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ARBUSCULAR MYCORRHIZAL FUNGI INOCULATION PROMOTES GROWTH OF VEGETATION IN REFUSE DUMP SOILS OF OPEN CAST MINE FIELD

A. MUTHUKUMAR*, SANDHYA G. M., MAMATHA N. AND DAKSHAYINI G.

Forest Protection Division, Institute of Wood Science and Technology, Bengaluru, Karnataka, India

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Abstract - Removal of soil from natural forest during open cast mining operation leads to severe disturbances not only to the local ecosystem also to livability of people. Reforestation is becoming a challenging task in post-open cast mine land as trees struggle to survive in refuse mine dump soils. Use of Arbuscular Mycorrhizal (AM) fungi can increase vegetation growth in disturbed soils. A study was conducted at refuse dump soils of Ballari, India. The objective was to investigate the effect of AM fungi in vegetation growth in the refuse dump soils. Twenty species were selected based on their ecological values *viz*., medicinal properties, firewood, fruits and shelter for birds *etc*. The saplings were inoculated with native AM fungi and maintained under nursery conditions for twelve months. The seedlings were observed for their growth characters by measuring height and collar diameter at regular intervals of every 3rd, 6th and 12th month. AM inoculated seedlings showed a greater increase in height than the control or non-inoculated seedlings. The increase in growth was three times in *Syzygiumcumini*, *Thespesiapopulnea*, *Grevillearobusta* and *Holoptelaintegrifolia* and two times in *Mangiferaindica*, *Cordiaoblique*, *Tectonagrandis*, *Swieteniamahogany*, *Azadirachtaindica*, *Ficusbenghalensis*, *Ficusreligiosa* and *Phyllanthusemblica*. Enhancement of collar diameter was three times in *Thespesia populnea, A. indica, Ficus benghalensis*, *Ficus religiosa*, *Syzygiumcumini*, *Holoptela integrifolia* and *Grevillea robusta.* The observation on establishment and survival rate of transplanted species like *Tamarindus indica, Butea monosperma, Phyllanthus emblica*and *Cordia obliqua*to the main field was better when compared to other species. The study thus indicates the need and beneficial effect of AM fungi as growth promoters for tree species in refuse dump soils of opencast coal mine land.

INTRODUCTION

Even though mining is regarded as a crucial economic activity worldwide, it has a significant negative impact on environment. Due to its nature, especially opencast mining inevitably leads to serious degradation on ecological and aesthetic values of the landscape. Topography and drainage, air, soil and water quality, vegetation including forest ecosystems, noise levels and ground vibrations, human health and habitation can be listed as the typical parameters that are mainly affected by opencast mining activities. The process of opencast mining consists of tree logging, topsoil stripping, removal of overburden, and exploitation of minerals (Ghose and Majee, 2000).

The negative impacts of surface mining on environment are, occupation of large farming areas needed for excavation and dumping operations, alteration of land morphology, disturbance of native fauna and flora, modification of surface and ground water balance, resettlement of residential areas, roads and railways, release of air, liquid and solid pollutants and noise pollution (Kavourides *et al*., 2002).

Studies had proven that open cast mining operations and other associated activities degrade the land to a large extent creating problems of changing drainage patterns, landslides and soil erosion. In the process of opencast mining significant amount of forest is lost in the form of soil, fauna, flora and surface water during pre-mining removal of overburden covering the mineral extract (Kundu and Ghose, 1998). The overburden is considered as undesirable waste for industry and dumped within mining area or public land thereby leading to deleterious impacts by the unstable materials from dump leading to degradation of land (Upgupta and Singh, 2017).

Reforestation of degraded land is to restore the productive capability of the land with an ecosystem that is composed of native species that will function to provide a diversity of economic and ecological values (Macdonald *et al*., 2015). Post-opencast mine land is physically, chemically, and biologically infertile habitat that hinders vegetation development (Sheoran *et al*., 2010) and therefore requires several hundred years for restoration consists of the initial, middle, and climax stages (Burger and Zipper, 2002). Management of soil erosion through establishment of grasses and legumes will be the primary focus to encourage grading and smoothing of reclaimed land surfaces of open-cast mine land (Plass, 1982; Torbert and Burger, 2000) followed by tree plantation (Skousen *et al*., 2006). Survival and establishment of tree species depends on health condition of the refuse dump soils of open-cast mine land. In order to maintain the nutrient status of such soils utilization of beneficial microorganisms has been suggested as a possible alternative way for the restoration of post-opencast mine land (Juwarkar and Jambhulkar, 2008; Taheri and Bever, 2010).

AM fungi are obligatory fungal symbionts forming a symbiosis with up to 80% of land plant species on earth and thereby play an important role in the establishment and maintenance of plant communities in forest ecosystems (Alkan *et al*., 2006; Brundrett, 1991; Roy-bolduc and Hijri, 2011).

It has been reported that AM fungal inoculation improved growth and nutrient uptake of tropical tree species in growth chambers and nurseries (Tawaraya and Turjaman, 2014).

AM fungi increased seedling growth in 23 of 28 species from a lowland tropical rainforest in Costa Rica under nursery conditions (Janos, 1980). The inoculation of *Azadirachta indica* (Meliaceae) with AM fungi improved shoot growth compared with control seedlings under nursery conditions (Muthukumar *et al*., 2001). *Casuarina equisetifolia* seedlings inoculated with *Glomusgeosporum* exhibited improved growth, nutrient acquisition, and quality under nursery conditions (Muthukumar and Udaiyan, 2010).

Apart from being major nutrient mobilizer AM fungi enhance plant survival from biotic and abiotic stress such as nutrient limitations, fungal and bacterial plant pathogens, plant-parasitic nematodes, salinity, drought, trace elements and petroleum hydrocarbon pollutants (Davies *et al*., 2002; Hassan, 2013; Ismail and Hijri, 2012; Ismail *et al*., 2013).

A study was conducted to answer the question "Do native trees planted in mine soils grow at rates equal to or better than trees planted in native forest soils?", where it was found tree heights for tree species in mine soils after 9 and 11 years were lower than heights estimated from pre-mining native forest soils (Dallaire and Skousen, 2019).

In our study we have made an attempt to experiment the compatibility of AM fungi with twenty locally grown tree species under nursery and field conditions at mining area of Ballari, Karnataka.

MATERIALS AND METHODS

The study was conducted in mining area at Ballari district (15.15°N 76.93°E and 495 above MSL), Karnataka, India. Some of the native tree species *viz*., *Ficus benghalensis, Ficus religiosa, Swietenia mahogany, Azadirachta indica, Tectona grandis, Tamarindus indica, Mangifera indica, Phyllanthus emblica, Pithecellobium dulce, Artocarpus heterophyllus, Cordia oblique, Thespesia populnea, Salvadora persica, Syzygiumcumini, Syzygium sp., Pongamia pinnata, Hardwikiabinnata, Holoptela integrifolia, Butea monosperma*and *Grevillea robusta*were selected which are important for their various ecological values and benefits for mankind. The seedlings were raised at Belagal nursery in the mining area of Ballari managed by Karnataka Forest Department. Seedlings of uniform and moderate height of age 6 months were transferred to polybag of size 14"X20" containing pot mixture of farmyard manure, sand and soil in the ratio of 1:1:2 by volume. These seedlings were treated with AM fungi obtained from Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamil Nadu.

Fifty grams of AM fungal inoculum were applied to each plant near the root zone while planting the seedling in polybag. The experiment was laid out with 3 blocks (Replication) and with 20 seedlings for each block. Sixty plants were taken for treatment and sixty plants for control.

Spore count Analysis

AM fungi remain outside the root covers the root surface like cottony growth and multiply in the soil in the form of spores. A rhizosphere soil sample collected from six-month-old seedlings and the estimation of fungal spores was done in the laboratory. Spores were collected on filter paper using wet sieving and decanting technique (Gerdemann and Nicolson, 1963). Soil substrate with spores, hyphae and colonized root pieces of 300 to 350 spores per 100gm of soil served as good inoculum.

Growth characters of host plant in nursery at mining area

After 90 days seedlings physical parameters like growth (height), collar diameter and disease incidence *etc*., were observed and maintained under the ambient condition with normal watering in the nursery. The pots were evenly watered in a regular way to maintain the moisture at field capacity and other usual care was taken to protect the plants from pests and diseases.

Phosphorous uptake analysis

The primary factor is the amount of P (inorganic phosphorus) in the soil. Since the relationship between plant and fungi involved helping the plant to access low levels of 'P' in the soil. Mycorrhizae do not grow and colonize roots when the P level is high. P level above 10 ppm in the soil will impact the growth and establishment of mycorrhizae.

Seedling Quality Index

Seedlings were ready for transplantation after one year of management and randomized nine species in triplicate from each species of AM fungi treated and control were brought to the laboratory for measurement of shoot height with tape and basal diameter with calipers. The same seedlings were destructively harvested, soil adhering to the root system was gently removed. Root and shoot were separated at the root collar region.

The roots were washed, fresh weight of shoots and roots were measured separately on a sensitive balance, and then individually packed in paper bags and oven-dried to a constant weight at 70 ^{o}C for 48 h to calculate the seedling quality index. Dickson quality index (DQI) has been considered a promising tool or good indicator of seedling quality. DQI or better known as seedling quality index (SQI) was calculated according to (Dickson *et al*. 1960) using the following formula:

SQI = Total dry weight / Height (cm)/Root collar diameter (cm) +SDW/RDW

$$SQI = \frac{TSDW}{H/D+SDW/RDW}$$

TSDW= Total seedling dry weight (shoot and root dry weight in g.)

H=Seedling height (Cm)

D=Collar diameter (mm)

SDW=Shoot dry weight

RDW=Root dry weight

Establishment of seedlings in open cast mining area

Selected, treated and untreated seedlings were shifted to Vibhuthi Gudda mine area for transplantation during regular rainy season i.e. in the month of September 2018. Observation were carried out for survivability of the transplanted species.

RESULTS AND DISCUSSION

Spore Count Analysis (Host plant species and AM fungi spore abundance)

In our study the efficiency of AM fungi was evaluated against different locally grown species at Ballari, Karnataka, India. The AM fungi was procured from Institute of Forest Genetics and Tree Breeding, Coimbatore. The spore abundance of AM fungi is determined by the host plant species and the environmental variables rather than by the AM fungal species itself (Koske and Halvorson, 1981). The host plant species selected in our study were of those species that are grown locally and found suited to the local micro climatic conditions, especially mining areas at Ballari. Soil type (Joshi and Singh, 1995), species, soil pH, soil fertility (Abbott and Robson, 1991) and micro climate conditions have been reported to influence AM spore abundance. The spore abundance was in the range 20 to 600 for inoculated host plant species, while the range was 10 to 400 for un-inoculated plant species.

The considerable spore population for definitive coherence between AM fungi root colonization and plant growth parameters was 219 spores 100 g^{-1} in *Azadirachta indica* (Reena and Bagyaraj, 1990). The maximum spore abundance was observed in *Mangifera indica*, *Cordia oblique*, *Hardwickiabinata*, *Ficus religiosa*, *Syzygiumcumini*, *Holoptelea integrifolia*, *Syzygium*Sp., *Millettia pinnata* and *Butea monosperma* among the 20 species studied (Table 1). Analysis of the rhizosphere soils showed that mycorrhizal spores were present in all seedlings. The No. of spores found in 100 g of dry soil varied between 30-500. The AM fungi used in this study was having a considerable spore population, hence with this improved effect of inoculation the competitive ability of the introduced AM fungi was better when compared to native AM fungi, which was in covenant with earlier reports (Reena and Bagyaraj, 1990). The response in abundance of spore was visible in growth characters of the host plant species.

Growth characters of host plant in nursery at mining area

Overall growth performance of host plant species were compatible to the introduced AM fungi which was obvious from the augment inshoot height and collar diameter of the 14 plant species considered for growth parameter study. The augment in growth characters were observed at three intervals *viz*., third, sixth and twelfth month of the growing period under the prevailing nursery conditions at Ballari.

The species *Cordia oblique, Thespesia populnea, Azadirachta indica, Ficus benghalensis, Ficus religiosa, Holoptelea integrifolia, Grevillea robusta* and *Syzygium* Sp., were found reciprocating well in shoot height to the AM fungi (Table 2). *Cordia oblique* was with shoot height of 236.63 cm, while the uninoculated host plant species / control with inborn AM fungi was 219.5 cm height at 12th month, thus indicating the role of introduced AM fungi in enhanced plant growth over the control plant.

The other growth parameter observed in our study was collar diameter of inoculated versus uninoculated host plant species. The literature points that AM fungi can play a positive role in the establishment of plants with overall growth of the plant. Inoculated plants with AM fungi showed collar diameter (Barua *et al*., 2010), shoot height and leaf number of seedlings larger than those of control seedlings three months after sowing with gradual further increase from fourth month onwards (Wulandari *et al.*, 2014). The collar diameter readings taken during 3rd, 6th and 12th month of *Cordia oblique, Thespesia populnea, Azadirachta indica,Ficus benghalensis, Ficus religiosa, Holoptelea integrifolia* and *Grevillea robusta* showed the positive response of these host species to introduced AM fungi.

AM fungi differ considerably in their efficiency and plant species to colonize and influence plant growth. The increase in shoot height because of inoculation was 34% compared to uninoculated plants showed a positive influence of the selected AM fungi on the growth of *Phyllanthus emblica*

Table 1. Spore count analysis

Sl. No.	Name of the species / Family	Local Name (Common Name)	Spore Count Range (No. of spores per 100 gm of rhizosphere soil)	
			AM fungi inoculated	Control
1.	*Mangifera indica*/ Anacardiaceae	Maavina mara (Mango)	500-600	100-120
2.	*Artocarpus integrifolia (A. heterophyllus)*/ Moraceae	Halasumara (Jack Fruit)	70-80	10-20
3.	*Cordia oblique*/ Boraginaceae	Challe mara (Clammy Cherry)	300-350	90-100
4.	*Tamarindus indica*/ Fabaceae	Hunase mara(Tamarind tree)	200-250	70-80
5.	*Pithecellobium dulce*/ Fabaceae	SeemeHunase mara (Madras thorn tree)	20-30	20-30
6.	*Hardwickiabinate*/ Fabaceae	Kammara (Indian Blackwood)	300-400	140-160
7.	*Tectona grandis*/ Lamiaceae	Thega mara (Teak tree)	200-250	Absent
8.	*Thespesia populnea*/ Malvaceae	Bugari mara(Indian Tulip tree)	20-30	Absent
9.	*Swietenia mahagoni*/ Meliaceae	Mahogany	30-40	20-30
10.	*Azadirachta indica*/ Meliaceae	*Bevina mara (Neem tree)*	*100-120*	Absent
11.	*Ficus benghalensis* / Moraceae	Aala mara(Banyan tree)	180-200	100
12.	*Ficus religiosa*/ Moraceae	Arali mara (Sacred Fig tree)	300-350	10-20
13.	*Syzygiumcumini*/ Myrtaceae	Dodda Nerale mara (Indian blackberry)	400-500	350-400
14.	*Holoptelea integrifolia*/ Ulmaceae	Tapasi mara(Indian elm tree)	300-350	10-20
15.	*Grevillea robusta*/ Proteaceae	Silver Oak	240-250	20-30
16.	*Phyllanthus emblica*/ Phyllanthaceae	Nelli (Indian Gooseberry)	Absent	Absent
17.	*Syzygium Species*/ Myrtaceae	ChikkaNeralemara	300-400	10-20
18.	*Salvadora persica*/ Salvadoraceae	Goni mara(Tooth brush tree)	80-90	30-40
19.	*Millettia pinnata* / Fabaceae	Honge mara (Pongam Oil tree)	300-400	150-200
20.	*Butea monosperma*/ Fabaceae	Muttugamara(Flame-of-the-forest)	300-400	50-60

seedlings (Nikhil *et al.*, 2019). In contrast, our experiment revealed the growth increment value (shoot height and collar diameter) of *Thespesia populnea, Swietenia mahagoni, Cordia oblique, Ficus benghalensis* and *Syzygium* Sp. were better when compared to *Phyllanthus emblica* (Table 2). The growth increment value of collar diameter of *Ficus religiosa*was (+) 7.19, while the next lowest value was (+) 2.14 (*Swietenia mahagoni*) indicating the suitability of the introduced AM fungi to *Ficus religiosa*.

Although, the outcome of this study generally agree with former reports on the compatibility of AM fungi to tree seedlings for positive growth (Young, 1990; Michelsen, 1993), it contradicts with *Tectona grandis* and *Tamarindus indica* as revealed by growth incremental value of the species respectively (Table 3). There are few previous reportson tropical trees where mycorrhizal inoculation failed to

Table 2. Growth parameters of selected species in nursery

Sl. No.	Name of the species	By the end of 3rd Month		By the end of 6th Month		By the end of 12th Month	
		AM fungi inoculated / Control					
		Shoot Height (cm)	Collar Diameter (mm)	Shoot Height (cm)	Collar Diameter (mm)	Shoot Height (cm)	Collar Diameter (mm)
1.	*Mangifera indica*	26.23/25.33	6.48/6.68	35.23/30.21	8.28/7.02	42.5/38.93	12.7/12.24
2.	*Artocarpus integrifolia*	65.2/52.1	8.27/7.42	74.9/64.77	19.24/19.13	78.93/72.5	12.02/11.99
3.	*Cordia obliqua*	132.13/122.63	19.25/19.03	166.33/141	28.03/26.47	236.63/219.5	32.12/31.1
4.	*Tamarindus indica*	53.3/45.27	5.92/4.56	58.48/47.21	6.01/4.98	69.8/69.6	7.06/7.01
5.	*Tectona grandis*	23.7/23.32	5.5/5.46	24.14/24.26	7.41/7.27	46.72/44.22	8.17/7.45
6.	*Thespesia populnea*	39.17/38.27	6.3/6.29	100.25/95.56	10.29/8.56	141.33/117.6	16.46/14.67
7.	*Swietenia mahagoni*	37.73/29.07	6.98/5.97	51.45/35.55	10.14/9.16	77.5/47.79	12.93/10.79
8.	*Azadirachta indica*	84.9/79.6	6.2/5.18	87.17/86.03	12.87/12.19	147/144.83	15.4/14.06
9.	*Ficus benghalensis*	74.67/69.8	5.68/4.91	92.2/90	12.58/9.62	140.34/128.87	17.69/16.56
10.	*Ficus religiosa*	70.59/70.43	5.3/5.22	89.23/87.4	16.39/14.22	152/142.83	19.87/12.68
11.	*Holoptelea integrifolia*	69.9/69.5	2.2/2.0	85.73/84.33	12.41/12.94	147.5/142.83	17.1/16.8
12.	*Grevillea robusta*	57.67/48.17	13.94/7.16	101.77/96.9	14.34/14.17	154.81/145.73	19.95/19.21
13.	*Phyllanthus emblica*	30.21/30.07	6.11/6.69	35.5/31.67	10.41/10.31	68.7/63.52	10.8/10.76
14.	*Syzygium Sp.*	35.47/27.87	3.79/3.0	58.6/48.73	6.55/5.10	104.76/82.67	9.75/8.23

Table 3. Growth increment (Shoot and Collar diameter) values

Sl. No.	Name of the species/Family	Growth increment value					
		By the end of 3rd Month		By the end of 6th Month		By the end of 12th Month	
		Shoot Height (cm)	Collar Diameter (mm)	Shoot Height (cm)	Collar Diameter (mm)	Shoot Height (cm)	Collar Diameter (mm)
1.	*Mangifera indica*	(-) 0.9	(-) 0.2	(+) 5.02	(+) 1.26	(+) 3.57	(-) 0.46
2.	*Artocarpus integrifolia*	(+) 13.1	(+) 0.85	(+) 10.13	(-) 0.11	(+) 6.43	(-) 0.03
3.	*Cordia oblique*	(+) 9.5	(-) 0.22	(+) 25.33	(+) 1.56	(+) 17.13	(+) 1.02
4.	*Tamarindus indica*	(+) 8.03	(+) 1.36	(-) 1.27	(+) 1.03	(-) 0.2	(-) 0.05
5.	*Tectona grandis*	(-) 0.38	(+) 1.72	(-) 0.12	(-) 0.14	(-) 2.5	(-) 0.72
6.	*Thespesia populnea*	(-) 0.9	(-) 0.14	(+) 4.69	(+) 1.73	(+) 23.73	(+) 1.79
7.	*Swietenia mahagoni*	(+) 8.66	(-) 0.04	(+) 15.9	(+) 0.98	(+) 29.71	(+) 2.14
8.	*Azadirachta indica*	(+) 5.3	(-) 0.1	(-) 1.14	(+) 0.68	(-) 2.17	(+) 1.34
9.	*Ficus benghalensis*	(+) 4.87	(+) 1.01	(-) 2.2	(+) 2.96	(+) 11.47	(+) 1.13
10.	*Ficus religiosa*	(-) 0.16	(+) 1.02	(-) 1.83	(+) 2.17	(+) 9.17	(+) 7.19
11.	*Holoptelea integrifolia*	(+) 7.6	(-) 0.2	(-) 1.4	(+) 0.53	(+) 4.67	(-) 0.3
12.	*Grevillea robusta*	(-) 0.4	(+) 6.78	(+) 4.87	(-) 0.17	(+) 9.08	(-) 0.74
13.	*Phyllanthus emblica*	(+) 9.5	(-) 0.58	(+) 3.83	(-) 0.1	(+) 5.18	(-) 0.04
14.	*Syzygium Species*	(-) 0.14	(-) 0.79	(+) 9.87	(+) 1.45	(+) 22.09	(+) 1.52

improve tree seedling growth (Cornet *et al*., 1982; Cuenca *et al*., 1990).

Phosphorus uptake

AM fungi play an important role in plant health and hence the shoot and root growth is affected by their abundance and diversity in the soil (Lekberg and Koide, 2005). Mycorrhizal root systems have a higher P absorption capacity compared with non-mycorrhizal roots and seem to be able to selectively absorb P from deficient soils. Comparison of plant P content between inoculated and uninoculated soil show that plants grown inoculated soils had a higher P concentration than in the uninoculated soil, the differences between treatments was possibly due to the introduced AM fungi, excepting *Thespesia populnea* was contradictory. The P concentration in *Thespesia populnea* with introduced AM fungi was 0.35 %, whereas in uninoculated seedling was having 0.49 % (Fig. 1).

The uptake of enhanced phosphorous nutrition by AM fungi is benefit to plants (Plenchette *et al*., 2005), in stimulating the production of growth regulating substances, increasing photosynthesis efficiency, improving osmotic adjustment under drought and salinity stresses and increasing resistance to insect pests and soil dwelling pathogens (Al-Karaki, 2006). The positive response and advantage in shoot height and collar diameter of most of the 14 species with inoculated AM fungi over the uninoculated in our study shows the importance of AM fungi as symbiont and P

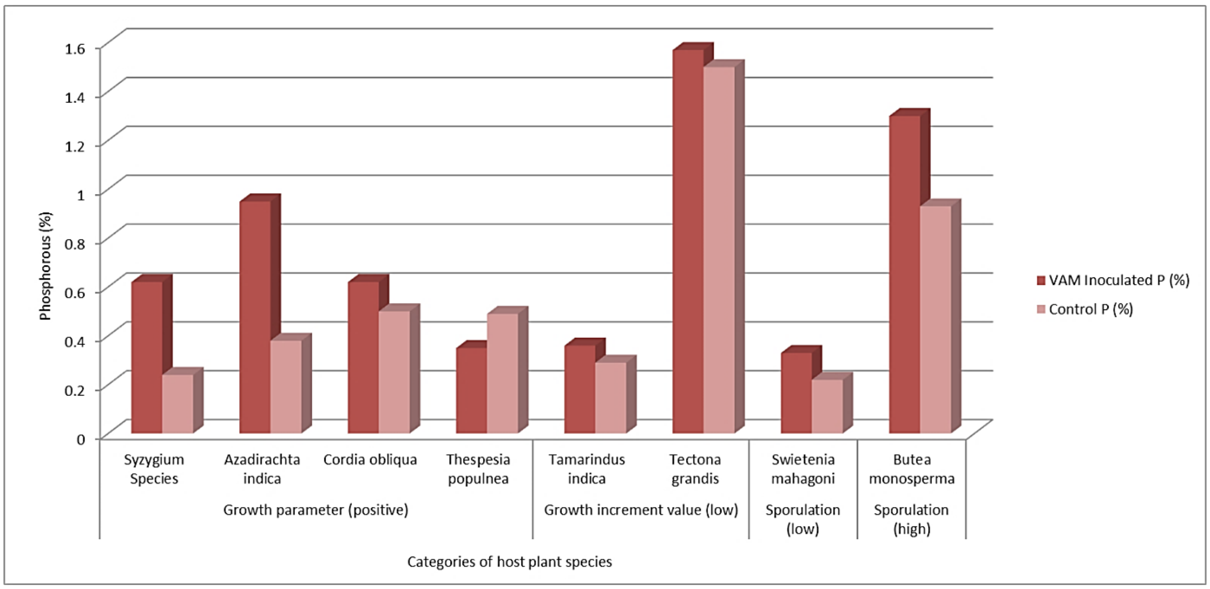
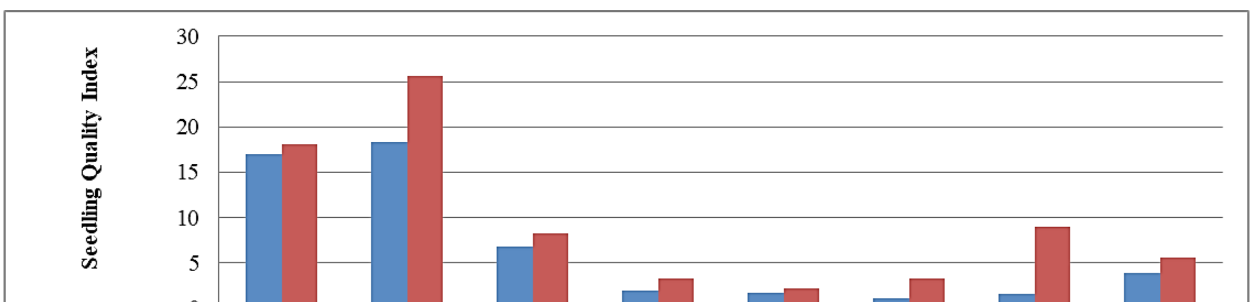


Fig. 1. Comparison of Phosphorus uptake



	Grevillea robusta	Cordia obliqua	Tamarindus indica	Tectona grandis	Swietenia mahagoni	Syzygium Sp.	Thespesia populnea	Azadirachta indica
Control	17.05	18.34	6.82	1.95	1.68	1.07	1.62	3.91
VAM treatment	18.07	25.59	8.22	3.29	2.15	3.31	9.01	5.61

Fig. 2 Seedling Quality Index of AM fungi infected species

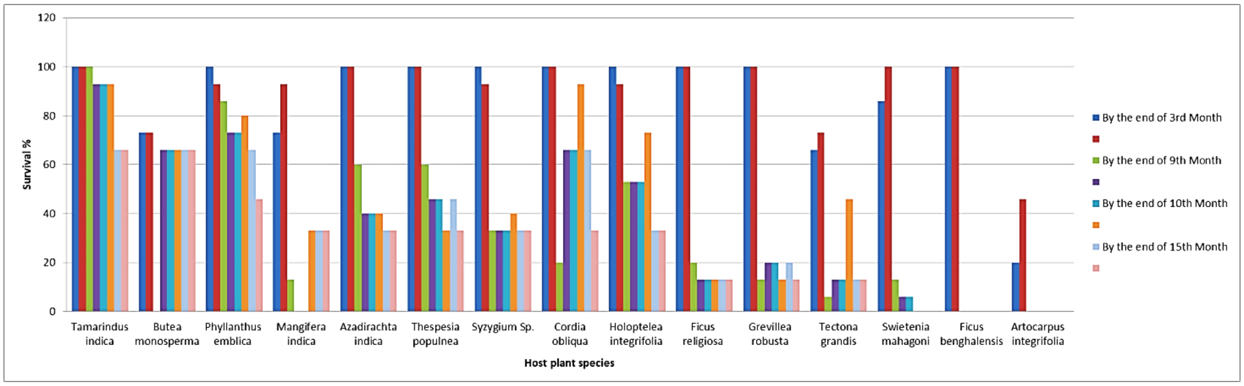


Fig. 3. Establishment of AMF infected an un-infected species in field

mobilizer.

Seedling Quality Index

All the treatments significantly improved the seedling quality, wherein maximum seedling quality index (25.59) was recorded in *C. obliqua* inoculated plants, followed by *G. robusta* (Fig. 2).

Establishment of seedlings in open cast mining area

Transplanted seedlings were well established with good survival percentage. Third-month observation was taken after the establishment of seedlings (December 2018). Survival percentage of most of the species was less as shown in 9thmonth column (June 2018), which was due to scarcity of water. Dried seedlings recovered after receiving the rains in the mine area, which was evident by the emergence of new leaf shoots in the plants as illustrated in the figure (No. 3) for 10th month column.

Those species performed well in open cast mining area even after 15 months were *Tamarindus indica* (60%), *Cordia obliqua*(60%) and*Butea Monosperma* (60%). The other species of *Phyllanthus emblica, Thespesia populnea, Syzygium Sp.* and *Holoptelea integrifolia* showed survival percentage near to about 40% after 15th month. The reduced survival percentage of other species could be due to disturbed soils in mining area, as highly disturbed habitats such as mine sites have found reduced levels of mycorrhizal propagules (Danielson, 1985; Brundrett, 1991).

CONCLUSION

Seedling quality parameters of all the tested plant species have been improved, when they were inoculated with AMF under nursery conditions except *Millettia pinnata, Salvadora persica, Pithecellobium dulce, Syzygiumcumini, Hardwickiabinata* and *Butea monosperma.*

Cordia oblique, Thespesia populnea, Azadirachta indica, Ficus benghalensis, Ficus religiosa, Holoptelea integrifolia and *Grevillea robusta* exhibited better growth characters when compared to control. Phosphorus analysis between AMF inoculated and control revealed the supplementing effect of AMF as P mobiliser. Seedlings inoculated with AMF exhibited better SQI when compared to uninoculated.

AMF inoculated *Phyllanthus emblica, Holoptelea integrifolia* and *Syzygium* sp., exhibited 100% survival during the 3rd month observation when compared to control, while control of *Tamarindus indica, Cordia obliqua, Thespesia populnea, Azadirachta indica, Ficus religiosa, Grevillea robusta*and *Ficus benghalensis* were on par with treated. 15th month observation revealed *Tamarindus indica, Butea monosperma, Phyllanthus emblica* and *Cordia obliqua* exhibited maximum survival percentage of more than 60%, followed by *Holoptelea integrifolia, Thespesia* populnea, *Syzygium* sp., *Azadirachta indica* and *Mangifera indica* with survival percentage near to 40%, while the least percentage of 20% was with *Ficus religiosa*, *Grevillea robusta* and *Tectona grandis* species.

Conflict of Interest

The research findings in this article do not have any conflict of interest.

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