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Research Article

EFFECT OF GROWTH REGULATORS ON SUCKER PRODUCTION IN EXOTIC VARIETIES OF HELICONIA

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ABSTRACT

The demend of heliconias for cut flower trade is increasing day-by-day because of the long vase life, attractive colour and exotic shape. A study was conducted to standardize growth regulators for enhacing propagation efficiency in three *viz.*, St. Vincent Red (small erect type), Golden Torch Adrian (hybrid) and Sexy Pink (large pendent type) . Two field trials were carried out for this purpose. Based on the results of the preliminary field trial, second experiment was laid out. At varietal level, significant difference was evident in the total number of suckers. In the first experiment, the variety St. Vincent Red (3.82) was significantly superior in terms of total number of suckers. However, in the second experiment, St. Vincent Red (4.06) was on par with Golden Torch Adrian (4.10). Application of growth regulators had pronounced effect on sucker production at all the stages during the first experiment when BA 750 mg l^{-1} produced the highest number (4.19) of total suckers. In the second experiment, variation was evident in the total number of suckers. Here, BA 850 mg l^{-1} produced the highest number (4.33) of suckers and it was on par with BA 700 mg l^{-1} (4.00) and GA_3 650 mg l^{-1} (3.79). VG interaction exerted significant variation in the number of suckers. At varietal level, BA 750 mg l^{-1} produced the highest number of suckers in St. Vincent Red (4.75), GA_3 500 mg l^{-1} in Golden TorchAdrian(4.63)and GA_3 750 mg l^{-1} in Sexy Pink (4.00). Among VG treatment combinations in the second experiment, the highest number of suckers (4.75) in the variety St. Vincent Red was produced by BA 700 mg l^{-1}. The varieties Golden Torch Adrian (4.88) and Sexy Pink (3.75) recorded the highest with BA 850 mg l^{-1}. The economics of foliar application of growth regulators revealed that BA 850 mg l^{-1} significantly enhanced the profit in the varieties Golden Torch Adrian and Sexy Pink. Although negligible,BA 700 mg l^{-1} recorded slight positive response in the variety St. Vincent Red with respect to profit.

KEY WORDS: heliconia, growth regulators, propagation, sucker production

INTRODUCTION

Heliconias (*Heliconia* spp.) are attractive tropical plants with banana-like leaves and beautiful, long lasting inflorescences. Each inflorescence is made up of several colorful bracts which enclose the true flowers. Heliconias are also valued as garden plants as their long lasting flowers stand out with striking visual effect on plants. Easiness in cultivation and hardy nature with tolerance to major pests and diseases make this crop more appealing for widespread cultivation. All species of heliconia do not set seeds. Moreover, seed is erratic to germinate and the seedlings may take 12 months or more to emerge. Propagation by rhizomes is the fastest and most reliable method of cultivation. Most of the present day heliconia varieties which are greatly in demand are exotic introductions. Hence, it is essential to evolve techniques for mass multiplication of such varieties making possible

the production of large numbers of planting material in limited time. Standardization of faster multiplication techniques using growth regulators would serve as a means to bring down the cost of cultivation of elite varieties. Hence the study was aimed at the enhancement of propagation efficiency in three exotic varieties of heliconia *viz.*, St. Vincent Red (*H. psittacorum*), Golden Torch Adrian (*H. psittacorum* x *H. spathocircinata*) and Sexy Pink (*H. chartacea*). with the objective of standardizing the growth regulators for *in vivo* propagation.

MATERIALS AND METHODS

The study was carried out with an objective to enhance the sucker production in exotic varieties of heliconia by using growth regulators.

The preliminary field trial was laid out in split plot design with 39 treatments which include three control plots. The trial was replicated four times. Each treatment had four plants as observational plants. Varieties were taken as main plot treatment and growth regulators and methods of application as sub plot treatments. The details of the treatments tried for the preliminary field trial are furnished in Table 1. Three varieties of heliconia belonging to three distinct groups procured from the Department of Pomology and Floriculture, College of Agriculture, Vellayani, were used for the experiment, *viz.*, St. Vincent Red (*Heliconia psittacorum*) , Golden Torch Adrian (*H. psittacorum* x *H. spathocircinata*) and Sexy Pink (*H. chartacea*) which are herein referred to as V_1, V_2 and V_3 respectively. Two plant growth regulators namely BA and GA_3 were tried each at three different concentrations *viz.*, G_1 (BA 500 mg l^{-1}), G_2 (BA 750 mg l^{-1}), G_3 (BA 1000 mg l^{-1}), G_4 (GA_3 500 mg l^{-1}, G_5 (GA_3 750 mg l^{-1}) and G_6 (GA_3 1000 mg l^{-1}). Each growth regulator was applied in two different ways *viz.*, M_1 (Rhizome dip) and M_2 (Foliar spray).

The land was cleared, levelled and ploughed to a fine tilth and trenches were made to demarcate the individual plots. Uniform sized suckers of the three selected varieties were planted at a spacing of 75 x 75 cm between the plants and 1.50 m between the rows. At the time of land preparation, dried cowdung was incorporated into the soil in fine tilth at the rate of 4.00 kg m^{-2}.The plants were given soaking irrigation daily. Weeding was done occasionally. Spray solutions of GA_3 and BA were first dissolved in minimum quantity of 95 per cent ethanol and NaOH, respectively and the volume of each was made up to 1000 ml with distilled water. Treatment solutions of the required concentrations were prepared from the stock solution by proper dilution with distilled water. Few drops of labolene were added to the prepared solution to serve as wetting agent. Spraying was done on the same day with hand sprayer till run off started on the foliage.

Two modes of application were tried i.e., rhizome dip and foliar spray. The rhizomes of suckers were dipped in the prepared solution of desired strength for 30 minutes just before planting. Foliar sprays were started at one month after planting and carried out at fortnightly intervals for two months (five sprays). Control plots were maintained without rhizome dip or foliar spray.

Observations were recorded at monthly intervals starting from two months after planting. Four plants from each plot were taken as observational plants. After recording the observations, suckers were dug out and replanted at fortnightly intervals. Number of suckers produced by the observational plants were counted and recorded.

The experimental data were analyzed statistically by applying the technique of analysis of variance for split plot design (Gomez and Gomez, 1984). The critical differences for comparison of all the main effects and interaction were computed based on the formula for split plot design.

Based on the results of the preliminary field trial, treatments were modified and the second crop was planted. Details of the treatments tried for the second field experiment are given in Table 2. Land preparation, planting and other management practices were carried out as in the preliminary field trial. Based on the results of the preliminary field trial, foliar spray alone was selected as the method of application. BA and GA_3 were sprayed each at three different concentrations viz., G_{11} (BA 700 mg l^{-1}), G_{12} (BA 850 mg l^{-1}), G_3 (BA 1000 mg l^{-1}), G_4 (GA_3 500 mg l^{-1}), G_{15} (GA_3 650 mg l^{-1}) and G_{16} (GA_3 800 mg l^{-1})

The second field trial was laid out in factorial Randomized Block Design (RBD) with 18 treatments. The trial was replicated twice. Each treatment had four plants as observational plants. The growth regulators were applied as foliar spray at fortnightly intervals for two months from one month after planting. Observations were recorded on the number of suckers. Economics of growth regulator application with respect to sucker production was worked out in all the three varieties.

The data pertaining to the experiment were analyzed applying the Analysis of Variance Technique (ANOVA) proposed by Panse and Sukhatme (1985).

Table 1: Details of the treatments tried for the preliminary field trial

Sl. No.	Treatment codes	Treatment combinations	Treatments
1.	T_1	$V_1M_1G_1$	St.Vincent Red - BA 500 mg l^{-1} - Rhizome dip
2.	T_2	$V_1M_1G_2$	St.Vincent Red - BA 750 mg l^{-1} - Rhizome dip
3.	T_3	$V_1M_1G_3$	St.Vincent Red - BA 1000 mg l^{-1} - Rhizome dip
4.	T_4	$V_1M_1G_4$	St.Vincent Red - GA_3 500 mg l^{-1} - Rhizome dip
5.	T_5	$V_1M_1G_5$	St.Vincent Red - GA_3 750 mg l^{-1} - Rhizome dip
6.	T_6	$V_1M_1G_6$	St.Vincent Red - GA_3 1000 mg l^{-1} - Rhizome dip
7.	T_7	$V_1M_2G_1$	St.Vincent Red - BA 500 mg l^{-1} - Foliar spray
8.	T_8	$V_1M_2G_2$	St.Vincent Red - BA 750 mg l^{-1} - Foliar spray
9.	T_9	$V_1M_2G_3$	St.Vincent Red - BA 1000 mg l^{-1} - Foliar spray
10.	T_{10}	$V_1M_2G_4$	St.Vincent Red - GA_3 500 mg l^{-1} - Foliar spray
11.	T_{11}	$V_1M_2G_5$	St.Vincent Red - GA_3 750 mg l^{-1} - Foliar spray
12.	T_{12}	$V_1M_2G_6$	St.Vincent Red - GA_3 1000 mg l^{-1} - Foliar spray
13.	T_{13}	$V_2M_1G_1$	Golden Torch Adrian - BA 500 mg l^{-1}- Rhizome dip
14.	T_{14}	$V_2M_1G_2$	Golden Torch Adrian - BA 750 mg l^{-1} - Rhizome dip
15.	T_{15}	$V_2M_1G_3$	Golden Torch Adrian - BA 1000 mg l^{-1} - Rhizome dip
16.	T_{16}	$V_2M_1G_4$	Golden Torch Adrian - GA_3 500 mg l^{-1} - Rhizome dip
17.	T_{17}	$V_2M_1G_5$	Golden Torch Adrian - GA_3 750 mg l^{-1} - Rhizome dip
18.	T_{18}	$V_2M_1G_6$	Golden Torch Adrian - GA_3 1000 mg l^{-1} - Rhizome dip
19.	T_{19}	$V_2M_2G_1$	Golden Torch Adrian - BA 500 mg l^{-1} - Foliar spray
20.	T_{20}	$V_2M_2G_2$	Golden Torch Adrian - BA 750 mg l^{-1} - Foliar spray
21.	T_{21}	$V_2M_2G_3$	Golden Torch Adrian - BA 1000 mg l^{-1} - Foliar spray
22.	T_{22}	$V_2M_2G_4$	Golden Torch Adrian - GA_3 500 mg l^{-1} - Foliar spray
23.	T_{23}	$V_2M_2G_5$	Golden Torch Adrian - GA_3 750 mg l^{-1} - Foliar spray
24.	T_{24}	$V_2M_2G_6$	Golden Torch Adrian - GA_3 1000 mg l^{-1} - Foliar spray
25.	T_{25}	$V_3M_1G_1$	Sexy Pink - BA 500 mg l^{-1} - Rhizome dip
26.	T_{26}	$V_3M_1G_2$	Sexy Pink - BA 750 mg l^{-1} - Rhizome dip
27.	T_{27}	$V_3M_1G_3$	Sexy Pink - BA 1000 mg l^{-1} - Rhizome dip
28.	T_{28}	$V_3M_1G_4$	Sexy Pink - GA_3 500 mg l^{-1} - Rhizome dip
29.	T_{29}	$V_3M_1G_5$	Sexy Pink - $GA_3$750 mg l^{-1} - Rhizome dip
30.	T_{30}	$V_3M_1G_6$	Sexy Pink - $GA_3$1000 mg l^{-1} - Rhizome dip
31.	T_{31}	$V_3M_2G_1$	Sexy Pink - BA 500 mg l^{-1} - Foliar spray
32.	T_{32}	$V_3M_2G_2$	Sexy Pink - BA 750 mg l^{-1} - Foliar spray
33.	T_{33}	$V_3M_2G_3$	Sexy Pink - BA 1000 mg l^{-1} - Foliar spray
34.	T_{34}	$V_3M_2G_4$	Sexy Pink - GA_3 500 mg l^{-1} - Foliar spray
35.	T_{35}	$V_3M_2G_5$	Sexy Pink - GA_3 750 mg l^{-1} - Foliar spray
36.	T_{36}	$V_3M_2G_6$	Sexy Pink - GA_3 1000 mg l^{-1} - Foliar spray
37.	T_{37}	$V_1M_0G_0$	St.Vincent Red - Control
38.	T_{38}	$V_2M_0G_0$	Golden Torch Adrian - Control
39.	T_{39}	$V_3M_0G_0$	Sexy Pink - Control

Table 2: Details of the treatments tried for the second field experiment

Sl. No.	Treatment codes	Treatment combinations	Treatments
1.	T_1	V_1G_{11}	St.Vincent Red - BA 700 mg l^{-1} - foliar spray
2.	T_2	V_1G_{12}	St.Vincent Red - BA 850 mg l^{-1} - foliar spray
3.	T_3	V_1G_3	St.Vincent Red - BA 1000 mg l^{-1} - foliar spray
4.	T_4	V_1G_4	St.Vincent Red - GA_3 500 mg l^{-1} - foliar spray
5.	T_5	V_1G_{15}	St.Vincent Red - GA_3 650 mg l^{-1} - foliar spray
6.	T_6	V_1G_{16}	St.Vincent Red - GA_3 800 mg l^{-1} - foliar spray
7.	T_7	V_2G_{11}	Golden Torch Adrian - BA 700 mg l^{-1} - foliar spray
8.	T_8	V_2G_{12}	Golden Torch Adrian - BA 850 mg l^{-1} - foliar spray
9.	T_9	V_2G_3	Golden Torch Adrian - BA 1000 mg l^{-1} - foliar spray
10.	T_{10}	V_2G_4	Golden Torch Adrian - GA_3 500 mg l^{-1} - foliar spray
11.	T_{11}	V_2G_{15}	Golden Torch Adrian - GA_3 650 mg l^{-1} - foliar spray
12.	T_{12}	V_2G_{16}	Golden Torch Adrian - GA_3 800 mg l^{-1} - foliar spray
13.	T_{13}	V_3G_{11}	Sexy Pink - BA 700 mg l^{-1} - foliar spray
14.	T_{14}	V_3G_{12}	Sexy Pink - BA 850 mg l^{-1} - foliar spray
15.	T_{15}	V_3G_3	Sexy Pink - BA 1000 mg l^{-1} - foliar spray
16.	T_{16}	V_3G_4	Sexy Pink - GA_3 500 mg l^{-1} - foliar spray
17.	T_{17}	V_3G_{15}	Sexy Pink - GA_3 650 mg l^{-1} - foliar spray
18.	T_{18}	V_3G_{16}	Sexy Pink - GA_3 800 mg l^{-1} - foliar spray

Table 3: Main effects of varieties and methods of application of growth regulators on the number of suckers at different stages of growth of heliconia

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
Varieties (V)					
V_1	1.25	0.92	0.83	0.83	3.82
V_2	1.04	0.83	0.90	0.88	3.65
V_3	0.82	0.81	0.80	0.80	3.30
F	207.241**	56.275**	10.028*	7.068*	51.604**
SE	0.015	0.007	0.015	0.016	0.042
CD (0.05)	0.051	0.025	0.053	0.055	0.147
Methods of application (M)					
M_1	0.86	0.83	0.80	0.79	3.27
M_2	1.21	0.88	0.89	0.88	3.86
F	472.154**	10.764**	28.003**	29.318**	270.459**
SE	0.012	0.010	0.013	0.012	0.025
CD (0.05)	0.033	0.029	0.035	0.033	0.071

* Significant at 5% level

** Significant at 1% level

MAP - months after planting

Table 4: Main effects of varieties and methods of application of growth regulators on the number of suckers at different stages of growth of heliconia

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
G_1	1.01	0.80	0.78	0.82	3.42
G_2	1.24	0.88	1.04	1.03	4.19
G_3	1.18	0.83	0.87	0.85	3.73
G_4	0.96	1.06	0.83	0.83	3.68
G_5	1.05	0.89	0.92	0.87	3.72
G_6	0.76	0.67	0.62	0.62	2.66
F	71.189**	51.293**	43.138**	42.487**	135.401**
SE	0.020	0.018	0.022	0.020	0.044
CD (0.05)	0.057	0.050	0.061	0.057	0.123

** Significant at 1% level

MAP - months after planting

Table 5: Interaction effect of varieties and growth regulators on the number of suckers at different stages of growth of heliconia (A)

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
V_1G_1	1.38	1.13	0.69	0.78	3.97
V_1G_2	1.50	0.75	1.25	1.25	4.75
V_1G_3	1.47	0.75	0.84	0.81	3.88
V_1G_4	0.88	1.20	0.81	0.81	3.70
V_1G_5	1.25	1.01	0.75	0.66	3.67
V_1G_6	1.00	0.66	0.63	0.69	2.97
V_2G_1	0.94	0.53	0.91	0.94	3.32
V_2G_2	1.34	1.00	1.00	0.97	4.31
V_2G_3	1.19	0.88	0.88	0.88	3.81
V_2G_4	1.25	1.25	1.06	1.06	4.63
V_2G_5	0.91	0.66	1.00	0.94	3.50
V_2G_6	0.59	0.69	0.53	0.50	2.31
V_3G_1	0.72	0.75	0.75	0.75	2.97
V_3G_2	0.88	0.88	0.88	0.88	3.50
V_3G_3	0.88	0.88	0.88	0.88	3.50
V_3G_4	0.75	0.72	0.63	0.63	2.72
V_3G_5	1.00	1.00	1.00	1.00	4.00
V_3G_6	0.69	0.66	0.69	0.66	2.69
F	28.996**	46.788**	15.685**	20.943**	42.610**
SE	0.035	0.031	0.038	0.035	0.076
CD (0.05)	0.098	0.086	0.106	0.100	0.214

** Significant at 1% level

MAP - months after planting

Table 6: Interaction effect of varieties and methods of application on the number of suckers at different stages of growth of heliconia

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
V_1M_1	1.01	0.90	0.81	0.82	3.54
V_1M_2	1.48	0.93	0.84	0.84	4.10
V_2M_1	0.75	0.79	0.82	0.80	3.17
V_2M_2	1.32	0.88	0.97	0.96	4.13
V_3M_1	0.80	0.80	0.75	0.75	3.10
V_3M_2	0.83	0.82	0.85	0.84	3.35
F	101.492**	1.661	3.589*	5.503**	32.654**
SE	0.020	0.018	0.022	0.020	0.044
CD (0.05)	0.057	0.050	0.061	0.057	0.123

* Significant at 5% level

** Significant at 1% level

MAP - months after planting

Table 7: Interaction effect of methods of application and growth regulators on the number of suckers at different stages of growth of heliconia

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
M_1G_1	0.84	0.85	0.79	0.79	3.28
M_1G_2	1.08	0.83	0.92	0.92	3.75
M_1G_3	1.19	0.83	0.92	0.92	3.86
M_1G_4	0.67	1.15	0.79	0.79	3.40
M_1G_5	0.77	0.75	0.83	0.79	3.15
M_1G_6	0.58	0.56	0.52	0.54	2.21
M_2G_1	1.19	0.75	0.77	0.85	3.56
M_2G_2	1.40	0.92	1.17	1.15	4.63
M_2G_3	1.17	0.83	0.81	0.79	3.61
M_2G_4	1.25	0.97	0.88	0.88	3.97
M_2G_5	1.33	1.03	1.00	0.94	4.30
M_2G_6	0.94	0.77	0.71	0.69	3.11
F	29.418**	25.115**	9.677**	8.725**	33.564**
SE	0.029	0.025	0.031	0.029	0.062
CD (0.05)	0.080	0.071	0.086	0.081	0.174

** Significant at 1% level

MAP - months after planting

Table 8: Main effect of varieties on the number of suckers at different stages of growth of heliconia (B)

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
V_1	1.42	0.88	0.88	0.90	4.06
V_2	1.40	0.96	1.00	0.75	4.10
V_3	0.83	0.79	0.67	0.71	2.98
F	40.596**	1.427	4.654*	2.758	23.376**
SE	0.052	0.070	0.078	0.059	0.132
CD (0.05)	0.155	0.208	0.233	0.177	0.394

* Significant at 5% level

** Significant at 1% level

MAP - months after planting

Table 9: Main effect of growth regulators on the number of suckers at different stages of growth of heliconia (B)

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
G_{11}	1.29	0.88	0.88	0.96	4.00
G_{12}	1.29	1.00	1.13	0.92	4.33
G_3	1.21	0.79	0.83	0.67	3.50
G_4	1.25	0.88	0.67	0.75	3.50
G_{15}	1.29	0.92	0.75	0.83	3.79
G_{16}	0.96	0.79	0.83	0.58	3.17
F	3.143*	0.64	1.98	3.005*	4.956**
SE	0.073	0.10	0.11	0.084	0.187
CD (0.05)	0.219	0.29	0.33	0.250	0.557

* Significant at 5% level

** Significant at 1% level

MAP - months after planting

Table 10: Interaction effect of varieties and growth regulators on the number of suckers at different stages of growth of heliconia (B)

Treatments	Number of suckers per plant				
	2 MAP	3 MAP	4 MAP	5 MAP	Total
V_1G_{11}	1.63	0.75	1.13	1.25	4.75
V_1G_{12}	1.50	1.00	0.88	1.00	4.38
V_1G_3	1.50	0.75	0.63	0.63	3.50
V_1G_4	1.25	0.88	1.00	0.88	4.00
V_1G_{15}	1.63	1.00	0.75	1.00	4.38
V_1G_{16}	1.00	0.88	0.88	0.63	3.38
V_2G_{11}	1.50	1.25	1.00	1.00	4.75
V_2G_{12}	1.38	1.00	1.63	0.88	4.88
V_2G_3	1.13	0.75	1.00	0.63	3.50
V_2G_4	1.75	1.13	0.50	0.88	4.25
V_2G_{15}	1.38	0.88	0.75	0.63	3.63
V_2G_{16}	1.25	0.75	1.13	0.50	3.63
V_3G_{11}	0.75	0.63	0.50	0.63	2.50
V_3G_{12}	1.00	1.00	0.88	0.88	3.75
V_3G_3	1.00	0.88	0.88	0.75	3.50
V_3G_4	0.75	0.63	0.50	0.50	2.25
V_3G_{15}	0.88	0.88	0.75	0.88	3.38
V_3G_{16}	0.63	0.75	0.50	0.63	2.50
F	2.435	0.999	1.890	1.325	2.627*
SE	0.127	0.171	0.191	0.145	0.323
CD (0.05)	0.380	0.510	0.571	0.433	0.964

* Significant at 5% level

MAP - months after planting

RESULTS AND DISCUSSION

Observations were recorded on the number of suckers at four growth stages of the crop namely 2 MAP, 3 MAP, 4 MAP and 5 MAP during the preliminary trial and second trial. Obviously, varietal variation was observed in the characters studied.

Methods of application

Two methods of application were tried for the preliminary experiment *viz.*, rhizome dip for thirty minutes before planting and fortnightly foliar spray for two months starting from one month after planting. M_2 (foliar spray) exhibited superiority over M_1 (rhizome dip) in terms of number of suckers at all the four stages of observation (Table 3). Totally M_2 resulted in 3.86 suckers against 3.27 suckers in M_1. Moreover, rhizome dip resulted in delayed sucker emergence and drying up of the mother plants in due course mostly in the case of V_3 (Sexy Pink). Hormone dip might have produced some sort of shock to the rhizomes which resulted in delayed sucker emergence and drying up of mother plants. This is in agreement with the findings of Kuehny et al. (2002) in *Curcuma alismatifolia* cv. Chiang

Mai Pink. They observed delayed shoot emergence when the rhizomes were soaked for 10 minutes in a solution containing gibberellic acid (200, 400 or 600 mg l^{-1}). Based on the results of the preliminary field trial, only foliar spray was attempted for the second experiment.

Growth regulators

Application of growth regulators had pronounced effect on sucker production at all the stages during the first experiment when BA 750 mg l^{-1} produced the highest number (4.19) of total suckers (Table 4). In the second experiment, variation was evident only in the total number of suckers. Here, BA 850 mg l^{-1} produced the highest number (4.33) of suckers (Table 10) and it was on par with BA 700 mg l^{-1} (4.00) and GA_3 650 mg l^{-1} (3.79).

Effect of growth regulators on sucker production was highly significant at all the stages of observation during the first experiment. G_2 (BA 750 mg l^{-1}) produced the highest number of total suckers (4.19) and G_6 (GA_3 1000 mg l^{-1}) recorded the lowest (2.66). Gibberellic acid at higher concentrations might have inhibited sucker production. Cytokinins are well known for their effect on increasing the rate of cell division and to induce bud break in above ground and underground plant parts. Effect of BA on sucker production was earlier confirmed by several workers in other crops. Pytlewski and Hetman (1985) observed that BA 800 mg l^{-1} was the most effective treatment, increasing the lateral shoot production in *Fosterelia penduliflora*. Henny (1986) successfully used foliar sprays of BAP to increase lateral shoot production in a non-branching *Dieffenbachia* hybrid. He found that three sprays at 500 or 750 mg l^{-1} BAP yielded more shoots than the lower dose. Apical dominance is due to correlative inhibition of lateral buds which is hormonal in nature. Cytokinins are known to release intact plants from correlative inhibition (Saches and Thimman, 1967). Shade house grown anthurium plants treated with 1000 ppm BA recorded highest number of side-shoots per plant as reported by Maitra, Soumen (2014).

The total number of suckers significantly differed with the growth regulators in the second trial. G_{12} (BA 850 mg l^{-1}) excelled in the total number of suckers (4.33) though it was on par with G_{11} (BA 700 mg l^{-1}) which recorded 4.00 and G_{15} (GA_3 650 mg l^{-1}) which recorded 3.79 suckers. The growth regulators could not exert any significant influence on the number of suckers at 3 MAP and 4 MAP. At 2 MAP and 5 MAP, although treatments were significant, only G_{16} (GA_3 800 mg l^{-1}) was inferior and all the others were on par in terms of number of suckers. This can be attributed to the residual effect of growth regulators applied during the first field trial.

As regards the concentration of growth regulators, it was observed that G_1 (BA 500 mg l^{-1}) and G_6 (GA_3 1000 mg l^{-1}) could not exert any significant effect on the number of suckers. Hence the concentration range of BA and GA_3 were slightly modified for the second experiment. Accordingly, concentration range of BA was fixed as 700-1000 mg $l^{-1}$and GA_3 as 500-800 mg l^{-1}.

Varieties

It is evident that the three varieties selected for the study significantly differed among themselves in suckering ability with V_3 inferior to the other two. With the application of growth regulators, similar trend was exhibited among the three although sucker production was enhanced at the individual level.

During the preliminary field trial, among the three varieties, V_1 produced the highest number of total suckers (3.82) and it was significantly superior to V_2 (Golden Torch Adrian) which produced 3.65 suckers and V_3 (Sexy Pink) which recorded 3.30 suckers (Table 3). Throughout the observational period, the variety V_3 produced the lowest number of suckers. Although varietal difference in the number of suckers was highly pronounced during the first stage (2 MAP) of second experiment, it was insignificant during later stages except at 4 MAP. However, significant variation was observed among the three varieties in the total number of suckers (Table 9). As in the first experiment, here also V_3 recorded significantly lower number of total suckers (2.98) when compared to V_1 (4.06) and V_2 (4.10).

Interaction effect of varieties and growth regulators

VG interaction exerted significant variation in the number of suckers. Among VG combination treatments, V_1G_2 recorded the highest number of suckers at almost all the stages except at 3 MAP. However, regarding the total number of suckers produced throughout the observational period, V_1G_2 (4.75) was on par with V_2G_4 (4.63). The lowest number of suckers was observed in V_2G_6 (2.31). At varietal level, G_2 (BA 750 mg l^{-1}) produced the highest number of suckers in V_1 (4.75), G_4 (GA_3 500 mg l^{-1}) in V_2 (4.63) and G_5 (GA_3 750 mg l^{-1}) in V_3. In all the three varieties, G_6 (GA_3 1000 mg l^{-1}) produced the lowest number of suckers (Table 6). These findings support the observations made by several workers. **Henny (1986)** found that three foliar sprays at 500 or 750 mg l^{-1} BAP yielded more shoots in a non-branching *Dieffenbachia* hybrid. BA, belonging to cytokinin group, is a root produced regulator which promotes cell division and anabolic metabolism. This might be the reason for more sucker production by BA. When Imamura and **Higaki (1988)** applied GA_3 (500 mg l^{-1}) and BA (500 and 1000 mg l^{-1}), it was found that the number of new shoots in anthurium 'Mauna Kea' increased linearly with increasing BA concentration. GA_3 at 500 mg l^{-1} increased shoot number for both topped and intact plants. They also observed a slight linear decrease in shoot number in untopped plants with increasing GA_3 concentration. In the present study, it was found that G_5 (GA_3 750 mg l^{-1}) produced the highest number of suckers in V_3 (4.00). According to **Anu (1997),** *Anthurium andreanum* produced maximum (4.67) lateral suckers with GA_3 750 mg l^{-1} in topped plants. Salvi (1997) also reported that in *Anthurium andreanum* cv. 'Hawaiian Red',GA_3 750 mg l^{-1} produced the maximum number of branches.

In the second experiment, although VG interaction could not influence the number of suckers at individual growth stages, it had pronounced effect on the total number of suckers Among VG treatment combinations, V_2G_{12} (4.88)

recorded the highest number of total suckers and the lowest was observed in V_3G_4 (2.25). In V_1, the highest number of suckers (4.75) was produced by G_{11} (BA 700 mg l^{-1}). However, V_2 (4.88) and V_3 (3.75) recorded the highest with G_{12} (BA 850 mg l^{-1}). This is in conformity with the report of Imamura and Higaki (1988) in anthurium.

Effect of varieties and methods of application

As regards the number of suckers, VM interaction had significant influence at almost all the stages except at 3 MAP. As far as total number of suckers is concerned, V_2M_2 (4.13) and V_1M_2 (4.10) were on par and significantly superior to the other combinations (Table 7). It was observed that in all the three varieties, M_2 (foliar spray) resulted in significantly higher number of total suckers than M_1 (rhizome dip). Foliar spray at fortnightly intervals might have resulted in better absorption of growth regulators when compared to rhizome dip. The rhizome dip might have prevented root development and hence delayed emergence of suckers resulted. This is similar to the findings of Criley (2001) in heliconia. When 400 mg l^{-1} BA was used for the rhizome soak treatment, all of the non-treated controls survived, but there was 40 per cent mortality for the rhizome soak.

Effect of methods of application and growth regulators

Significant variation in the number of suckers was observed among the MG combination treatments at all stages of observation. Except G_3 (BA 1000 mg l^{-1}) all other growth regulators were more effective in enhancing sucker production when applied as foliar spray (Table 8). M_2G_2 (4.63) recorded the highest number of total suckers and M_1G_6 (2.21) the lowest. Henny (1986) also reported that three foliar sprays at 500 or 750 mg l^{-1} BAP yielded more shoots in a non-branching *Dieffenbachia* hybrid.

Effect of varieties, methods of application and growth regulators

In variety V_1, combination with M_2G_2 recorded the highest number of suckers (5.50) compared to 3.88 in the control plants. In the case of V_2, combination with M_2G_2 (5.38) was superior, though it was on par with M_2G_4 (5.25). Here, the control produced only 3.31 suckers. Among the VMG combination treatments in V_3, M_2G_3, M_2G_5, M_1G_2 and M_1G_5 were equally good and produced 4.00 suckers each compared to 2.81 in the control(Table 5).

The results showed that the growth regulators G_2 (BA 750 mg l^{-1}) and G_4 (GA_3 500 mg l^{-1}) along with M_2 had a synergistic effect and led to the production of higher number of suckers. However, there was difference among the varieties regarding the response to treatments especially method of application. In the variety V_3 (Sexy Pink), application of growth regulators as rhizome dip wasequally effective as foliar spray especially when combined with G_5 (GA_3 750 mg l^{-1}).

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