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INFLUENCE OF PROPAGATION CHAMBERS AND GROWTH REGULATORS ON ROOTING OF ROSEMARY (*ROSMARINUS OFFICINALIS* L.)

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ABSTRACT

The experiment was conducted during the *rabi* season of 2023 at department of Plantation, Spices, Medicinal and Aromatic crops in College of Horticulture, Bagalkot. It was laid out in factorial Completely randomized design (FCRD) with two replications, comprising two levels of propagation chambers and nine levels of growth regulators, with a total of 18 treatment combinations. Among the propagation chambers the closed media sachet (P_2) showed the earliest root initiation (11.67 days) and maximum rooted cuttings (66.11 %), whereas shade house (P_1) showed the maximum number of roots per cutting (19.21), length of the longest root (11.50 cm), fresh (1.179 g) and dry (0.265 g) weight of roots, the earliest sprout initiation (20.50 days), the higher number of sprouts (9.39 and 14.98 at 45 and 60 DAP respectively), the maximum length of the longest sprout (5.83 and 10.75 cm at 45 and 60 DAP respectively) and the highest survival percentage (81.92 %). Among the various growth regulators IBA @ 2000 ppm (G_2) showed the earliest root initiation (9.50 days), the maximum percentage of rooted cuttings (84.50 %), number of roots (23.00), length of the longest root (12.19 cm), fresh (1.641 g) and dry (0.362 g) weight of roots, earliest sprout initiation (18.25 days), the maximum number of sprouts (8.75 and 13.50 at 45 and 60 DAP respectively), length of the longest sprout (5.28 and 8.73 cm at 45 and 60 days respectively) and the highest survival percentage (80.19 %). Among the different treatment combinations, T_{11} (P_2G_2) gave the highest percentage of rooted cuttings (88.00 %) and T_2 (P_1G_2) recorded the highest number of roots (33.10), length of the longest root (17.00 cm), fresh (2.029 g) and dry (0.408 g) weight of roots, number of sprouts (12.20 and 17.30 at 45 and 60 days respectively), length of the longest sprout (7.48 and 12.83 cm at 45 and 60 DAP).

Keywords: Rosemary, Cuttings, Shade house, Closed media sachet (CMS), Growth regulators

Introduction

Rosemary (*Rosmarinus officinalis* L.), is an aromatic, evergreen and highly branched shrubby herb, belonging to the family Lamiaceae/Labiate. Mainly cultivated in Mediterranean countries, such as Spain, Morocco, Tunisia, France and Italy. In India it is cultivated in Karnataka (Bengaluru, Mysuru, Coorg, Shivamogga *etc.*), Tamil Nadu (Nilgiris, Ooty, Kodaikanal *etc.*), Jammu and Kashmir (Srinagar, Baramulla, Doda, Jammu, Kathua, Samba, Udhampur *etc.*). The leaves and flowering tops on steam-distillation or hydro distillation yield the essential oil.

Rosemary is a hardy evergreen shrub reaches to a height of one meter, the stem is erect and divided into

many long, slender branches. The leaves are sessile, opposite, two to four centimetre long and cylindrical, leathery, green on top, white and hairy below. The flowers are hermaphrodite and are located as little clusters towards the end of the branches. Calyx is two lipped, the upper lip with one single broad oval lobe, the lower lip is with two segmented triangular lobes. The corolla is two-lipped as well, featuring two violet stamens and a long, projecting style. The mode of pollination is allogamy and the fruit is called as cremocarp which is oval and four sectioned (Farooqi and Sreeramu, 2004). There are mainly two types of rosemary namely French rosemary with white flowers and superior oil quality usually grown in southern India and Italian rosemary with purple flowers and inferior oil quality commonly grown in northern India.

The chief volatile compounds in rosemary includes camphor and 1,8-cineole, followed by borneol, verbenone, α-pinene and camphene. There are three different chemotypes of rosemary such as cineoliferum with high percentage of 1,8-cineole, camforiferum with more than 20 per cent of camphor and verbenoniferum with more than 15 per cent of verbenone. (Gonzalez-Minero *et al.,* 2022).

The essential oil of rosemary is prized for its applications in the cosmetic, culinary, medicinal and fragrance industries. It is a great fixative material and the oil adds a strong fresh odour that mops up the disagreeable smell of some other ingredients in any preparation and combines well with other oil odours (Farooqi and Sreeramu, 2004). Additionally, it is utilised in compounded oil compositions to flavour meat, sauces, condiments and other food items. In cooking, the leaves are used for garnishing the dishes, seasoning the soups and stews.

The growing demand for drugs and cosmetics derived from rosemary essential oil is attracting interest of researchers on its propagation. Propagation by seed is not encouraging as it is cross pollinated. The primary cause for the cross pollination is a very strong protandry wherein non simultaneous maturation of anthers and stigma occur and also the seeds are very small and exhibit slow germination.

The germination of seed in rosemary is a researchable issue due to the mucilaginous seed coat and poor seed germination (10-20 %) resulting in non-uniform crop establishment (Sharma *et al*., 2020). Even with seed treatment, the maximum possible germination can be obtained to an extent of 50 per cent.

Among the different methods of vegetative propagation, propagation by cuttings is the easiest and widely applied method in wide range of horticultural crops. The rooting and field establishment of rosemary by stem cutting is poor (Poornima *et al*., 2012). To enhance the rooting in the rosemary stem cuttings various growth regulators, especially auxins are employed. The propagation chambers will also have a greater impact on the rooting of rosemary. The primary objective of this study was to know the effect of propagation chambers, growth regulators individually and in combination on the rooting of rosemary stem cuttings.

Materials and Methods

The present investigation was conducted during *rabi*-2023 at the Department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, University of Horticultural Sciences, Udyanagiri, Bagalkot. The experimental site was located at 16 ^{0}C 10' North latitude, 74 ^{0}C 42' East longitudes. Altitude of 542.0 m above mean sea level (MSL). Karnataka's northern dry zone consists this domain (Zone- III). The research was set out in factorial CRD and replicated twice in 18 treatment combinations that is two different propagation chambers (P_1- Shade house and P_2- Closed media sachet) and nine levels of growth regulators (G_1– Control, G_2-IBA @ 2000 ppm, G_3-IBA @ 2500 ppm, G_4-NAA @ 2000 ppm, G_5-NAA @ 2500 ppm, G_6-Humic acid @ 2 ml L^{-1}, G_7-Humic acid @ 4 ml L^{-1}, G_8-Cow urine 30 minutes soaking and G_9 - Cow urine 60 minutes soaking).

The lower 2 cm section of the cuttings, including the basal node, was immersed in the specified growth regulator solution for 5 minutes. Afterwards, the cuttings were planted in a rooting medium inside a polythene bag, ensuring that one basal node was buried beneath the surface of the medium.

Preparation of media

Shade house: A rooting medium was prepared by mixing soil, sand, farmyard manure, and cocopeat in a ratio of 4:1:1:1. To prevent fungal infections, 0.2 per cent Carbendazim was thoroughly incorporated into the medium before planting. This mixture was then transferred into 5 × 3-inch polythene bags, leaving enough room for adequate aeration. Before planting, the basal portion of rosemary cuttings was dipped in a Carbendazim solution at a concentration of 2 grams per litre.

Closed media sachet (CMS): Transparent poly covers of size 14 × 7 inch were filled with wet sand up to one fourth of the poly cover. After planting of ten cuttings per cover, the poly cover was made air tight by closing it with binder paper clips.

Observations recorded

The planted cuttings were kept for rooting for 60 days. They were carefully removed from the polythene bags and dipped in water to remove the rooting medium adhering to the roots. The observations pertaining to root such as time taken for root initiation was recorded by observing daily whereas the percentage of rooted cuttings, number of roots per cutting, length of the longest root, fresh and dry weight of roots were recorded at 60 days after planting. The time taken for sprout initiation was recorded, shoot parameters such as number of sprouts per cutting and length of the longest sprout per cutting were recorded at 45 and 60 days after planting. The survival percentage of rooted cuttings was recorded at 60 days after transplanting.

Statistical analysis

The data recorded on various root, shoot parameters and survival percentage were subjected to Fisher's method of "Analysis of variance" (ANOVA) as suggested by Panse and Sukathme (1967). The F-test was tested at one per cent level of significance and data was interpreted using critical difference at a probability of 0.01 per cent. The data was analysed using the OPSTAT online software.

Results and Discussion

Root parameters

Time taken for root initiation (days)

The data pertaining to time taken for root initiation is presented in the Table 1. The CMS showed the earliest root initiation with 11.67 days compared to shade house as a propagation chamber, where it took 14.39 days. This early root initiation may be due to the coarse texture of sand media used in CMS which provides good air circulation around the developing roots and may also be due to the micro-environment that retains moisture around the cuttings which is essential for preventing dehydration and encouraging root initiation same as that of the mist house. Similar findings were obtained by Venugopal *et al.* (2018) in the mist house environment for rosemary cuttings.

The earliest root initiation was noticed at IBA @ 2000 ppm (9.50 days) as compared to control (16.5 days). The exogenous auxin application especially IBA caused maximum root formation and also faster and denser root formation. Auxins promote root growth by triggering root initials that differentiate from cells in the young secondary phloem, cambium, and pith tissue. Enhanced root formation may also result from the buildup of metabolites at the application site, which leads to the synthesis of new proteins, increased cell division and enlargement, higher nitrogen content and callus development (Poornima *et al.,* 2012). The use of IBA at the base of cuttings likely facilitated the downward movement of substances like rhizocaline, which are essential for the root formation. The results were in conformity with the findings of Poornima *et al.* (2012) and Venugopal *et al.* (2018) in rosemary cuttings.

The interaction effect was found to be non-significant for the time taken for root initiation of rosemary cuttings.

Percentage of rooted cuttings (%)

The data regarding the percentage of rooted cuttings is shown in Table 1. The highest percentage (66.11) of rooted rosemary cuttings was viewed in the cuttings planted in the CMS when compared to cuttings in the shade house (54.89 %). CMS provides good air circulation around the developing roots, the closed system protects the cuttings from pests and diseases and it may also provide the micro-environment that retains moisture around the cuttings which is essential for preventing dehydration and encouraging root formation. These results were in accordance with findings of Venugopal *et al.* (2018) and Gudeva *et al.* (2017) in rosemary.

The maximum rooting percentage was recorded in the cuttings treated with IBA @ 2000 ppm (84.50 %), the lowest percentage of rooted rosemary cuttings were recorded in the cuttings without any treatment (49.50 %). This is probably due to the partitioning of photosynthates and utilization of stored carbohydrates and phenols towards root development, this may also be attributed to the stimulative and promotive effects of IBA. The present findings are in line with the reports of Poornima *et al.* (2012), Shahhoseini *et al.* (2015), Gudeva *et al.* (2017), Venugopal *et al.* (2018) in rosemary cuttings, Farooq *et al.* (2022) in *Lavandula officinalis,* Reed *et al.* (2021) in *Lavandula* x *intermedia* cuttings and Rajamani *et al.* (2018) in *Coleus aromaticus*.

The highest percentage of rooted cuttings was recorded at the treatment combination of IBA @ 2000 ppm treated cuttings planted in CMS (88.00 %). The lowest percentage of rooted cuttings was observed at control (41.00 %) which were kept in shade house for rooting. This interaction effect may be due to the benefits of both CMS and also the IBA which contribute to the root formation, similar findings were reported by Shahhoseini *et al.* (2015), Gudeva *et al.* (2017) and Venugopal *et al.* (2018) in plastic tunnel under mist system.

Table 1 : Time taken for root initiation (days), Percentage of rooted cuttings, Number of roots per cutting and Length of the longest root (cm) of rosemary cuttings as influenced by different propagation chambers and growth regulators

Propagation chamber/ Growth regulator	Time taken for root initiation (days)			Percentage of rooted cuttings			Number of roots per cutting			Length of the longest root (cm)		
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
G_1	20.50	12.50	**16.50**	41.00	58.00	**49.50**	12.30	9.40	**10.85**	6.68	3.36	**5.02**
G_2	11.00	8.00	**9.50**	81.00	88.00	**84.50**	33.10	12.90	**23.00**	17.00	7.37	**12.19**
G_3	11.50	8.50	**10.00**	59.00	82.00	**70.50**	27.60	10.50	**19.05**	13.58	6.78	**10.18**
G_4	13.50	11.50	**12.50**	60.00	58.00	**59.00**	18.70	14.50	**16.60**	14.25	6.17	**10.21**
G_5	15.50	12.50	**14.00**	58.00	66.00	**62.00**	19.40	12.40	**15.90**	13.57	5.72	**9.65**
G_6	15.50	13.50	**14.50**	54.00	60.00	**57.00**	20.30	10.40	**15.35**	12.20	3.82	**8.01**
G_7	14.50	14.00	**14.25**	57.00	63.00	**60.00**	14.90	14.00	**14.45**	12.86	3.69	**8.28**
G_8	13.50	12.50	**13.00**	42.00	61.00	**51.50**	14.00	10.30	**12.15**	6.75	3.80	**5.28**
G_9	14.00	12.00	**13.00**	42.00	59.00	**50.50**	12.60	11.70	**12.15**	6.58	3.62	**5.10**
Mean	**14.39**	**11.67**		**54.89**	**66.11**		**19.21**	**11.79**		**11.50**	**4.93**	
For comparing means of	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1%)**	**S. Em.±**		**CD (1%)**
Propagation chamber	0.371		1.110	1.027		3.076	0.078		0.233	0.033		0.100
Growth regulator	0.786		2.354	2.179		6.526	0.165		0.494	0.071		0.211
P × G	1.112		NS	3.082		9.229	0.233		0.699	0.100		0.299

(P_1-Shade house, P_2-CMS, G_1-Control, G_2- IBA 2000 ppm, G_3-IBA 2500 ppm, G_4-NAA 2000 ppm, G_5-NAA 2500 ppm, G_6-Humic acid- 2 ml L^{-1}, G_7-Humic acid- 4 ml L^{-1}, G_8- Cow urine-30 min, G_9-Cow urine-60 min and NS-Non significant)

Number of roots per cutting

The data regarding the number of roots per cutting is presented in Table 1. The shade house as a propagation chamber showed the greater number of roots per cutting (19.21) than in the cuttings planted in CMS (11.79), this variation may be due to the nutrient availability, proper aeration in the combined media in the polybags kept in shade house for rooting compared to CMS and may also be due to the various environmental variations between the propagation chambers. These findings are similar to the reports of Rawat *et al.* (2020) in rosemary cuttings planted in combined media of soil and cocopeat.

The maximum number of roots were observed in the treatment with IBA @ 2000 ppm (23.00), the lowest number of roots were recorded in the cuttings which were not treated with any of the growth regulators (10.85). The application of growth regulators caused greater metabolic activity of sugar and nitrogen substances from stem and leaves which helps in the initiation of root primordial in cuttings. Higher number of roots over the control may be due to enhanced hydrolysis of carbohydrates caused by the treatment of growth regulators as reported by Poornima *et al.* (2012), Abu-Zahra *et al.* (2013) in rosemary and Rajamani *et al.* (2018) in *Coleus aromaticus*.

The higher number of roots were noticed in the cuttings treated with IBA @ 2000 ppm (33.10) kept in shade house, the lowest number of roots (9.40) was recorded in CMS with no treatment of growth regulators. This may be due to the synergistic effect of media with proper aeration and water holding capacity used in polybags kept in shade house, environmental conditions in shade house and the contribution of growth regulators, which was also reported by Poornima *et al.* (2012) in rosemary cuttings.

Length of the longest root (cm)

The data pertaining to length of the longest root is depicted in the Table 1. The cuttings which were planted in polybags and kept in shade house exhibited the longer mean root length (11.50 cm), similar observations were recorded in rosemary by Rawat *et al.* (2020), where coco peat mixed with soil showed more root length in comparison to cuttings grown with vermicompost mixed with soil. Cocopeat is known to have high water holding capacity, better aeration which enhanced root growth. This variation may also be due to the congenial conditions of shade house as a propagation chamber, when compared to the rosemary cuttings which were planted in CMS (4.93 cm) for rooting.

The greater length of the longest root was recorded in the cuttings treated with IBA @ 2000 ppm (12.19 cm), the least length of the longest root in the rosemary cuttings was observed in the cuttings without any growth regulator treatment (5.02 cm). Increase in

root length with IBA may be attributed to its stimulative and promotive effects on cell division and cell elongation. These results are in conformity with the findings of Poornima *et al.* (2012) in rosemary, Rajamani *et al.* (2018) in *Coleus aromaticus,* Izgi (2020) in damask rose, thunberg barberry, rosemary and lavender and Karakoyun *et al.* (2023) in *Lavandula angustifolia* and *Lavandula × intermedia*.

The highest root length was observed in the cuttings treated with IBA @ 2000 ppm (17.00 cm) and kept in shade house, whereas the smaller root length was found at the cuttings with no growth regulator treatment (3.36 cm) and planted in CMS. This interaction effect may be due to the above-mentioned reasons.

Fresh and dry weight of roots (g)

The data on fresh and dry weight roots is presented in the Table 2. The cuttings which were planted in polybags and kept in shade house recorded the maximum fresh root weight (1.179 g) and dry root weight (0.265 g) and they were found lowest in the cuttings which were planted in the CMS (0.569 g and 0.111 g fresh and dry weight, respectively). This may be attributed to general improvement in the physical and chemical properties of the rooting medium and the congenial conditions of shade house as a propagation chamber. Similar results were obtained by Rawat *et al.* (2020) in rosemary.

Table 2 : Fresh weight (g) and dry weight (g) of roots in rosemary cuttings as influenced by different propagation chambers and growth regulators

Propagation chamber/ Growth regulator	Fresh weight of roots (g)			Dry weight of roots (g)		
	P_1	P_2	Mean	P_1	P_2	Mean
G_1	0.557	0.295	**0.426**	0.108	0.063	**0.085**
G_2	2.029	1.253	**1.641**	0.408	0.317	**0.362**
G_3	1.053	0.633	**0.843**	0.285	0.110	**0.197**
G_4	1.252	0.696	**0.974**	0.314	0.106	**0.210**
G_5	1.358	0.706	**1.032**	0.323	0.104	**0.214**
G_6	1.531	0.382	**0.957**	0.356	0.081	**0.218**
G_7	1.558	0.401	**0.980**	0.364	0.080	**0.222**
G_8	0.647	0.373	**0.510**	0.110	0.066	**0.088**
G_9	0.625	0.383	**0.504**	0.116	0.069	**0.093**
Mean	**1.179**	**0.569**		**0.265**	**0.111**	
For comparing means of	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1%)**
Propagation chamber	0.007		0.021	0.001		0.004
Growth regulator	0.015		0.044	0.003		0.008
P × G	0.021		0.062	0.004		0.012

(P_1-Shade house, P_2-CMS, G_1-Control, G_2- IBA 2000 ppm, G_3-IBA 2500 ppm, G_4-NAA 2000 ppm, G_5-NAA 2500 ppm, G_6-Humic acid- 2 ml L^{-1}, G_7- Humic acid- 4 ml L^{-1}, G_8- Cow urine-30 min and G_9- Cow urine-60 min)

The cuttings which were treated with IBA @ 2000 ppm recorded the greatest fresh weight of roots (1.641 g) and dry weight (0.362 g), the least fresh and dry weight of roots was recorded in the cuttings with no growth regulator treatment (0.426 g and 0.085 g, respectively), the increased root number and root length increased the fresh weight of the roots. The application of IBA resulted in better mobilization of metabolites towards better root formation, which may be the reason for greater fresh weight and dry weight, which was also reported by Poornima *et al.* (2012), Kiuru *et al.* (2015), Mehrabani *et al.* (2016) in rosemary, Paradikovic *et al.* (2013) in sage and rosemary.

The maximal fresh and dry weight of roots in the rosemary rooted cuttings was viewed in the cuttings which were treated with IBA @ 2000 ppm (2.029 g and 0.408 g, respectively) kept in the shade house, the minimal fresh and dry root weight (0.295 g and 0.063 g, respectively) was recorded in the control cuttings planted in CMS, higher number of roots and longer root length was observed in the same treatment which caused the increase in fresh and dry weight, this may be due to the effect of IBA application which is reported by Poornima *et al.* (2012) in rosemary and the enhanced physical and chemical properties of media used in polybags kept in shade house (Rawat *et al.,* 2020).

Shoot parameters

Time taken for sprout initiation (days)

The data on time taken for sprout initiation is presented in Table 3. The cuttings kept in the shade house showed the early sprouting (20.50 days) which

was probably due to the controlled environment with regulated light, temperature and humidity, which is conducive to sprouting than that of the CMS (23.28 days).

The earliest sprouting of the cuttings was observed at IBA @ 2000 ppm (18.25 days) concentration. The earliness in sprouting in the treated cuttings was may be due to better utilization of stored carbohydrates, nitrogen and other factors with the aid of auxins. These findings are in conformity with Poornima *et al.* (2012) in rosemary and Rajamani *et al.* (2018) in *Coleus aromaticus*. The late sprouting was observed in control (24.00 days) and cow urine-soaked cuttings (24.50 days).

Table 3 : Time taken for sprout initiation (days), Number of sprouts per cutting at 45 and 60 days after planting and Length of the longest sprout (cm) at 45 and 60 days after planting in rosemary cuttings as influenced by different propagation chambers and growth regulators

Propagation chamber/ Growth regulator	Time taken for sprout initiation (days)			Number of sprouts per cutting						Length of the longest sprout (cm)					
				45 days after planting			60 days after planting			45 days after planting			60 days after planting		
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
G_1	22.00	26.00	**24.00**	6.70	3.70	**5.20**	11.50	6.50	**9.00**	3.73	1.90	**2.82**	7.09	3.23	**5.16**
G_2	15.50	21.00	**18.25**	12.20	5.30	**8.75**	17.30	9.70	**13.50**	7.48	3.08	**5.28**	12.83	4.62	**8.73**
G_3	17.50	22.50	**20.00**	11.70	4.10	**7.90**	16.90	8.70	**12.80**	6.91	2.44	**4.68**	12.35	3.75	**8.05**
G_4	19.00	20.50	**19.75**	9.80	5.10	**7.45**	14.50	9.30	**11.90**	6.64	2.49	**4.57**	12.42	4.04	**8.23**
G_5	21.00	21.00	**21.00**	9.50	5.70	**7.60**	15.50	9.50	**12.50**	6.33	2.08	**4.21**	11.88	3.48	**7.68**
G_6	20.00	24.00	**22.00**	10.30	4.50	**7.40**	16.10	8.30	**12.20**	6.06	2.12	**4.09**	10.64	4.27	**7.46**
G_7	21.50	24.50	**23.00**	10.30	4.30	**7.30**	16.40	8.70	**12.55**	5.97	2.11	**4.04**	11.57	3.44	**7.51**
G_8	23.50	25.50	**24.50**	7.50	3.70	**5.60**	13.70	7.70	**10.70**	5.28	2.19	**3.74**	9.89	3.32	**6.61**
G_9	24.50	24.50	**24.50**	6.50	4.00	**5.25**	12.90	7.90	**10.40**	4.08	1.91	**3.00**	8.11	3.28	**5.70**
Mean	**20.50**	**23.28**		**9.39**	**4.49**		**14.98**	**8.48**		**5.83**	**2.26**		**10.75**	**3.71**	
For comparing means of	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1%)**	**S. Em. ±**		**CD (1 %)**
Propagation chamber	0.412		1.234	0.068		0.204	0.039		0.118	0.027		0.081	0.028		0.085
Growth regulator	0.874		2.617	0.144		0.432	0.083		0.250	0.058		0.172	0.060		0.181
P × G	1.236		NS	0.204		0.611	0.118		0.353	0.081		0.244	0.085		0.256

(P_1-Shade house, P_2-CMS, G_1-Control, G_2- IBA 2000 ppm, G_3-IBA 2500 ppm, G_4-NAA 2000 ppm, G_5-NAA 2500 ppm, G_6-Humic acid- 2 ml L^{-1}, G_7- Humic acid- 4 ml L^{-1}, G_8- Cow urine-30 min, G_9- Cow urine-60 min and NS- Non significant)

The interaction effect was found to be non-significant for time taken for sprout initiation in rosemary cuttings.

Number of sprouts per cutting at 45 and 60 days after planting

The data on number of sprouts per cutting is represented in the Table 3. The shade house as a propagation chamber showed the greater number of sprouts per cutting at 45 and 60 days after planting (9.39 and 14.98 respectively) than in the cuttings planted in CMS (4.49 and 8.48 respectively). The shade house provides a controlled environment with regulated light, temperature and humidity, which is conducive to sprouting and also combined media used. The CMS may trap heat and moisture, creating fewer stable conditions that could inhibit sprout growth. These findings were in conformity with the reports of Rawat *et al.* (2020).

The cuttings treated with IBA @ 2000 ppm showed the highest number of sprouts per cutting at 45 and 60 days after planting (8.75 and 13.50 respectively). The lowest number of sprouts per cutting was recorded at control (5.20 and 9.00 at 45 and 60 DAP respectively). The increase in the number of sprouts may be attributed to the growth regulator activated shoot growth leading to a greater number of sprouts which is also reported by Poornima *et al.* (2012) in rosemary and was same as the findings of Rajamani *et al.* (2018) in *Coleus aromaticus.*

The highest number of sprouts per cutting at 45 and 60 DAP was observed in the cuttings treated with IBA @ 2000 ppm (12.20 and 17.30 respectively) and kept in shade house, Whereas the least number of sprouts was found at the cuttings with no growth regulator treatment and planted in CMS (3.70 and 6.50 at 45 and 60 DAP, respectively), which was also reported by Poornima *et al.* (2012) in rosemary and Rajamani *et al.* (2018) in *Coleus aromaticus.*

Length of the longest sprout (cm) at 45 and 60 days after planting

The data pertaining to the length of the longest sprout is presented in Table 3. Among the propagation chambers, the cuttings kept in shade house exhibited the longer mean length of the longest sprout at 45 and 60 DAP (5.83 and 10.75 cm, respectively) which was similar to the report of Rawat *et al.* (2020), when compared to the rosemary cuttings which were planted in CMS (2.26 and 3.71 cm at 45 and 60 DAP respectively).

Table 4 : Survival percentage of rooted cuttings (%) as influenced by propagation chamber and growth regulator

Propagation chamber/ Growth regulator	P_1	P_2	Mean
G_1	74.64	65.72	**70.18**
G_2	89.93	70.44	**80.19**
G_3	83.11	70.66	**76.88**
G_4	87.95	72.27	**80.11**
G_5	84.41	69.58	**76.99**
G_6	79.67	69.97	**74.82**
G_7	80.37	71.67	**76.02**
G_8	78.64	70.58	**74.61**
G_9	78.61	68.00	**73.30**
Mean	81.92	69.88	

For comparing means of	S. Em. ±	CD (1 %)
Propagation chamber	1.309	3.918
Growth regulator	2.776	NS
P × G	3.926	NS

(P_1-Shade house, P_2-CMS, G_1-Control, G_2- IBA 2000 ppm, G_3-IBA 2500 ppm, G_4-NAA 2000 ppm, G_5-NAA 2500 ppm, G_6-Humic acid- 2 ml L^{-1}, G_7- Humic acid- 4 ml L^{-1}, G_8- Cow urine-30 min, G_9- Cow urine-60 min and NS- Non significant)

The greater length of the longest sprout at 45 and 60 DAP was recorded in the cuttings treated with IBA @ 2000 ppm (5.28 and 8.73 cm, respectively), the least length of the longest sprout in the rosemary cuttings at 45 and 60 DAP was observed in the cuttings without any growth regulator treatment (2.82 and 5.16 cm, respectively), the increase in number of sprouts caused the increase in length of sprout, by the same treatment and consequently a greater number of nodes were also developed, these results were in accordance with Poornima *et al.* (2012), Elhaak *et al.* (2015) and Kiuru *et al.* (2015) in rosemary cuttings.

The highest sprout length was observed in the cuttings treated with IBA @ 2000 ppm (7.48 and 12.83 cm at 45 and 60 DAP, respectively) kept in shade house, whereas the smaller sprout length was found at the cuttings with no growth regulator treatment (1.90 and 3.23 cm at 45 and 60 DAP, respectively) and planted in CMS, these results were in accordance with Poornima *et al.* (2012) and Rawat *et al.* (2020) in rosemary.

Survival percentage of rooted cuttings (%)

The data regarding the survival percentage of rooted cuttings is depicted in Table 4. The rosemary cuttings which were planted in the polybags and kept in shade house showed the greater survival percentage of 81.92 per cent when compared with the cuttings planted in CMS (69.88 %). This may be due the growing media used in shade house which improved water relationship, nutrient retention, free air movement and also the media retains moisture and nutrients for growth of the plants probably due to optimum bulk density, potentiality of adequate water absorption of growing media (Rawat *et al.,* 2020).

The growth regulators and the interactions did not cause significant variation for the survival percentage of rooted rosemary cuttings.

Conclusion

From the present study it is concluded that among the propagation chambers P_1 (shade house) was more effective than P_2 (closed media sachet) for rosemary stem cuttings and among the growth regulators G_2 (IBA @ 2000 ppm) was found best for rooting, sprouting and better survival of rosemary cuttings. The treatment combination T_2 (P_1G_2- Shade house + IBA @ 2000 ppm) was found best for vegetative propagation of rosemary through stem cuttings.

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References

Abu-Zahra, T.R., Al-Shadaideh, A.N., Abubaker, S.M. and Qrunfleh, I.M. (2013). Influence of auxin concentrations on different ornamental plants rooting. *Int. J. Bot.*, **9(2)**, 96-99.

Elhaak, M.A., Matter, M.Z., Zayed, M.A. and Gad, D.A. (2015). Propagation principles in using indole-3-butyric acid for rooting rosemary stem cuttings. *J. Horti.,* **2**, 121.

Farooq, S., Gangoo, S.A., Bhat, B.A., Ayoob, B., Singh, A. and Islam, M.A. (2022). A comparative study of various concentrations of indole-3-butyric acid on rooting of *Lavandula officinalis* stem cuttings. *SKUAST J. Res.*, **24(1),** 109-111.

Farooqi, A.A. and Sreeramu, B.S. (2004). Cultivation of medicinal and aromatic crops, *1st Edition. Universities Press*, India.

Gonzalez-Minero, F.J., Bravo-Diaz, L. and Ayala-Gomez, A. (2020). *Rosmarinus officinalis* L. (Rosemary): An ancient plant with uses in personal healthcare and cosmetics. *Cosmetics*, **7(4)**, 77.

Gudeva, K.L., Trajkova, F., Mihajlov, L. and Troiciki, J. (2017). Influence of different auxins on rooting of rosemary, sage and elderberry. *Annu. Res. Rev. Biol.*, **12(5)**, 1-8.

Izgi, M.N. (2020). Effects of different doses of IBA (indole-3-butyric acid) and rooting media on rooting of some medicinal plants. *Turkish J. Agri. Res.,* **7(1)**, 9-16.

Karakoyun, M., Ural, M. and Arikan, S. (2023). The effects of growth regulatory agents in varying doses on *Lavandula angustifolia* and *Lavandula× intermedia* species in different rooting media. *Selcuk J. Agri. Food Sci.*, **37(1)**, 25-32.

Kiuru, P., Muriuki, S.J.N., Wepukhulu, S.B. and Muriuki, S.J.M. (2015). Influence of growth media and regulators on vegetative propagation of rosemary (*Rosmarinus officinalis* L.). *East African Agri. For. J.*, **81(2-4)**, 105-111.

Mehrabani, L.V., Kamran, R.V., Hassanpouraghdam, M.B., Kavousi, E. and Aazami, M.A. (2016). Auxin concentration and sampling time affect rooting of *Chrysanthemum morifolium* L. and *Rosmarinus officinalis* L. *Azarian J. Agri.,* **3(1)**, 11-16.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for Agriculture workers. *Indian Council of Agriculture Pub.,* New Delhi. 327-340.

Paradikovic, N., Zeljkovic, S., Tkalec, M., Vinkovic, T., Dervic, I. and Maric, M. (2013). Influence of rooting powder on propagation of sage (*Salvia officinalis* L.) and rosemary (*Rosmarinus officinalis* L.) with green cuttings. *Agric.*, **19(2)**, 10-15.

Poornima, K.S., Chandregowda, M., Pushpa, T.N. and Srikantaprasad, D. (2012). Studies on effect of growth regulators on rooting of two rosemary types and estimation of biochemical changes associated with rooting. *Crop Res.*, **43 (1-3)**, 245-248.

Rajamani, K., Kumar, K.M. and Adivappar, N. (2018). Influence of type of cuttings and growth regulators on rooting in Indian Borage (*Coleus aromaticus* L.). *J. Pharmacogn. Phytochem.*, **7(3S)**, 182-185.

Rawat, R., Vasishth, A. and Kumar, V. (2020). Effect of growing media on growth parameters of two important aromatic crops of Garhwal Himalaya. *J. Pharmacogn. Phytochem.*, **9(2)**, 417-421.

Reed, D., Montague, T. and Simpson, C. (2021). Adventitious rooting of *Lavandula* x *intermedia* cuttings. *J. Environ. Horti.*, **39(4)**, 150-159.

Shahhoseini, R., Moghaddam, M., Kiani, D. and Mansori, R. (2015). Effect of different concentrations of IBA and NAA on rooting of semi-hardwood cuttings of rosemary (*Rosmarinus officinalis* L.). *Iranian J. Med. Aromat. Plants Res.*, **31(4)**, 574-586.

Sharma, Y. Fagan, J. and Schaefer, J. (2020). Influence of organic pre-sowing seed treatments on germination and growth of rosemary (*Rosmarinus officinalis* L.). *Biol. Agric. Hortic.*, **36(1)**, 35-43.

Venugopal, C.K., Sajjan, R.M., Sharma, Y. and Yashavantakumar, K.H. (2018). Effect of different concentrations of indole-3-butyric acid (IBA) on rooting of rosemary (*Rosmarinus officinalis*) under mist house environment. *Int. J. Chem. Stud.*, **6(3)**, 1524-1526.