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Influence of Plant Growth Regulators on Growth and Development of *Coffea arabica* Var. Sln. 9 Seedlings

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ABSTRACT

The growth and development of Arabica coffee seedlings variety Selection 9 was studied using various growth regulators. Glyricidia sepium + Lanatana camera extract (1 %), Arka Microbial Consortium (1 %), Lantana camera + DMSO + $CuSo_4$ (1 %), Salicylic Acid (0.025 %) and Alpha Napthyl Acetic Acid (0.025 %) were used as PGRs for boosting growth of coffee seedlings in comparison with control and water sprayed seedlings. The results indicated that the increase of growth parameters was statistically significant in PGR treated seedlings. The increase was 48.4 to 50 % in plant height, 30.5 to 34.7 % in root length, 29.2 to 36.1 % in number of nodes, 29.4 to 36.4 % in number of leaves. Increase in leaf area was by 96.4 to 119.8 % and leaf area index by 21.1 to 36.8 %. Shoot weight increased by 47.02 to 49.23 % and root weight increased by 45.38 to 48.46 %. Significant increase in nutrients Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur status of leaves was observed with PGR treated seedlings. All the growth parameters increased were statistically on par among the different PGRs used in the study. Whereas, the control and water sprayed seedlings recorded significantly lower growth parameters as compared to PGRs sprayed seedlings. Hence, the growers can make use any of the tested PGRs in this study for boosting growth of coffee seedlings.

Key Words: Coffee Seedlings, Glyricidia and Lantana extract, Microbial Consortium, Napthyl Acetic Acid, PGR

INTRODUCTION

Coffee being traded as the second highest commodity in the world is one of the most important commercial crops of Southern India. It is the backbone of farmers of Western Ghats regions of Karnataka, Kerala and Tamil Nadu. *Coffea arabica* and *Coffea canephora* commonly known as Arabica and Robusta respectively are the two major species grown across India. Coffee plantations being grown in heavy rainfall regions of India, face huge competition from weeds and high variation of climatic conditions. Arabica being the shade grown mild coffee comes to bearing in about three to four years of planting in main field. The well established coffee plantation strives for more than three to four decades under good management. However, such an establishment of a good plantation is mainly influenced by planting of healthy and vigorous coffee seedlings.

The Central Coffee Research Institute, India has recommended using good quality nursery mixture containing Jungle Soil, Farm Yard Manure and Sand in 6:2:1 ratio to raise seedlings in polybags of size 9 x 6 inch dimension (Anon, 2014). However, in recent decades, the availability of fertile jungle soil and good quality Farm Yard Manure has become scarce and growers are using very small bags of 5 x 4 inch size with poor soil and Farm Yard Manure. Coffee Research Station recommends to plant seedlings at 6 or 18 months old in main field when they attain ideal growth and development. Due to lack of good nursery mixture, it has become very difficult for growers to raise good seedlings of 6 months old and usually wait for two season seedlings i.e. 18 months to take up planting. Hence, there is a need to boost the growth of coffee seedlings by external means such that they can be planted at 6 months age only instead of waiting for one more season. However, application of excessive fertilizers leads to succulent growth of seedlings instead of hard seedlings. This has lead to an attempt on usage of growth regulators to promote seedlings growth.

Over decades, many attempts have been made in the field of Agriculture Research in different crops to identify different plant growth regulators, including both chemicals and plant extracts that have PGR properties. Among such materials, NAA, Salicylic Acid, Microbial consortia and plant extracts such as *Glyricidia sepia* and *Lantana camara* are common. Even the oldest chemical, DMSO as a carrier of agricultural toxicants, first received attention by Norris and Freed (1963). Garren (1967) has reported on the rapid uptake and distribution of labelled DMSO when applied to leaves and stems of fruit trees. Further, he noted its enhancing effect on phosphorus-32 transport. Schiuchetti (1967) has noted that growth and alkaloid content of the drug producing plant Datura were enhanced not only by growth regulators applied to DMSO but also by DMSO alone. Its unique solvent and membrane transport properties (Jacob Bischel, and Herschler, 1964) might have played important role in such influence.

Many studies were conducted to boost the growth of seedlings using plant extracts like *Lantana camera* (2003), *Glyricidia sepium* (Anon, 2004) and Salicylic acid (Anon, 2006) that have growth promoting properties. However, these studies limited to only increase the crop yield. Not much emphasis was given in the past to boost growth of seedlings using these extracts. Among the natural plant growth promoting materials, most abundantly available in coffee growing regions of South India are *Glyricidia sepia* and *Lantana camara* which are commonly known as Glyricida and Lantana respectively. Glyricidia is grown as temporary shade tree in young coffee plantations and as a nutrient supplement plant in other fields. The other one is *Lantana camera* grown naturally as a weed all over the waste lands. Growth promoting natural properties of *Lantana camara* L. one percent leaf extract had been observed by George Daneil *et al* (2010) to significantly increase the water use efficiency and yield of robusta in various parts of coffee growing tracts.

Many attempts have been made in the past to boost the growth of coffee seedlings with organic manures (Muralidhara *et al*., 1996), many commercial composts (Kamala Bai *et al*, 2002) and bio-fertilizers (Biradar *et al*., 2006). Studies reported by Muralidhara HR *et al*. (1996) indicated that use of organic manures while filling bags would increase of growth of seedlings significantly. Similarly, Kamala Bai S. *et al* (2002) have studied the influence of 'Bhoomilabh' on growth of seedlings of Cauvery and CxR. The results indicated that application of 'Bhoomilabh', commercial organic manure applied into polybags while transplanting, increased the growth and development of coffee seedlings significantly. Plant height, number of leaves, tap root length, collar girth, leaf area and total dry weight of seedlings increased significantly. Another trial in coffee by Panneer Selvam (2008) indicated that application of microbial consortium (5.0 g seedling$^{\hat{a}^{``}1}$) plus AM fungi (5.0 g seedling$^{\hat{a}^{``}1}$) on arabica coffee seedlings found to be superior in increasing all the growth parameters *viz.*, leaf area, shoot length, shoot girth, root length, dry weight, leaf chlorophyll, total phenol of leaf and roots**.** Even though many studies have been conducted in coffee to promote the growth of coffee seedlings, the outcomes are very few with usage of costly or rarely available external inputs. In the study by Dias-Moreira *et al*. 2019, the effects of three AMF (Rhizophagus clarus, Claroideoglomus etunicatum, Dentiscutata heterogama) on the development of the coffee seedlings of var. Catuaí Vermelho IAC 99, growing in non-sterile soil were evaluated. The results showed a significant increase in the growth of plants in all the evaluated traits in AMF-inoculated plants. As the earlier studies concentrated only towards the addition of composts, biofertilizers into the nursery mixture and much efforts were not made to take up foliar sprays to boost growth of seedlings, this study was taken up at Coffee Research Sub Station, Chettalli, Kodagu District, Karnataka in India during 2016-18 for two seasons using Sln. 9 with the following objectives.

- To know the effect of PGR formulations on growth and development of coffee seedlings
- To understand the nutritional changes that occur in seedlings with PGR

MATERIAL AND METHODS

Treatments: The study was conducted at Coffee Research sub Station during 2016 to 2018 for two seasons to confirm the results. The study was taken up in seedlings using Arabica coffee variety Sln. 9. Seven treatments were finalized as given below including the standard recommended PGR.

T1: No spray (control)
T2: Water spray (Control)
T3: Plant extract (*Gliricidia sepia* & *Lantana camara*) 1%
T4: Arka Microbial Consortium 1 % (ICAR)
T5: *Lantana camera* + Dimethyl Sulfoxide (DMSO) + $CuSo_4$ 1 %
T6: Salicylic acid 0.025 %
T7: Alpha (α) Napthyl Acetic Acid 0.025 % (Standard Recommendation in coffee)

Plant Material: Trial was conducted using Arabica Coffee cultivar Sln. 9. This is a cross between the arabica genotypes 'Hybrido de Timor (HDT)' and 'Tafarikela' and very popular among the growers. A tall Arabica variety with drooping branches and long internodes. The leaves are broader with bronze tip. The fruit clusters are tight,

early ripening and gives around 65-70% `A' grade beans. A crop yield of 1000 Kg clean coffee per ha could be expected under well maintained estates.

Arka Microbial Consortia: Arka Microbial Consortium, developed by ICAR is a carrier based product which contains N fixing, P & Zn solubilizing and plant growth promoting microbes in a single formulation. 10 ml formulation was mixed in one liter water and used for spraying.

***Glyiricidia and Lantana Extraction*:** These being found in all tropical areas of coffee growing regions are available in plenty. Hence, were used to prepare extraction. Leaves of both *Glyricidia sepia* and *Lantana camara* were collected fresh. 2 Kg leaves of both were chopped into small pieces and immersed in 10 litre of boiled water and kept for 24 hours. Then the solution was filtered using a cloth and the filtrate was mixed with 200 litres of water. The extract so prepared was sprayed to the plants covering the lower surface of the leaves.

Dimethyl Sulfoxide (DMSO): Among the more important properties of DMSO, its ability to readily penetrate biological membranes to increase the uptake of essential plant nutrients and to influence the growth habit of crops is very important. Besides, Dimethyl Sulfoxide (DMSO) is a widely used solvent for the extraction of chlorophylls from leaves of higher plants. The method is preferred because the time-consuming steps of grinding and centrifuging are not required and the extracts are stable for a long time period (Dimosthenis Nikolopoulos *et al* 2008). Hence, in this study, to increase the efficacy and solubility of Lantana camera extract (1 %), DMSO and $CuSO_4$ were used in combination with these extracts as one of the treatments.

Salicylic Acid: Salicylic acid (SA) is one of the potential plant growth regulators (PGRs) that regulate plant growth and development by triggering many physiological and metabolic processes. Being less studied chemical in coffee, this was used as one of the treatments in the present study in comparison with the standard recommendation.

αNAA - Alpha Napthyl Acetic Acid : This is tested and recommended as standard in coffee by CCRI (Anon, 2014) mostly used only for inducing flowering and enhancing yield of coffee. Hence, this is included as one of the treatments for standard comparison.

Treatment Imposition: All the formulations were sprayed to coffee seedlings on the lower side of leaves, one month after transplanting into polybags at monthly interval till they attain planting stage (6 Months).

Observations and Data Analysis: Observations were made on growth and nutritional parameters. The growth parameters are plant height, root length, number of nodes and leaves, plant weight, shoot & root ration and leaf area parameters. To understand the nutritional changes, observations were made on nutritional contents of leaves in seedlings. Major nutrients namely Nitrogen, Phosphorus and Potassium, minor nutrients namely Calcium, Magnesium and Sulphur were analyzed using standard prescribed methodologies. The observations recorded were analyzed by Randomized Complete Block Design and significance was tested 5 % probability.

RESULTS

Plant Height and Root Length

The plant height and root length are the most important growth parameters that help in better establishment of seedlings in fields. The plant height and root length were significantly influenced by the treatments imposed. The data indicated that the average plant height was 12.6 and 13.9 cm in control and water sprayed plants respectively. The plant height was very good and significantly higher among various treatments ranging from 18.7 to 19.4 cm and all the treatments were on par with each other. Over two years average, the highest plant height of 19.4 cm was recorded by Glyricidia + Lantana extract spray followed by the DMSO + Plant extracts (18.9 cm). All other treatments viz. microbial consortia, salicylic acid and NAA had the same length of 18.7 cm. On an average, the plant height of seedlings increased by 48.4 to 50 % with PGRs over control. Results obtained were of similar trend with respect to root length also. The highest root length of 25.6 cm was recorded with Glyricidia + Lantana plant extract spray followed by other treatments. Root length of seedlings in all the treatments ranged from 24.8 to 25.6 cm which is significantly higher compared to control (19 cm) and water sprayed (19.9 cm) seedlings, but on par among the treatments. Root length increased by 31.6 to 34.7 % with the usage of PGRs when compared to control. The results are presented in Table 1.

Table 1. Plant height and root length of Sln. 9 Seedlings Influenced by PGRs

Treatments	Plant Height (Grams)			Variation (%)	Root Length (Cm)			Variation (%)
	Year 1	Year 2	**Mean**		Year 1	Year 2	**Mean**	
T1	12.00	13.20	**12.60**		17.30	20.73	**19.00**	
T2	12.30	13.40	**12.90**	**2.4**	18.00	21.70	**19.90**	**4.7**
T3	18.00	20.80	**19.40**	**54.0**	23.00	28.14	**25.60**	**34.7**

T4	17.60	19.70	**18.70**	**48.4**	22.20	27.40	**24.80**	**30.5**
T5	17.90	19.90	**18.90**	**50.0**	22.80	27.16	**25.00**	**31.6**
T6	17.70	19.70	**18.70**	**48.4**	22.50	27.97	**25.20**	**32.6**
T7	17.30	20.10	**18.70**	**48.4**	22.70	27.79	**25.20**	**32.6**
F Test	91.437*	348.006*			50.569*	108.097*		
C.D.	0.701	0.434			0.858	0.753		

Number of Nodes & Leaves

During the two years of experimentation, all the seedlings treated with PGRs had significantly higher number of nodes and leaves when compared to control and water treated seedlings. The number of nodes ranged from 9.3 to 9.8 per seedlings which is 29.2 to 36.1 % increase over control (7.2) and water sprayed (6.9) seedlings. Number of nodes among all the PGR treated plants is statistically on par with each other. Statistically similar results were obtained with number of leaves also. All seedlings treated with PGRs showed 18.5 to 19.5 leaves per plant which is 29.4 to 36.4 % increase over control (14.3) and water sprayed (13.7). Statistically all the PGRs treatments had number of leaves on par with each other. Results are presented in Table 2.

Table 2. Number of nodes and leaves of Sln. 9 Seedlings Influenced by of PGRs

Treatment	Number of Nodes (No.)			Variation	Number of Leaves (No.)			Variation
	Year 1	Year 2	**Mean**	(%)	Year 1	Year 2	**Mean**	(%)
T1	6.40	7.90	**7.20**		12.80	15.70	**14.30**	
T2	6.30	7.40	**6.90**	**-4.2**	12.60	14.70	**13.70**	**-4.2**
T3	9.10	10.10	**9.60**	**33.3**	18.20	20.20	**19.20**	**34.3**
T4	8.90	10.20	**9.60**	**33.3**	17.80	20.40	**19.10**	**33.6**
T5	9.20	10.10	**9.70**	**34.7**	18.30	20.20	**19.30**	**35.0**
T6	9.30	9.20	**9.30**	**29.2**	18.60	18.40	**18.50**	**29.4**
T7	8.90	10.60	**9.80**	**36.1**	17.70	21.20	**19.50**	**36.4**
F Test	65.581*	28.617*			65.581*	28.617*		
C.D.	0.402	0.583			0.806	1.165		

Leaf Area and Leaf Area Index

An important growth parameter of a plant is leaf area. In both the years of study, leaf area of seedlings is on par in control and water sprayed seedlings. Among the PGR treated seedlings, leaf area was significantly high when compared to control and water sprayed seedlings. The average of two years data indicated that NAA recorded the highest leaf area of 919.4 cm2 followed by DMSO (898.9 cm2), Microbial Consortium (885.6 cm2), Glyricidia + Lantana sprayed seedlings (877.7 cm^2) and Salicylic Acid (821.6 cm^2). The leaf area of seedlings was on par among the PGR treated seedlings and ranged from 821.6 cm^2 to 919.4 cm^2 which is 96.4 to 119.8 % increase over control (418.3 cm^2)and water (407.5 cm^2) sprayed seedlings.

Leaf area index indicates the ground cover of the foliage and is an important growth parameter that is observed in this study. Similar to leaf area, leaf area index also was significantly high with PGR treated seedlings statistically but remained on par within them. However, the average leaf area index was the highest 2.6 with NAA followed by 2.5 with DMSO and Microbial Consortium treated seedlings, Glyricida+Lantana extract (2.4) and Salicylic Acid (2.3) treated seedlings. The leaf area index was significantly influenced by treatments as compared to the leaf area index of control (1.9) and water sprayed plants (1.8). On an average, leaf area index of seedlings increased by 21.1 to 36.8 % over control. This indicated that PGR equally induced very good growth of foliage for every unit area of the ground effectively. Data is presented in Table 3.

Shoot Weight & Root Weight

As an indicator of healthy seedlings, biomass production in terms of shoot weight and root weight are the most important parameters for consideration. The observations of the study indicated that shoot weight of seedlings was statistically and significantly high among the PGR treated seedlings in both the years of study compared to control and water sprayed seedlings. The mean of two season indicated that shoot weight varied from 43.15 gram to 43.80 grams per plant that is significantly high with treatments of PGRs as compared to control (29.35 gram) and water sprayed (28.6 gram) seedlings. The shoot weight was on par among all the treatments but significantly higher when compared to control and water spray treatments. PGRs increased the shoot weight by 47.02 to 49.23 % when compared to control.

Table 3. Leaf area and leaf area index of Sln. 9 Seedlings Influenced by of PGRs

	Leaf Area (Cm^2)			Variation	Leaf Area Index			Variation
Treatments	Year 1	Year 2	**Mean**	(%)	Year 1	Year 2	Mean	(%)
T1	255.10	581.40	**418.30**		1.15	2.61	**1.90**	

T2	258.60	556.40	**407.50**	**-2.6**	1.14	2.46	**1.80**	**-5.3**
T3	694.30	1061.10	**877.70**	**109.8**	1.91	2.93	**2.40**	**26.3**
T4	699.60	1071.60	**885.60**	**111.7**	1.97	3.00	**2.50**	**31.6**
T5	680.30	1117.50	**898.90**	**114.9**	1.89	3.14	**2.50**	**31.6**
T6	661.30	981.90	**821.60**	**96.4**	1.87	2.78	**2.30**	**21.1**
T7	691.20	1147.50	**919.40**	**119.8**	1.95	3.22	**2.60**	**36.8**
F Test	52.809*	36.035*			16.738*	3.672*		
C.D.	70.681	103.268			0.227	0.354		

Similar to shoot weight, root weight also on par with PGR treated seedlings and significantly high when compared to control and water sprayed seedlings in both the years of study. The root weight was significantly high and remained on par among the PGR treatments. The mean of two seasons indicated that root weight ranged from 9.45 to 9.65 grams among the treatments when compared to control (6.5 grams) and water sprayed seedlings (6.65 gram) which is 45.38 to 48.46 % increase over control. Table 4 shows data on shoot and root weight.

Shoot to Root and Root to Shoot Ratio

Shoot to root ratio results as indicated in Table 5, varied compared from that of plant weight.. During the first year of study, shoot to root ratio varied significantly and statistically. Higher ratio was recorded with PGR treated seedlings ranging from 4 to 4.2. During the second year, shoot to root ratio remained on par in all treatments ranging from 5 to 5.3. The two years mean indicated that shoot to root ratio was slightly higher among PGR treated seedlings ranging from 4.45 to 4.65 followed by control (4.5) and water sprayed seedlings (4.3), which is just 1.11 to 3.33 % increase over control. Statistically results were similar with root to shoot ratio. Over the period of two years, root to shoot ratio remained on par with all treatments and was slightly higher in control (0.23) and water sprayed seedlings (0.24) followed by PGR sprayed seedlings, where in the root to shoot ratio ranged between 0.22 to 0.23. This indicated that root development was not sufficient under control and water sprayed treatments.

Table 4. Shoot and root weight of Old Sln. 9 Seedlings influenced by PGRs

	Shoot Weight (Grams)			Variation	Root Weight (Grams)			Variation
Treatments	Year 1	Year 2	**Mean**	(%)	Year 1	Year 2	**Mean**	(%)
T1	22.50	36.20	**29.35**		6.10	6.90	**6.50**	
T2	22.00	35.20	**28.60**	**-2.56**	6.20	7.10	**6.65**	**2.31**
T3	34.20	52.10	**43.15**	**47.02**	8.80	10.50	**9.65**	**48.46**
T4	33.60	53.10	**43.35**	**47.70**	8.30	10.60	**9.45**	**45.38**
T5	34.30	52.50	**43.40**	**47.87**	8.50	10.50	**9.50**	**46.15**
T6	35.30	52.30	**43.80**	**49.23**	8.50	10.40	**9.45**	**45.38**
T7	34.00	52.40	**43.20**	**47.19**	8.70	10.20	**9.45**	**45.38**
F Test	94.235*	51.718*			44.795*	69.906*		
C.D.	1.493	2.790			0.432	0.496		

Plant Nutrient Status

At nursery stage, most important nutrients are primary and secondary nutrients than micro nutrients that enhance seedlings growth. Both the years, Nitrogen content was significantly higher in PGR treated seedlings compared to control and water treated plants, but remained on par within the PGR treated seedlings. On an average, control seedlings had 2.15 % N and same ranged between 2.63 to 2.67 % under various treatments. Nitrogen content of leaves is on par with all the treatments and the percent increase of N content ranged from 22.09 to 23.95 % over control. Results with Phosphorus and Potassium were in the similar trend. Phosphorus content was more and highly significant in PGR treated seedlings compared to control and water sprayed seedlings (0.11 %) and the phosphorus content of seedlings with PGRs ranged from 0.14 to 0.15 %, which is 29.63 to 34.26 % higher over control and were on par among the treatments. Similarly, Potassium content varied significantly higher over control and water sprayed plants (2.26 %) and ranged from 2.79 to 2.82 % which is 23.59 to 24.92 % increase over control. Both the years, results were significantly high in PGR treatments and remained on par among the PGR treatments. Data on major nutrient contents of seedlings is presented in Table 6.

Secondary nutrients namely Calcium, Magnesium and Sulphur were also analysed. Results indicated that all the secondary nutrients were significantly higher in PGR treated seedlings when compared to control and water sprayed seedlings. Calcium content was 0.63 % in control and 0.62 % in water sprayed seedlings. In treated plants with PGRs the calcium content ranged from 1.04 to 1.08 %, which are 65.6 to 72.8 % higher compared to control. Similarly, Magnesium content was 0.15 % in both control and water sprayed treatments. PGR treated seedlings had 0.35 to 0.36 % Magnesium that are 133.11 to 139.86 % higher compared to control. Similar to Magnesium, sulphur content was same in both control and water sprayed seedlings (0.15 %). The sulphur content was almost equal 0.21

% in all treated seedlings. Both the years, secondary nutrients were on par in PGR treated seedlings. Table 7 shows secondary nutrients status of coffee seedlings.

Table 5. Shoot and root ratio of 6 Months Old Sln. 9 Seedlings influenced by PGRs

Treatments	Shoot to Root Ratio			Variation (%)	Root to Shoot Ratio			Variation (%)
	Year 1	Year 2	**Mean**		Year 1	Year 2	**Mean**	
T1	3.70	5.30	**4.50**		0.27	0.19	**0.23**	
T2	3.60	5.00	**4.30**	**-4.44**	0.28	0.20	**0.24**	**4.35**
T3	3.90	5.00	**4.45**	**-1.11**	0.26	0.20	**0.23**	**0.00**
T4	4.10	5.00	**4.55**	**1.11**	0.25	0.20	**0.23**	**-2.17**
T5	4.10	5.10	**4.60**	**2.22**	0.25	0.20	**0.23**	**-2.17**
T6	4.20	5.10	**4.65**	**3.33**	0.24	0.20	**0.22**	**-4.35**
T7	4.00	5.20	**4.60**	**2.22**	0.26	0.19	**0.23**	**-2.17**
F Test	4.679*	0.525NS			4.653*	0.543NS		
C.D.	0.246	0.427			0.016	0.017		

Table 6. Primary nutrients status of Sln 9 arabica seedlings influenced by PGRs

Treatments	Nitrogen (%)			Variation (%)	Phosphorus			Variation (%)	Potassium (%)			Variation (%)
	Year 1	Year 2	**Mean**		Year 1	Year 2	**Mean**		Year 1	Year 2	**Mean**	
T1	2.08	2.22	**2.15**		0.10	0.12	**0.11**		1.97	2.55	**2.26**	
T2	2.09	2.26	**2.18**	**1.16**	0.10	0.12	**0.11**	**1.85**	1.96	2.55	**2.26**	**-0.11**
T3	2.76	2.57	**2.67**	**23.95**	0.13	0.16	**0.15**	**34.26**	2.44	3.15	**2.80**	**23.81**
T4	2.77	2.55	**2.66**	**23.72**	0.12	0.16	**0.14**	**29.63**	2.49	3.15	**2.82**	**24.92**
T5	2.74	2.55	**2.65**	**23.02**	0.12	0.17	**0.15**	**34.26**	2.47	3.14	**2.81**	**24.25**
T6	2.70	2.55	**2.63**	**22.09**	0.12	0.17	**0.15**	**34.26**	2.48	3.09	**2.79**	**23.37**
T7	2.76	2.53	**2.65**	**23.02**	0.12	0.17	**0.15**	**34.26**	2.44	3.14	**2.79**	**23.59**
F Test	169.79*	99.71*			21.09*	117.11*			41.15*	33.80*		
C.D.	0.061	0.036			0.005	0.005			0.094	0.121		

Table 7. Secondary nutrients status of Sln 9 arabica seedlings influenced by PGRs

Treatments	Calcium (%)			Variation (%)	Magnesium (%)			Variation (%)	Sulphur (%)			Variation (%)
	Year 1	Year 2	**Mean**		Year 1	Year 2	**Mean**		Year 1	Year 2	**Mean**	
T1	0.60	0.65	**0.63**		0.15	0.15	**0.15**		0.16	0.14	**0.15**	
T2	0.58	0.66	**0.62**	**-0.80**	0.14	0.16	**0.15**	**1.35**	0.16	0.14	**0.15**	**0.00**
T3	0.99	1.08	**1.04**	**65.60**	0.31	0.40	**0.36**	**139.86**	0.21	0.20	**0.21**	**36.67**
T4	0.97	1.12	**1.05**	**67.20**	0.30	0.39	**0.35**	**133.11**	0.22	0.20	**0.21**	**40.00**
T5	1.02	1.14	**1.08**	**72.80**	0.31	0.40	**0.36**	**139.86**	0.22	0.19	**0.21**	**36.67**
T6	1.01	1.12	**1.07**	**70.40**	0.30	0.41	**0.36**	**139.86**	0.21	0.20	**0.21**	**36.67**
T7	1.03	1.12	**1.08**	**72.00**	0.28	0.41	**0.35**	**133.11**	0.22	0.21	**0.22**	**43.33**
F Test	59.40*	189.19*			41.55*	173.50*			73.29*	17.77*		
C.D.	0.066	0.040			0.028	0.023			0.009	0.017		

DISCUSSION

In the study conducted for two years, growth parameters were significantly increased by the use of plant growth regulators used in the study. There was considerable increase in the plant height and root length in PGR sprayed seedlings when compared to control and water sprayed seedlings. Similarly, number of nodes and leaves per seedling, leaf area and leaf area index, shoot and root weights, also increased significantly. These could be attributed to increased nutrient uptake and status of the seedlings which could be seen from the results that all the PGR treated seedlings had increased primary and secondary nutrient status in leaves. Results indicated that increase in growth parameters remained on par statistically among all the treatments over control and water sprayed seedlings. In the present study DMSO used as an accelerator to enhance the effectiveness of Lantana camera extract. As the results were on par and some studies have indicated the negative effect of DMSO, Lantana camera alone can be better utilized as a part of sustainable agriculture to enhance the growth of coffee seedlings. The enhanced growth of seedlings with Lantana camera can be attributed to the reason that it enhances the water use

efficiency of plants (George Daniel, 2006). Even Glyricidia as green manure crop, its etract along with Lantana increased the growth of seedlings by enhanced number of nodes, leaves and plant height. Such results were earlier obtained and growth of Sln. 9 coffee seedlings was increased by Glyricidia extracts at various concentrations (Anon, 2003). Arka microbial consortia used in this study also enhanced the growth of coffee seedlings. Such influence on growth of seedlings was earlier studied and confirmed by Panneer Selvam *et al*. (2008). Similar results of increased seedling growth were reported by Kamala Bai *et al* (2002) and Muralidhara *et al (*1996) with the use of external supply of composts and biofertilizers (Biradar *et al* , 2006). The use of NAA is already in recommendation by the Central Coffee Research Institute. Hence, farmers can make use any of the materials used in this study for enhancing growth of coffee seedlings depending on the abundance of the material and economics. The growth of coffee seedlings in both control and water sprayed seedlings remained significantly low and on par between each other. This is for the reason that regular watering of seedlings is a common practice in nurseries for maintenance. Hence, additional spray of water didn't enhance coffee seedlings growth significantly.

CONCLUSION

The growth and development of Arabica coffee variety Sln. 9 seedlings at 6 months age was significantly increased by treating the seedlings with *Glyricidia sepia* + *Lantana camara* extract, Arka Microbial Consortium, *Lantana camara* + DMSO+$CuSO_4$, Salicylic Acid and NAA. The results indicated that the growth parameters influenced by PGRs were significantly higher compared to control and water sprayed seedlings. However, the growth parameters remained non significant and on par among these five PGRs used in the study. Being water sprayed seedlings, the growth and development of seedlings under control and water sprayed remained on par. This could be attributed to the reason that regular watering is a common practice of nursery and just spraying water alone had no special effect on growth of seedlings. The higher growth of seedlings under various treatments was due to increased nutrient status of seedlings that was enhanced by PGRs. Further, there is a need to study individual PGRs of this study with different concentrations to optimise economic dosage for boosting of seedlings.

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