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Effect of Calcium Nitrate on Growth and Rhizome Production in Alstroemeria (*Alstroemeria hybrida* L.) during Spring and Summer Seasons of Kashmir Valley

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A B S T R A C T

An experiment entitled "Effect of Calcium nitrate on growth and rhizome production in Alstroemeria (*Alstroemeria hybrida* L.) during spring and summer seasons " was conducted to evaluate the response of three cultivars of Alstroemeria namely Alladin, Pluto and New Pink to three concentrations (0, 1 and 1.5%) and two frequency of applications (10, 20 days) of Calcium nitrate during spring and summer seasons of Kashmir valley. Eighteen different treatment combinations were replicated thrice in a Randomized Completely Block Design. The investigation revealed that Calcium nitrate @ 1.5% at 10 days frequency recorded maximum number of vegetative shoots, shoot diameter, shoot length, leaf number, chlorophyll content, number of rhizomes, fresh weight of rhizome cluster/plant, dry weight of rhizome cluster/plant, rhizome diameter, number of new storage roots and propagation coefficient in all three varieties. Shoot and rhizome production was found maximum in New pink variety. Production of rhizomes was higher during spring in all the three cultivars. Maximum rhizome production was obtained in New pink cultivar with application of 1.5% CaN at 10 days interval during spring season.

Introduction

Alstroemeria hybrid L. (1) commonly known as the Peruvian Lily or the Lily of the Incas is a native of South America. The genus is a rhizomatous monocot and belongs to family Alstroemeriaceae (2). Previously, Alstroemeria was assigned to family Amaryllidaceae and Liliaceae (3) (4). Alstroemeria plants are widely cultivated in many countries especially in Western Europe and North America and popularity has increased recently due to its long-vase life, large variety of colours and low energy requirement during cultivation (5). In Kenya in terms of popularity and foreign exchange Alstroemeria stands third after roses and statice (6). The popularity of this flower is still growing and has attained the status of one of the ten most important cut flowers in the world.

Alstroemeria are generally propagated by rhizome division of three year old plants. However multiplication rate is low. Propagation through seed is not commonly practiced due to variability and heterozygosity in hybrids and long and difficult germination. The legal planting material is still very costly. This has spurred investigation into multiplication of plant-lets *in-vitro*. However multiplication unit is limited to rhizome tips which renders propagation rate rather low in comparison to other crops. In Alstroemeria growing regions of Himachal, Ooty and Jammu and Kashmir propagation through rhizome division is still the main method of multiplication. Alstroemeria remains vegetative if divided every 12 weeks. This opens up the possibility of exploring propagation potential of Alstroemeria rhizomes over the seasons (7).

Materials and Methods

The present investigation was carried out at the Research farm of Division of Floriculture and Landscape Architecture, *Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar,* in 2017.The organic carbon of the soil was found to be 0.98 per cent and pH/6.93. The climate of the area in general is temperate-cum Mediterranean and of continental type characterized by hot summers and severe winters. Hottest months are July and August during which temperature shoots upto 32°C.The experiment was conducted in Randomized block design, the total number of treatments combinations were eighteen, three cultivars (Alladin, Pluto, New pink) were used with three levels of CaN (0, 1, 1.5%) and two frequency of application (10, 20 days) with three replications. Single uniform rhizome plantation was done and 20 rhizomes were planted per 1sqm plot in first week of April for spring crop and in first week of August for summer crop. Foliar application of CaN was applied @ 0, 1, 1.5% from 40DAP at 10 (total 6) and 20 (total 4) days interval up to mid-July in case of spring planting and up to mid- November in Summer planting. The harvesting of the rhizomes was done in last week of July for spring crop and last week of November for summer crop. The observations were recorded on number of vegetative shoots, shoot diameter, shoot length, leaf number, chlorophyll content, number of rhizomes, fresh weight of rhizome cluster/plant, dry weight of rhizome cluster/plant, rhizome diameter, number of new storage roots and propagation coefficient from randomly selected plants from each treatment in every replication at 80 and 120 days after planting in both seasons. The statistical analysis was done at 5% level of significance.

Results and Discussion

The present work was undertaken to study the effect of different levels and frequency of application of Calcium nitrate in Alladin, Pluto and New cultivars of Alstroemeria during spring and summer season with the ultimate aim to enhance the propagation rate in Alstroemeria by optimizing application of Calcium Nitrate spray. Result presented in Table 1, 2 and 3 revealed that the growth and rhizome parameters of Alstroemeria in all the three cultivars were significantly altered due to the application of Calcium nitrate during both seasons.

Effect of CaN on vegetative parameters

The analysis of data (Table 1 and 2) revealed that influence of different levels and frequency of Calcium nitrate application had significant effect on number of vegetative shoots, shoot diameter, shoot length, leaf number, chlorophyll content at 80 and 120 days after planting during both seasons.

Table.1 Effect of calcium nitrate sprays on vegetative parameters of Alstroemeria at 80DAP during spring and summer seasons

Treatment code	Treatment combinations	Spring					Summer				
		No. of vegetative shoots	Shoots diameter (mm)	Shoot length	Leaf no.	Chlorophyll content	No. of vegetative shoots	Shoots diameter	Shoot length	Leaf no.	Chlorophyll content
T_1	$V_1N_0F_1$	3.88	2.58	19.13	20.44	9.44	4.66	2.77	27.04	26.22	9.92
T_2	$V_1N_1F_1$	4.99	3.16	22.69	24.55	9.72	7.22	3.24	31.62	29.11	10.13
T_3	$V_1N_2F_1$	6.88	**3.54**	**25.07**	**28.33**	**10.28**	9.11	**3.62**	**34.13**	**32.00**	**10.46**
T_4	$V_1N_0F_2$	3.77	2.93	19.22	20.33	9.40	4.88	2.80	27.17	26.22	9.98
T_5	$V_1N_1F_2$	4.11	3.15	21.59	22.66	9.52	6.00	3.19	30.99	27.44	10.07
T_6	$V_1N_2F_2$	5.44	3.48	22.85	24.22	10.07	7.77	3.08	32.61	29.66	10.10
T_7	$V_2N_0F_1$	4.44	2.36	17.71	18.88	7.26	5.00	2.74	25.44	24.00	7.56
T_8	$V_2N_1F_1$	6.11	2.88	20.73	23.00	7.81	7.33	3.05	27.50	25.22	8.96
T_9	$V_2N_2F_1$	7.44	3.48	23.17	26.33	8.31	8.44	3.57	30.06	28.33	9.25
T_{10}	$V_2N_0F_2$	4.88	2.37	17.66	19.00	7.33	5.22	2.80	25.25	23.89	7.50
T_{11}	$V_2N_1F_2$	4.55	2.52	19.80	21.66	7.63	6.66	2.97	26.98	24.88	7.66
T_{12}	$V_2N_2F_2$	5.77	3.33	21.52	23.55	8.12	6.55	3.48	28.84	26.66	8.26
T_{13}	$V_3N_0F_1$	6.77	2.46	10.88	16.22	8.48	13.77	2.65	17.67	21.55	8.62
T_{14}	$V_3N_1F_1$	8.22	2.67	14.99	21.11	8.85	15.77	2.74	19.84	23.33	9.02
T_{15}	$V_3N_2F_1$	**9.55**	3.04	17.11	24.55	9.46	**18.11**	3.24	22.26	26.11	9.58
T_{16}	$V_3N_0F_2$	6.44	2.30	10.77	17.00	8.28	13.66	2.32	17.48	21.11	8.62
T_{17}	$V_3N_1F_2$	6.89	2.54	13.77	19.88	8.63	14.11	2.51	18.92	22.66	8.75
T_{18}	$V_3N_2F_2$	7.89	2.95	15.48	22.00	9.07	16.33	3.05	20.90	23.66	9.15
	Mean	6.00	2.87	18.56	21.87	8.76	9.48	3.01	25.82	25.67	8.98
	CD(0.05) Var.	0.655	0.208	0.387	0.756	0.156	0.685	0.170	0.604	0.826	0.192
	CaN	0.655	0.208	0.387	0.756	0.156	0.685	0.170	0.604	0.826	0.192
	CaN x Freq.	0.926	NS	0.547	1.069	0.221	0.969	NS	NS	NS	NS

Table.2 Effect of calcium nitrate sprays on vegetative parameters of Alstroemeria at 120 DAP during spring and summer seasons

Treatment code	Treatment combinations	Spring					Summer				
		No. of vegetative shoots	Shoots diameter	Shoot length	Leaf no.	Chlorophyll content	No. of vegetative shoots	Shoots diameter	Shoot length	Leaf no.	Chlorophyll content
T_1	$V_1N_0F_1$	5.66	2.90	31.07	30.55	9.74	8.66	2.91	38.31	41.00	9.07
T_2	$V_1N_1F_1$	7.66	3.50	36.41	35.33	9.87	10.66	3.41	41.44	45.55	9.38
T_3	$V_1N_2F_1$	10.44	**3.69**	**40.54**	**37.33**	**10.28**	13.44	**3.69**	**44.02**	**47.33**	**9.73**
T_4	$V_1N_0F_2$	5.77	3.00	30.93	30.00	9.59	8.77	2.94	38.13	40.77	9.10
T_5	$V_1N_1F_2$	6.44	3.33	34.36	32.77	9.69	9.44	3.28	40.76	41.77	9.21
T_6	$V_1N_2F_2$	8.88	3.64	37.10	34.66	10.09	12.00	3.54	42.42	43.77	9.56
T_7	$V_2N_0F_1$	6.77	2.55	28.92	31.22	7.61	11.33	2.94	35.06	38.00	8.84
T_8	$V_2N_1F_1$	8.66	3.02	31.85	36.11	7.96	12.55	3.53	37.96	43.33	9.13
T_9	$V_2N_2F_1$	11.00	3.75	35.25	37.33	8.85	15.00	3.85	40.02	45.55	9.33
T_{10}	$V_2N_0F_2$	6.66	2.90	28.66	31.11	7.76	11.66	2.83	34.93	36.77	8.74
T_{11}	$V_2N_1F_2$	7.89	2.57	30.81	33.22	7.75	11.44	3.25	36.67	39.22	8.96\
T_{12}	$V_2N_2F_2$	9.77	3.62	33.51	34.44	8.63	13.00	3.46	38.16	42.11	9.18
T_{13}	$V_3N_0F_1$	10.77	2.69	23.73	32.11	8.62	15.44	2.50	27.73	36.00	9.03
T_{14}	$V_3N_1F_1$	13.11	2.73	25.81	34.11	8.96	20.33	2.74	29.56	39.66	9.23
T_{15}	$V_3N_2F_1$	**15.33**	3.36	28.84	36.22	9.88	**24.47**	3.44	32.20	42.77	9.69
T_{16}	$V_3N_0F_2$	10.89	2.55	23.42	30.00	8.54	15.33	2.50	27.15	35.89	9.07
T_{17}	$V_3N_1F_2$	11.66	2.82	24.63	31.55	8.92	17.77	2.68	26.88	36.66	9.16
T_{18}	$V_3N_2F_2$	13.00	3.18	26.80	33.00	9.47	20.66	3.22	28.99	39.00	9.58
	Mean	9.47	3.10	30.70	33.39	9.01	14.00	3.15	35.28	40.84	9.22
	CD(0.05) Var.	0.502	0.201	0.482	0.838	0.153	0.545	0.133	0.745	0.836	0.192
	CaN	0.502	0.201	0.482	0.838	0.153	0.545	0.133	0.745	0.836	0.192
	CaN x Freq.	0.709	NS	0.682	1.185	NS	0.771	NS	1.054	1.183	NS

Table.3 Effect of calcium nitrate sprays on rhizome parameters of Alstroemeria during spring and summer seasons

Treat. code	Treatment combinations	Spring						Summer					
		No. of rhizomes	Fresh wt. of rhizome cluster/pl.	Dry wt of rhizome cluster/pl.	Rhizome dia (mm)	No. of new storage roots	Propagation Coefficient	No. of rhizomes	Fresh wt. of rhizome cluster/plant	Dry wt of rhizome cluster/p	Rhizome dia (mm)	No. of new storage roots	Prop. Coefficient
T_1	$V_1N_0F_1$	2.33	69.08	20.54	9.78	3.33	233.00	1.11	33.37	6.04	8.29	2.11	111.00
T_2	$V_1N_1F_1$	4.44	121.28	25.80	11.52	5.89	444.00	2.11	52.16	8.88	9.99	3.33	211.00
T_3	$V_1N_2F_1$	6.22	159.39	30.09	12.74	7.66	622.00	2.77	60.84	11.53	11.13	5.55	277.00
T_4	$V_1N_0F_2$	2.66	67.97	20.20	9.68	3.55	266.00	1.00	30.85	5.95	8.31	2.00	100.00
T_5	$V_1N_1F_2$	3.89	115.84	21.29	11.24	4.55	389.00	1.44	43.59	7.84	9.76	3.00	144.00
T_6	$V_1N_2F_2$	5.66	153.52	25.46	12.33	6.89	566.00	2.66	53.69	8.76	10.88	4.33	266.00
T_7	$V_2N_0F_1$	3.33	95.47	22.69	7.76	4.33	333.00	1.66	51.76	11.03	6.95	2.22	166.00
T_8	$V_2N_1F_1$	5.33	150.25	27.47	8.96	6.78	533.00	3.00	67.28	14.16	7.87	3.66	300.00
T_9	$V_2N_2F_1$	6.66	189.63	31.20	10.57	8.44	666.00	3.55	80.92	19.51	9.37	4.33	355.00
T_{10}	$V_2N_0F_2$	3.44	94.62	22.63	7.67	4.44	344.00	1.55	50.04	10.55	6.99	2.33	155.00
T_{11}	$V_2N_1F_2$	4.66	144.06	23.99	8.68	5.66	466.00	2.00	58.61	10.92	7.62	3.11	200.00
T_{12}	$V_2N_2F_2$	5.55	183.23	27.65	9.91	7.33	555.00	2.44	73.58	15.84	8.99	3.78	244.00
T_{13}	$V_3N_0F_1$	6.89	207.84	35.41	8.29	9.22	689.00	3.66	105.29	25.50	7.37	5.22	366.00
T_{14}	$V_3N_1F_1$	9.11	252.53	46.27	9.93	11.55	911.00	4.44	134.21	46.28	8.98	5.89	444.00
T_{15}	$V_3N_2F_1$	**10.88**	**289.97**	**68.75**	**11.71**	**12.55**	**1088.00**	**6.00**	**159.51**	**52.25**	**10.81**	**7.89**	**600.00**
T_{16}	$V_3N_0F_2$	6.22	206.68	35.03	8.34	9.11	622.00	3.55	103.84	25.24	7.40	5.07	355.00
T_{17}	$V_3N_1F_2$	7.33	246.28	41.25	9.47	10.55	733.00	3.78	123.10	41.36	8.76	6.55	378.00
T_{18}	$V_3N_2F_2$	9.89	282.92	61.31	11.28	11.66	989.00	4.78	151.99	48.33	10.49	7.00	478.00
	Mean	5.75	168.36	32.61	9.99	7.42	574.00	2.87	79.702	20.39	8.89	4.30	287.00
	CD(0.05) Var.	0.429	1.285	0.975	0.240	0.421	42.851	0.259	3.512	0.732	0.371	0.386	26.473
	CaN	0.429	1.285	0.975	0.240	0.421	42.851	0.259	3.512	0.732	0.371	0.386	26.473
	CaN x Freq.	0.606	1.817	1.379	NS	0.596	60.601	0.366	NS	1.036	NS	NS	37.438

During spring season maximum number of vegetative shoots (9.55 and 15.33) was observed at 80 and 120 DAP respectively in T_{15} cv. New pink with application of 1.5% CaN at 10 days intervals. Maximum Shoot diameter (3.54 and 3.69mm), shoot length (25.07 and 40.54cm), leaf number (28.33 and 37.33) and Chlorophyll content (10.28 and 10.28) was observed at 80 and 120 DAP respectively in T_3Alladin variety with application of 1.5% CaN at 10 days intervals. T_9 shows maximum number of vegetative shoots (7.44 and 11.00), shoot diameter (3.48 and 3.75mm), shoot length (23.17 and 35.25cm), leaf number (26.33 and 37.33) and chlorophyll content (8.31 and 8.85) at 80 and 120 DAP respectively in cv. Pluto with application of 1.5% CaN at 10 days intervals whereas T_{15}shows maximum number of vegetative shoots (9.55 and 15.33), shoot diameter (3.04 and 3.36mm), shoot length (17.11 and 28.84cm), leaf number (24.55 and 36.22) and chlorophyll content (9.46 and 9.88) at 80 and 120 DAP respectively in cv. New pink when applied with 1.5% CaN at 10 days intervals. During summer season maximum number of vegetative shoots (18.11 and 24.47) was again observed in T_{15} cv. New pink with application of 1.5% CaN at 10 days intervals. Maximum Shoot diameter (3.62 and 3.69 mm), shoot length (34.13 and 44.02cm), leaf number (32.00 and 47.33) and Chlorophyll content (10.46 and 9.73) was observed in T_3 cv. Alladinat 80 and 120 DAP respectively with application of 1.5% CaN at 10 days intervals. In cv. Pluto maximum number of vegetative shoots (8.44 and 15.00), shoot diameter (3.57 and 3.85), shoot length (30.06 and 40.02cm), leaf number (28.33 and 45.55) and chlorophyll content (9.25 and 9.33) was observed in $T_9$with 1.5% CaN at 10 days intervals.

The difference in the growth pattern of three cultivarsis due to their genetic makeup as Alladin and Pluto are relatively taller than New Pink (8). The improvement in vegetative parameters due to the supply of higher doses and frequencies of Calcium nitrate in each variety may be attributed to its effect on cell division and elongation. It is also a well-known fact that the optimum quantity of Nitrogen could enhance plant growth mainly due to the reasons that nitrogen is an important content of nucleic acid and protein synthesis(9). Similar findings have also been reported by (10), (11) and (12).

Higher vegetative shoot formation during summer is proposed to have been promoted by the relatively high temperatures in July-August and retarded by low day and night temperatures in April-May period. These observations are comparable to those reported by (13), and (14) working on 'Orchid' and 'Regina' cultivars of Alstroemeria. (15), similarly reported that high soil temperatures (21°C) also stimulated vegetative shoot growth in 'Regina' while low temperatures (15°C), inhibited it. Besides temperature, day length has been noted to influence growth in Alstroemeria. Vegetative shoot formation in Alstroemeria 'orchid' was stimulated by short days (8 hr day length) and inhibited by long days (>12 hrs) (15)

Effect of CaN on rhizome parameters

The perusal of data (Table 3) revealed that influence of different levels and frequency of Calcium nitrate application had significant effect on Number of rhizomes, fresh weight of rhizome cluster/plant, dry weight of rhizome cluster/plant, number of new storage roots and propagation coefficient during spring and summer seasons. However the frequencies of calcium nitrate show insignificant effect on rhizome diameter in both seasons. Maximum number of rhizomes (10.88), fresh weight of rhizome cluster/plant (289.97gm), dry weight of rhizome cluster/plant (68.75gm), rhizome diameter

(11.71mm), number of new storage roots (12.55) and propagation coefficient (1088) was noted in T_{15} cv. New pink with application of 1.5% CaN at 10 days intervals during spring seasons followed by T_{18} cv. New pink with application of 1.5% CaN at 20 days intervals. During summer higher number of rhizomes (6.00), fresh weight of rhizome cluster/plant (159.51gm), dry weight of rhizome cluster/plant (52.25gm), rhizome diameter (10.81mm), number of new storage roots (7.79) and propagation coefficient (600) was noted in T_{15} cv. New pink with application of 1.5% CaN at 10 days intervals. In cv. Alladin and pluto T_3 and T_9 treatment combinations with 1.5% CaN at 10 days intervals were found to be superior.

All the three cultivars responded in the same manner with respect to different levels and frequencies of calcium nitrate. However cultivar new pink is genetically vigorous produce maximum number of shoots and had better rhizome production in both seasons with maximum during spring season. A marked positive effect of higher dose and frequencies of calcium nitrate on rhizome production may be attributed to the fact that rhizome is important sink for photosynthates (photoassimilates) and therefore the increased number of shoots in the present study might have maximized the total photosynthetic capacity thus provide greater photosynthates to the rhizome and help in increasing the number as well fresh weight of the rhizomes. The results regarding increase in rhizome number, fresh and dry weight under the influence of $CaNO_3$ spray doses as compared to control may be due to the positive effect of nitrogen on stimulation of vegetative growth that increased the translocation and accumulation of the organic matter in the rhizome, eventually resulting in increased in number, fresh and dry weight of rhizomes. The present findings are in accordance with the results of (16), who reported that use of nitrogen at 6 g /plant resulted in maximum increase of corm dry weight in gladiolus cv. Sancerre. (17) reported improved RGR under four splits application of nitrogen in corm development from cormels of gladiolus (18); (19) reported increase in the size of the ginger and turmeric rhizome with increase in the dose of nitrogen.

However in summer planting the rhizome production shows reverse trend i.e. plants produce higher number of shoots but lesser rhizomes than spring which may be due to reduction in photosynthates sink from shoots to tubers due to shorter day length during Oct-Nov as in low light intensity source activity is decreased (20).

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