International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 13 Issue 3, March-2024, Impact Factor: 8.375

Role of Natural Plant Growth Regulators for Improving Robusta (*Coffeacanephora*) Coffee Yield and Quality

Nagarathnamma, R.[1], Rajeshwari N. Babu[2], Muralidhara, H.R.[3]

[1]Research Assistant, Department of Plant Physiology, Central Coffee Research Institute
[2]Principal, Sahyadri College, Kuvempu University, Shivamogga, India
[3]Senior Liaison Officer, Coffee Board, Chikkamagaluru 577102

ABSTRACT

A trial was conducted at Coffee Research Sub Station in Coorg District during 2016-18 to understand the effect of natural plant growth regulators on yield and quality of Robusta coffee. Arka Microbial Consortium, *Lantana camara* and *Glyricidiasepium* were used in comparison with chemicals viz. Salicylic acid and Alpha – NAA. Results indicated that spraying all growth regulators twice @ 0.025 to 1.0 % concentration enhanced the yield parameters such as bearing nodes per branch (16.85 %), flower buds per node (18.3 %) and fruit set (15.75 %) of Robusta coffee as compared to control and water sprayed plants. This resulted in 13.02 % increase in yield of coffee with 11.11 %.increase in out turn ratio. There was an increase of 3.33 % and 29.3 % in percent 'AB' grade beans and bean weight respectively in plants treated with plant growth regulators as compared to control. PGR treated plants had 27.68 % higher caffeine in beans. Both control and water sprayed plants had resulted in yield and quality on par with each other. All PGR treated plants had resulted in statistically and significantly higher yield and quality in Robusta coffee over control and water sprayed plants. However, among the different plant growth regulators, results were statistically on par indicating that both natural and chemical plant growth regulators are equally effective in enhancing yield and quality of coffee and growers can make use of these at their choice based on the method of cultivation that they adapt.

Key Words: Robusta coffee, plant growth regulators, yield and quality, *Lantana camara, Glyricidiasepium*

INTRODUCTION

The coffee being a perennial plant with an average economical life span of 30 to 40 years, it flowers and gives crop only once in a year. Besides, the coffee plant has the biennial bearing habit. Most of the times irrespective of any factor yield is influenced not only by climatic factor but also by its biennial bearing habit. Hence, in coffee is very much important to understand the growth and development of bearing nodes, flower buds, fruit setting percentage, out turn ratio from fruits to clean coffee etc. which may to the most extent sometimes eliminates the biennial effect. Many studies have indicated that exogenous application of plant growth regulators (PGRs) found useful to improve the physiological attributes (D'Souza *et al.*,2004; Mallikarjun G. Awati*et al.* 2007; George Daniel *et al.*, 2010) in coffee besides coffee yield.

Author Contact: Nagarathnamma R, Asst. Physiologist, Coffee Board, Behind ZillaPanchayath, Jyothi Nagar Post, Chikkamagaluru – 577 102

Application of growth regulators have proved to improve both yield and quality in different horticulture crops like sapota (Kavyashree*et al.*, 2018), Mango (Kulkarni*et al.* 2017), pepper (Ramesh Kumar *et al*. 2022). Hence, in this study yield parameters, yield, out turn and quality etc. are studied in detail in Robusta coffee.

METHODOLOGY

Treatments: The study was taken up in seedlings using Arabica coffee variety Sln. 9. Seven following treatments were finalized including the standard recommended PGR.

T1: No spray (control)
T2: Water spray (Control)
T3: Plant extract (*Glyricidia sepia*&*Lantana camera*) 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)

Treatment Imposition: All the formulations were sprayed twice to Robusta coffee plants of 20 year old on the lower side of leaves. The first spray was done after post blossom and another spray during pre monsoon before the onset of monsoon.

Plant Material:Trial was conducted using Robusta cv. C *x* R (*Coffea canephora Pierre ex froehner*)**:** This variety is being cultivated commonly in the coffee growing zones of India. It is a selected cultivar known for large bush size with robust growth. The leaves are broad and oblong. It is a semi drooping type with large number of secondary and tertiary branches. The long internodes of 5 to 7 cm with large clusters of fruits vary from 25 to 50 per cropping nodes. This variety found to have high root biomass, good water use efficiency, vigorous growth and resistance to major pest and diseases. The cultivar possesses high carbon exchange rates. The fruits are bolder in size with around 70% `AB' grades. The fruits are reddish to dark red in color. A crop yield of 1800 to 2000 Kg/ha Clean Coffee could be expected under well cultivation practices.

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.

Observations and Data Analysis: Yield parameters such as number of bearing nodes, flower buds per node, percent fruit set and retention were observed for two cropping seasons on marked growth regulator treated plants. Yield recording was done in whole treated plots. Unsprayed and water sprayed plots were control plots.

Assessment of bean physical characteristics: Out turn and grading was done following standard procedures. Bean physical characteristics like percent A and AB grade beans, bean weight were assessed as per standard

Assessment of Quality Parameters: Caffeine being the most important component of coffee quality, it was estimated using standard procedure.

RESULTS

Yield parameters are very important in determination of crop yield. Important yield parameters are bearing nodes per branch; number of flower buds per branch and fruit set percentage. Data on these parameters are presented in Table. 1.

Bearing nodes per branch: During the both year of study, bearing nodes per branch were significantly high in PGR treated plants as compared to control and water sprayed plants. On an average, bearing nodes were same 7.95 to 8.0 in control and water sprayed plants which was 15.09 to 17.61 % less compared to 9.15 to 9.40 nodes per branch among the PGR treated plants.

Flower buds per Node: On an average, flower buds per node were 50.8 in control and 49.5 in water sprayed plants which were 16.55 to 19.8 % less compared to 59.2 to 60.8 flower buds per nodes under PGR treated plants.

Fruit set percent: Percentage flowers pollinated and pin head fruits set were significantly higher in PGR treated plants as compared to control and water sprayed plants. On an average, fruit set in PGR treated plants ranged from 74.8 to 75.6 % which was 15.25 to 16.49 % less compared to 64.9 % and 65.05 % fruit set respectively in control and water sprayed plants.

Yield and Out Turn in CxR: Data on crop yield and out turn ratio is presented in Table 2. Effect of PGRs on yield and quality parameters was studied. Yield of CxR coffee was significantly high in PGR treated plants compared to control and water sprayed plants. Over two years study, mean yield was 1238 and 1234 Kg/ha in control and water sprayed plants. Among the PGRs, highest yield was recorded in DMSO (1410 Kg/ha) followed by NAA (1406), Microbial consortium (1398 Kg/ha), Glyricidia + Lantana (1396 Kg/ha) and Salicylic acid (1387Kg/ha), which were 12.04 to 13.88 % increase over control.

Fruit to clean coffee ratio (Out Turn) is the key factor in quality parameter for increasing yield in coffee. Out turn was found to be significantly and statistically higher in PGR treated plants in both the years of the study. Mean out turn percent was 20.99, 20.97, 20.95, 20.92 and 20.87 % respectively in Salicylic acid, Glyricidia + Lantana, NAA, DMSO and Microbial consortia which was 10.75 to 11.36 % higher compared to Out turn percent in control (18.85 %) and water sprayed (18.93%) plants.

Table 1. Crop yield and out turn % of Robusta variety C x R as affected by PGRs

Treatments	Clean Coffee Kg/ha			Variation (%)	Out Turn (%)			Variation (%)
	Year 1	Year 2	Mean		Year 1	Year 2	Mean	
T1	1175.5	1301.1	1238		18.8	18.9	18.85	
T2	1165.0	1303.8	1234		19.0	18.8	18.93	
T3	1298.8	1493.2	1396	**12.74**	21.0	20.9	20.97	**11.25**
T4	1305.7	1490.1	1398	**12.89**	20.8	20.9	20.87	**10.75**
T5	1302.6	1517.8	1410	**13.88**	20.9	21.0	20.92	**11.01**
T6	1294.9	1480.0	1387	**12.04**	21.0	21.0	20.99	**11.36**
T7	1312.6	1499.5	1406	**13.55**	20.9	21.0	20.95	**11.17**
F Test 5 %	25.871*	105.974*		13.02	50.72*	29.258*		11.11
C.D.	31.363	22.677			0.333	0.472		

Bean Grade and Bean Density: Bean quality parameters are presented in Table 3.In robusta varieties, grade 'AB' beans constitute the major portion in a lot which contribute to yield. The AB Grade Bean % was significantly and statistically higher in all PGR treated plants as compared to control and water sprayed plants during the two years of the study. The mean AB Grade Bean % over two years of study ranged from 63.4 to 63.64 % which was 3.13 to 3.51 % increase over AB Grade Bean % in control (61.48 %) and water sprayed (61.4 %) plants.

Bean weight was worked out by weighing 100 AB beans randomly. AB bean weight was also significantly higher in PGR treated plants compared to bean weight in control and water sprayed plants. The mean AB weight was 0.43 grams in control and water sprayed plants. Among the PGRs, Microbial consortium, DMSO and Salicylic acid treated plants had 0.56 grams bean weight followed by 0.55 grams in Glyricidia + Lantana and NAA treated plants which were 27.91 to 30.23 % increase over control.

Table 2. Bean parameters of Robusta variety C x R as affected by PGRs

Treatments	AB Grade Bean in CxR (%)			Variation (%)	AB Grade Bean Weight in CxR (Grams)			Variation (%)
	Year 1	Year 2	Mean		Year 1	Year 2	Mean	

T1	61.37	61.58	61.48		0.43	0.43	0.43	
T2	61.23	61.56	61.40		0.43	0.42	0.43	
T3	63.28	63.61	63.45	**3.20**	0.55	0.55	0.55	**27.91**
T4	63.72	63.55	63.64	**3.51**	0.57	0.55	0.56	**30.23**
T5	63.79	63.35	63.57	**3.41**	0.55	0.56	0.56	**30.23**
T6	63.43	63.37	63.40	**3.13**	0.56	0.55	0.56	**30.23**
T7	63.71	63.39	63.55	**3.38**	0.54	0.56	0.55	**27.91**
F Test 5 %	52.143*	89.352*		3.33	181.377*	268.995*		29.3
C.D.	0.385	1.018			0.01	0.049		

Caffeine Content: Caffeine being the most important chemical constituent of coffee beans is the main property that decides quality of coffee beans. Caffeine was statistically and significantly higher in all PGR treated plants as compared to control and water sprayed plants. On an average, both control and water treated plants had 2.16 % caffeine in beans. Caffeine in all PGR treated plants ranged from 2.74 to 2.79 % which was 26.85 to 29.17 % increase over caffeine content in the beans of control and water sprayed plants. Data is shown in Table 8.12.

Table 3. Caffeine content of Robusta variety C x R as affected by PGRs

Treatments	Caffeine (%) in CxR			Variation (%)
	Year 1	Year 2	Mean	
T1	2.14	2.17	2.16	
T2	2.18	2.13	2.16	
T3	2.70	2.80	2.75	**27.31**
T4	2.77	2.76	2.77	**28.24**
T5	2.74	2.74	2.74	**26.85**
T6	2.80	2.78	2.79	**29.17**
T7	2.72	2.75	2.74	**26.85**
F Test 5 %	101.94*	106.383*		27.68
C.D.	0.069	0.175		

Table 4 Yield parameters of Robusta variety C x R as affected by PGRs

	Bearing Nodes/ Branch			Variation (%)	Buds/Node			Variation (%)	Fruit Set %			Variation (%)
Treatments	Year 1	Year 2	Mean		Year 1	Year 2	Mean		Year 1	Year 2	Mean	
T1	7.4	8.5	7.95		45.6	55.9	50.8		62.3	67.5	64.90	
T2	7.5	8.5	8.00		45.0	53.9	49.5		62.4	67.7	65.05	
T3	8.6	10.2	9.40	**18.24**	55.6	66.0	60.8	**19.80**	72.3	77.5	74.90	**15.41**
T4	8.4	9.9	9.15	**15.09**	53.7	64.6	59.2	**16.55**	72.0	77.6	74.80	**15.25**
T5	8.5	10.0	9.25	**16.35**	54.7	65.9	60.3	**18.82**	72.7	77.6	75.15	**15.79**
T6	8.6	10.1	9.35	**17.61**	55.7	64.7	60.2	**18.62**	73.2	78.0	75.60	**16.49**
T7	8.5	10.1	9.30	**16.98**	54.6	64.9	59.8	**17.73**	72.8	77.5	75.15	**15.79**
F Test 5 %	51.168*	71.978*		16.85	54.941*	86.742*		18.3	225.989*	182.352*		15.75
C.D.	0.182	0.22			1.562	1.344			0.817	0.888		

Nutritional Parameters in Robusta Coffee

Major Nutrients – Analysed status of major or macro nutrients is presented in Table 5.

The mean nitrogen content varied from 3.46 to 3.51 % among the PGR treated plants which was 29.16 to 31.03 % increase over nitrogen content of control (2.68 %) and water sprayed (2.66 %) plants.The mean phosphorus content of two years study was 0.083 % in control and 0.088 % in water sprayed plants. Phosphorus varied from 0.138 to 0.150 % among the PGR treated plants which was 66.27 to 80.12 % increase over control. Over a period of two years, average potassium was

2.67 % and 2.65 % respectively in control and water sprayed plants which was 19.66 to 24.34 % increase over the potassium content of 3.195 to 3.32 % among PGR treated plants.

Table 5. Macro nutrients status as affected by Growth Regulators in plants of C x R

Treatments	Nitrogen (%)			Variation (%)	Phosphorus			Variation (%)	Potassium (%)			Variation (%)
	Year 1	Year 2	Mean		Year 1	Year 2	Mean		Year 1	Year 2	Mean	
T1	2.65	2.70	2.68		0.077	0.089	0.083		2.54	2.80	2.670	
T2	2.63	2.68	2.66		0.082	0.094	0.088		2.52	2.78	2.650	
T3	3.37	3.54	3.46	**29.16**	0.141	0.135	0.138	**66.27**	3.25	3.26	3.255	**21.91**
T4	3.46	3.53	3.50	**30.65**	0.142	0.136	0.139	**67.47**	3.43	3.19	3.310	**23.97**
T5	3.47	3.52	3.50	**30.65**	0.143	0.141	0.142	**71.08**	3.35	3.04	3.195	**19.66**
T6	3.46	3.51	3.49	**30.28**	0.149	0.150	0.150	**80.12**	3.37	3.27	3.320	**24.34**
T7	3.44	3.57	3.51	**31.03**	0.143	0.152	0.148	**77.71**	3.35	3.19	3.270	**22.47**
F Value	135.166*	228.949*		30.35	148.965*	18.51*		72.53	40.434*	8.803*		22.47
CD	0.083	0.066			0.007	0.014			0.156	0.175		

Secondary Nutrients – Data on secondary nutrients is presented in Table 6

The mean calcium content among the PGR treated plants varied from 0.98 % to 1.015 % which was 38.03 to 42.96 % increase over 0.71 % calcium of control and 0.695 % calcium of water sprayed plants.Mean magnesium over two years of study varied from 0.40 to 0.42 % among the PGR treated plants which were 42.86 to 48.21 % increase over magnesium content in control (0.28 %) and water sprayed plants (0.29 %).The average sulphur content among the PGR treated plants was varying from 0.150 to 0.160 % which was 57.89 to 68.42 % increase over 0.095 % sulphur content of control and water sprayed plants.

Table 6. Secondary nutrients status as affected by Growth Regulators in plants of C x R

Treatments	Calcium (%)			Variation (%)	Magnesium (%)			Variation (%)	Sulphur (%)			Variation (%)
	Year 1	Year 2	Mean		Year 1	Year 2	Mean		Year 1	Year 2	Mean	
T1	0.69	0.73	0.710		0.29	0.27	0.28		0.10	0.09	0.095	
T2	0.69	0.70	0.695	**-2.11**	0.30	0.27	0.29	**1.79**	0.10	0.09	0.095	**0.00**
T3	0.95	1.06	1.005	**41.55**	0.44	0.39	0.42	**48.21**	0.16	0.15	0.155	**63.16**
T4	0.96	1.07	1.015	**42.96**	0.43	0.38	0.41	**44.64**	0.16	0.15	0.155	**63.16**
T5	0.92	1.04	0.980	**38.03**	0.42	0.38	0.40	**42.86**	0.15	0.16	0.155	**63.16**
T6	0.98	1.03	1.005	**41.55**	0.44	0.37	0.41	**44.64**	0.16	0.16	0.160	**68.42**
T7	0.94	1.04	0.990	**39.44**	0.43	0.39	0.41	**46.43**	0.15	0.15	0.150	**57.89**
F Value	9.823*	41.883*		33.57	48.836*	37.043*		38.1	36.665*	46.655*		52.63
CD	0.101	0.062			0.024	0.023			0.012	0.012		

Micro Nutrients – The data on most important micro nutrients is given in Table 7 and 8.

The average Manganese content was 136.59 and 135.53 ppm respectively in control and water sprayed plants which were 44.03 to 48.02 % less compared to 196.74 to 202.19 ppm manganese content in PGR treated plants. The average iron content over two years of study indicated that PGR treated plants had 27.92 to 31.52 % higher iron content ranging from 268.32 to 275.87 ppm when compared to 209.75 ppm in control and 200.87 ppm in water sprayed plants. The mean boron content varied from 42.62 ppm to 43.40 ppm among the PGR treated plants which were 20.96 to 23.19 % increase over control. The mean copper content was 11.29 ppm in control and 11.5 ppm in water sprayed plants. Among the PGR treated plants, copper content varied from 13.73 to 14.25 ppm which were 21.67 to 26.27 % increase over control.Mean zinc content was almost same both in control (15.9 ppm) and water sprayed (15.47 ppm) plants which were 49.94 to 63.3 %

increase over the zinc content of 23.84 to 25.97 ppm in PGR treated plants.Mean molybdenum content was 0.16 and 0.15 ppm respectively in control and water sprayed plants. The mean molybdenum content ranged from 0.46 to 0.5 ppm among the PGR treatedplants which were 187.5 to 212.5 % increase over control.

Table 7. Micro nutrients status as affected by Growth Regulators in plants of C x R

Treatments	Manganese (Mn)			Variation (%)	Iron (ppm)			Variation (%)	Boron (ppm)			Variation (%)
	Year 1	Year 2	Mean		Year 1	Year 2	Mean		Year 1	Year 2	Mean	
T1	130.83	142.35	136.59		213.65	205.85	209.75		38.01	32.45	35.23	
T2	128.33	142.72	135.53		204.91	196.82	200.87		37.65	32.33	34.99	
T3	200.82	197.56	199.19	**45.83**	275.86	260.77	268.32	**27.92**	43.88	42.48	43.18	**22.57**
T4	201.14	197.39	199.27	**45.89**	273.73	264.54	269.14	**28.31**	43.59	41.64	42.62	**20.96**
T5	199.71	199.98	199.85	**46.31**	271.58	268.23	269.91	**28.68**	43.96	42.84	43.40	**23.19**
T6	200.70	203.67	202.19	**48.02**	280.94	270.80	275.87	**31.52**	44.14	42.38	43.26	**22.79**
T7	198.87	194.60	196.74	**44.03**	272.1	266.16	269.13	**28.31**	43.74	42.77	43.26	**22.78**
F Value	416.912*	328.713*		46.02	76.758*	127.016*		28.95	36.815*	34.38*		22.46
CD	4.143	3.721			9.024	6.933			1.191	2.053		

Table 8. Micro nutrients status as affected by Growth Regulators in plants of C x R

Treatments	Copper (ppm)			Variation (%)	Zinc (ppm)			Variation (%)	Molybdenum (Mo)			Variation (%)
	Year 1	Year 2	Mean		Year 1	Year 2	Mean		Year 1	Year 2	Mean	
T1	11.28	11.29	11.29		14.79	17.01	15.90		0.14	0.18	0.160	
T2	11.48	11.52	11.50		14.66	16.27	15.47		0.13	0.17	0.150	
T3	13.64	14.75	14.20	**25.79**	25.96	21.72	23.84	**49.94**	0.42	0.50	0.460	**187.50**
T4	13.31	15.19	14.25	**26.27**	25.06	24.46	24.76	**55.72**	0.45	0.48	0.465	**190.63**
T5	13.95	13.74	13.85	**22.68**	25.51	26.42	25.97	**63.30**	0.48	0.52	0.500	**212.50**
T6	13.19	14.27	13.73	**21.67**	24.64	26.49	25.57	**60.79**	0.46	0.47	0.465	**190.63**
T7	13.17	14.76	13.97	**23.75**	25.41	26.43	25.92	**63.02**	0.48	0.52	0.500	**212.50**
F Value	7.24*	26.896*		24.03	45.238*	20.801*		58.55	35.116*	48.737*		198.75
CD	0.955	0.754			1.89	2.403			0.064	0.055		

DISCUSSION

The higher yields obtained in PGR sprayed plants could be attributed to not only increased yield parameters like number of bearing nodes, flower buds per node and fruit set but also due to increased out turn ratio, % ‘AB’ grade beans and ‘AB’ grade beans weight. The increased bearing nodes under PGR treatments could be attributed to increased nitrogen status of plants, which is very essential for increased vegetative growth of plants. The increase in flower buds and fruit set under PGR treatments could be attributed to increased phosphorus status of plants, a very essential nutrient in coffee responsible for flower buds production. Central Coffee Research Institute recommends phosphorus supplement through water soluble

fertilizers like DAP or SSP in summer for increasing flower bud production and fruit set of coffee. Further, potassium was also high under PGR treated plants. This element is particularly responsible for increasing bean weight and out turn ratio in coffee. Such increased yields in coffee were reported in earlier studies by D Souza *et al.* (2004), Mallikarjuna*et al*.(2007), George Daniel *et al*. (2010), where in there was increase of coffee yield due to improved physiological activities. In other crops like sapota (Kavyashree*et al.*, 2018; Akshay Mishra *et al.*, 2020), mango (Roy *et al*., 2016; Kulkarni et al., 2017) and pepper also PGRs proved to improve yield parameters and yield considerably along with quality. Hence, it is recommended that natural plant growth regulators are as effective as chemical growth regulators and can be exploited for improving yield and quality in coffee while growers adopt natural and organic farming cultivation practices.

REFERENCES

[1]. Akshay Mishra, DevendarChaha, MandeepRathee and Dinesh Thomar, 2020.Influence of plant growth regulators on flowering, fruiting, yield and quality of sapota [manilkarazapota.Ind. J. Pure App. Biosci.(2020) 8(4),499-50

[2]. D'Souza, G.F., D.Venkataramanan,GeorgeDaniel,N.Sadananda,N.Ramamurthy and MallikarjunG.Awati. 2004. Biozyme granules as biostimulants for crop improvement in Coffee. J.Plantation rops,32,December 2004:61-63

[3]. George Daniel, G.F. D Souza, C.G. Anand, B. Lamani, M.G. Awati, V.M. Saraswathy and N. Sadananda, 2010. Effect of foliar application of Lantana camara leaf extract. J. Coffee Res., 38 (1&2) : 48-58

[4]. Mallikarjun G. Awati, G.F. D Souza, N.S. Renukaswamy, D. Venkataramanan and C.G. Anand, 2007.Influence of foliar application of Mepiquat chloride and Ethephon on flowering and crop yield in Arabica coffee. J. Coffee Res. 35 (1&2); 1-9.

[5]. Kavyashree, N., HemlaNaik, B and Thippesha D., 2018.Effect of plant growth regulators on yield and quality of sapota (Achraszapota l.) through crop regulation under hill zone of Karnataka.International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 4 (2) : 13-17.

[6]. Kulkarni, S.S., Patil, S.S. and Magar, S.D., 2017.Effect of plant growth regulators on yield and quality of mango (Mangiferaindica L.) cv. Kesha. Journal of Pharmacognosy and Phytochemistry 2017; 6(5): 2309-2313

[7]. Ramesh Kumar, A., Sathiamoorthy, S. and Subbiah, A. 2022.Effect of plant growth regulators on yield parameters, yield and quality of black pepper *(Piper nigram*L.) variety Panniyur – 1.*Journal of Spices and Aromatic Crops* 11 (2) : 125-128.

[8]. Roy,D., Thirupathi, N., Das, K. and Ghosh, S.N. 2016. Effect of Plant Growth Regulators on Fruit Retention and Physico-chemical Properties of Mango cv. Amrapali Gown in Laterite Soil at Close Spacing. Natural Resource Management: Ecological Perspectives Indian Ecological Society: International Conference-2016. SKUAST-Jammu (18-20 February 2016).