2

Mean±SE of mean (n=3).

Table 5: Rhizospheric soil organic Carbon percentage of *Corymbia citriodora* of different seasons for 2 year

ECM treatment	1st year				2nd year			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
R. rosea	0.88±0.01	1.2±0.4	0.8±0.3	0.86±0.2	1.2±0.05	1.7±0.05	2.3±0.5	0.9±0.34
S. citrinum	1.8±0.34	2.7±0.6	0.9±0.25	0.73±0.1	0.76±0.03	0.9±0.04	2±0.4	2.2±0.5
Control	0.6±0.14	0.9±0.14	0.9±0.2	0.1	1.6±0.2	1.6±0.2	1.64±0.2	0.9±0.34

Mean±SE of mean (n=3).

Table 6: Rhzisopheric soil organic carbon percentage of *Cryptomeria japonica* of different season

ECM treatment	1st year				2nd year			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
R. rosea	1.2±0.16	1.5±0.6	1.1±0.4	1.1±0.5	0.6±0.14	1.4±0.2	1.9±0.07	1.69±0.8
S. citrinum	0.8±0.1	0.32±0.2	2.15±0.81	0.83±0.12	0.9±0.14	0.72±0.2	1.6±0.5	1.4±0.4
Control	0.82±0.17	0.5±0.19	0.9±0.1	0.73±0.23	0.4±0.02	0.5±0.21	1.35±0.4	1.3±0.1

Mean±SE. Each mean is value of three replicate.

Table 7: Soil pH of rhizospheric soil of *Dipterocarpus retusus* of different seasons

ECM treatment	1^{st} year				2^{nd} year			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
R. rosea	4.7±0.1	5.4±0.2	5.1±0.2	5.3±0.1	4.5±0.2	5.3±0.08	5±0.05	5±0.05
S. citrinum	5.2±0.1	5.3±0.03	5.4±0.1	5.1±0.2	4.5±0.2	5.4±0.2	5.06±0.03	5±0.05
Control	5.1±0.2	5.7±0.08	5.2±0.3	5.4±0.2	5.2±0.2	5.6±0.08	5.5±0.1	5.1±0.06

Mean±SE of mean (n=3)

Table 8: Soil pH of rhizospheric soil of *Corymbia citriodora* of different seasons

ECM treatment	1^{st} year				2^{nd} year			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
R. rosea	4.13±0.2	5.4±0.3	5.1±0.24	5.4±0.2	4.9±0.12	5.4±0.1	4.8±0.08	5.3±0.05
S. citrinum	4.4±0.2	5.4±0.2	5.6±0.2	5.5±0.15	5.7±0.08	5.4±0.2	5±0.05	5.1±0.03
Control	4.5±0.3	5.5±0.3	5.2±0.2	5.5±0.21	5.5±0.12	5.4±0.2	4.83±0.08	5.2±0.07

Mean±SE of mean (n=3)

Table 9: Soil pH of rhizospheric soil of *Cryptomeria japonica* of different seasons

ECM treatment	1^{st} year				2^{nd} year			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
R. rosea	4.4±0.1	5.4±0.2	5.4±0.2	5.7±0.1	4.8±0.08	5.6±0.05	5.3±0.2	5.1±0.2
S. citrinum	4.5±0.4	5.3±0.1	5.2±0.2	5.6±0.08	4.8±0.1	5.3±0.1	5.2±0.1	5±0.2
Control	4.8±0.3	5.4±0.2	5.2±0.2	5.2±0.3	5.2±0.08	5.6±0.1	5.6±0.1	5.6±0.03

Mean±SE of mean (n=3)

Table 10: Soil moisture of rhizospheric soil of *Dipterocarpus retusus* of different seasons

ECM treatment	1^{st} year				2^{nd} year			
	Summer	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**
R. rosea	28±0.05	19.1±1.05	18±0.3	14.3±0.8	23.1±0.3	19.5±0.1	15.03±0.3	24.6±2.4
S. citrinum	26.7±0.1	21.4±0.04	22.5±0.4	15.6±0.3	25.7±0.1	22±0.4	21.6±0.3	24±2.1
Control	21.6±0.2	20.3±0.2	19.6±0.8	14.6±1.2	25.8±0.6	15.3±0.03	15.2±0.1	21.6±2

Mean±SE of mean percentage (n=3)

Table 11:Soil moisture of rhizospheric soil of *Corymbia citriodora* of different seasons

ECM treatment	1st year				2nd year			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
R. rosea	26.7±0.1	21.2±0.3	21.3±0.3	15.6±1.2	20±2.4	23.18±0.3	23±0.2	21.2±0.3
S. citrinum	24±0.5	20.3±0.2	20.3±0.2	18±0.5	25.5±0.3	18.7±0.7	15±0.7	25.3±1.7
Control	21±2.08	13±0.3	18±2.4	14.3±0.8	23.6±0.4	22.2±1.2	14.2±0.2	21.3±2.02

Mean±SE of mean percentage (n=3)

Table 12: Soil moisture of rhizospheric soil of *Cryptomeria japonica* of different seasons

ECM treatment	1st year				2nd year			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
R. rosea	26.4±0.5	22.5±0.05	18.9±0.7	14.6±0.6	18.4±0.3	17.3±0.1	13.9±0.1	24.7±0.1
S. citrinum	26.7±0.5	24.6±1.7	20±0.005	17±1.5	23.5±0.07	13.1±0.3	14.5±0.1	20.3±1.2
Control	21.6±0.2	13±0.5	18.3±0.5	13.3±1.4	19.3±2.3	16±0.2	8.9±0.1	20.3±1.2

Mean±SE of mean percentage (n=3)

Table 13: Rhizospheric soil urease activity of *Dipterocarpus retusus*

ECM treatment	Summer	Autumn	Winter	Spring
R. rosea	0.02±0.02	0.025±0.002	0.007±0.001	0.017±0.004
S. citrinum	0.24±0.008	0.021±0.004	0.014±0.002	0.02±0.004
Control	0.019±0.006	0.013±0.006	0.005±0.01	0.016±0.003

Mean±SE. Each value is mean of three replicate. Each value is mg/gm of dry soil/ 3 hrs at 37°C.

Table 14: Root urease activity of *Dipterocarpus retusus*

ECM treatment	Summer	Autumn	Winter	Spring
R. rosea	0.043±0.003	0.026±0.003	0.026±0.002	0.015±0.005
S. citrinum	0.038±0.001	0.03±0.001	0.023±0.001	0.01±0.002
Control	0.035±0.002	0.017±0.001	0.01±0.003	0.003±0.0

Mean±SE. Each value is mean of three replicate. Each value is mg/gm of dry root/ 3 hrs at 37°C.

Table 15: Urease activity of rhizospheric soil of *Corymbia citriodora*

ECM treatment	Summer	Autumn	Winter	Spring
R. rosea	0.035±0.003	0.05±0.006	0.04±0.001	0.018±0.006
S. citrinum	0.026±0.008	0.03±0.01	0.023±0.01	0.01±0.003
Control	0.03±0.01	0.02±0.002	0.02±0.005	0.013±0.01

Mean±SE. Each value is mean of three replicate. Each value is mg/gm of dry soil/ 3 hrs at 37°C.

Table 16: Root urease activity of *Corymbia citriodora*

ECM treatment	Summer	Autumn	Winter	Spring
R. rosea	0.011±0.003	0.01±0.003	0.015±0.001	0.014±0.003
S. citrinum	0.021±0.003	0.02±0.005	0.01±0.01	0.015±0.005
Control	0.015±0.001	0.01±0.002	0.007±0.003	0.007±0.005

Mean±SE. Each value is mean of three replicate. Each value is mg/gm of dry root/ 3 hrs at 37°C.

Table 17: Rhizospheric soil urease activity of *Cryptomeria japonica*

ECM treatment	Summer	Autumn	Winter	Spring
R. rosea	0.04±0.01	0.07±0.004	0.027±0.003	0.034±0.001
S. citrinum	0.04±0.01	0.02±0.01	0.036±0.004	0.03±0.002
Control	0.033±0.004	0.006±0.01	0.036±0.001	0.009±0.002

Mean±SE. Each value is mean of three replicate. Each value is mg/gm of dry soil/ 3 hrs at 37°C.

Table 18: Root urease activity of *Cryptomeria japonica*

ECM treatment	Summer	Autumn	Winter	Spring
R. rosea	0.03±0.001	0.022±0.01	0.035±0.02	0.03±0.004
S. citrinum	0.04±0.005	0.07±0.003	0.02±0.002	0.03±0.01
Control	0.03±0.004	0.05±0.01	0.02±0.004	0.023±0.003

Mean±SE. Each value is mean of three replicate. Each value is mg/gm of dry root/ 3 hrs at 37°C.

Table 19: Total nitrogen content of rhizospheric soil and seedlings roots of *Dipterocarpus retusus*

ECM treatment	Seedlings root (%)	Soil (%)
R. rosea	0.69±0.08	0.44±0.03
S. citrinum	0.82±0.09	0.43±0.03
Control	0.67±0.11	0.42±0.01

Mean±SE of means percentage (n=3)

Table 20: Total nitrogen content of rhizospheric soil and seedling roots of *Corymbia citriodora*

ECM treatment	Seedlings root (%)	Soil (%)
R. rosea	0.45±0.21	0.42±0.04
S. citrinum	0.85±0.04	0.46±0.005
Control	0.29±0.11	0.27±0.01

Mean±SE of means percentage (n=3)

Table 21: Total nitrogen content of rhizospheric soil and seedlings roots of *Cryptomeria japonica*

ECM treatment	Seedlings root (%)	Soil (%)
R. rosea	0.35±0.08	0.41±0.006
S. citrinum	0.29±.028	0.51±0.05
Control	0.27±0.02	0.47±0.00

Mean±SE of means percentage (n=3)

Table 22: Phosphorus content of rhizospheric soil and seedlings roots of *Dipterocarpus retusus*

ECM treatment	Seedlings root	Soil
R. rosea	33.3±9.3	6.5±1.9
S. citrinum	29.7±10.1	8.6±0.8
Control	5.7±4.2	6.4±3.2

Mean±SE (n=3). Each value is expressed as mg/100g of sample.

Table 23: Phosphorus content of rhizospheric soil and seedlings roots of *Corymbia citriodora*

ECM treatment	Seedlings root	Soil
R. rosea	19.3±2.3	2.06±0.17
S. citrinum	31.1±1.04	2.4±0.8
Control	14.8±6.7	0.92±0.5

Mean±SE (n=3). Each value is expressed as mg/100g of sample.

Table 24: Phosphorus content of rhizospheric soil and seedlings root of *Cryptomeria japonica*

ECM treatment	Seedlings root	Soil
R. rosea	15.5±3.7	11.8±1.9
S. citrinum	31.9±9.2	12.1±5.7
Control	20±7.02	14.9±2.14

Mean±SE (n=3). Each value is expressed as mg/100g of sample

Table 25: Potassium content of rhizospheric soil and seedlings root of *Dipterocarpus retusus*

ECM treatment	Seedlings root	Soil
R. rosea	135.3±2.3	41.1±1.09
S. citrinum	136.6±8.4	40.6±1.3
Control	122.6±1.4	38.6±0.6

Mean±SE of mean (n=3). Each value is expressed as mg/100g of sample.

Table 26: Potassium content of rhizospheric soil and seedlings of *Corymbia citriodora*

ECM treatment	Seedlings root	Soil
R. rosea	161±0.5	41.6±0.6
S. citrinum	143±5.3	40.7±1.2
Control	127.3±11.7	26.1±2.3

Mean±SE of mean (n=3). Each value is expressed as mg/100g of sample.

Table 27: Potassium content of rhizospheric soil and seedlings root of *Cryptomeria japonica*

ECM treatment	Seedlings root	Soil
R. rosea	122.6±5.1	44.3±1.6
S. citrinum	117±4.5	44.5±4
Control	111.3±5.1	29±0.5

Mean±SE of mean (n=3). Each value is expressed as mg/100g of sample

Table 28: Growth of *Dipterocarpus retusus* seedlings at different months

ECM treatment		4th month	8th month	12th month	16th month	20th month	24th month
R. rosea	SH	23.5±3.6	37.4±.9	52±2.1	78±6.2	91.2±9.6	90±20.7
	LFL	10.3±1.5	22±.3	27.5±2.6	34.8±1.6	34±.5	32.7±1.1
	RL	8.2±.3	14±.8	23±.9	23.6±1.8	29±2.4	37±4.1
	RC	0.4±.04	0.5±.03	0.4±.04	0.6±.05	2.2±.1	3.4±0.3
S. citrinum	SH	28±2.2	38.8±1	51.2±5.9	76.6±9.8	78.6±10.8	88.2±32.2
	LFL	8.6±.6	23.2±.5	29±2.7	33.2±1.7	33.8±11.4	33.2±0.6
	RL	10.2±.66	13.2±.9	22.8±1.1	24.4±1.4	27.8±.9	36±4.8
	RC	0.4±.07	0.5±.04	0.5±.05	0.6±.1	1.5±.1	3.2±0.2
Control	SH	19.1±1.1	29.8±1.7	6.2±2.7	78±6.2	37.4±2.4	41±1.8
	LFL	8±.4	12.8±.8	23.6±2.7	30.8±1.6	31.8±8.7	32.2±.8
	RL	7.8±.5	11.6±1.2	16.6±.5	20±1.7	21.6±.92	27.8±1
	RC	0.3±.04	0.48±.06	.4±.05	.6±.05	1.4±.1	1.9±.3

Mean±SE of mean (n=5). SH= Shoot height (cm), LFL= Leaf length (cm), RL= Root length (cm) and RC= Root collar diameter (cm)

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Table 29: Growth of *Corymbia citriodora* seedlings at different months

ECM Treatment		4th month	8th month	12th month	16th month	20th month	24th month
R. rosea	SH	116±5.03	253.3±18.5	340.7±46.4	538.6±66.3	583.33±66.9	710.6±51.7
	LFL	13.37±0.13	17±2	15±0.57	17±0.57	17±0.57	17±0.57
	RL	30.13±1.16	64.3±2.96	20.3±14.2	330±25.2	360±30.5	436.6±29.6
	RC	0.55±0.03	0.70±0.05	0.9±0.05	1.03±0.08	3±0.28	10.2±0.4
S. citrinum	SH	143.33±10.3	200±10	296±44.06	525±59	53.3±59.2	642.2±35.09
	LFL	15.16±1.9	13.67±1.2	14.7±0.3	16.66±0.8	16.66±0.8	17.4±0.5
	RL	38.3±0.8	63.6±0.6	243.3±3.3	291.6±4.4	333±33.3	370±6.1
	RC	0.6±0.10	0.57±0.03	0.66±0.03	0.86±0.03	3.06±0.17	9.1±0.12
Control	SH	89 ±4.5	127.3±19.5	181.3±32.6	314.6±9.8	333.3±26.6	397±27.54
	LFL	14.3±0.97	42.3±0.3	11.6±0.17	15.8±0.6	17±0.57	16.8±0.7
	RL	24±2.09	51.6±0.08	163.3±3.3	170±6.3	168.3±6	210±10.4
	RC	0.49±0.03	0.6±0.03	0.6±0.03	0.80±0.04	1.9±0.35	7.94±0.18

Mean±SE of mean (n=5). SH= Shoot height (cm), LFL= Leaf length (cm), RL= Root length (cm) and RC= Root collar diameter (cm).

Table 30: Growth of *Cryptomeria japonica* at different months

ECM Treatment		4th month	8th month	12th month	16th month	20th month	24th month
R. rosea	SH	62±2.5	106.6±8.3	133.4±6.4	245.6±14.06	273±6.6	322±12.7
	LFL	6.3±0.5	11.2±0.5	11.7±0.7	13.3±14.06	13.7±0.3	14.4±0.4
	RL	25.6±1.2	63.2±1.9	112±6.6	131±15.5	153±10.9	179±6.7
	RC	0.3±0.2	0.5±0.04	0.83±0.04	0.7±0.14	2.9±0.12	3.4±0.3
S. citrinum	SH	56±1.2	106.6±8.3	128.4±10.4	136±2.3	224±12.8	375±7.4
	LFL	5.6±0.5	10.4±0.6	11.2±0.7	12.2±0.8	13±0.3	15±0.3
	RL	24.6±1.4	60.8±0.3	105.2±9.6	115±2.8	141±6.4	181±5.5
	RC	0.3±0.4	0.4±0.08	0.5±0.06	0.7±0.06	2.8±0.09	3.1±0.24
Control	SH	54.4±3.2	89.2±7	93.4±7.4	130.4±9.9	162±14.9	202.6±10.1
	LFL	4.8±0.3	11.4±0.5	10.4±0.5	12.2±0.37	13±0.31	13.4±0.5
	RL	22.4±0.6	43.3±1.7	84±7.4	89±6.4	141±6.4	107±5.3
	RC	0.31±0.02	0.5±0.01	0.41±0.02	0.63±0.03	2.8±0.09	2.7±0.2

Mean±SE of mean (n=5). SH= Shoot height (cm), LFL= Leaf length (cm), RL= Root length (cm) and RC= Root collar diameter (cm)