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Rapid multiplication in chrysanthemum (*Dendranthema grandiflora* Ramat.) using plant growth regulators

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Abstract
The present investigation was carried out to standardize the planting material, growing media and growth regulators for rapid multiplication in chrysanthemum. The study was conducted at the Botanic garden, Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2017-2018. The first experiment standardization of cuttings, media and growth regulators for induction of rooting in chrysanthemum consists three factors *viz.*, two types of planting material (leaf bud cutting and single bud cutting), three types of media *viz.*, enriched cocopeat, cocopeat + sand, and dam silt and 12 different concentrations of the growth regulators (IBA @ 50, 100, 200, 300ppm, NAA @ 50, 100, 200, 300 ppm, BA @ 25, 50 ppm, Coconut water and Keradix-F @ 20 ppm and control. The results revealed that leaf bud cutting was found to be the best planting material when compared to the single bud cutting. The best rooting media identified for rooting of cuttings was enriched cocopeat. The growth regulator effective for most of the parameters was coconut water followed by keradix-F and BA 25 ppm. Among the treatment combinations, leaf bud cuttings grown in enriched cocopeat + BA 25 ppm exhibited earlier rooting (5.50 days). Maximum root induction (17.00) was observed in two treatment combinations *viz.*, leaf bud + enriched cocopeat + keradix-F 20 ppm and leaf bud + enriched cocopeat + coconut water. The highest survival percentage (90%) was recorded in leaf bud + enriched cocopeat + coconut water and recorded maximum leaf numbers in rooted cuttings (4.5 and 10.5) and highest shoot length (4.25 cm and 8.70 cm) after 25 and 45 days respectively. As the treatment leaf bud + enriched cocopeat + keradix-F had positive effect on root induction after 25 days, the length of roots (14.40 cm) and total height of rooted leaf bud cuttings (18.80 cm) were also significantly influenced by the same treatment. From the present study it is confirmed that leaf buds had highest regeneration ability and can be used for rapid multiplication of chrysanthemum, when treated with coconut water or keradix-F 20 ppm in enriched cocopeat media.

Keywords: Chrysanthemum; propagation; leaf cuttings; growth regulators; plant regeneration

Introduction
Floriculture is an emerging science being perceived as a lucrative business and now considered to be one of the most important and escalating commercial trades in agriculture for its attractive cut flowers and potted plants that are sold daily for its aesthetic value across the world. In the World market, chrysanthemum is recognized as one of the most important top ranking flowers next to Rose, in the global floriculture trade. It is believed to be the native of Europe and Asia and also valued as a potted plant. It is commercially cultivated as cut flower crop in many of the countries. In India, chrysanthemum is widely grown in open fields for loose flower especially for making garlands. Suitable agro climatic condition coupled with high soil fertility followed by good rains ensure good production of chrysanthemum under tropical and sub tropical flowers throughout the year.

Chrysanthemum is mainly propagated through vegetative propagation. When chrysanthemums are propagated through suckers they produce tall plants, which are not suitable for decorative purpose. The rate of multiplication of chrysanthemum through micro-propagation is quite high but it is not economic for marginal and poor farmers. The availability of quality planting material at low price has always been a challenge in chrysanthemum cultivation in India. Terminal stem cuttings taken from healthy mother plants is the commercial method of propagation followed by the farmers. Conventional methods of propagation by terminal stem cuttings in chrysanthemum result in production of only a single plant from one stem.

Hence, a rapid multiplication technique of chrysanthemum need to be developed to get more plants from the same quantity of initial propagating material (mother stock) so as to solve the problem related to the non-availability of quality planting material.

With the above futuristic background, the present investigation was carried out to standardize the planting material for rapid propagation technique using single bud cutting and leaf bud cutting and to study the influence of different media and growth regulators on rooting of cuttings in chrysanthemum.

Materials and Methods

The present investigation was carried out. at the Botanic gardens, Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2017-2018 in Chrysanthemum "Co 1" variety, a high yielding cultivar (16.70 t/ha) with medium sized canary yellow flowers, used for garland making was selected as the study material, which is widely grown in Tamil Nadu.

The experiment was conducted under mist chamber and shade net house condition in the nursery. Two types of cutting *viz.*, Single bud cutting (An axillary bud attached to the nodal region of the stem, without petiole and leaf blade) and Leaf bud cutting (An axillary bud attached to the nodal region of the stem with a petiole and leaf blade) were used as the planting material.

Single bud cutting **Leaf bud cutting**

The rooting media used for the study was enriched cocopeat (Urea + DAP + Humic acid) (2:1:1:1), Cocopeat and sand (2:1) and Dam silt. The rooting medium was thoroughly mixed and it was filled in protrays. Uniform and healthy single bud and leaf bud cutting were taken from different portion of the plants. The cuttings were given a slant cut just below each node with secateurs. Healthy single bud and leaf bud cutting without growth regulators were also planted which served as control.

IBA, NAA and BA were dissolved in small quantities of 95 per cent ethyl alcohol and were diluted with distilled water to get the appropriate concentration of each chemical. The cuttings were dipped with respective concentration of each plant growth regulator for 15 minutes in such a way that the basal node was in contact with the growth regulator and they were planted in rooting medium in protrays. Quick dip method was adopted for Keradix-F and Coconut water for treatment of cuttings.

Hundred cuttings were used for each treatment which was replicated two times in a factorial completely randomized design (FCRD). The experiment was conducted in a mist chamber and poly tunnel. The cuttings were watered regularly with rose can to avoid desiccation and 25 days old rooted cuttings were moved to open and shade condition and details of survival and rooting were observed. Fifteen cuttings were kept separately for each treatment to observe the time taken to root. Observations were recorded for various morphological parameters at nursery stage *viz.*, survival percentage (%), days to root initiation, number of leaves per cutting, number of roots per cutting, length of shoots (cm), length of roots (cm) and height of rooted cuttings (cm) at 25 and 45 days respectively except survival and days to root initiation.. The data recorded from various treatment combinations were subjected to standard statistical analysis and results were interpreted.

Results and Discussion

In the present study, the effect of different media and growth regulators on the growth of two different planting material showed significant results for all root and shoot parameters (Table 1). Survival percentage the important criteria, decides the influence of different growth regulators and media for rooting of cuttings. Among the two planting materials studied, leaf bud cutting was found to be the best when compared to the single bud cutting. It is similar to the findings reported earlier that the propagation of chrysanthemum through leaf cuttings under *in vivo* conditions, increased the rate of regeneration of plants by 10-15 times as compared to the conventional method of propagation by terminal stem cuttings [1]. Of the three growing media taken for study, enriched cocopeat followed by cocopeat + sand were identified as the best when compared to dam silt. The effect of growth regulator on planting material revealed that coconut water followed by Keradix-F 20 ppm and BA 25 ppm were found to have pronounced effect in inducing better rooting in leaf bud cuttings.

Table 1: Influence of media, growth regulators and types of cutting on survival percentage

Growth regulator	M_1			M_2			M_3			Mean
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
G_1	7.50 (15.67)	40.00 (39.10)	23.75 (27.39)	7.50 (15.67)	40.00 (39.20)	23.75 (27.44)	7.50 (15.67)	25.00 (29.88)	16.25 (22.78)	21.25 (25.87)
G_2	10.00 (18.43)	30.00 (33.21)	20.00 (25.82)	10.00 (18.43)	27.50 (31.60)	18.75 (25.02)	7.50 (15.67)	27.50 (31.60)	17.50 (23.64)	18.75 (24.83)
G_3	12.50 (20.61)	20.00 (26.56)	16.25 (23.58)	7.50 (15.67)	17.50 (24.67)	12.50 (20.17)	10.00 (18.43)	22.50 (28.28)	16.25 (23.35)	15.00 (22.38)
G_4	10.00 (18.43)	20.00 (25.82)	15.00 (22.12)	10.00 (18.43)	20.00 (26.39)	15.00 (22.41)	7.50 (15.67)	15.00 (22.50)	11.25 (19.08)	13.75 (21.21)
G_5	12.50 (20.61)	25.00 (29.88)	18.75 (25.25)	12.50 (20.61)	25.00 (29.88)	18.75 (25.25)	12.50 (20.61)	30.00 (33.21)	21.25 (26.91)	19.58 (25.80)
G_6	10.00 (18.43)	25.00 (29.88)	17.50 (24.16)	10.00 (18.43)	27.50 (31.41)	18.75 (24.92)	10.00 (18.43)	17.50 (24.67)	13.75 (21.55)	16.66 (23.55)
G_7	15.00	20.00	17.50	15.00	20.00	17.50	12.50	17.50	15.00	16.66

	(22.78)	(26.56)	(24.67)	(22.78)	(26.39)	(24.59)	(20.61)	(24.67)	(22.64)	(23.97)
G_8	12.50 (20.61)	20.00 (25.82)	16.25 (23.21)	12.50 (20.61)	22.50 (27.99)	17.50 (24.30)	12.50 (20.61)	20.00 (26.56)	16.25 (23.58)	16.66 (23.70)
G_9	15.00 (22.50)	75.00 (60.11)	45.00 (41.31)	15.00 (22.50)	67.50 (55.26)	41.25 (38.88)	15.00 (22.50)	32.50 (34.74)	23.75 (28.62)	36.66 (36.27)
G_{10}	10.00 (18.43)	50.00 (45.00)	30.00 (31.71)	10.00 (18.43)	47.50 (43.56)	28.75 (31.00)	10.00 (18.43)	27.50 (31.60)	18.75 (25.02)	25.83 (29.25)
G_{11}	15.00 (22.50)	72.50 (58.39)	43.75 (40.45)	15.00 (22.50)	70.00 (58.28)	42.50 (40.39)	15.00 (22.50)	52.50 (46.48)	33.75 (34.49)	39.16 (38.44)
G_{12}	20.00 (25.82)	90.00 (76.51)	55.00 (51.17)	20.00 (25.82)	87.50 (67.50)	53.75 (46.66)	15.00 (22.50)	75.00 (60.11)	37.50 (30.25)	61.25 (42.69)
G_{13}	20.00 (26.56)	85.00 (67.50)	52.50 (47.03)	17.50 (24.67)	85.00 (67.50)	51.25 (46.08)	10.00 (18.43)	85.00 (67.50)	42.50 (33.95)	48.75 (42.35)
Mean	13.07 (20.88)	43.84 (42.77)	28.46 (31.82)	12.50 (20.35)	41.53 (39.98)	27.02 (30.17)	9.23 (16.15)	36.15 (36.59)	22.69 (26.37)	26.05 (29.45)
Mean of cuttings									C_1	11.60
									C_2	40.51

Significant test	C	M	G	C×M	M×G	C×G	C×M×G
SE(d)	0.80	0.98	2.04	1.38	3.53	2.88	4.99
CD (P=0.05)	1.59	1.95	4.06	2.75	7.02	5.73	9.93
CD (P =0.01)	2.11	2.58	5.38	3.65	9.31	7.60	13.17

*Values in parentheses are Arcsine transformed values

The survival percentage of cuttings had significant effect based on the interaction between media, growth regulators and stem cuttings. Among the various treatment combinations, $C_2M_1G_{12}$ (Leaf bud + Enriched cocopeat + Coconut water) followed by the treatments $C_2M_3G_9$ (Leaf bud cuttings + Dam Silt + BA 25 ppm) and $C_2M_1G_{11}$ (Leaf bud + Enriched cocopeat + Keradix-F 20 ppm) exhibited better survival percentage at 25 days after planting of cuttings. The single bud cutting recorded very low survival percentage in comparison with leaf bud cutting.

Maximum survival in leaf bud cutting may be due to the presence of phytohormones especially cytokinins, indole-3-acetic acid (IAA) [2], gibberellins [3] and trans-zeatin [4] in coconut water supports the present study. IAA from coconut water extract treated *Dracena purplecompacta* L. canes exhibited better adventitious rooting than those canes treated with similar concentrations of authentic IAA hormone [5]. This is because coconut water consists of 1,3 diphenyl urea and auxins. In addition to this, coconut water can also stabilize the growing media, as it contains malic acid, succinic acid and citric acid [6].

Production of roots at the earliest is one of the desirable character that determines the better survival of the plants (Table 2). Among the two planting material studied, days taken for root initiation in leaf bud cutting was found to be earlier when compared to the single bud cutting. Of the three growing media taken for study, root initiation was earlier in cocopeat + sand followed by enriched cocopeat whereas in dam silt the rooting was delayed. Root induction was earlier in cuttings treated with BA 25 ppm followed by keradix-F 20 ppm and coconut water. Beneficial effect of cocopeat on root system was reported earlier in *Osteospermum* (African Daisy) cuttings [7].

Table 2: Influence of media, growth regulators and types of cutting on days to root initiation

Growth Regulator	M_1			M_2			M_3	Mean		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
G_1	14.00	13.50	13.75	13.50	13.50	13.50	14.00	14.50	14.25	13.83
G_2	14.50	14.00	14.25	14.50	13.50	14.00	15.00	15.50	15.25	14.50
G_3	13.50	15.00	14.25	14.50	14.50	14.50	13.50	15.50	14.50	14.42
G_4	15.50	13.00	14.25	13.50	13.50	13.50	16.00	13.50	14.75	14.17
G_5	15.50	14.00	14.75	15.50	13.50	14.50	15.50	14.00	14.75	14.67
G_6	13.00	14.00	13.50	13.50	13.50	13.50	13.00	13.50	13.25	13.42
G_7	15.00	10.50	12.75	14.50	10.50	12.50	16.00	11.50	13.75	13.00
G_8	15.00	9.00	12.00	10.50	9.50	10.00	15.00	10.50	12.75	11.58
G_9	10.00	5.50	7.75	13.50	6.00	9.75	10.00	8.50	9.25	8.92
G_{10}	13.00	6.50	9.75	13.50	6.50	10.00	13.50	9.50	11.50	10.42
G_{11}	11.00	7.50	9.25	11.00	7.50	9.25	11.00	8.50	9.75	9.42
G_{12}	9.00	7.00	8.00	9.50	7.00	8.25	14.00	8.00	11.00	9.08
G_{13}	11.00	8.00	9.50	10.50	7.50	9.00	14.50	9.00	11.75	10.08
Mean	13.08	10.58	11.83	12.92	10.50	11.71	13.92	11.69	12.81	12.16
Mean of cuttings							C_1	13.31		
							C_2	10.92		

Significant test	C	M	G	C×M	M×G	C×G	C×M×G
SE(d)	0.21	0.25	0.53	0.36	0.71	0.94	1.29
CD (P=0.05)	0.41	0.50	1.05	0.91	1.81	2.40	2.56
CD (P =0.01)	0.54	0.67	1.39	0.74	1.48	1.96	3.40

The leaf bud cutting in the following combinations *viz.*, $C_2M_1G_9$ (Leaf bud + Enriched cocopeat + BA 25 ppm), $C_2M_2G_9$ (Leaf bud + Cocopeat and sand + BA 25 ppm), $C_2M_1G_{10}$ (Leaf bud
+ Enriched cocopeat + BA 50 ppm) and $C_2M_2G_{10}$ (Leaf bud + Cocopeat and sand + BA 50 ppm) exhibited fastest root initiation, whereas in single bud cutting, the minimum days for root initiation was recorded in the treatment $C_1M_1G_{12}$ (Single bud + Enriched cocopeat + Coconut water). Early rooting of leaf bud cuttings may be due to the fact that carbohydrates enhance the metabolic activities inducing cell division that takes place at the base of the cuttings [8].

Table 3: Influence of media, growth regulators and types of cutting for number of leaves @ 45 days after planting

Growth regulator	M_1			M_2			M_3			Mean
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
G_1	0.00 (0.70)	9.00 (3.02)	4.50 (1.86)	0.00 (0.70)	9.00 (3.03)	4.50 (1.87)	0.00 (0.70)	8.50 (2.94)	4.25 (1.82)	4.41 (1.85)
G_2	0.00 (0.70)	9.00 (3.10)	4.50 (1.90)	0.00 (0.70)	9.00 (3.02)	4.50 (1.86)	0.00 (0.70)	8.00 (2.90)	4.00 (1.80)	4.33 (1.86)
G_3	0.00 (0.70)	7.00 (2.73)	3.50 (1.72)	0.00 (0.70)	7.00 (2.73)	3.50 (1.72)	0.00 (0.70)	8.50 (3.00)	4.25 (1.85)	3.75 (1.77)
G_4	0.00 (0.70)	7.00 (2.73)	3.50 (1.72)	0.00 (0.70)	7.00 (2.72)	3.50 (1.71)	0.00 (0.70)	7.50 (2.84)	3.75 (1.77)	3.58 (1.74)
G_5	0.00 (0.70)	7.00 (2.71)	3.50 (1.71)	0.00 (0.70)	7.50 (2.77)	3.75 (1.74)	0.00 (0.70)	9.00 (3.05)	4.50 (1.88)	3.91 (1.78)
G_6	0.00 (0.70)	5.50 (2.39)	2.75 (1.55)	0.00 (0.70)	5.00 (2.40)	2.50 (1.55)	0.00 (0.70)	8.50 (3.00)	4.25 (1.85)	3.16 (1.66)
G_7	0.00 (0.70)	7.00 (2.72)	3.50 (1.71)	0.00 (0.70)	7.00 (2.72)	3.50 (1.71)	0.00 (0.70)	8.00 (2.91)	4.00 (1.81)	3.66 (1.75)
G_8	0.00 (0.70)	7.00 (2.74)	3.50 (1.72)	0.00 (0.70)	7.00 (2.80)	3.50 (1.75)	0.00 (0.70)	8.00 (2.91)	4.00 (1.81)	3.66 (1.76)
G_9	0.00 (0.70)	10.00 (3.18)	5.00 (1.94)	0.00 (0.70)	8.50 (3.04)	4.25 (1.87)	0.00 (0.70)	8.00 (2.91)	4.00 (1.80)	4.41 (1.87)
G_{10}	0.00 (0.70)	9.00 (3.01)	4.50 (1.86)	0.00 (0.70)	7.50 (2.86)	3.75 (1.78)	0.00 (0.70)	9.00 (3.09)	4.50 (1.90)	4.25 (1.85)
G_{11}	4.00 (2.07)	10.00 (3.17)	7.00 (2.62)	4.00 (2.06)	8.50 (3.01)	6.25 (2.53)	5.00 (2.36)	9.00 (3.03)	7.00 (2.69)	6.75 (2.62)
G_{12}	4.00 (2.07)	10.50 (3.27)	7.25 (2.67)	4.50 (2.12)	8.00 (2.93)	6.25 (2.53)	0.00 (0.70)	9.50 (3.13)	4.75 (1.91)	6.08 (2.37)
G_{13}	0.00 (0.70)	9.50 (3.13)	4.75 (1.92)	0.00 (0.70)	9.00 (3.10)	4.50 (1.90)	0.00 (0.70)	8.00 (2.88)	4.00 (1.79)	4.41 (1.88)
Mean	0.62 (0.91)	8.27 (2.92)	4.44 (1.92)	0.65 (0.92)	7.69 (2.86)	4.17 (1.89)	0.38 (0.83)	8.42 (2.97)	4.40 (1.90)	4.34 (1.91)
Mean of cuttings									C_1	0.55
									C_2	8.13

Significant test	C	M	G	C×M	M×G	C×G	C×M×G
SE(d)	0.01	0.02	0.04	0.03	0.07	0.05	0.09
CD (P=0.05)	0.03	0.04	0.08	0.05	0.13	0.11	0.18
CD (P =0.01)	0.04	0.05	0.10	0.07	0.17	0.14	0.25

*Values in parentheses are square root transformed values

Number of leaves determines the photosynthetic efficiency of plants that influences the carbohydrate metabolism, photosynthate accumulation and assimilates portioning (Table 3). More leaf production may be due to enhanced biosynthesis of proteins and carbohydrates which in turn enhance the initiation of leaf primordia [9]. Among the two planting materials more number of leaves was recorded in leaf bud cutting when compared to single bud cutting at both 25 and 45 days after planting. The media cocopeat + sand and enriched cocopeat exhibited maximum number of leaves at 25 and 45 days respectively.

The influence of growth regulator for number of leaves at both stages revealed that Keradix-F 20 ppm followed by coconut water were found to be more effective when compared to other growth regulators. Similarly the interaction effect between media, growth regulators and stem cuttings had significant effect on the number of leaves per cutting at both stages. The treatment combination $C_2M_1G_2$ (Leaf bud + Enriched cocopeat + IBA 100ppm) and $C_2M_2G_{11}$ (Leaf bud + Cocopeat and sand + Kearadix-F 20 ppm) recorded the maximum value at 25 days after planting whereas the treatment combinations $C_2M_1G_{12}$ (Leaf bud + Enriched cocopeat + Coconut water) and $C_2M_3G_{12}$ (Leaf bud + Dam silt + Coconut water) exhibited maximum number of leaves at 45 days after planting. In chrysanthemum, reported that leaf number increased in cocopeat + FYM (2:1) followed by cocopeat + FYM (1:1) and cocopeat + vermiculite + FYM (1:1:1) (10). also the increased number of leaves in 12% coconut water in *Catharanthus roseus* compared to synthetic plant growth regulators has been reported earlier [11]. The possible reason for such increase in number of leaves may be due to activation of shoot growth which probably might have increased the number of nodes that leads to development of more number of leaves as reported in Marigold [12] and in Rose [13].

Increased number of roots induced by the application of auxins is a common feature in many of the herbaceous plants. It is one of the important parameter that determines the penetration of roots and stability of plants (Table 4). The results of the present study exhibited that number of roots per cutting was increased when the leaf bud cuttings were treated with Keradix - F 20 ppm followed by coconut water and other

auxins. The effect of different media on the growth of two different planting material showed significant results with the medium enriched cocopeat. Maximum number of roots per cutting at 25 and 45 days after planting was recorded in enriched cocopeat when compared to other media.

The best treatment combination identified for more number of roots was $C_2M_1G_{11}$ (Leaf bud cutting + Enriched cocopeat + Keradix - F 20 ppm) at 25 and 45 days after planting respectively. The increased number of roots may be due to increase in the internal free NAA that enhanced the root formation and may also be due to translocation of carbohydrates from the leaves which play an important role in development of roots. Also, the enhanced hydrolysis activity in the presence of exogenously applied growth hormones would be the main reason for the increased rooting in auxin treated cuttings. Similar results were reported using coconut water in chrysanthemum [6].

Table 4: Influence of media and growth regulators for number of roots @ 45 days after planting

Growth regulator	M_1			M_2			M_3			Mean
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
G_1	0.00 (0.70)	22.00 (4.70)	11.00 (2.71)	0.00 (0.70)	25.00 (5.04)	12.50 (2.88)	0.00 (0.70)	23.50 (4.91)	11.75 (2.80)	11.75 (2.79)
G_2	0.00 (0.70)	29.00 (5.46)	14.50 (3.08)	0.00 (0.70)	31.50 (5.62)	15.75 (3.16)	0.00 (0.70)	28.50 (5.38)	14.25 (3.04)	14.83 (3.10)
G_3	0.00 (0.70)	23.50 (4.87)	11.75 (2.79)	0.00 (0.70)	23.50 (4.88)	11.75 (2.79)	0.00 (0.70)	23.00 (4.84)	11.50 (2.77)	11.66 (2.78)
G_4	0.00 (0.70)	21.00 (4.63)	10.50 (2.67)	0.00 (0.70)	21.00 (4.63)	10.50 (2.67)	0.00 (0.70)	21.00 (4.62)	10.50 (2.66)	10.50 (2.67)
G_5	0.00 (0.70)	28.00 (5.36)	14.00 (3.03)	0.00 (0.70)	28.00 (5.34)	14.00 (3.02)	0.00 (0.70)	28.00 (5.30)	14.00 (3.10)	14.00 (3.03)
G_6	0.00 (0.70)	29.00 (5.42)	16.00 (3.62)	0.00 (0.70)	23.00 (4.88)	13.00 (3.23)	0.00 (0.70)	27.00 (5.27)	14.75 (3.50)	14.58 (3.48)
G_7	0.00 (0.70)	19.00 (4.44)	9.50 (2.58)	0.00 (0.70)	19.00 (4.44)	9.50 (2.57)	0.00 (0.70)	18.50 (4.38)	9.25 (2.54)	9.41 (2.56)
G_8	0.00 (0.70)	21.00 (4.63)	10.50 (2.67)	0.00 (0.70)	21.00 (4.64)	10.50 (2.67)	0.00 (0.70)	20.50 (4.60)	10.25 (2.65)	10.41 (2.66)
G_9	0.00 (0.70)	31.50 (5.66)	15.75 (3.18)	0.00 (0.70)	27.00 (5.21)	13.50 (2.96)	0.00 (0.70)	28.50 (5.39)	14.25 (3.10)	14.50 (3.06)
G_{10}	0.00 (0.70)	27.00 (5.26)	13.50 (2.78)	0.00 (0.70)	21.50 (4.65)	10.75 (2.68)	0.00 (0.70)	25.00 (5.04)	12.50 (2.87)	12.25 (2.85)
G_{11}	3.00 (1.82)	33.50 (5.85)	16.75 (3.28)	3.00 (1.77)	32.50 (5.77)	16.25 (3.24)	2.50 (1.72)	33.00 (5.81)	16.50 (3.25)	16.50 (3.25)
G_{12}	3.50 (2.01)	32.00 (5.70)	17.75 (3.86)	3.50 (1.99)	31.50 (5.64)	17.50 (3.82)	0.00 (0.70)	32.00 (5.69)	16.00 (3.20)	17.08 (3.63)
G_{13}	0.00 (0.70)	29.50 (5.45)	14.75 (3.08)	0.00 (0.70)	22.00 (4.72)	11.00 (2.71)	0.00 (0.70)	26.00 (5.16)	13.00 (2.94)	12.91 (2.91)
Mean	0.50 (0.89)	26.61 (5.18)	13.55 (3.04)	0.50 (0.88)	25.11 (5.03)	12.80 (2.96)	0.19 (0.78)	25.73 (5.10)	12.96 (2.95)	13.11 (2.98)
Mean of cuttings									C_1	0.40
									C_2	25.82

Significant test	C	M	G	C×M	M×G	C×G	C×M×G
SE(d)	0.03	0.03	0.07	0.05	0.12	0.10	0.17
CD (P=0.05)	0.05	0.07	0.14	0.09	0.24	0.20	0.34
CD (P =0.01)	0.07	0.09	0.18	0.12	0.32	0.26	0.45

*Values in parentheses are square root transformed values

Shoot length is one of the desirable feature in all herbaceous plants that produce more number of leaves. The leaf bud cutting, enriched cocopeat and the growth regulator Keradix-F 20 ppm followed by leaf bud + Enriched cocopeat + Coconut water were found to be more effective in inducing the shoot length at both stages of the crop. In the interaction effects, the treatment combination $C_2M_1G_5$ (Leaf bud + Enriched cocopeat + NAA 50 ppm) was found to be the best followed by $C_2M_1G_{12}$ (Leaf bud + Enriched cocopeat + Coconut water) and $C_2M_1G_9$ (Leaf bud + Enriched cocopeat + BA 25 ppm). The increase in shoot length has also been reported by [11] in *Catharanthus roseus* and in potato using coconut water [14].

Table 5: Influence of media, growth regulators on height of rooted cuttings @ 45 days

Growth regulator	M_1			M_2			M_3			Mean
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	
G_1	0.00 (0.04)	34.20 (1.54)	18.57 (0.81)	0.00 (0.04)	32.55 (1.52)	16.27 (0.78)	0.00 (0.04)	30.45 (1.49)	15.22 (0.76)	16.69 (0.78)
G_2	0.00 (0.04)	26.55 (1.43)	13.27 (0.74)	0.00 (0.04)	25.55 (1.42)	12.77 (0.73)	0.00 (0.04)	22.75 (1.37)	11.37 (0.70)	12.47 (0.72)
G_3	0.00 (0.04)	20.55 (1.33)	10.27 (0.68)	0.00 (0.04)	21.05 (1.34)	10.52 (0.69)	0.00 (0.04)	22.90 (1.35)	11.45 (0.70)	10.75 (0.69)

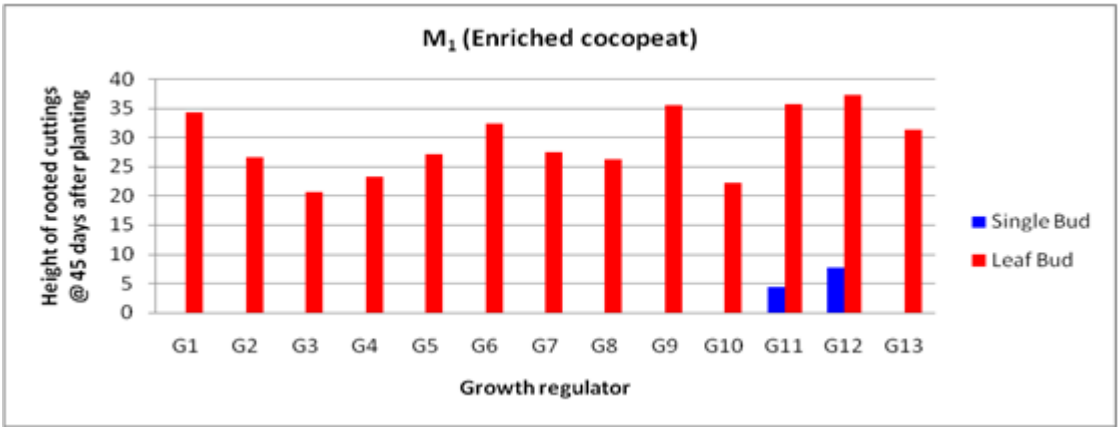
G_4	0.00 (0.04)	23.30 (1.38)	11.65 (0.71)	0.00 (0.04)	23.30 (1.38)	11.65 (0.71)	0.00 (0.04)	20.10 (1.32)	10.05 (0.68)	11.11 (0.70)
G_5	0.00 (0.04)	27.10 (1.45)	13.55 (0.74)	0.00 (0.04)	27.50 (1.45)	13.75 (0.74)	0.00 (0.04)	26.05 (1.43)	13.02 (0.73)	13.44 (0.74)
G_6	0.00 (0.04)	32.40 (1.52)	16.20 (0.78)	0.00 (0.04)	28.15 (1.46)	14.07 (0.75)	0.00 (0.04)	30.60 (1.50)	15.30 (0.77)	15.19 (0.76)
G_7	0.00 (0.04)	27.50 (1.45)	13.75 (0.74)	0.00 (0.04)	24.25 (1.40)	12.12 (0.72)	0.00 (0.04)	25.85 (1.43)	12.92 (0.73)	12.93 (0.73)
G_8	0.00 (0.04)	26.25 (1.43)	13.12 (0.73)	0.00 (0.04)	27.40 (1.45)	13.70 (0.74)	0.00 (0.04)	25.55 (1.42)	12.77 (0.73)	13.20 (0.74)
G_9	0.00 (0.04)	35.50 (1.56)	17.77 (0.80)	0.00 (0.04)	34.00 (1.54)	17.75 (0.80)	0.00 (0.04)	30.55 (1.49)	15.27 (0.77)	16.93 (0.79)
G_{10}	0.00 (0.04)	22.10 (1.36)	11.05 (0.70)	0.00 (0.04)	20.35 (1.33)	10.17 (0.68)	0.00 (0.04)	19.90 (1.32)	9.95 (0.68)	10.39 (0.69)
G_{11}	4.35 (0.73)	35.55 (1.56)	19.17 (1.14)	5.25 (0.80)	29.75 (1.48)	17.50 (1.14)	5.25 (0.80)	31.55 (1.51)	18.40 (1.15)	18.35 (0.14)
G_{12}	7.75 (0.94)	37.15 (1.58)	19.47 (1.22)	7.85 (0.95)	26.55 (1.44)	17.20 (1.19)	0.00 (0.04)	29.05 (1.47)	14.52 (0.75)	17.06 (1.06)
G_{13}	0.00 (0.04)	31.20 (1.50)	17.10 (0.79)	0.00 (0.04)	27.25 (1.45)	13.62 (0.74)	0.00 (0.04)	33.25 (1.53)	16.62 (0.78)	15.78 (0.77)
Mean	0.93 (0.16)	29.06 (1.47)	14.99 (0.81)	1.00 (0.16)	26.85 (1.44)	13.93 (0.80)	0.40 (0.09)	26.81 (1.43)	13.60 (0.76)	14.18 (0.80)
Mean of cuttings									C_1	0.78
									C_2	27.58

Significant test	C	M	G	C×M	M×G	C×G	C×M×G
SE(d)	0.01	0.01	0.01	0.01	0.02	0.02	0.03
CD (P=0.05)	0.01	0.01	0.03	0.02	0.05	0.04	0.06
CD (P =0.01)	0.01	0.02	0.03	0.02	0.06	0.05	0.08

*Values in parentheses are Log transformed values

G_1 - IBA 50 ppm
G_2 - IBA 100 ppm
G_3 - IBA 200 ppm
G_4 - IBA 300 ppm
G_5 - NAA 50 ppm
G_6 - NAA 100 ppm
G_7 - NAA 200 ppm
G_8 - NAA 300 ppm
G_9 - BA 25 ppm
G_{10} - BA 50 ppm
G_{11}- Keradix-F 20 ppm
G_{12} - Coconut water
G_{13} - Control
C_1 - Single bud cutting
C_2 - Leaf bud cutting
M_1- Enriched Cocopeat
M_2- Cocopeat + Sand
M_3- Dam Silt
C_1 - Single bud cutting
C_2 - Leaf bud cutting

Root length had influence on penetrating ability and more water absorption from the soil. The effect of different media and growth regulators on the growth of two different planting material exhibited significant results on the length of roots per cutting at 25 and 45 days after planting respectively. Leaf bud cutting in enriched cocopeat and cocopeat + sand with IBA 100 ppm was found to be the best treatment followed by $C_2M_1G_{11}$ (Leaf bud + Enriched cocopeat + Keradix-F 20ppm) at 25 days and 45 days after planting of cuttings when compared to single bud cutting and other growth regulators. It was earlier reported that the media added with coconut water and IAA resulted in higher root length compared to treatment added with BA [6]. The physiological changes in auxin concentration and high endogenous auxin concentration are normally associated with a high rooting rate at beginning rooting process in chrysanthemum which is similar to the findings in potato [14].



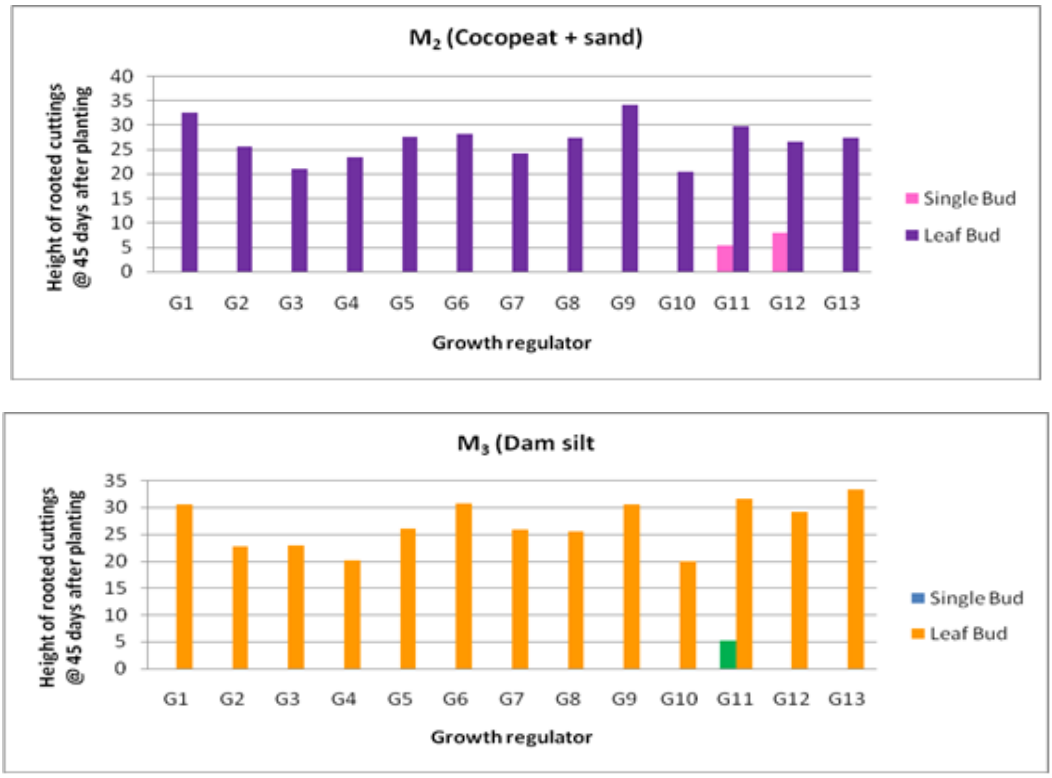
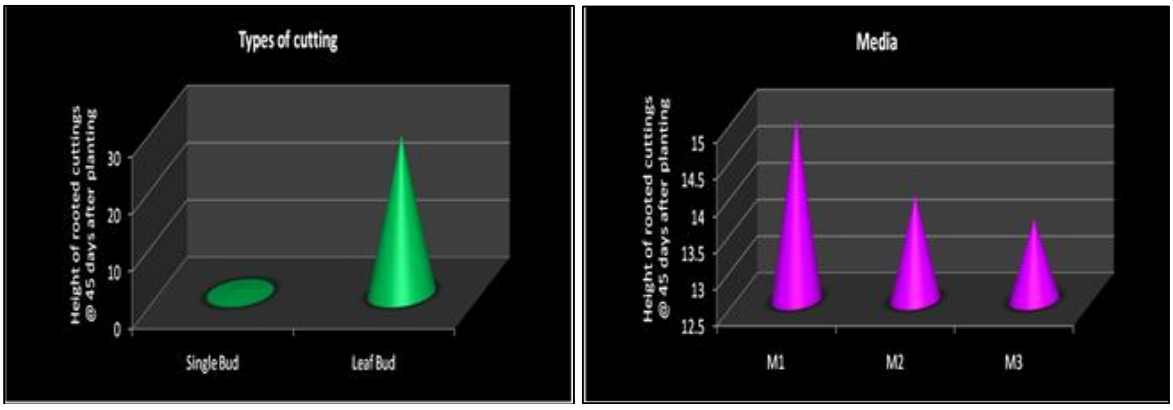
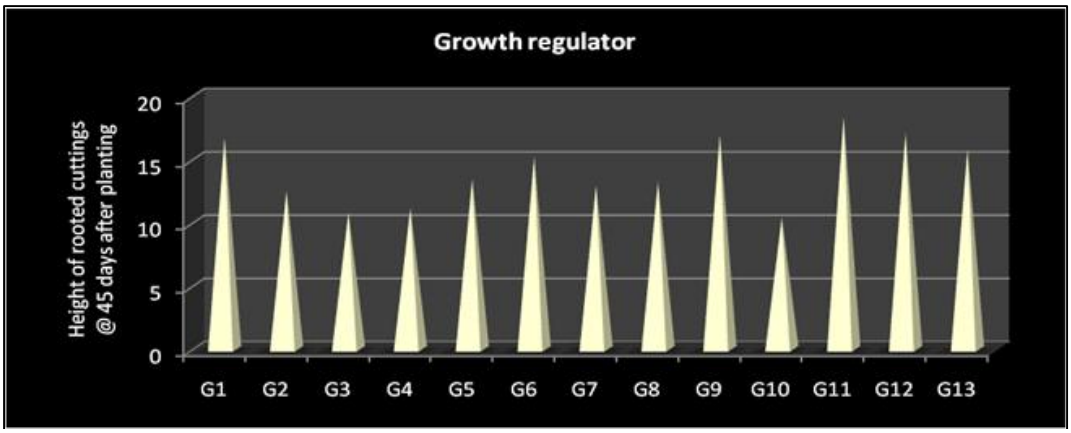


Fig 1: Influence of media, growth regulators and types of cutting on height of rooted cuttings @ 45 days after planting

Height of the rooted cuttings is an important character that increases the number of roots and leaves which in turn influence the partitioning of translocates in the plant (Table 5). Leaf bud cuttings in enriched cocopeat media + coconut water followed by Keradix-F 20 ppm and BA @ 25 ppm had significant effect on the growth of rooted cuttings when compared to single bud cutting with other treatments. The interaction effect between media, growth regulators and leaf bud cuttings revealed that $C_2M_1G_{11}$ (Leaf bud + Enriched cocopeat + Keradix-F 20 ppm) followed by $C_2M_1G_{12}$ (Leaf bud + Enriched cocopeat + Coconut water) at 25 days and 45 after planting of cuttings are the best combinations (Fig. 1, 2 & 3). This may be due to the better utilization of carbohydrates and other nutrients that are aided by the growth regulators that enhances the plant growth [14]. In single bud cutting, the height of the rooted cuttings was very negligible when compared to all other combinations (Fig. 4, 5).





Conclusion

Based on the results of the present study, it was found that the leaf bud cutting grown in enriched cocopeat treated with coconut water was found to be superior for most of the growth attributes. In the present study it was confirmed that leaf buds has the higher regeneration ability to produce new plants from a single leaf bud. Therefore, a healthy mother plant with good number of branches can produce upto 10-15 leaf buds and the leaf bud cuttings taken from the mother plant can be used for rapid multiplication of chrysanthemum, when a suitable growing media like enriched cocopeat is supplemented with coconut water or with commercial rooting hormones Keradix-F. This multiplication is simple, easy and economic for the farmers and it is particularly useful when propagation material is scarce, as in the case of introducing new cultivars.

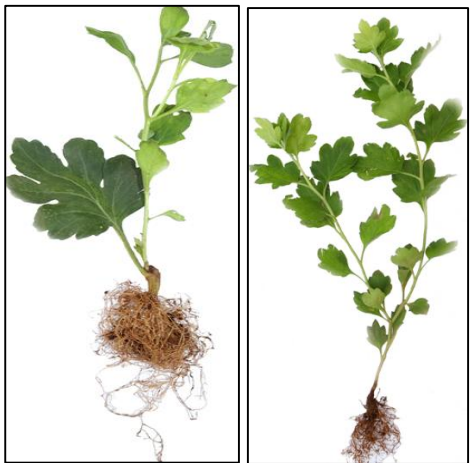


Fig 2: Growth of Leaf bud in Coconut water

Fig 3: Growth of Leaf bud in Keradix 20ppm

Fig 4: Growth of Single bud in Coconut water

Fig 5: Growth of Single bud in Keradix 20ppm

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