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

# Role Of Plant Based Pgrs Against Chemical Pgrs For Growth And Development Of Robusta Coffee *Coffeacanephora* var. Cx Rseedlings

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

**Corresponding Author:** Nagarathnamma R. Email ID: nagu_rediffmail.com, Research Assistant, Coffee Board, Chikkamagaluru , Karnataka, India – 577102

## ABSTRACT

**The growth and development of coffee seedlings in Robusta coffee variety C x Rat 18 months stage was studied using various growth regulators. *Glyricidiasepium* + *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. Final growth parameters were recorded at 18 months age when seedlings were ready for field planting. The results indicated that the increase of growth parameters were statistically significant in PGR treated seedlings. The seedlings of CxRRobusta coffee were 11.32 % taller and had 16.7 % more longer roots. 33.78% more nodes with 32.68 % higher internode length were found. 27.02 % more leaves due to 63.27 % more primaries in PGR treatments.Shoot and root weight was respectively 31.68 % and 30.54 % higher in PGR treated Robusta seedlings compared to control seedlings. Leaf area was 141.46 % larger with 72.72 % higher specific leaf area.48.64 % higher leaf area index and 72.64 % higher leaf area ratio were found in Robustaseedlings treated with PGRs. All treatments had 10.92 % higher absolute growth rate and 29.24 % higher net assimilation rate in PGR treated seedlings over control seedlings.Significant increase in major nutrientsviz. Nitrogen, Phosphorus, Potassiumstatus of leaves was found 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 study highlights the importance on use of PGRs in boosting the growth and development of 18 months old Robustacoffee seedlings.**

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

## INTRODUCTION

Coffee is the important economical crop of farmers in the Western Ghats regions of South India. *Coffeaarabica* and *Coffeacanephora* commonly known as Arabica and Robusta respectively are the two major species grown across India. Robusta is grown as major crop in low elevation places of Karnataka, Kerala and Tamil Nadu states of India. Being perennial and wide spaced crop, robusta coffee faces huge competition from weeds in the initial years of plantingupto five to six years. Hence, establishment of good Robusta coffee plantation is mainly influenced by planting of healthy and vigorous coffee seedlings.Robusta has more succulent and thin leaves in seedlings compared to Arabica seedlings. The seedlings planted in main field face huge competition from weeds and geteasily damaged by insects and survive hard to come up whenplanted at six months age.

Hence, in recent years, many coffee growers are maintaining nursery seedlings for two seasons till they attain good size and then plant the seedlings in main field when they are sturdy.

The Central Coffee Research Institute 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. 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 quality 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. But because of sufficient land space, growers are not maintaining seedlings with a good spacing making them to grow well. Instead, they retain six months seedlings till next planting season in baskets as usual without keeping them apart and planting apart in nursery. Hence, there is a need to boost the growth of Robusta coffee seedlings by external means such that they can be planted at 18 months. However, application of excessive fertilizers leads to succulent growth of seedlings instead of hard seedlings. This haslead to an attempt on usage of growth regulators to promote seedlingsgrowth.

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 camera*are common. Even the oldest chemical, DMSO as a carrier of agricultural toxicants, first received attention by Norris and Freed (1963 and because of Its unique solvent and membrane transport properties (Jacob Bischel, and Herschler, 1964) might have played important role as PGR.

Many studies were conducted to boost the growth of seedlings using plant extracts like *Lantana camera* (Anon, 2003), *Glyricidiasepium*(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 Indiaare *Glyricidia sepia*and *Lantana camera* 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 camera* 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;PanneerSelvam*et al.* (2008).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. As the earlier studies concentrated only towards the addition of composts, biofertilizers into the nursery mixture and much effort 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 Robusta CxR with the following objectives.

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

## MATERIAL AND METHODS

**Treatments:** The study was taken up in seedlings using Robusta coffee variety CxR. 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: ArkaMicrobial Consortium1 % (ICAR)
T5: *Lantana camera* + Dimethyl Sulfoxide (DMSO) + $CuSo_4$1 %
T6: Salicylic acid 0.025 %
T7:Alpha (α) Napthyl Acetic Acid 0.025 % (Standard Recommendationin coffee)

**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 per ha 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. 10ml 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, DimethylSulfoxide (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 treatmentsfor 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 (18 Months).

**Observations and Data Analysis**: Observations were made on growth and nutritional parameters. The growth parameters are plant height, root length, number of nodes, internode length, number of leaves, leaf area, shoot & root weight and AGR and NAR. To understand the nutritional changes, observations were made on nutritional contents of leaves in seedlings. Major nutrients namely Nitrogen, Phosphorus and Potassium 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:** Data on plant height and root length is presented in Table 1. Plant height was statistically and significantly higher in all PGR treated seedlings when compared to control and water sprayed seedlings in both the years of study. The average plant height was highest 54.9 cm in NAA, 54.5 cm in Microbial consortium, 54.4 cm in *Glyricidia + Lantana*& Salicylic acid and 54 cm in DMSO treated seedlings which were 10.4 to 12.3 % increase over the plant height of control (48.9 cm) and water sprayed (49.6 cm) seedlings. Statistically and significantly longest roots were found with PGR treated seedlings in both the years of the study as compared to control and water treated seedlings. Mean root length was highest 28.7 cm both with *Glyricidia + Lantana* and Microbial consortium followed by 28.6 with DMSO, 28.5 cm both with NAA and Salicylic acid treated seedlings which were 16.3 to 17.1 % increase over the root length of 24.5 cm in control and 24.4 cm in water sprayed seedlings.

**Number of nodes and internode length:** The average number of nodes per plant was same 8.7 both in control and water sprayed seedlings which were 32.2 to 35.6 % lower compared to 11.5 to 11.8 nodes per plant among the PGR treatments. Data is shown in table 2. Internode length (Table 2) over two years, was highest 6.6 cm in Salicylic acid followed by 6.5 cm in Microbial consortium, DMSO and NAA treated seedlings, 6.4 in *Glyricidia + Lantana* which were 30.6 to 34.7 % increase over inter node length 4.9 cm in control and 4.7 cm in water sprayed seedlings.

| Table 1. Plant height and root length of 18 month old seedlings of Robusta variety C x R | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | Plant Height (cm) | | | Variation | Root Length (cm) | | | Variation |
| | Year 1 | Year 2 | Mean | (%) | Year 1 | Year 2 | Mean | (%) |
| T1 | 47.2 | 50.5 | 48.9 | | 22.7 | 26.3 | 24.5 | |
| T2 | 47.8 | 51.4 | 49.6 | | 22.4 | 26.3 | 24.4 | |
| T3 | 52.6 | 56.2 | 54.4 | 11.20 | 27.9 | 29.6 | 28.7 | 17.10 |
| T4 | 52.4 | 56.5 | 54.5 | 11.50 | 27.9 | 29.5 | 28.7 | 17.10 |
| T5 | 52.4 | 55.6 | 54.0 | 10.40 | 27.6 | 29.6 | 28.6 | 16.70 |
| T6 | 52.9 | 55.9 | 54.4 | 11.20 | 27.5 | 29.4 | 28.5 | 16.30 |
| T7 | 53.0 | 56.7 | 54.9 | 12.30 | 27.3 | 29.6 | 28.5 | 16.30 |
| F Test 5 % | 58.407* | 33.567* | | 11.32 | 43.906* | 231.868* | | 16.7 |
| CD 5 % | 0.815 | 1.094 | | | 0.917 | 0.255 | | |

| Table 2. Number of nodes and internode length in 18 month old seedlings of Robusta variety C x R | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | No. of Nodes | | | Variation | Inter-node Length | | | Variation |
| | Year 1 | Year 2 | Mean | (%) | Year 1 | Year 2 | Mean | (%) |
| T1 | 8.6 | 8.7 | 8.7 | | 4.5 | 5.2 | 4.9 | |
| T2 | 8.5 | 8.8 | 8.7 | | 4.5 | 4.9 | 4.7 | |
| T3 | 11.4 | 12.2 | 11.8 | 35.60 | 5.9 | 6.9 | 6.4 | 30.60 |
| T4 | 11.0 | 11.9 | 11.5 | 32.20 | 6.0 | 6.9 | 6.5 | 32.70 |
| T5 | 11.0 | 12.3 | 11.7 | 34.50 | 6.0 | 6.9 | 6.5 | 32.70 |
| T6 | 11.0 | 12.2 | 11.6 | 33.30 | 6.1 | 7.0 | 6.6 | 34.70 |
| T7 | 11.3 | 11.9 | 11.6 | 33.30 | 5.9 | 7.1 | 6.5 | 32.70 |
| F Test 5 % | 70.757* | 51.171* | | 33.78 | 34.905* | 42.16* | | 32.68 |
| CD 5 % | 0.368 | 0.564 | | | 0.31 | 0.355 | | |

**Number of leaves and Number of Primaries:** Table 3 shows the data on number of leaves and number of primary branches. Number of leaves was statistically and significantly higher in PGR treated seedlings as compared to control and water sprayed seedlings in both the years of study. On an average, both control (22.2) and water sprayed (22.3) seedlings had 25.7 to 27 % less leaves as compared to number of leaves in *Glyricidia + Lantana* (28.5), DMSO, Salicylic acid and NAA (28.2) and Microbial consortium (27.9) seedlings.Primary branches are the most important growth indicators of seedling growth at 18 months old stage. Significantly large number of primary branches was found in both the years with PGR treatments as compared to control and water sprayed seedlings. Over a period of two years, mean number of primary branches were found highest in NAA (5.3) followed by *Glyricidia + Lantana* (5.1), DMSO and Salicylic acid (5) and lastly Microbial consortium (4.9) which were 58.1 to 71 % high compared to primary branches in control (3.1) and water sprayed (3) seedlings.

| Table 3. Number of leaves and primaries of 18 month old seedlings of Robusta variety C x R | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | No. of Leaves | | | Variation | Number of Primary branches | | | Variation |
| | Year 1 | Year 2 | Mean | (%) | Year 1 | Year 2 | Mean | (%) |
| T1 | 22.1 | 22.3 | 22.2 | | 3.1 | 3.1 | 3.1 | |
| T2 | 22.0 | 22.6 | 22.3 | | 2.9 | 3.0 | 3.0 | |
| T3 | 27.7 | 29.3 | 28.5 | 28.40 | 5.2 | 5.0 | 5.1 | 64.50 |
| T4 | 26.9 | 28.8 | 27.9 | 25.70 | 5.0 | 4.7 | 4.9 | 58.10 |
| T5 | 26.9 | 29.5 | 28.2 | 27.00 | 5.0 | 4.9 | 5.0 | 61.30 |
| T6 | 26.9 | 29.4 | 28.2 | 27.00 | 5.1 | 4.9 | 5.0 | 61.30 |
| T7 | 27.5 | 28.8 | 28.2 | 27.00 | 5.2 | 5.3 | 5.3 | 71.00 |
| F Test 5 % | 70.757* | 51.171* | | 27.02 | 62.188* | 38.329* | | 63.24 |
| CD 5 % | 0.735 | 1.127 | | | 0.317 | 0.381 | | |

**Shoot and Root Weight:** Shoot weight was statistically and significantly high in PGR treated seedlings during both the years of study as compared to control and water treated seedlings (Table 4). The average shoot weight of seedlings was highest in NAA (79.6 grams) followed by *Glyricidia + Lantana* (79.2 grams), Microbial Consortium (78.4 grams), Salicylic acid (78.1 grms) and DMSO (77.8 grams) which were 30.3 to 33.3 % increase over shoot weight of control (59.7 grams) and water treated (59 grams) seedlings.In the study of two years, from table 4 found that root weight was

significantly influenced by PGRs and statistically higher root weights were recorded. Mean root weight was highest 19.7 grams in DMSO followed by 19.6 grams in *Glyricidia + Lantana* and Salicylic acid, 19.5 grams in Microbial consortium and NAA treated seedlings which were 30 to 31.3 % increase over root weight of control (15 grams) and water treated (14.7 grams) seedlings.

**Table 4. Shoot and root weight of 18 month old seedlings of Robusta variety C x R**

| Treatments | Shoot Weight | | | Variation | Root Weight | | | Variation |
|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Mean | (%) | Year 1 | Year 2 | Mean | (%) |
| T1 | 47.3 | 72.0 | 59.7 | | 12.2 | 17.7 | 15.0 | |
| T2 | 47.9 | 70.1 | 59.0 | | 12.1 | 17.2 | 14.7 | |
| T3 | 69.7 | 88.6 | 79.2 | 32.70 | 17.4 | 21.8 | 19.6 | 30.70 |
| T4 | 70.4 | 86.4 | 78.4 | 31.30 | 17.0 | 22.0 | 19.5 | 30.00 |
| T5 | 67.8 | 87.8 | 77.8 | 30.30 | 17.6 | 21.8 | 19.7 | 31.30 |
| T6 | 70.3 | 85.8 | 78.1 | 30.80 | 16.9 | 22.2 | 19.6 | 30.70 |
| T7 | 71.5 | 87.7 | 79.6 | 33.30 | 17.2 | 21.8 | 19.5 | 30.00 |
| F Test 5 % | 135.678* | 30.524* | | 31.68 | 67.033* | 144.069* | | 30.54 |
| CD 5 % | 2.308 | 3.539 | | | 0.744 | 0.451 | | |

**Leaf Area and Specific Leaf Area:** Leaf area being one of the most important growth factor, significantly lowest leaf area was recorded in both control and water sprayed seedlings in two years, while each were on par. The average leaf area of seedlings was highest in Salicylic acid (1647.4 $cm^2$) followed by 1641.9, 1638.7, 1633.3 and 1626.7 $cm^2$ respectively in DMSO, NAA, *Glyricidia + Lantana* and Microbial consortium which were 139.9 to 142.9 % increase over leaf area of control (678.2 $cm^2$) and water treated (689.5 $cm^2$) seedlings. Table 5represents data on leaf area.Specific leaf area is the parameter that indicates leaf area produced for every unit dry weight of leaves. In both the years of study, from the table 5, it was found that Specific Leaf Area was statistically and significantly high in PGR treated seedlings as compared to control and water sprayed seedlings, but remained on par within them. On an average, Specific Leaf Area was highest (78.5 $cm^2/g$) in Microbial consortium and DMSO followed by 78.2 $cm^2/g$ in Salicylic acid & NAA and 77.9 $cm^2/g$ In *Glyricidia + Lantana* which were 72 to 73.3 % increase over Specific Leaf Area of control (45.3 $cm^2/g$) and water sprayed (46.4 $cm^2/g$) seedlings.

**Table 5. Leaf area and specific leaf area of 18 month old seedlings of Robusta variety C x R**

| Treatments | Leaf Area ($cm^2$) | | | Variation (%) | Specific Leaf Area ($cm^2/g$) | | | Variation (%) |
|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Mean | | Year 1 | Year 2 | Mean | |
| T1 | 594.3 | 762.0 | 678.2 | | 48.6 | 42.0 | 45.3 | |
| T2 | 609.8 | 769.2 | 689.5 | | 50.2 | 42.5 | 46.4 | |
| T3 | 1130.6 | 2135.9 | 1633.3 | 140.80 | 64.4 | 91.4 | 77.9 | 72.00 |
| T4 | 1167.6 | 2085.7 | 1626.7 | 139.90 | 67.0 | 90.0 | 78.5 | 73.30 |
| T5 | 1159.2 | 2124.6 | 1641.9 | 142.10 | 66.6 | 90.3 | 78.5 | 73.20 |
| T6 | 1144.5 | 2150.2 | 1647.4 | 142.90 | 64.9 | 91.4 | 78.2 | 72.50 |
| T7 | 1153.7 | 2123.7 | 1638.7 | 141.60 | 66.0 | 90.4 | 78.2 | 72.60 |
| F Test 5 % | 113.506* | 302.422* | | 141.46 | 25.885* | 154.276* | | 72.72 |
| CD 5 % | 61.732 | 93.508 | | | 3.881 | 4.668 | | |

**Leaf area index and leaf area ratio:** In the two years of study on influence of PGRs, all seedlings treated with PGRs had significantly higher Leaf area index compared to control and water sprayed seedlings. The mean Leaf area index was 3.17, 3.12, 3.1, 3.09 and 3.08 with T3, T4, T6, T7 and T5 respectively which were 47.3 to 51.4 % increase over Leaf area index of control (2.09) and water sprayed (2.14) seedlings (Table 6). Leaf area ratio (Table 5) on an average was lowest in *Glyricidia + Lantana* (69.6) and ranged from 70.3 to 70.7 in other PGR treated seedlings which was 70.9 to 73.5 % increase over control (40.7) and water sprayed (41.6) seedlings.

**Table 5. Leaf area ratio and leaf weight ratio of 18 month old seedlings of Robusta variety C x R**

| Treatments | Leaf Area Index | | | Variation | Leaf Area Ratio | | | Variation |
|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Mean | (%) | Year 1 | Year 2 | Mean | (%) |
| T1 | 2.07 | 2.12 | 2.09 | | 43.95 | 37.54 | 40.7 | |
| T2 | 2.16 | 2.12 | 2.14 | | 44.83 | 38.42 | 41.6 | |
| T3 | 2.99 | 3.35 | 3.17 | 51.4 | 57.3 | 81.94 | 69.6 | 70.9 |
| T4 | 2.91 | 3.33 | 3.12 | 48.8 | 60.37 | 80.84 | 70.6 | 73.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| T5 | 2.77 | 3.4 | 3.08 | 47.3 | 59.31 | 81.2 | 70.3 | 72.5 |
| T6 | 2.8 | 3.41 | 3.1 | 48.1 | 57.92 | 83.09 | 70.5 | 73 |
| T7 | 2.85 | 3.33 | 3.09 | 47.6 | 58.81 | 82.56 | 70.7 | 73.5 |
| F Test 5 % | 46.098* | 83.944* | | 48.64 | 28.881* | 119.282* | | 72.64 |
| CD 5 % 5 % | 0.135 | 0.163 | | | 3.229 | 4.817 | | |

**Absolute Growth Rate and Net Assimilation Rate:** Data is presented in Table 6. The average Absolute growth rate was highest 0.087 in NAA followed by 0.085 in all other PGR treatments which were 10.4 to 13 % higher compared to 0.077 and 0.079 Absolute growth rate in the seedlings of control and water sprayed seedlings respectively. The Net Assimilation Rate was also statistically significant in PGR treated seedlings. The average Net Assimilation Rate was same 0.026 both in control and water sprayed seedlings. Both Microbial consortium and NAA treated seedlings had the same 0.033 and others had the same 0.034 Net Assimilation Rate which were 26.9 to 30.8 % increase over Net Assimilation Rate in control and water sprayed seedlings.

**Table 6. Absolute growth and net assimilation rate of 18 month old seedlings of Robusta variety C x R**

| Treatments | Absolute Growth Rate | | | Variation | Net Assimilation Rate | | | Variation |
|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Mean | (%) | Year 1 | Year 2 | Mean | (%) |
| T1 | 0.072 | 0.082 | 0.077 | | 0.018 | 0.034 | 0.026 | |
| T2 | 0.074 | 0.084 | 0.079 | | 0.018 | 0.033 | 0.026 | |
| T3 | 0.081 | 0.089 | 0.085 | 10.40 | 0.029 | 0.039 | 0.034 | 30.80 |
| T4 | 0.080 | 0.090 | 0.085 | 10.40 | 0.028 | 0.038 | 0.033 | 26.90 |
| T5 | 0.081 | 0.088 | 0.085 | 10.40 | 0.028 | 0.039 | 0.034 | 30.80 |
| T6 | 0.082 | 0.088 | 0.085 | 10.40 | 0.029 | 0.038 | 0.034 | 30.80 |
| T7 | 0.082 | 0.091 | 0.087 | 13.00 | 0.028 | 0.038 | 0.033 | 26.90 |
| F Test 5 % | 20.889* | 6.29* | | 10.92 | 264.677* | 16.026* | | 29.24 |
| CD 5 % 5 % | 0.002 | 0.003 | | | 0.001 | 0.001 | | |

**Nutrient Status of 18 Months Old Seedlings of Robusta Variety C x R**

Nitrogen, phosphorus and potassium are the most important primary nutrient for normal growth and development of coffee seedlings. The analysed values of these nutrients are presented in Table 7.

**Nitrogen:** Nitrogen being the most important nutrient for vegetative growth was found significantly high in all PGR treated seedlings as compared to control and water treated seedlings during the study period. On the average, both control and water soluble treated seedlings had same 2.34 %. Highest nitrogen of 2.74 % was found in *Glyricidia + Lantana* followed by 2.72 % both in Microbial consortium and Salicylic acid, 2.71 % in DMSO and NAA treated seedlings which were 15.8 to 17.1 % higher compared to control.

**Phosphorus:** Phosphorus content was also highly significant in PGR treated seedlings compared to control and water sprayed seedlings. On an average, mean phosphorus was 0.17 % in *Glyricidia + Lantana*, Microbial and NAA treated seedlings followed by 0.16 % in DMSO and Salicylic acid treated seedlings which were 23.1 to 30.8 % increase over control and water sprayed seedlings (0.13 %).

**Potassium:** During the two years of study, potassium content was significantly higher in PGR treated seedlings as compared to control and water treated seedlings. Mean Potassium content was 2.29 % in both control and water sprayed seedlings which was 19.7 to 20.5 % lower to potassium contents of PGR treated seedlings i.e. 2.76 % in Microbial consortium, 2.75 % in *Glyricidia + Lantana*, DMSO and NAA, 2.74 in Salicylic acid treated seedlings.

**Table 7. Major nutrients status of 18 month old seedlings of Robusta variety 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 | 2.28 | 2.39 | 2.34 | | 0.15 | 0.104 | 0.13 | | 2.21 | 2.37 | 2.29 | |
| T2 | 2.29 | 2.38 | 2.34 | | 0.15 | 0.108 | 0.13 | | 2.19 | 2.39 | 2.29 | |
| T3 | 2.71 | 2.77 | 2.74 | 17.10 | 0.19 | 0.154 | 0.17 | 30.80 | 2.86 | 2.64 | 2.75 | 20.10 |
| T4 | 2.76 | 2.67 | 2.72 | 16.20 | 0.19 | 0.149 | 0.17 | 30.80 | 2.85 | 2.66 | 2.76 | 20.50 |
| T5 | 2.73 | 2.69 | 2.71 | 15.80 | 0.18 | 0.146 | 0.16 | 23.10 | 2.86 | 2.63 | 2.75 | 20.10 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T6 | 2.73 | 2.70 | 2.72 | 16.20 | 0.18 | 0.137 | 0.16 | 23.10 | 2.84 | 2.63 | 2.74 | 19.70 |
| T7 | 2.72 | 2.69 | 2.71 | 15.80 | 0.18 | 0.164 | 0.17 | 30.80 | 2.85 | 2.64 | 2.75 | 20.10 |
| F Test 5 % | 127.677* | 13.819* | | 16.22 | 24.94* | 18.515* | | 27.72 | 411.937* | 29.748* | | 20.1 |
| CD 5 % 5 % | 0.047 | 0.106 | | | 0.009 | 0.012 | | | 0.038 | 0.057 | | |

## DISCUSSION AND CONCLUSION

The results indicated that the increase of growth parameters were statistically significant in PGR treated seedlings. The seedlings of CxR Robusta coffee were 11.32 % taller and had 16.7 % more longer roots. 33.78 % more nodes with 32.68 % higher internode length were found. 27.02 % more leaves due to 63.27 % more primaries in PGR treatments. Shoot and root weight was respectively 31.68 % and 30.54 % higher in PGR treated Robusta seedlings compared to control seedlings. Leaf area was 141.46 % larger with 72.72 % higher specific leaf area. 48.64 % higher leaf area index and 72.64 % higher leaf area ratio were found in Robusta seedlings treated with PGRs. All treatments had 10.92 % higher absolute growth rate and 29.24 % higher net assimilation rate in PGR treated seedlings over control seedlings. Significant increase in major nutrients viz. Nitrogen, Phosphorus, Potassium status of leaves was found with PGR treated seedlings.As per the statistical analysis, all plant growth regulators had equal influence on growth parameters of coffee seedlings in Robusta coffee. The increased vegetative growth in terms of height, nodal length, leaf area could be attributed to higher nitrogen content of seedlings. Further, the increase in shoot and root weight could be attributed to increased phosphorus and potassium content. The growth parameters were statistically on par among the PGR treatments. Glyricidia and Lantana have been proved to be good growth regulators to improve coffee in earlier studies conducted and reported (Anon, 2003; Anon,2004) at Central Coffee Research Institute. Even the Salicylic acid (Anon, 2006) also has proved in improving coffee. The improvement in growth parameters of seedlings using Microbial consortium could be attributed to its composition that contains N fixing, P & Zn solubilizing and plant growth promoting microbes as a single formulation. Use of microbial consortium also reported to improve the growth of coffee seedlings as evidenced by PanneerSelvam*et al*. 2008. Enhanced growth parameters using NAA could be attributed to growth promoting characters of NAA by enhancing root growth. Eric Randy and Barney (2016) reported similar results with usage of NAA nearer to concentration used in this study (100-150 ppm) for boosting robusta clonal seedlings. In an another study, similar results were obtained with Cindy Liana (2022) where the results of the study showed that presenting IBA with a concentration of 300 ppm had a significant effect on the parameters of shoot height, root wet weight and root dry weight and the administration of NAA with concentrations of 100 ppm and 200 ppm gave the best results on the number of leaves, root length, root wet weight, root dry weight of robusta seedlings. Salicylic acid also as growth promoter enhanced the growth of coffee seedlings. This can be supported by the study of Novie and Fakhrusy (2021) who reported that in general, the application of salicylic acid could enhance the growth of Robusta coffee seedlings. The application of 0.6 mM salicylic acid increased plant growth of coffee seedlings. There was different response to concentration of application salicylic acid for both clones. The application of 0.6 mM salicylic acid could increase plant growth of BP 308, include plant height, leaf area, stem dry mass, leaf dry mass, root/shoot ratio and total dry mass. Meanwhile, on Sintaro clone, application of 1.2 mM salicylic acid could increase leaf area, stem, leaf and total dry mass.

As a universal solvent and absorbent, DMSO mixed with CuSo4, Glyricidia Lantana enhanced the growth of coffee seedlings in the present study. Even though studies using DMSO are limited in coffee, a study using with Dymethylsulphoxide (DMSO) on carrot plants grown under field conditions on the leaves to determine its effects on fresh biomass accumulation indicated that when $7xl0^{-3}$ M solution sprayed on two occasions during plant development, increase in root fresh weight was 28%, root length 10% and shoot fresh weight 41 % higher in DMSO treated plants than in control plants (San Miguel *et al.*2003).

In case of control and water sprayed seedlings, growth parameters were on par statistically with each other but had significantly inferior growth compared to that of seedlings grown using PGRs. The on par growth between control and water sprayed seedlings could be attributed to the reason that even in normal maintenance of nursery, water spraying or irrigation everyday is common for moisture and micro climate maintenance. Hence, spray of water as treatment during treatment imposition had no special effect on growth and development of coffee seedlings. Overall the present study indicated the plant growth regulators influenced greatly the growth and development of coffee seedlings. Farmers therefore can make use of either chemical or natural growth regulators depending on the kind of agriculture practice during the cultivation or raising nursery for growth better quality and superior seedlings than that they grow in normal practice.

Acknowledgment: The main author acknowledges greatly the contribution of third Author of this article for having rendering his valuable guidance in statistical analysis of the data and preparation of this manuscript. The main author greatfuly acknowledges the high valued suggestions and guidance of the second author for conducting this field trial. And

the author is also very thankful to the Head, Division of Plant Physiology, The Deputy Director, Coffee Research Sub Station, Chettallli and The Director of Research, CCRI for having co-operated in taking up this study.

## REFERENCES

[1]. Anonymous (2003), Combating soil saturation effects. Fifty Seventh Annual Report, 2003-04, Coffee Board Research Deparatment, pp. 91-92
[2]. Anonymous (2004).Evolving Economic Drought Ameliorative Measures. Fifty Eighth Annual Report, 2004-05, Coffee Board Research Deparatment, pp. 55-57
[3]. Anonymous (2006). Enhancing flower bud production in arabica coffee cultivars. Sixtieth Annual Report, 2006-07, Coffee Board Research Department, pp. 113
[4]. Biradar, I.B., Raghuramaulu, Y., Muralidhara, H.R. and Sudhakar S. Bhat (2006).Effect of Biofertilizers and PGPRs on growth and development of coffee seedlings. J. Coffee Res, 34 (1&2): 57-63.
[5]. Cindy Liana, 2022. Effectiveness of NAA and IBA with some concentrations on the growth of robusta coffee stock (coffeacanephora p. )https://sipora.polije.ac.id/17360/1/Abstract.pdf
[6]. Dimosthenis Nikolopoulos, Christina Korgiopoulou, Kyriakos Mavropoulos, Georgios Liakopoulos, George Karabo urniotis. (2008). Leaf anatomy affects the extraction of photosynthetic pigments by DMSO. Talanta, 76(5): 1265-1268.
[7]. Eric Randy R. Dr. Politud and Barney Avako, 2016.Performance of coffee (coffeaconephora) shoot cuttings in response to levels of naphthalene acetic acid under clonal chamber condition. International Journal of Scientific and Research Publications, Volume 6 (5): 58-60.
[8]. George Daniel, D'Souza, G.F., Anand, C.G., Lamani, B., Awati, M.G., Saraswathi, V.M. and Sadananda, N. (2006).Effect of foliar application of *Lantana camara* leaf extract and chlormequat chloride (CCC) for drought tolerance in robusta coffee. J. Coffee Res., 38 (1&2): 48-58.
[9]. 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
[10]. Kamala Bai, S. Muralidhara, H.R. Hariyappa N. and Raghuramulu Y. 2002. Effect of Bhumilabh – An organic manure on growth and development of coffee seedlings. J. Coffee Res. 30 (1):34-39.
[11]. Muralidhara, H R, Hariyappa, N and Raghuramulu Y. 1996. Influence of commercial orgnaic manure on growth of coffee seedlings. J. Coffee Res., 26(2): 81-84.
[12]. NoviePranataErdiansyah and FakhrusyZakariyya, 2021. Growth Response of Robusta Coffee (*Coffeacanephora*L.) Seedlings to Exogenous Salicylic Acid Application.Pelita Perkebunan 37 (3) 2021, 197—206 (Cross Ref)
[13]. Panneerselvam, P., Thangaraju, M., Senthilkumar, M., &Jayarama, .(2008). Microbial consortium and its effect on controlling coffee root-lesion nematode (pratylenchuscoffeae) under nursery conditions. Journal of Biological Control, *22*(2): 425–432.
[14]. San Miguel-Chávez R , P Aristeo-Cortés and, A Larqué-Saavedra. 2003.The effect of dimethyl sulphoxide DMSO) on carrot plants grown in the field.https://cicy.repositorioinstitucional.mx/jspui/bitstream/1003/1495/1/id547_R_San_Miguel. pdf