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Govindappa M
Ph.D. Scholar, Department of Agronomy, Faculty of Agriculture, Annamalai University, Tamil Nadu, India

Thiruppathi M
Associate Professor, Department of Agronomy, Faculty of Agriculture, Annamalai University, Tamil Nadu, India

Shivaprasad P
Head, Department of Soil Science & Argil. Chemistry, CRS, CCRI, Balehonnur, Karnataka, India

Imayavaramban V
Prof & Head, Dept.of of agronomy, Faculty of agriculture, Annamalai University, Tamilnadu, India

Sriramachandrasekharan MV
Prof & Head, Department of Soil Science & Argil. Chemistry, Faculty of Agriculture, Annamalai University, Tamil Nadu, India

Corresponding Author
Govindappa M
Ph.D. Scholar, Department of Agronomy, Faculty of Agriculture, Annamalai University, Tamil Nadu, India

Impact of varied levels of substrates as potting media on growth and development of arabica coffee (*Coffea arabica* L.) seedlings

Govindappa M, Thiruppathi M, Shivaprasad P, Imayavaramban V and Sriramachandrasekharan MV

Abstract
With the primary objective of assessing the influence of using different proportions of organic sources of nutrients and foliar nutrition at two leaf stage in Arabica coffee seedlings, nursery experiment was conducted at Coffee Research Substation, Chettalli, Kodagu District, Karnataka state during 2018-19. The experiment consists of different ratio of substrates in the main plot namely PM_{1}- 6:2:1, (jungle soil, farm yard manure and river sand - farmer's practice) PM_{2}- 6:3:1(jungle soil, farm yard manure and river sand), PM_{3}- 6:3:1(jungle soil, goat manure and river sand), PM_{4}- 6:2:1 (jungle soil, goat manure and river sand), PM_{5}-6:3:1 (jungle soil, sheep manure and river sand), PM_{6}- 6:2:1 (jungle soil, sheep manure and river sand). In the Subplots, nutrient management practice was accommodated such as control (without nutrient), application of DAP @ 2.0 g $plnat^{-1}$ with and without foliar application of ammonium nitrate at 1.0 and 1.5 per cent at 2 leaves stage. The results indicated that seedling height and girth, shoot and root dry matter, number of seminal roots and root volume of seedlings were higher with the potting mixture of six parts jungle soil, three parts goat manure and one part river sand. Application of 2 g DAP per seedlings along with foliar application of 1 per N at two leaves stages excelled all other nutrient management treatments. However, Growing of Arabica coffee seedlings in the potting substrate of six parts jungle soil, three parts goat manure and one part river sand along with soil application of DAP @2 g $seedling^{-1}$ and foliar application of 1.0 per cent N through ammonium nitrate was found to be the best management practice for producing robust arabica coffee seedlings.

Keywords: FYM, jungle soil, goat manure, sheep manure, coffee seedling

Introduction
The young coffee seedlings required an adequate nutrition and protection against the climatic conditions; hence, management of these requirements was done through suitable nutrient rich substrates hasten the establishment of seedlings in the field (Andrade Neto., *et al*., 1999) [3].
Coffee is the most popular beverage crop in the world because of its higher economic value, employment generation and trade commodity. Coffee is a perennial crop and productive up to 30 years. Establishment of coffee plantation, yield and quality of coffee under high density plantation solely depends on the planting of healthy seedling and its establishment rate. Production of vigorous, healthy and quality seedlings in coffee is of tough task. Even though, Arabica coffee is self pollinated, the availability of quality seedlings is very scares during the planting seasons in present days. The primary pace towards the success of well establishment of coffee plantation was with the selection of good quality coffee seedlings Mendes and Guimaraes, (1998); Arthur, (2013) [5]. The farm yard manure used as a substrate material (potting media) nowadays was contaminated due to usage of injections and concentrated feed for both milching and non milching animals (cow's). The substrate material currently using for the production of coffee seedlings in the coffee nurseries was in the ratio of 6:2:1, i.e. six parts of jungle soil, two parts of farm yard manure and one part of sand. But, 60-70 per cent of the seedlings produced were stunted growth, weak girth, and lesser number of pairs of leaves. Keeping these in view, to replace the farm yard manure, a pot culture experiment was initiated to identify and standardize an appropriate potting substrate and its mixture with the adoption of suitable nutrient management.

Materials and Methods
The Coffee Research Sub Station (CRSS) is situated at, Chettalli, Kodagu District, Karnataka. The station geographical coordinates were 24.1 º to 12.º 23' 13.8 'N latitude and 75 ^{O} 50" to

11.8 "to 75^{O} 50" 42.1" E longitude. The station is being situated at an altitude of 1034 meters above the mean sea level (MSL). The experiment was conducted from December 2018 to September 2019 under protected green shade net maintained scientifically with optimum weather conditions including shade, minimum and maximum temperature, relative humidity, intermittent solar radiation and water facility ideally suitable for the better growth and development of the coffee nursery. The destructive samplings were collected by the random selection of coffee seedlings plants from each treatment and the biometric observations were recorded.

Preparation of Primary Seed Beds All the required inputs including Arabica coffee-Chandtagiri seeds, (250 grams), virgin jungle soil (110 kg), farm yard manure, (10.0 kg), Goat manure, (36 kg) sheep manure (36 kg) and sand (18 kg) were procured and subjected to sieving. Separate primary seed beds were prepared with the dimension of 1.00 meter width, 15 cm height and 1.0 meter length. The required potting mixtures like Pot Mixture: PM-$_1$– Jungle soil +Farm yard manure + Sand in 6:3:1 ratio, PM-$_2$ -Jungle soil +Farm yard manure + Sand in 6:2:1 ratio as a standard check, PM-$_3$, Jungle soil+ goat manure +sand in 6:3:1ratio, PM-$_4$, Jungle soil+ goat manure+ sand in 6:2:1ratio, PM-$_5$ Jungle soil+ Sheep manure+ Sand in 6:3:1 ratio and finally PM-$_6$ as Jungle soil + sheep manure +sand in 6:2:1ratio's were prepared and the sieved pot mixtures (PM) were weighed separately as per the ratio and incorporated thoroughly in to these respective primary beds, fine and smooth seed bed tilth was prepared. After the complete preparation of primary seed beds, the sowing of chandragiri coffee seeds at 1.0 cm depth, 2.5 cm apart as bulged side upward and flat side downwards was taken up sowing in primary sewed beds on 05-January-2019. These primary seed beds were covered with paddy straw and watered with rose can periodically to maintain sufficient moisture level. The germination per cent (%) was recorded in all the primary seed beds after (43-46 days) of sowing.

Preparation of Secondary Seed Beds
The secondary seed beds were prepared by using poly bags of size 9"x6" (23x15 cm) of 150 gauge thickness which were made with punches on both sides (For good drainage & aeration). These poly bags were filled with the different ratios of pot mixtures as aforesaid and are replicated three times. Transplanting of coffee seedlings were carried out at the topy stage, by making hole at the center of the poly bag so as the root length of topy seedlings must be proportionately fit in the poly bag pressed properly so as it must be in the center of the poly bag. These were maintained up to two leaf development stage and thereafter the nutritional management with the application of both di-ammonium phosphate (DAP) at the rate of 2.0 g per plant and foliar application of ammonium nitrate at the rate of 1.0% and 1.5% in fixed intervals. The germination per cent (%), epicotyls length (cm), plant height (cm), girth of the seedlings (cm), Total number of leaves (no), leaf area index, tap root length (cm), number of seminal roots (no), root volume (cc), leaf dry matter,(g), stem dry matter (g), root dry matter (g) total dry matter production (g) and Dickson's quality index were observed from 30 DATP to 180 days after transplanting.

Experimental Results
Seedling height and girth
Among the different potting substrates, potting mixtures of jungle soil, goat manure and river sand @ 6:3:1 (PM_3) produced significantly taller seedling of 43.40 cm seedling height and seedling girth of 3.27 cm. This was followed by the potting mixtures of jungle soil, sheep manure and sand @ 6:3:1 and jungle soil goat manure and sand @ 6:2:1 and were on-par with each other. However, the minimum seedling height of 35.67 cm and girth of 2.80 cm was recorded in the potting mixture of six parts of jungle soil two parts of farm yard manure and one part of sand (PM_1), control.
Application of 2.0 g plant^{-1} of DAP and foliar nutrition with 1.0% ammonium nitrate at 2 leaves stage significantly registered healthier seedlings with taller values of 50.18 cm and seedling girth of 3.78 cm. The weaker seedlings were noticed in the control plot (FN_1).
Interaction effect of potting media and nutrient management had a significant effect on coffee seedlings (Table: 1). Growth of coffee seedlings in a potting media of six parts jungle soil, three parts of goat manure and one part of river sand along with the addition of DAP 2.0 g seedling^{-1} with foliar application of 1.0 per cent N through ammonium nitrate at 2 leaves stage significantly registered maximum seedling height of 54.77 cm and girth of 4.56 cm. This was followed by P_3F_3, P_5F_5 and P_4F_5 and on-par among themselves. The lower seedling height of 24.65 and the girth 2.17 cm was registered with the potting mixture of six parts of jungle soil, two parts of farm yard manure and one part of sand, control (PM_1FN_1)

Table 1: Effect of potting substrates and nutrient management on Plant height (cm) and plant girth (cm) of Arabica coffee seedling

Treatments	Height (cm) at 180 DATP							Girth (cm) at 180 DATP						
	FN_1	FN_2	FN_3	FN_4	FN_5	FN_6	Mean	FN_1	FN_2	FN_3	FN_4	FN_5	FN_6	Mean
PM_1	21.33	41.80	44.42	30.69	45.09	30.71	35.67	1.82	2.92	3.16	2.70	3.41	2.72	2.80
PM_2	24.10	42.96	44.93	31.41	48.51	34.62	37.76	2.07	3.00	3.40	2.75	3.46	2.76	2.91
PM_3	30.05	43.93	52.67	39.10	54.77	39.85	43.40	2.48	3.01	3.95	2.80	4.56	2.82	3.27
PM_4	24.33	43.66	49.34	35.36	52.50	36.07	40.21	2.12	2.95	3.48	2.77	3.92	2.77	3.00
PM_5	24.46	43.71	49.84	36.42	52.67	38.22	40.89	2.50	2.98	3.52	2.79	3.93	2.80	3.09
PM_6	23.65	42.73	44.24	30.78	47.53	31.06	36.67	2.00	3.07	3.16	2.73	3.41	2.74	2.85
Mean	24.65	43.13	47.57	33.96	50.18	35.09	-	2.17	2.99	3.45	2.76	3.78	2.77	-
		SEd		CD(p=0.05)					SEd		CD (p=0.05)			
PM		0.337		0.75					0.38		0.76			
FN		0.37		0.75					0.38		0.76			
PM x FN		0.91		1.83					0.94		1.87			

Dry matter production of coffee seedling
Higher shoot and root dry matter production of 45.39 and 12.80 g plant^{-1}, respectively noticed with the potting mixtures of jungle soil, goat manure and river sand @ 6:3:1(PM_3). This was followed by the potting mixtures of jungle soil, sheep manure and sand @ 6:3:1 and jungle soil goat manure and

sand @ 6:2:1 and were statistically comparable with each others. The minimum shoot and root dry matter production of 39.89 and 11.29 g plant^{-1} were recorded in the potting mixture of jungle soil, FYM and sand @ 6:2:1 (PM_1).

In respect of nutrient management, addition of 2.0 g DAP plant^{-1} and foliar nutrition of 1.0% ammonium nitrate at 2 leaves stage (FN_5) registered higher seedling shoot and dry matter production of 51.84 and 13.41g plant^{-1}. Growing of seedlings without addition of DAP and foliar application of N ($FN_{1)}$ significantly resulted lower values.

Significant interaction effect on the dry matter production of coffee seedlings was noticed as the results of integrated use of potting media and nutrient management practice (Table 2.). Shoot and root dry matter production of coffee seedlings in a potting media of six parts jungle soil, three parts of goat manure and one part of river sand along with the addition of DAP 2.0 g plant^{-1}and foliar application of 1.0 per cent N through ammonium nitrate at 2 leaves stage significantly increased the seedlings shoot and root dry matter production of 56.28 and 14.49 g plant^{-1}. This was followed by the treatment combination of PM_3FN_3, PM_5FN_5 and PM_4FN_5 and on par among the treatment combinations. The lower shoot and root dry matter production of 29.53 and 9.45 g plant^{-1} were registered with the potting mixture of six parts of jungle soil, two parts of farm yard manure and one part of sand (PM_1FN_1), control.

Table 2: Effect of potting substrates and nutrient management on shoot and root dry matter production (g^{-1}plant) of Arabica coffee seedling

Treatments	Shoot dry matter production (g^{-1} plant) at 180 DATP							Root dry matter production (g^{-1} plant) at 180 DATP						
	FN_1	**FN_2**	**FN_3**	**FN_4**	**FN_5**	**FN_6**	**Mean**	**FN_1**	**FN_2**	**FN_3**	**FN_4**	**FN_5**	**FN_6**	**Mean**
PM_1	26.13	42.13	46.93	37.05	49.45	37.65	39.89	7.46	12.65	12.80	10.58	12.84	11.39	11.29
PM_2	30.30	43.35	49.22	39.84	49.83	41.56	42.35	9.84	12.58	12.80	11.64	12.86	11.65	11.90
PM_3	31.31	46.64	53.89	42.10	56.28	42.12	45.39	10.58	12.78	13.82	12.55	14.49	12.57	12.80
PM_4	30.33	43.79	49.87	41.64	52.36	41.80	43.30	9.86	12.69	12.86	11.66	13.68	11.66	12.07
PM_5	30.55	46.58	49.93	41.84	53.64	41.95	44.08	10.55	12.75	12.90	11.67	13.71	11.68	12.21
PM_6	28.58	42.84	46.68	38.94	49.47	39.82	41.05	8.38	12.63	12.78	11.48	12.85	11.55	11.61
Mean	29.53	44.22	49.42	40.24	51.84	40.82	-	9.45	12.68	12.99	11.60	13.41	11.75	-
		SEd					CD (p=0.05)							
		0.44					0.88							
		0.44					0.88							
		1.09					2.17							

Seedling root character

Among the different potting substrates, potting mixtures of jungle soil, goat manure and river sand @ 6:3:1(PM_3) resulted significantly higher number of seminal root (28.25 plant^{-1}) and root volume (1.50 cc) and it was followed by the potting mixtures of jungle soil, goat manure and sand @ 6:2:1 and jungle soil, sheep manure and sand @ 6:3:1.. However, the minimum number of seminal roots and root volume of 25.42 and 1.29 cc plant^{-1} were recorded in the potting mixture of six parts of jungle soil two parts of farm yard manure and one part of sand.

Application of 2.0 g DAP seedling^{-1} and foliar nutrition with 1.0% ammonium nitrate at 2 leaves stage significantly registered higher number of seminal roots (31.11 plant^{-1}) and root volume of 1.70cc. The minimum values on the coffee seedlings were observed with the control (FN_1).

Interaction effect of potting media and nutrient management had a significant effect on coffee seedlings (Table. 3). Grown of coffee seedlings in a potting media of six parts jungle soil, three parts of goat manure and one part of river sand along with the addition of DAP 2.0 g plant^{-1} and foliar application of 1.0 per cent N through ammonium nitrate at 2 leaves stage (PM_3FN_5) significantly registered higher number of seminal root of 35.12 plant^{-1} and 1.95 cc of root volume. This was followed by PM_3FN_3, PM_5FN_5 and PM_4FN_5 and on par among themselves. The lower number of seminal roots of 19.29 and 1.01 cc of root volume were registered with the potting mixture of six parts of jungle soil, two parts of farm yard manure and one part of sand (PM_1FN_1). As production more number of seminal roots indicates the higher growth and development in the potting media which received goat manure in the ratio of six parts of jungle soil, three parts of goat manure and one part of sand.

Table 3: Effect of potting substrates and nutrient management on number of seminal roots and root volume (cc) of Arabica coffee seedling

	seminal roots plant^{-1} 180 DATP							Root volume(cc) 180 DATP						
Treatments	**FN_1**	**FN_2**	**FN_3**	**FN_4**	**FN_5**	**FN_6**	**Mean**	**FN_1**	**FN_2**	**FN_3**	**FN_4**	**FN_5**	**FN_6**	**Mean**
PM_1	16.16	26.63	27.36	26.00	28.85	26.08	25.18	0.84	1.35	1.56	1.20	1.57	1.20	1.29
PM_2	19.07	26.75	28.82	26.15	29.20	26.18	26.03	1.03	1.38	1.56	1.22	1.60	1.26	1.34
PM_3	22.03	27.22	32.56	26.27	35.12	26.28	28.25	1.10	1.54	1.76	1.33	1.95	1.34	1.50
PM_4	19.58	26.79	29.22	26.21	32.05	26.22	26.68	1.04	1.40	1.62	1.27	1.74	1.28	1.39
PM_5	21.99	27.21	29.34	26.24	32.49	26.26	27.25	1.08	1.52	1.62	1.30	1.76	1.32	1.43
PM_6	16.93	26.65	27.36	26.13	28.96	26.14	25.36	0.98	1.35	1.55	1.20	1.58	1.22	1.31
Mean	19.29	26.88	29.11	26.17	31.11	26.19	-	1.01	1.42	1.61	1.25	1.70	1.27	-
		SEd		CD(p=0.05)					SEd		CD (p=0.05)			
		0.27		0.73					0.01		0.03			
		0.27		0.73					0.01		0.03			
		0.67		0.78					0.04		0.07			

Discussion and Summary

Addition of goat manure has shown differential results with respect seedlings height, girth, shoot and root dry matter production, seminal roots number and root volume highly influenced with the incorporation of six parts of virgin jungle soil, three parts of goat manure and one part of river sand. The

higher biometric values recorded in the best treatment was due to the higher concentration nitrogen (N) which was essentially needed for the vegetative growth and development. In addition, application of DAP at the rate of 2.0 g per plant along with the foliar application of 1.0 per cent ammonium nitrate further boosted the seedlings growth in terms of increased seedling height, girth and root volume in PM_3, it was may be due to the increased soil pH with the creation of neutral soil condition Gichangi and Mnkeni (2009) [9], Application of goat manures also aid in the higher plant height, stem diameter or girth, shoot and root dry matter productin, number of seminal roots and root volume as reported by Adejoblk *et al* (2011) [2].

The similar kind of results were recorded by Ade Astri *et al*, 2015 and application of N based urea along with plant hormonal has resulted in the higher growth of the coffee seedlings as reveled in Coffee Guide (2014).

Conclusion

Based on the results of present investigation it can be concluded that healthier arabica coffee seedlings could be produced with the incorporation of goat manure at the rate of three parts instead of farm yard manure two parts in coffee nurseries seedlings production along with application of 2.0 g DAP seedling^{-1} and foliar application of 1.0 per cent ammonium nitrate at 2 leaves stage.

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