Journal of Biofertilizers & Biopesticides
ISSN: 2155-6202
D'souza, et al, J Biofertil Biopestici 2014, 6:1
DOI: 10.4172/2155-6202.1000148

Reasearch article Open Access

Evaluation of Bio-inoculants Enriched Marginal Soils as Potting Mixture in Coffee Nursery

Shiva Prasad P, Hareesh SB, Maria Violet D'souza*, Manjunath AN and Jayarama

Central Coffee Research Institute, Chikmagalur, Karnataka, India

***Corresponding author:** Violet D'Souza M, Central Coffee Research Institute, Karnataka, India, Tel: +91-80- 22266991-994; E-mail: m.violet@gmail.com

Received date: August 14, 2014; **Accepted date:** August 15, 2014; **Published date:** August 22, 2014

Abstract

Fertile jungle soil is a primary ingredient of potting mixture used in coffee nursery to raise healthy, vigorous seedlings and in recent times its availability has diminished due to the receding forest lands in traditional coffee cultivating areas. Hence a nursery trial was conducted with the objective of exploring the possibility of utilizing marginal or less fertile soils enriched with bio-inoculants in the potting mixture. Two soils, (soil-1 and soil-2), which are less fertile and marginal in characteristics compared to the jungle soil enriched with bio-inoculants consortia of *Azosprillum*, *Pseudomonas flurosence*, Phosphate Solubilising Bacteria (PSB) and Vesicular Arbuscular Mycorrihiza (VAM) were employed in the secondary nursery to raise coffee seedlings and monitored for growth parameters, nutrient uptake, soil nutrient status and colony forming units for about 200 days after sowing. The results of the study indicated that the recommended Standard Package of Practice (SPP) with jungle soil, Farm Yard Manure (FYM) and sand in the 6:2:1 proportion is a best suited potting mixture to raise the coffee nursery. But in absence of the fertile jungle soil, the marginal soils also can be utilized as an ingredient of potting mixture with due care to incorporate adequate quantity of farm yard manure and the microbial consortia is not a substitute for FYM in the potting mixture.

Keywords: Jungle soil; Soil-1; Soil-2; Bio-inoculants

Introduction

Raising vigorous and healthy coffee seedlings in the nursery is a must for establishing superior coffee plantation in a long run. The recommended Standard Package of Practice (SPP) for coffee nursery includes a primary sowing bed prepared using the fertile jungle soil and mixture of jungle soil, Farm Yard Manure (FYM) and sand in the ratio of 6:2:1 [1] for the poly bag/secondary nursery. Nowadays due to dwindling of forest lands in the traditional coffee growing areas and various other associated problems, procuring of fertile jungle soil in large quantity to raise the nursery is not an easy task. Under such a situation the farmers are compelled to use the easily available marginal/ less fertile soils for raising nursery which in turn will result into weak and unhealthy seedlings. The advantageous uses of bio-inoculants for boosting growth in the nursery are known in many crops and also in coffee. The individual and consortia of *Azosprillum*, *Pseudomonas flurosence*, Phosphate Solubilising Bacteria (PSB) and Vesicular Arbuscular Mycorrihiza (VAM) have been tried in coffee nursery [2-4] along with SPP. Hence an effort was made to improve the marginal soils by enriching with bio-inoculants and a nursery trial was conducted to study the possibility of utilizing these enriched soils in potting mixture.

Materials and Methods

A nursery trial on Chandragiri (arabica) seedlings was conducted during the year 2010-11 at Central Coffee Research Institute, Chikmagalur District to explore the possible utility of marginal soils enriched with bio-inoculants in nursery mixture. A Randomized Block Design (RBD) with seven treatments (T_1-T_7), three replications per treatment and about 100 seedlings per treatment was adopted in the trial where in two types of soils namely, soil-1 and soil-2 were employed. Microbial inoculants viz., *Azosprillum*, *Pseudomonas flurosence*, Phosphate Solubilizing Bacteria (PSB) and Vesicular Arbuscular Mycorrihiza (VAM) procured from University of Agricultural Sciences, Dharwad were used to prepare bio-inoculants consortia. Adequate numbers of seeds were sown in three different primary beds prepared using jungle soil, soil-1 and soil-2 and seedlings in '*topi*' stage were raised. These seedlings were transplanted during April from primary bed to the secondary nursery with the following treatments.

T_1 – Soil 1 or Soil 2 only

T_2 –Standard package of practice (SPP)

[Jungle soil, farm yard manure (FYM) and sand in the ratio of 6:2:1]

T_3 – T2 + Consortia (100 g)

T_4 - Soil 1 / Soil 2: FYM: Sand - (4: 2: 3)

T_5 – Soil 1 / Soil 2 (4): Consortia (50 g): Sand (3)

T_6 – Soil 1 / Soil 2 (4): Consortia (100 g): Sand (3)

T_7 - Soil 1 / Soil 2 (4): Consortia (150 g): Sand (3)

Nursery was maintained under shade net and as per the existing package of practice all the necessary plant pest and disease care practices were followed strictly. At intervals of 100, 150 and 200 days after transplanting (DAT) observations on shoot and root length, stem girth, leaf area, dry weight of seedlings, soil chemical parameters like pH, EC, available major and secondary nutrients, organic carbon content and DTPA extractable micronutrients were determined by employing the standard methods. The soil biological properties, namely, microbial population [5], microbial respiration, Dehydrogenase activity (Incubation method) [6] and Biomass Carbon [7] were also recorded at different intervals. Nutrient uptake (N, P and K) from growth media was recorded at the end of the trial (200 DAT).

Results and Discussion

Soil characteristics

The soil physical, chemical and microbial parameters of the soils employed in the study are presented in Tables 1-3 respectively. Perusal of the data indicates that the two soils (Soil 1 and Soil 2) do not differ much from the jungle soil with respect to the sand, silt and clay contents.

Soil Type	Sand (%)	Silt (%)	Clay (%)	Classification
Jungle soil	46.5	17.6	35.3	Clay loam
Soil-1	49.9	19.3	31.0	Clay loam
Soil-2	49.3	17.0	33.2	Clay loam

Table 1: Soil physical properties (Initial)

			Available nutrients				DTPA extractable micronutrients			
Soil type	**pH**	**OC** (%)	**P** (kg/ha)	**K** (kg/ha)	**Ca** (ppm)	**Mg** (ppm)	**Cu** (ppm)	**Zn** (ppm)	**Mn** (ppm)	**Fe** (ppm)
Jungle Soil	5.9	3.0	23	159	1200	90	0.7	4.5	33.3	27.1
Soil-1	4.8	1.0	2	76	800	30	0.5	1.6	21.6	25.2
Soil-2	5.7	0.56	8	109	900	60	0.3	2.5	12.5	3.1

Table 2: Soil chemical properties (Initial)

Soil type	*P. Fluroscence* (10^3)	**PSB** (10^3)	*Azosprillum* (10^3)	**VAM** (%)	**Microbial Respiration** (CO_2 mg kg^{-1} soil hr^{-1})	**Dehydrogenase activity** (µg of PNP g^{-1} of soil hr^{-1})	**Biomass Carbon** (CO_2 mg kg^{-1} soil hr^{-1})
Jungle Soil	18	14	13	45	10.5	20.3	1575
Soil -1	10	8	3	20	3.1	2.5	357
Soil -2	7	7	5	30	1.1	3.8	295

Table 3: Microbial properties (Initial)

The jungle soil was far more superior to Soil 1 or Soil 2 (Table 2) in fertility status even though all the 3 soils registered acidic soil reaction. Soil 1 and Soil 2 had low organic carbon content and were deficient with respect to available P, K, Ca and Mg contents while the micro-nutrient status was not below respective critical limits. Hence Soil 1 and Soil 2 were referred to as marginal compared to the very fertile jungle soil. It can also be noted that Soil 1 and Soil 2 recorded lower microbial population as well as other biological properties compared to the jungle soil.

Growth parameters

The growth parameters of the seedlings in both the marginal soils recorded after 100 and 200 days of transplanting are presented in Tables 4 and 5 respectively. In general, the growth parameters increased in all the treatments over the period of observation. At 100 and 200 DAT, in both the marginal soils under study, the growth parameters, namely, plant height, root length, stem girth, number of leaves and leaf area were higher in seedlings receiving treatment T_3 (T_2+ 100 g consortia) compared to control T_1 (Soil 1/ Soil 2 only) at 100 DAT. The treatments T_2 (Standard package of practice- SPP) and T_4 (Soil 1/ Soil 2: FYM: Sand: 4: 2: 3), also recorded growth parameters on par with T_3. The growth of the seedlings receiving treatments T_5, T_6 and T_7 was poor compared to the seedlings under T_2, T_3 T_4. These observations are in lines of the results reported by Glory Swarupa, [4] who found significant increase in growth of coffee seedlings when treated with *Azospirillum*, Phosphobacteria and VAM. The potting mixtures under various treatments were subjected to analysis of nutrient status and biological properties to understand the variation in growth parameters observed under different treatments. Nutrient uptake of the seedlings was also studied.

Nutrient status of potting mixtures

At 200 DAT the potting mixtures were analyzed for the chemical properties (pH, OC) and nutrient status. The results are presented in Table 6 and 7 for Soil 1 and Soil 2 respectively. The soil reaction was near neutral in the treatments containing both the marginal soils with bio-inoculants. Per cent organic carbon and available P were significantly high in T_3 and on par with T_2 and T_4 compared to T_1 (Soil 1 and Soil 2 only). However, available K was high in T_7 and on par with T_5, T_6 and T_2 compared to T_1. Thus the soil analytical data clearly indicated the fact that the nutrient availability in T2 (SPP) is higher compared to the T_1 and the added microbial inoculants have the advantage of supplying nutrients in balanced and adequate quantities from the medium as seen in T_3.

Treatment	Soil-1					Soil-2				
	Plant height (cm)	**Root length (cm)**	**Stem Girth (mm)**	**No. of leaves**	**Leaf area**	**Plant ht.** (cm)	**Root length** (cm)	**Stem Girth** (mm)	**No. of leaves**	**Leaf area** (sq.cm)
T 1	6.6	9.4	2.35	3.9	14.17	7.0	8.5	1.42	2.7	13.66
T 2	8.3	12.7	1.45	4.8	21.74	8.0	11.9	1.52	4.5	18.30
T 3	9.3	11.8	1.50	4.8	20.75	8.8	11.9	1.78	5.3	20.33
T 4	7.7	11.8	1.34	5.5	20.47	8.1	10.8	1.47	5.1	14.42
T 5	5.8	9.7	1.34	2.2	10.95	7.2	9.5	1.44	2.6	13.31
T 6	5.5	10.8	1.33	2.0	11.81	6.1	9.9	1.46	2.1	10.89
T 7	5.2	8.9	1.30	2.2	11.70	6.9	9.1	1.40	3.5	10.13
Sem+/-	0.44	1.38	0.13	0.29	1.49	0.58	1.26	0.06	0.44	1.42
CD at 5%	0.92	2.88	0.26	0.60	3.10	1.22	2.63	0.12	0.92	2.96

Table 4: Growth parameters of seedlings - 100 DAT

Treatment	Soil-1					Soil-2				
	Plant ht. (cm)	**Root length** (cm)	**Stem Girth** (mm)	**No. of leaves**	**Leaf area**	**Plant ht.** (cm)	**Root length** (cm)	**Stem Girth** (mm)	**No. of leaves**	**Leaf area** (sq.cm)
T_1	7.1	14.7	2.0	7.0	9.5	9.7	16.1	2.5	8.3	15.2
T_2	16.3	17.3	3.6	11.5	46.3	16.2	16.7	3.8	11.1	39.6
T_3	16.8	19.1	3.9	12.3	51.6	19.2	19.4	4.0	12.8	56.1
T_4	16.2	15.1	3.4	10.7	38.5	15.4	15.2	3.4	10.9	34.1
T_5	7.9	16.1	2.4	9.6	11.2	9.6	16.2	2.6	9.9	14.4
T_6	10.4	15.9	2.6	10.6	21.8	9.0	15.2	2.6	10.4	14.1
T_7	9.5	14.7	2.4	9.9	19.5	9.7	16.0	2.9	9.5	15.3
Sem+/-	0.42	1.21	0.15	0.57	1.34	0.53	0.87	0.15	0.44	2.08
CD at 5%	0.87	2.47	0.31	1.17	2.75	1.08	1.78	0.31	0.90	4.28

Table 5: Growth parameters of seedlings (200 DAT)

Treat.	pH	OC (%)	Available nutrients				DTPA extractable micronutrients			
			P (kg/ha)	**K** (kg/ha)	**Ca** (ppm)	**Mg** (ppm)	**Cu** (ppm)	**Zn** (ppm)	**Mn** (ppm)	**Fe** (ppm)
T_1	4.6	0.9	13.7	199.7	700	30	0.5	4.5	28.5	25.9
T_2	5.7	4.2	104.0	388.7	800	130	0.6	7.5	107.0	27.5
T_3	6.3	4.2	98.0	434.7	1000	140	0.5	6.3	52.8	25.4
T_4	6.2	3.7	25.7	297.3	900	90	0.3	5.8	52.4	25.4
T_5	7.2	3.0	40.0	449.7	1600	240	0.3	5.6	41.7	20.7
T_6	7.9	3.8	26.7	413.3	1400	70	0.2	3.4	22.1	6.7

T_7	7.9	3.8	24.3	580.7	1400	100	0.2	4.2	41.1	7.5
Sem+/-	0.37	0.2	20.6	94.2	186.2	49.7	0.05	0.80	6.72	5.6
CD at 5%	0.77	0.5	43.2	197.8	NS	NS	NS	1.74	14.51	12.2

Table 6: Soil chemical properties of soil-1 at 200 DAT

			Available nutrients				**DTPA extractable micronutrients**			
Treat.	**pH**	**OC** (%)	**P** (kg/ha)	**K** (kg/ha)	**Ca** (ppm)	**Mg** (ppm)	**Cu** (ppm)	**Zn** (ppm)	**Mn** (ppm)	**Fe** (ppm)
T_1	5.9	0.8	6.0	210.7	1400	70	0.1	2.8	15.1	3.5
T_2	6.3	3.3	125.3	355.3	900	130	0.7	7.4	82.9	27.0
T_3	6.6	4.2	77.3	355.3	1400	50	0.4	3.4	50.7	12.7
T_4	6.6	3.2	45.0	232.0	1400	90	0.4	6.3	29.4	11.6
T_5	7.8	3.0	36.7	377.0	1500	60	0.1	4.4	11.9	3.7
T_6	8.0	3.4	15.0	438.7	1500	60	0.1	3.4	12.7	2.8
T_7	8.2	2.6	21.7	493.7	1500	100	0.2	3.5	23.0	3.6
Sem+/-	0.20	0.42	26.20	70.44	178.6	43.1	0.04	0.80	6.7	5.6
CD at 5%	0.42	0.88	55.02	147.91	NS	NS	NS	1.74	14.5	12.2

Table 7: Soil chemical properties of soil-2 at 200 DAT

Biological properties of potting mixtures

The potting mixtures under various treatments in which the seedlings were grown for 200 days were enumerated for microbial Colony Forming Units (cfus) and biological parameters like Microbial respiration, Dehydrogenase activity and Biomass carbon. The data is presented in Tables 8 and 9.

Treatments	*P.Fluroscence* (10^3)	**PSB** (10^3)	*Azosprillum* (10^3)	VAM (%)	**Microbial Respiration** (CO_2 mg kg^{-1} soil hr^{-1})	**Dehydrogenase activity** (µg of PNP g^{-1} of soil hr^{-1})	**Biomass Carbon** (CO_2 mg kg^{-1} soil hr^{-1})
T_1	15	10	5	40	7.8	12.2	1207
T_2	35	18	12	70	18.1	29.8	2809
T_3	40	20	14	70	18.8	37.4	2824
T_4	29	17	11	70	16.1	25.5	1783
T_5	18	13	6	50	12.7	13.9	785
T_6	24	14	8	60	14.3	12.7	1277
T_7	25	15	8	60	17.7	15.1	977
Sem+/-	3.01	2.0	1.38	4.1	2.4	4.1	390.7
CD at 5%	6.03	4.0	2.76	8.2	NS	8.2	781.5

Table 8: Colony forming units of Soil-1 at 200 DAT

In Soil-1, colony forming units of *P. Fluroscence*, PSB, *Azosprillum* and VAM were significantly high in T_3 (40, 20, 14 × 10^3 and 70% respectively) and on par with T_2 (35, 18, 12 × 10^3 and 70%) and T_4 (29, 17, 11 × 10^3 and 70%) compared to T_1 (15, 10, 5 × 10^3 and 40%). A similar trend has been noticed in Soil-2 also. Microbial observations like Microbial Respiration, Biomass Carbon and Dehydrogenase activity were also significantly high in T_3 (18.8, 2824 CO_2 mg kg^{-1} soil $hr^{-1}$and 37.4 µg of PNP g^{-1} of soil hr^{-1} respectively) and on par with T_2

(18.1, 2809 CO_2 mg kg^{-1} soil $hr^{-1}$and 29.8 µg of PNP g^{-1} of soil hr^{-1} respectively) and T_4 (16.1, 1783 CO_2 mg kg^{-1} soil $hr^{-1}$and 25.5 µg of PNP g^{-1} of soil hr^{-1} respectively) compared to T_1 (7.8, 1207 CO_2 mg kg^{-1} soil $hr^{-1}$and 12.2 µg of PNP g^{-1} of soil hr^{-1} respectively). Similar results have been recorded for Soil-2 also.

Treatments	*P.Fluroscence* (10^3)	PSB (10^3)	*Azosprillum* (10^3)	VAM (%)	Microbial Respiration (CO_2 mg kg^{-1} soil hr^{-1})	Dehydrogenase activity (µg of PNP g^{-1} of soil hr^{-1})	Biomass Carbon (CO_2 mg kg^{-1} soil hr^{-1})
T_1	26	13	7	50	12.3	4.9	1151
T_2	42	22	13	70	15.1	28.3	2147
T_3	43	27	20	70	16.4	32.7	2705
T_4	41	18	11	60	13.7	7.8	887
T_5	31	13	7	50	9.8	10.1	1109
T_6	38	15	9	60	9.9	5.5	971
T7	38	15	11	60	11.5	15.1	1696
Sem+/-	3.01	2.0	1.38	4.1	2.3	4.1	390.7
CD at 5%	6.03	4.0	2.76	8.2	NS	8.2	781.5

Table 9: Colony forming units Soil-2 at 200 DAT

These results also are in support of the best suitability of the T2 (SPP) as potting mixture. In T3, the externally added bio-inoculants consortia to T2 have improved the 'cfus' as well as other biological parameters. In presence of FYM the marginal soils also have performed on par with T2 and have indicated the possibility of utilizing them as potting mixture when jungle soil is unavailable.

Nutrient uptake by seedlings

The seedlings were uprooted at 200 DAT and plant parts were analyzed for the nutrient contents and the uptake was computed. The nutrient uptake of the seedlings grown in both the marginal soils is presented in Tables 10 and 11.

Treatments	Leaf			Stem			Root		
	N (mg/g)	P (mg/g)	K (mg/g)	N (mg/g)	P (mg/g)	K (mg/g)	N (mg/g)	P (mg/g)	K (mg/g)
T_1	2.0	0.2	1.1	1.5	0.1	0.6	2.1	0.1	1.0
T_2	30.2	3.5	15.3	9.2	1.3	5.6	11.3	1.3	6.4
T_3	31.6	3.6	16.0	9.8	1.5	7.0	14.6	1.7	8.3
T_4	26.3	3.0	13.0	8.1	1.3	5.3	10.8	1.1	5.1
T_5	3.8	0.6	2.0	1.9	0.2	0.7	3.8	0.3	1.8
T_6	11.9	1.2	4.0	2.6	0.4	1.1	5.0	0.5	2.4
T_7	10.3	1.1	4.6	2.1	0.4	1.3	4.0	0.4	2.1
Sem+/-	1.82	0.28	1.21	1.25	0.2	0.71	1.4	0.13	0.68
CD at 5%	NS	0.57	2.43	2.51	0.39	1.42	2.7	0.26	1.36

Table 10: Nutrient uptake of seedlings at 200 DAT in Soil-1

Uptake of N, P and K by leaf, stem and root of seedlings grown in Soil 1 and Soil 2, were significantly high in T_3 and on par with T_2 and T_4 compared to T_1. Thus the higher growth parameters observed under T_3 can be attributed to availability and uptake of balanced and higher quantum of nutrients to seedlings through FYM as well as bio-inoculants consortia compared to 'control'. The poor growth of seedlings observed in the treatments T_5, T_6 and T_7 compared to the seedlings under T_2, T_3, and T_4 may be due to the lack of adequate organic matter which is essential for establishment of externally supplied microbes in the form of bio-inoculants. Better growth of seedlings in T_4 confirms the fact that FYM is an inevitable ingredient of potting mixture for raising coffee seedlings as it is capable of providing the organic matter even when the soil used in the potting mixture is deficient in organic matter.

Treatments	Leaf			Stem			Root		
	N (mg/g)	P (mg/g)	K (mg/g)	N (mg/g)	P (mg/g)	K (mg/g)	N (mg/g)	P (mg/g)	K (mg/g)
T_1	2.3	0.3	1.1	1.3	0.1	0.6	1.5	0.1	0.9
T_2	28.0	3.5	12.1	8.3	1.2	4.9	10.3	1.2	6.3
T_3	29.3	3.8	14.5	9.3	1.3	6.7	14.6	1.5	8.1
T_4	26.3	2.9	11.3	8.1	1.2	4.8	9.9	1.1	6.1
T_5	6.3	0.5	2.4	1.6	0.2	0.8	3.1	0.4	1.7
T_6	9.7	0.9	4.8	2.4	0.4	1.2	4.8	0.5	2.3
T_7	8.8	0.9	4.3	2.2	0.3	1.4	4.0	0.4	2.1
Sem+/-	1.73	0.28	1.21	1.25	0.2	0.71	1.4	0.13	0.68
CD at 5%	NS	0.57	2.43	2.51	0.39	1.42	2.7	0.26	1.36

Table 11: Nutrient uptake of seedlings at 200 DAT in Soil-2

Conclusion

The growth parameters, nutrient status and biological parameters of the potting mixtures, and data on nutrient uptake by the seedlings under different treatments recorded in the nursery trial conducted with the objective of exploring the possibility of utilizing marginal or less fertile soils enriched with bio-inoculants in the potting mixture lead to a conclusion that the SPP (mixture of jungle soil, FYM and sand in the ratio 6:2:1) is the best suited potting mixture to raise the coffee nursery. But in absence of the fertile jungle soil, the marginal soil can be utilized as an ingredient of potting mixture with due care to incorporate adequate quantity of farm yard manure and the microbial consortia is not a substitute for FYM in the potting mixture. This is because of the fact that adequate organic matter is essential for establishment of externally supplied microbes in the form of bio-inoculants and FYM is capable of providing the organic matter even when the soil used in the potting mixture is deficient in organic matter.

References

1. Anonymous (1996) Coffee Guide. Coffee Board, Research Department. India. 180 pp.
2. Azizuddin M, Krishnamurthy RW (1984) Field and nursery experiment with Azototobacter. pp. 289-295. In: Proceedings of 6th Symposium on plantation crops, Rubber Institute of India, Kottayam, 16-20 Dec 1984. Vance ED, Brookes PC, Jenkinson DS (1987) An extraction method for measuring microbial biomass carbon. Soil Biol Biochem 19: 703-707.
3. Biradar IB, Raghuramulu Y, Muralidhara HR, Sudhakar SB (2006) Effect of Bio-fertilizers and PGPRS on growth and development of coffee seedlings. J Coffee Research 34: 57-63.
4. Glory Swarupa (1997) Effect of bio fertilizers on nutrient uptake by coffee seedlings. 3rd IFOAM-ASIA Scientific Conference. Bangalore. 54.
5. Buchanan RE, Gibbons NE (1974) Bergy's Manual of Determinative Bacteriology, 8th ed., William and Wilkins, Baltimore, p.1268.
6. Eivazi F, Tabatabai MA (1977) Phosphatases in soils. Soil Biol Biochem 9: 167-172.
7. Anderson JPE (1982) Soil respiration in Methods of soil Analysis. Part-2, Chemical and Microbiological properties, 2nd ed., (page, Al., et al., Eds), Soil Science Society of America Inc., USA. pp 831.