International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 54-60

Received: 05-07-2018
Accepted: 10-08-2018

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Enhancement of seedling vigour through biofertilizers application in gamhar (*Gmelina arborea* Roxb.)

Rashmiprava Maharana, Manmohan J Dobriyal, LK Behera and Madhuri Sukhadiya

Abstract
An experiment was conducted to assess the the growth performance of the Sivan (*Gmelina arborea* Roxb.) seedlings in response to various biofertilizers application, which was laid in CRD consisting twelve treatments (T_1 to T_{12}) of four biofertilizers AM, PSB, Azospirillum and Banana Pseudostem Sap (Novel) in sole and combinations along with control. The results revealed that biofertilizers application significantly influence the growth parameters, total biomass and quality of seedlings. Among all treatments, biofertilizers combination AM + PSB + Banana Pseudostem Sap reflected maximum seedling height (156.52 cm), collar diameter (13.20 mm), number of leaves per plant (24.67), leaf area per plant (3708.93 cm^2), root length (30 cm) and number of roots per plant (21.67), fresh and dry biomass of leaves shoot, shoot and whole plant after seven months of observations indicating greater quality and vigour of seedlings for better field establishment.

Keywords: *Gmelina arborea*, biofertilizers, seedling vigour, AM, PSB, azospirillum, banana pseudostem sap

Introduction

Gamhar or Shivan (*Gmelina arborea* Roxb.) belonging to the family Lamiaceae is native to India, Bangladesh, Sri Lanka, Myanmar, Thailand, southern China, Laos, Cambodia, and Sumatra. In India, it is found throughout greater part in eastern sub-Himalayan tract, Indo-Gangetic plains, Aravali Hills, central India, western Peninsula and western Himalayas. Characteristically, it is found scattered in dry deciduous and moist deciduous forests but occurs occasionally in evergreen forests. *G. arborea* is a commercial fast growing multipurpose tree species that grows up to 30 m in height and over 80 cm Diameter at Breast Height (DBH) with a growth rate of 40-50 m^3/ ha/ year in areas of good soils and rainfall. It performs best on fresh, well-drained, fertile alluvial soils where rainfall from 1200 to 4500 mm, temperature ranges from 20 to 45 °C and elevation 1000 m MSL (Tiwari, 1995) [35]. It is a light demander, moderately frost hardy and has good power of recovering but doesn't withstand excessive drought and bad drainage condition.

G. arborea wood is relatively light with a density of 420 to 640 kg per m^3 and a calorific value of about 4800 kcal per kg used in light construction, general carpentry, packaging, furniture, particle board, plywood, paper and pulp and matches (Azeez *et al.*, 2016) [4]. Different parts of the plant can be used medicinally like root, fruit, leaf, flower, bark etc. (Deepthi *et al.*, 2015) [9]. Its leaves can be used as fodder for goat and bucks as having high nutritive value and its flowers produce abundant nectar from which high quality honey is produced (Okafor *et al.*, 2002; Ukanwoko and Okehielem, 2016) [16].

It is widely grown as a component of agroforestry system in humid tropics (Pooja *et al*., 2017) [27], for which production of quality planting material in the nursery is essential for better establishment of seedlings in the agroforestry field (Orwa *et al.*, 2009) [24]. In the view of enormous potentiality of *G. arborea* for afforestation and realization of its multiple uses, large scale plantation programmes have been taken up by various organizations. It is also used as shade tree in coffee and cocoa plantations. Use of biofertilizers (AM fungi, PSB, Azospirillum, Azotobacter, Rhizobium, Acetobacter, seaweeds *etc*.) supplemented with organic manures during the initial period of growth is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the fertilizers for sustainable production. These accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants. The biofertilizers helps to develop the root profile (rhizosphere) of seedlings in nursery as well as in plantations. These organisms assimilate soil nutrients and improve soil structure essential for plant growth. Nowadays, pseudostem sap prepared from banana plant has been used as liquid fertiliser in agricultural crops as a good source of potassium, calcium and magnesium but not yet has been effectively used in tree crops due to wide information gap on its efficiency and utilization in tree nurseries. Therefore, emphasis should be given on the application of different biofertilizers in single and combinations for production of quality planting material organically. In the present study, the effect of different biofertilizers on the enhancement of seedling vigour of *G. arborea* was assessed for effective growth and development at nursery stage.

Materials and Methods

The present investigation was conducted during the academic year 2017-18, at the Green House Complex, College of Forestry (ACHF), Navsari Agricultural University, Navsari, Gujarat, India. The biofertilizers like AM (Mycozone) PSB and Azospirillum and Banana Pseuodostem Sap (Novel) were collected in required concentrations ahead of sowing. The seedlings were sown in polythene bag of size 6′ × 4′ filled with potting media (Soil: Sand: Vermicompost: 2:1:1). The transplanted seedlings were arranged in 30 seedlings group per replication in CRD with specific tagging. The biofertilizers were applied @ 20 ml/seedling in each treatment at 30 days interval after one month of transplanting. The biofertilizers were applied in two or more combinations, the concentration/amount were divided proportionally to make @ 20 ml/seedling. After 30 days of application of biofertlizers the growth parameters like seedling height, collar diameter and number of leaves/plant were recorded at monthly interval while other parameters like leaf area per plant, root length, number of roots per seedling, fresh and dry weight of leaves, shoot, root and whole plant were recorded after seven months (210 DAA). The seedling vigour indices like root length to shoot length ratio, root to shoot ratio, sturdiness quotient, quality index (Dickson, 1960) [10] and vigour index (Abdul-Baki and Anderson, 1973) [1] were derived from the above observations. The data obtained was subjected to statistical analysis using OPSTAT software to compare the treatment means, where the treatment effects were significant (Panse and Sukhatme, 1967) [25].

Treatment No.		Treatment Details
T_1	:	Without Biofertilizers (Control)
T_2	:	AM
T_3	:	PSB
T_4	:	Azospirillum
T_5	:	Banana Pseudostem Sap (NOVEL)
T_6	:	AM + PSB
T_7	:	AM + Azospirillum
T_8	:	AM + Banana Pseudostem Sap (NOVEL)
T_9	:	PSB + Azospirillum
T_{10}	:	PSB + Banana Pseudostem Sap (NOVEL)
T_{11}	:	Azospirilum + Banana Pseudostem Sap (NOVEL)
T_{12}	:	AM + PSB + Banana Pseudostem Sap (NOVEL)

Results and Discussions

The salient outcomes of the research results revealed that biofertilizers application on the seedlings at nursery stage significantly enhanced the growth parameters (seedling height, collar diameter and number of leaves per plant), fresh and dry biomass of seedlings and its parts (shoot, root, leaves) as well as the overall quality and vigour of *G. arborea* seedlings as compared to the uninoculated seedlings. A constant increment in the growth parameters and significant variation between treatments was observed during the period of study (from 30 to 210 DAA).

Throughout the growing period, (from 30 to 210 DAA), T_{12} (AM + PSB + Banana Pseudostem sap) shown maximum value for all the monthly monitored parameters (Fig - 1, 2 and 3). Among all the treatments at end of the trial (210 DAA), biofertilizers application in combination (AM + PSB + Banana Pseudostem sap) has resulted in higher increase in all growth parameters such as seedling height (156.83 cm), collar diameter (13.20 mm), root length (30 cm) and number of roots per seedling (21.67) (Table-1). Similar findings have been reported by many researchers like Barua *et al.*, 2010; [6] Mohan and Sreedhar, 2016 [8]; Verma *et al.*, 2008 [38] in *Tectona grandis* seedlings; Tomar, 2007 [36]; Sreedhar and Mohan, 2016 [8].

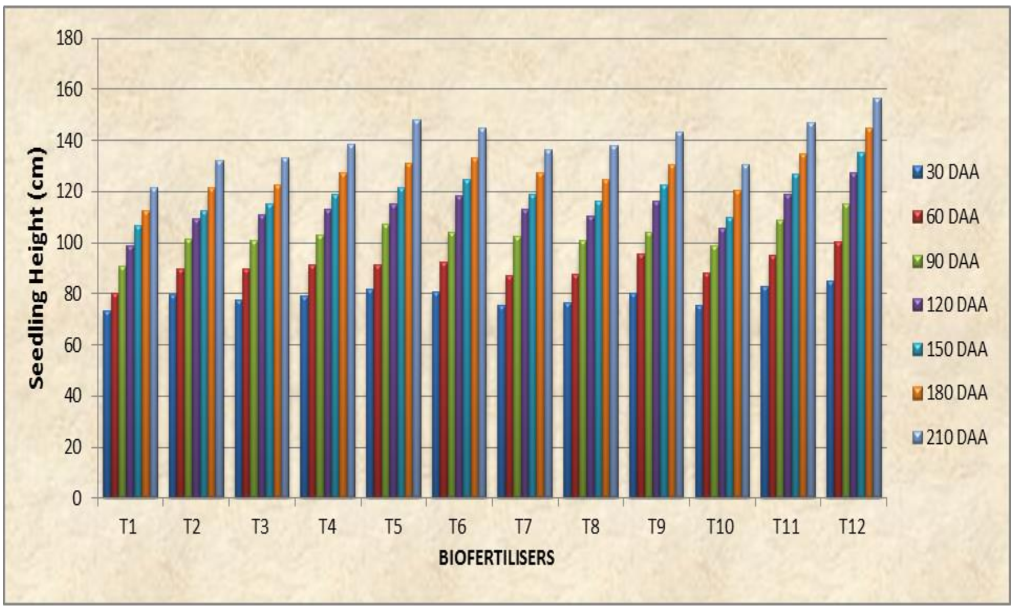


Fig 1: Influence of biofertilisers (T_1-T_{12}) on the growth in Seedling Height of *Gmelina arborea* Roxb. from 30 DAA to 210 DAA

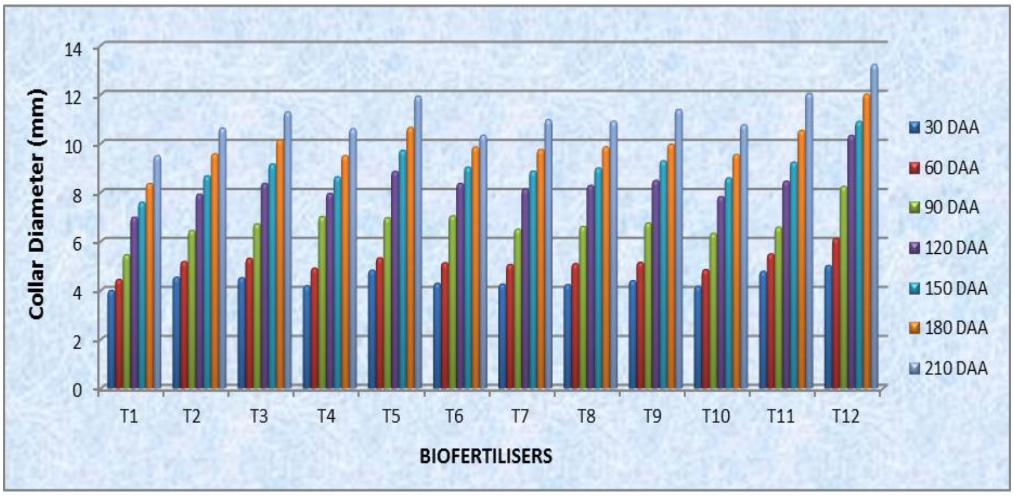


Fig 2: Influence of biofertilisers (T_1-T_{12}) on the growth in Collar Diameter of *Gmelina arborea* Roxb. seedlings from 30 DAA to 210 DAA

The average number of leaves per plant was maximum (25.39) at 120 DAA, then decreased (6.8) at 150 DAA and again increased upto 24.67 at 210 DAA (Fig-3). This is due to the rapid shedding of leaves in the leaf fall period (January) as Gmelina is a deciduous tree species. Similar results were reported by Abdullahi *et al.* (2012) [2] who revealed that application of liquid fertilizer complex on *Vitellaria paradoxa* seedlings increased no. of leaves and leaf chlorophyll content of plants.

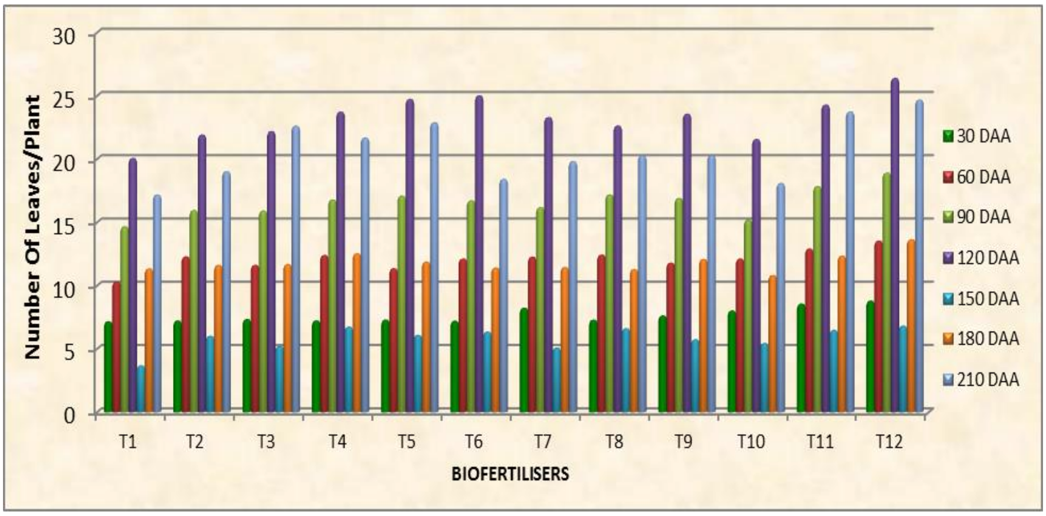


Fig 3: Influence of biofertilizers (T_1-T_{12}) on the growth in number of leaves/plant of *Gmelina arborea* Roxb. seedlings from 30 DAA to 210 DAA

The leaf area per plant also shown higher value (3708.93 cm^2) in biofertilizer treatment (AM + PSB + Banana Pseudostem sap) as compared to other treatments. Balasubramanian and Srinivasan (1995) [5] have also reported that inoculation with four AM fungi significantly increased the total biomass, leaf area and total chlorophyll content in leaves of *Ailanthus excelsa*, *Tectona grandis* and *Dalbergia sissoo* seedlings in nursery. The maximum root length (30 cm) and number of roots per plant (21.67) were observed in application of AM + PSB + Banana Pseudostem Sap followed by sole application of Banana Pseudostem Sap. Dudhane *et al.* 2011 [11] also confirmed the positive effect of Banana Pseudostem sap on plants in his study.

Table 1: Influence of biofertilizers on the growth parameters of *Gmelina arborea* Roxb. seedlings at 210 DAA

Treatments	Seedling Height (cm)	Collar Diameter (mm)	No. of Leaves/Plant	Leaf Area/Plant (cm^2)	Root Length (cm)	No. of Roots per Seedling
T_1	121.53	9.48	17.17	1125.97	18.56	16.44
T_2	132.17	10.61	19.00	1896.48	21.33	18.22
T_3	133.00	11.27	22.60	2449.23	22.22	19.00
T_4	138.53	10.58	21.67	2071.15	19.33	16.78
T_5	148.25	11.91	22.87	3090.13	26.11	20.67
T_6	145.90	10.31	18.40	2119.33	22.11	19.22
T_7	136.53	10.95	19.80	1751.57	23.44	20.11
T_8	137.86	10.89	20.27	1669.13	24.67	19.00
T_9	143.32	11.37	20.27	1704.47	22.67	18.44
T_{10}	130.67	10.74	18.07	1334.13	17.89	15.89

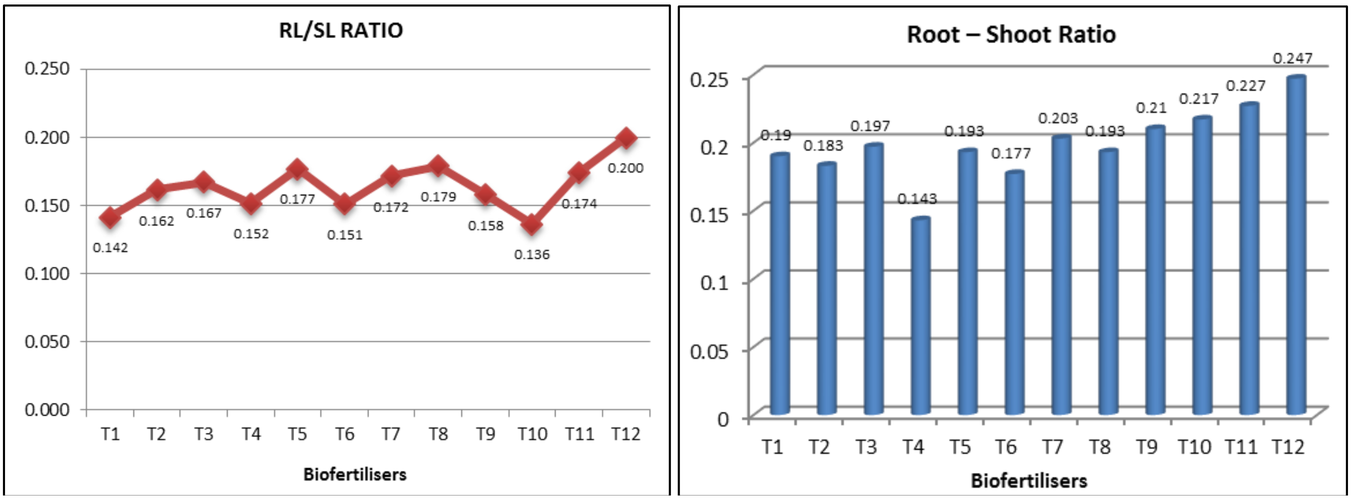
T_{11}	146.87	12.52	23.73	3323.18	25.50	19.33
T_{12}	156.52	13.20	24.67	3708.93	30.00	21.67
SEm (±)	5.35	0.45	0.85	124.63	0.95	0.68
CD (0.05)	15.71	1.32	2.49	363.75	2.80	1.99
CV %	6.65	6.94	7.11	9.87	7.23	6.27

The fresh and dry biomass of seedlings (whole seedling and parts as leaves, shoot and root) significantly varied between different treatments, significantly varied between different treatments, out of which the monthly application of AM + PSB + Banana Pseudostem sap gave maximum result in fresh weight of leaves (32.07 g), shoot (50.29 g), root (16.27 g) and the whole plant (98.63) as well as the dry weight of leaves (6.82 g), shoot (23.03 g), root (4.35 g) and the whole plant (34.2 g) after monthly application of biofertilizers (Table-2). Similar findings were reported by Rangarajan and Narayanan, 1990 in *Acacia decurrens*; Balasubramanian and Srinivasan (1995) [5] in *Tectona grandis, Dalbergia sissoo* and *Ailanthus excelsa*; Mohan and Rajendran (2014) [19] in *Feronia elephantum*; Choudhury (2016) [8] in *Santalum album* and Goetten *et al*. (2016) [14] in other woody species. Talukdar and Thakuria (2000) [34] also reported that AM fungi inoculated in *G. arborea* and *Tectona grandis* with organic amendments gave better yield in terms of shoot and root biomass in degraded soils.

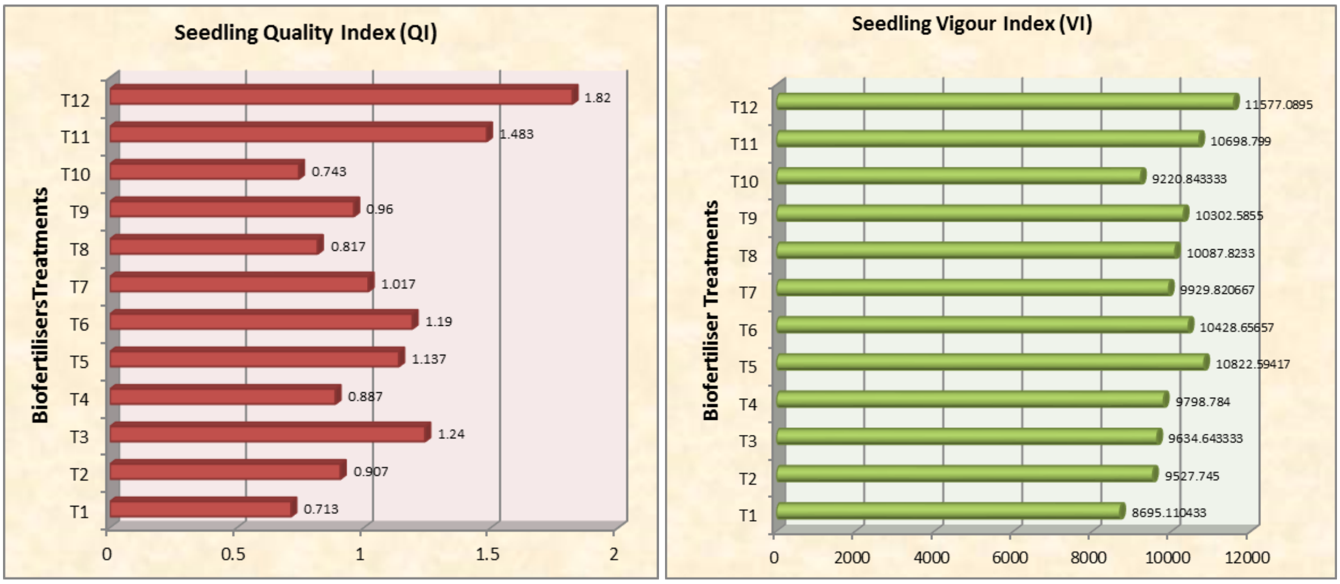
Table 2: Influence of biofertilizers on the fresh and dry biomass of *Gmelina arborea* Roxb. seedlings at 210 DAA

Treatments	Fresh Weight (g)				Dry Weight (g)			
	Leaves	Shoot	Root	Whole Plant	Leaves	Shoot	Root	Whole Plant
T_1	11.00	26.29	7.94	45.22	3.18	7.60	2.06	12.84
T_2	19.40	27.21	8.92	55.53	3.71	10.11	2.54	16.35
T_3	14.35	38.09	13.15	65.59	4.22	13.32	3.44	20.98
T_4	22.07	30.75	10.02	62.83	3.96	11.63	2.23	17.82
T_5	26.33	36.84	9.34	72.50	4.68	12.06	3.25	19.99
T_6	15.65	45.16	12.89	73.69	3.66	15.43	3.35	22.44
T_7	17.80	32.99	10.56	61.35	3.77	10.89	2.99	17.65
T_8	18.11	29.21	8.59	55.91	3.38	8.91	2.37	14.66
T_9	12.72	28.25	11.16	52.12	3.25	9.63	3.17	16.05
T_{10}	10.04	25.52	7.70	43.26	3.03	7.22	2.23	12.48
T_{11}	24.00	42.83	14.64	81.47	5.11	17.83	3.69	26.63
T_{12}	32.07	50.29	16.27	98.63	6.82	23.03	4.35	34.20
SEm (±)	0.79	1.29	0.40	1.83	0.17	0.47	0.10	0.46
CD (0.05)	2.33	3.78	1.16	5.38	0.50	1.38	0.30	1.36
CV %	7.37	6.47	6.26	4.96	7.24	6.63	6.04	4.15

The seedling quality parameters are the indicator of the overall growth of the seedlings. The root length to shoot length ratio (0.20) [Fig. 4(a)], root - shoot ratio (0.247) [Fig. 4(b)], seedling quality index (1.820) [Fig. 4(c)] and seedling vigour index (11577.09) [Fig. 4(d)] was maximum with treatment T_{12} (AM + PSB + Banana Pseudostem) at 210 DAA while Sturdiness Quotient (SQ) (11.75) was found lowest in T_{11} (Azospirillum + Banana Pseudostem). The SQ was found in order of $T_{11} < T_3 < T_{12} < T_{10} < T_5 < T_7 < T_2 < T_9 < T_8 < T_1 < T_4 < T_6$. The lowest value of SQ signifies the more robustness of the seedling in terms of field establishment. Chandra and Ujjaini (2002) [7] also witnessed similar results in tree seedlings treated with AM fungi + organic matter for seedling quality parameters. These findings are in accordance with the findings of earlier researchers on native and related tree species like *Tectona grandis* Ayswarya, 2008 [3]; Rajeshkumar *et al*., 2009 [28]; Joseph *et al*., 2010 [15]; and Mohan and Ayswarya, 2012 [20] and also in exotic species. Ratha Krishnan *et al*. (2004) [30] also reported that inoculation of Azospirillum, Azotobacter, PSB and AM fungi on *Simarouba glauca* seedlings resulted in increased root growth ratio as compare to control.



(a) (b)



(c) (d)

Fig 4: Influence of biofertilizers on (a) root length - shoot length ratio; (b) root - shoot ratio; (c) Seedling Vigour Index (QI) and (d) Seedling Quality Index (QI) of *Gmelina arborea* at 210 DAA

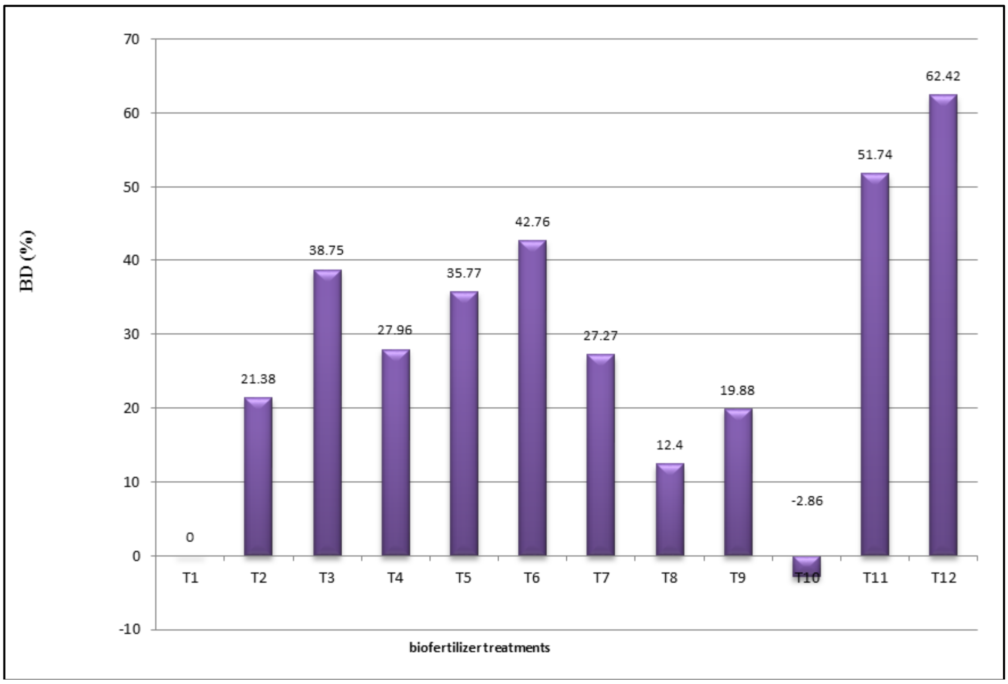


Fig 5: Influence of biofertilizers on biofertilizer dependancy (%) of *Gmelina arborea* seedlings in nursery

The biofertilizer dependency (BD%) of seedlings were reported positive in all the treatments except for control except T_{10} (PSB + Banana Pseudostem Sap). The BD (%) were recorded highest in T_{12} (AM + PSB + Banana Pseudostem) followed by T_{11} (Azospirillum + Banana Pseudostem Sap) at the end of the study indicating highest compatibility between plant root and inoculants (Fig. 5). Zambrano and Diaz (2008) [39] have also reported a positive correlation between mycorrhization and plant height, and a synergic effect between AM fungi, *Glomus spp.* and *Azospirillum brasilense* on *G. arborea* seedlings. Muthukumar and Udaiyan (2010) [22] found positive response in all growth parameters and nutrient uptake in *Casuarina equisetifolia* seedlings inoculated with biofertilizers under tropical nursery conditions, which in consonance to the findings of Patel, S. M., 2006 [26] and Rajeshkumar *et al.*, 2009 [28]. Kumar *et al.* (2015) [16] analyzed that the high percentage of root colonization in AMF treated seedlings is found to be directly correlated with an improved growth and physiology. Rashmi and Bhavana (2015) [29] stated that inoculation of VAM in seedlings of woody species at nursery stage can be aided in the development of agroforestry models and other floristic vegetation in the degraded land. Growth and yield enhancing role of Banana pseudostem sap also reported by Feriotti and Iguti, 2009 [12]; Rathod *et al.* 2017 [31] in *Punica granatum*; and Salunkhe *et al.*, 2013 in onion crop. It is known that biofertilizers can enhance plant growth and production under different conditions, including various soil stress conditions (Ghosh *et al.*, 2008; Manoharan *et al.*, 2010; Dudhane *et al.*, 2011 and Miransari *et al.*, 2011) [13, 17, 11, 18].

Conclusion

The use of biofertilizers and their different combinations to enhance seedling vigour is current need of the day for promotion of organic ecofriendly planting material. The present study throws light on the utility of new biofertilizers and suitable combinations of different bio-inoculants with positive synergistic interactions, for a given set of environmental conditions. Thus, soil micro-culture with biofertilizers during the initial stage of growth (nursery stage) increases seedling vigour and enhance growth by improving root activity and robustness of seedling for proper field establishment. In current study, the combined application of AM fungi, PSB and Banana pseudostem sap (Novel) followed by dual application of Azospirillum and Banana pseudostem sap (Novel); and sole application of Banana pseudostem sap (Novel) has enhanced the seedling vigour and seedling quality in *G. arborea* as compared to other biofertilizers. The overall seedling quality was enhanced which indicated greater seedling vigour and higher root density that may be helpful for production of quality seedling for field planting. These kinds of nursery practices will promote organic nurseries for raising quality planting material and establishment of economically viable plantations even in degraded sites.

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