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EFFECT OF N, P AND K ON THE GROWTH OF *COSTUS SPECIOSUS* (Koening) Smith

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Costus speciosus (Koening) Smith, a perennial herb belonging to the family Zingiberaceae is found throughout India. The plant assumed commercial significance when Das-Gupta and Pandey (1970) isolated the most important steroidal drug precursor diosgenin from its rhizomes. Prospects for its commercial cultivation in India are reported to be good (Sarin, 1974). But information on the scientific practices to be adopted for the cultivation of the crop is scanty. The present paper reports the role of the major nutrients N, P and K on different growth characters of the plant and the influence of these characters on the yield of diosgenin.

Materials and Methods

A field trial was laid out at the College of Horticulture, Vellanikkara. The design was a partially confounded factorial with two replications confounding NP^2K in replication I and NP^2K^2 in replication II. The replications consisted of three blocks of 1 0 plots each. One plot in every block was kept as absolute control. The treatment consisted of three levels of N, P_2O_5 and K_2O each at 15, 30 and 45 kg/ha. Ammonium sulphate, superphosphate and muriate of potash were used as the sources of nitrogen, phosphorus and potassium respectively. Nitrogen was applied in two splits, two-third 20 days after sowing and the remaining one-third 60 days after sowing. Half the quantity of P_2O_5 and K_2O was applied as basal and the remaining half top-dressed after 60 days.

Rhizome pieces containing two healthy buds were planted on raised beds 50 cm apart, at a depth of 10 cm below the soil surface, giving a population of 24 plants per plot. Cattle manure at the rate of 15 t/ha was applied to each plot before planting and incorporated by a shallow digging. Weeding was done thrice; at 60, 120 and 150 days after sowing. The soil was mulched with green leaves after the second split-application of fertilizers. The crop was harvested upon completing six months of growth. Observations on the growth characters were taken at the time of harvest.

Results and Discussion

Of the several plant characters studied (Table 1), the number of tillers per plant and the number of leaves per tiller were not found to be influenced by N, P or K individually. However, the effects of NP and NK interactions on the number of leaves were significant. The other characters, namely, the plant height, the length and breadth of leaves, the number of leaves per plant, the area per leaf and the total leaf area per plant were influenced by individual nutrients and/or their combinations.

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Application of N increased the growth of plants in terms of height, length and breadth of leaves, area per leaf and total leaf area per plant. However, it may be seen from the data (Table 1) that the effect of N on the total number of leaves produced per plant was not significant, despite a steep increase in the number of leaves at the N_3 level. This suggested that the role of nitrogen in increasing the total leaf area of the plant may be through its effect on the area per leaf. An increase in the area per leaf from 40.26 cm^2 at N_1 to 63.64 cm^2 at N_3 level of nitrogen application supported such a conclusion.

The role of nitrogen in enhancing the vegetative growth of the plants is widely established. There are reports of increased vegetative growth by the application of nitrogen in several medicinal plants. Spilenja (1957) observed increased rates of growth in belladonna and *Datura stramonium* by the application of ammonium sulphate. An increase in the plant height by the application of nitrogen was observed in dioscoreas by Nandi and Chatterjee (1975). In *Duboisia myoporoides* nitrogen application resulted in the improvement of plant height (Luarantana and Griffin, 1980). Reghunath (1981) also reported similar results in *Catharanthus roseus.*

In general, phosphorus exhibited a depressing effect on plant growth Specifically, the application of P led to a reduction in the number of leaves and area. per leaf. A drastic reduction occurred in the total leaf area per plant from 4320.62 cm^2 at P_1 level to 3029.39 cm^2 at P_3 level. Such an effect on the total leaf area may be a consequence of the effect of P on the area per leaf and the leaf production. These findings are in agreement with those obtained by Tsao *et al.* (1961) in *Digitalis lanata.*

The effect of potassium on the length, breadth and area of the leaves and total leaf area per plant was more or less similar to that of nitrogen. However, the increase in these growth characters was conspicuous only upto K_2 level, beyond which there was a decrease, except in the case of leaf length. On the whole, the beneficial effect of potassium was only marginal, as compared to that of nitrogen.

The depressing effect of phosphorus on the total leaf area per plant was minimised in the presence of either nitrogen or potassium. This was apparent from the significant interactions between phosphorus and:nitrogen as well as phosphorus and potassium. Of the two interactions, that between N and P was more effective in increasing the leaf area per plant. Significant influence of NP interaction on leaf production has been reported by Brewer and Hiner (1950) in belladonna and by Gupta *et al.*, (1977) in *Cassia angustifolia*.

None of the rhizome characters, except the internodal length was found to be influenced by N, P and K fertilizers (Table 2). In the case of internodal length, not only the main effects, but the NP and PK interactions were also significant. The effect of N and K was generally to decrease the internodal length while that of pho-

Table 1

Effect of NPK fertilization on the shoot characters

Treatments	Plant height (cm)	Number of tillers per plant	Number of leaves per tiller	Number of leaves per plant	Length of leaves (cm)	Width of leaves (cm)	Area per leaf (cm^2)	Leaf area per plant (cm^2)
Control	65.56	571	14.10	56.38	12.32	4.96	38 06	2151.4
N_1	66.81	6.01	14.21	72.37	12.89	4.89	40.26	2988.6
N_2	71.85	6.47	14.22	70.31	13.23	4.44	44.23	2966.3
N_3	74.86	6.16	14.92	74.37	14.59	6.37	63.64	4603.8
CD (0.05)	5.33	NS	NS	NS	0.65	0.33	1.45	466.9
P_1	72.91	6.29	14.34	83.91	13.78	5.17	50.70	4320.6
P_2	68.90	6.02	14.77	70.83	13.60	5.23	48 19	3319.8
P_3	71.70	6.33	14.24	62 31	13.33	5.30	49.24	3029.4
CD (0.05)	NS	NS	NS	8.45	NS	NS	1.45	466.9
K_1	71.73	.6.54	14.71	74.61	13.34	5.00	44.52	3475.7
K_2	72.97	6.12	14.15	72.39	13.15	5.53	52.02	3858.3
K_3	68.81	5.97	14.50	70.05	14.22	5.16	51.59	3335 8
CD (0.05)	NS	NS	NS	NS	0.65	0.33	1,45	466.9

NS: Not Significant

Table 2

Effect of NPK fertilization on the rhizome characters

Treatments	Number of rhizomes per plant	Length of rhizomes (cm)	Internodal length (cm)
Control	1.59	29.13	340
N_1	1.73	33.90	2.91
N_2	1.74	34.89	3.10
N_3	1.64	36.70	2.70
CD (0.05)	NS	NS	0.21
P_1	1.69	38.89	2.87
P_2	1.66	34.42	2.76
P.	1.80	32.19	3.07
CD (0.05)	NS	NS	0.21
K_1	1.70	38.18	3.07
K_2	1.78	35.29	2.85
K_3	1.67	32.02	2.80
CD (0.05)	NS	NS	0.21

NS: Not Significant

Table 3

Effect of NPK fertilization on the yield of rhizomes and diosgenin

Treatments	Yield of green rhizomes (t/ha)	Yield of dry rhizomes (t/ha)	Diosgenin content (%)	Yield of diosgenin (kg/ha)
Control	14.7	2.90	0.51	14.83
N_1	22.0	4.90	2.05	97.41
N_2	26.5	5.60	1.55	86.87
N_3	25.7	5.80	1.90	104.69
CD (0.05)	3.0	0.90	0.21	14.27
P_1	24.9	5.50	1.76	9248
P_2	25.0	5.50	1.69	93.27
P_3	24.4	5.20	2.04	103.21
CD (0.05)	NS	NS	0.21	NS
K_1	24.5	5.30	1.78	82.53
K_2	25.3	5.60	2.15	118 86
K_3	24.5	5.30	1.57	87.58
CD (0.05)	NS	NS	0.21	14.27

NS: Not Significant

Table 4

Relationship between plant characteristics and diosgenin yield (matrix of r values)

	Number of tillers per plant	Total leaf area per plant	Yield of green rhizome per plant	Yield of dry rhizome per plant	Yield of diosgenin per plant
Plant height	0.641**	0.568**	0.075	0.095	0.305*
Number of tillers per plant		0.748**	—0.057	0,255	0.073
Total leaf area per plant			0.095	0.004	0.475**
Yield of green rhizome per plant				0.770**	0.171
Yield of dry rhizome per plant					0.120

n=60 df=58 * Significant at 0.05 level ** Significant at 0.01 level

Table 5

Chemical characteristics of the soil of the experimental plot

	Total N (%)	Available P (ppm)	Available K (ppm)	pH
Pre-experiment	0.1890	13.33	211.2	5.10
Post experiment				
N_1	0.2150	20.64	240.0	5.26
N_2	0.2090	16.77	148 0	5.25
N_3	0.2280	1548	209.6	5.24
P_1	0.2280	20.64	238.4	5.16
P_2	0.2040	16.77	188.8	5.29
P_3	0.2400	18.49	264 8	5.21
K_1	0.2130	18.06	208.8	5.38
K_2	0.2180	18.49	176.8	5 25
K_3	0.2290	18.92	128.0	5.21
Control	0.1790	8.17	79.9	5.15

sphorus was to increase it. As in the case of shoot characters, the effect of phosphorus was modified by the addition of either nitrogen or potassium. The suppression of internodal length was more pronounced when potassium, rather than nitrogen, was applied along with phosphorus.

The effects of application of different levels of N, P and K on the yield of rhizomes and diosgenin are presented in Table 3. Among the three nutrients, only nitrogen influenced the yield of rhizomes. There was an increase in yield with the increased rate of application of nitrogen. The NP, NK and PK interactions also significantly influenced these characters. There was a tendency for the diosgenin content in the rhizome to decrease with increasing quantities of applied nitrogen. Application of phosphorus increased the rhizome diosgenin content. With potassium, the increase was observed upto K_2 level. Comparison of these results revealed the superiority of phosphorus over nitrogen or potassium. Addition of phosphorus generally improved the diosgenin content of rhizome's at the higher levels of either potassium or nitrogen.

Significant differences in the yield of diosgenin was observed among the levels of nitrogen and potassium. Though the application of phosphorus steadily increased the yield of diosgenin, the difference between any two levels of applied phosphorus failed to attain the level of significance. While studying the interaction effect, it was observed that the highest yield of diosgenin was obtained for N_3P_2 and P_2K_2 combinations.

In an attempt to identify the important growth characters which had a bearing on the diosgenin yield, simple correlations were worked out among them (Table 4). Of the growth parameters studied, the total leaf area and the plant height were found to be significantly correlated with diosgenin yield. The association of plant height with the yield of diosgenin may probably be indirect, due to its relationship with total leaf area (= 0.568**). The role of leaf area in increasing the yield of diosgenin can be attributed to the increased accumulation of photosynthates and consequent improvement in plant growth. Since the important plant components responsible for diosgenin yield in *Costus speciosus* are not yet fully understood, knowledge regarding the nature of association of these two characters with diosgenin yield will be useful in genetic improvement of this crop.

Summary

A field trial was conducted to find out the role of major nutrients on different growth characters of *Costus speciosus* and the important characters which had a bearing on diosgenin yield were identified. The results showed that N application increased the growth of plants in terms of height, length and breadth of leaves, area per leaf and total leaf area per plant. P had a depressing effect, especially on the number of leaves and area per leaf. The beneficial effect of K was only marginal, as compared to that of N. Application of N increased the yield of rhizomes. The diosgenin content of the rhizomes was found to be significantly influenced by N, P and K application while the yield of diosgenin was significantly influenced by different levels of N and K. Of the growth characters studied, the total leaf area and plant height were found to be significantly correlated with diosgenin yield.

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References

Brewer, W. R. and Hiner, D. L. 1950. Cultivation studies of solanaceous drugs II. The effect of nutritional and soil reaction on the yield and total alkaloid content of *Atropa belladonna* and *Hyoscyamus niger*. *J. Am. pharm. Ass. Sci. Ed.* 39 (10): 586-591

Das-Gupta, B. and Pandey, B. V. 1970. A new Indian source of diosgenin *(Costus speciosus). Experientia* **26** 475-476

Gupta, R., Modi, J. M. and Mehta, K. C. 1977. Studies on cultivation of senna in North Gujarat. *South Indian Hort.* 25 (1): 26-29

Luarantana, 0. and Griffin, W. J. 1980. Cultivation of a *Duboisia* hybrid. Part A. Nutritional requirements and effect of growth regulators on alkaloid content. *J. Nat. Prod* 43 (5): 546-551

Nandi, R. P. and Chatterjee, S. K. 1975. Modification of growth and development of medicinal dioscoreas and *Rauvolfia* by chemical and fertilizer treatments. *Sci. Cult.* 41 (11): 537-539

Reghunath, B. R. 1981. Effect of graded doses of nitrogen and potash on growth, root yield and alkaloid content of periwinkle. (*Catharanthus roseus* (L). M. Sc. (Hort) thesis, Kerala Agricultural University, Trichur, pp. 87

Sarin, Y. K. 1974. Raw material for Indian steroid industry. *Indian Drugs* 11 (10): 15-17

Spilenja, S. E. 1957. The correlation between alkaloid and chlorophyll accumulation in the solanaceae. *Bot Zurnal*. 44: 922-925

Tsao, D. P. N., Gomez, L. M. and Chaubal, M. G. 1961. Effect of nitrogen, phosphorus and potash on the growth and glycoside accumulation in *Digitalis lanata* (L). *J. pharm. Sci.* 50: 801-802