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EFFECT OF SOME GROWTH REGULATORS ON GROWTH AND APICAL DOMINANCE OF YOUNG TEA (*CAMELLIA SINENSIS*) (*L.*) O. KUNTZE) I — EFFECT OF INDOLE ACETIC ACID, BENZYL ADENINE AND ETHREL

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The effects of IAA, BA and ethrel on growth and apical dominance were studied in young free-growing tea plants. IAA was incorporated into hydrous lanolin and applied as a paste to decapitated stumps while BA and ethrel were given as foliar sprays. The response to BA was studied at two levels of fertilizer. IAA suppressed side shoot production over the duration of the experiment. The BA treatments induced more plants to remain in the active condition and produced more and longer side shoots. A significant interaction was noted between BA and level of fertilizer for the length of side shoots. The higher concentration of ethrel suppressed plant height and the dry weight of main stem, leaves and of plant. The possible involvement of these growth regulators in apical dominance of young tea is discussed.

INTRODUCTION

One of the usual methods of demonstrating the degree to which lateral bud growth is inhibited by the apical bud is to decapitate the apex and observe the extent of the outgrowth of the laterals. Decapitation usually releases buds from correlative inhibition by the apex, but this can be reimposed by the application of auxin to the decapitated stump (Thimann and Skoog, 1933, 1934). It is commonly held that auxin produced by the shoot apex and the young expanding leaves and transported basipetally down the stem, is the primary factor which causes the inhibition of the axillary buds. However, the observation that auxin does not readily enter the axillary buds (Snow, 1937) has led to the proposal of a number of possible mechanisms through which auxin may act (see Phillips, 1969, 1975).

Several studies have supported the involvement of cytokinins in the phenomenon of apical dominance (Phillips, 1975). It has been postulated that lack of growth of axillary buds is due to a deficiency in cytokinins as the root-synthesized cytokinins are transported to the shoot and monopolized by the apex, thus preventing the outgrowth of lateral buds. More recently, it has been held that shoots, may be capable of synthesizing cytokinins in the absence of roots (Wang and Wareing 1979).

Ethylene as a natural growth regulator has been implicated in several developmental processes (Burg, 1962). New light thrown on auxin/ethylene relations has revealed that many responses, so far regarded as auxin-mediated, may in fact be ethylene responses.

It is generally believed that no one hormone alone controls apical dominance and the response to any hormone is the resultant effect of an interaction between the hormones and a variety of environmental factors.

The effects of growth regulators on horticultural crops under temperate conditions have been extensively investigated. On the other hand, as yet, little information is available on tropical crops, especially the perennials. This paper reports information obtained on the patterns of response of young tea to some growth regulators.

MATERIALS AND METHODS

Effect of indole acetic acid on axillary bud growth of young tea

Plants of clone TRI 2025, 5 months of age, were grouped into 3 rows with 16 plants in each row. Plants in the first row had their apices intact. Plants in the remaining rows were decapitated by removing the terminal bud and the first two or three leaves (if the first leaf was not sufficiently expanded the third leaf was also removed to compensate for size) with included stem. The decapitation was done immediately below a node. Indole acetic acid (IAA) was incorporated into hydrous lanolin at a concentration of 0.05 per cent (w/w). Equal amounts of this preparation were placed in gelatine half-capsules which were used to cap the end of the stem stumps (third row). Decapitated plants not supplied with auxin were capped with plain hydrous lanolin (second row). IAA was renewed at 3-7 day intervals on 7 occasions.

The length of side shoots were measured weekly while the number was recorded fortnightly for a period of 12 weeks from commencement of treatments.

Preliminary experiment to determine whether a response could be seen to the application of benzyl adenine

Benzyl adenine (BA) at 50, 100, 200 and 250 ppm was painted daily on the leaves and axillary buds of young plants of clone TRI 2025 whose terminal buds were in the mature dormant condition, for 10 days. The treatments included a control as well. There were 4 plants for each treatment. An assessment was done 3 months after the first application of BA.

Effect of different concentrations of BA and fertilizer levels on growth of young tea

BA was sprayed at 25, 75 and 225 ppm on 5 occasions at 4-day intervals on young plants of clone TRI 2025. Two fertilizer levels at double (F2) and four (F4) times the recommended rate of fertilizer application were split on each BA treatment. Differential fertilizer application commenced on the day of the first BA application. Each plant received 3-4 ml of spray solution at each spray. The design of the experiment was randomized blocks with 5 replicates. Assessment was done at the end of 8 weeks after first spray.

Effect of different concentrations of ethrel on growth of young tea

Ethrel was sprayed at 50, 100, 200, 400, 800 and 1600 ppm, 3 times at 10-day intervals on young plants of clone TRI 2025 and DT 1. The treatments were replicated 3 times. An assessment was done at the end of 24 weeks after first spray

RESULTS

Effect of IAA on axillary bud growth of young tea

Plants which received the IAA treatment showed fewer and smaller side shoots than plants receiving plain lanolin over the duration of the experiment (Table 1, Fig. 1).

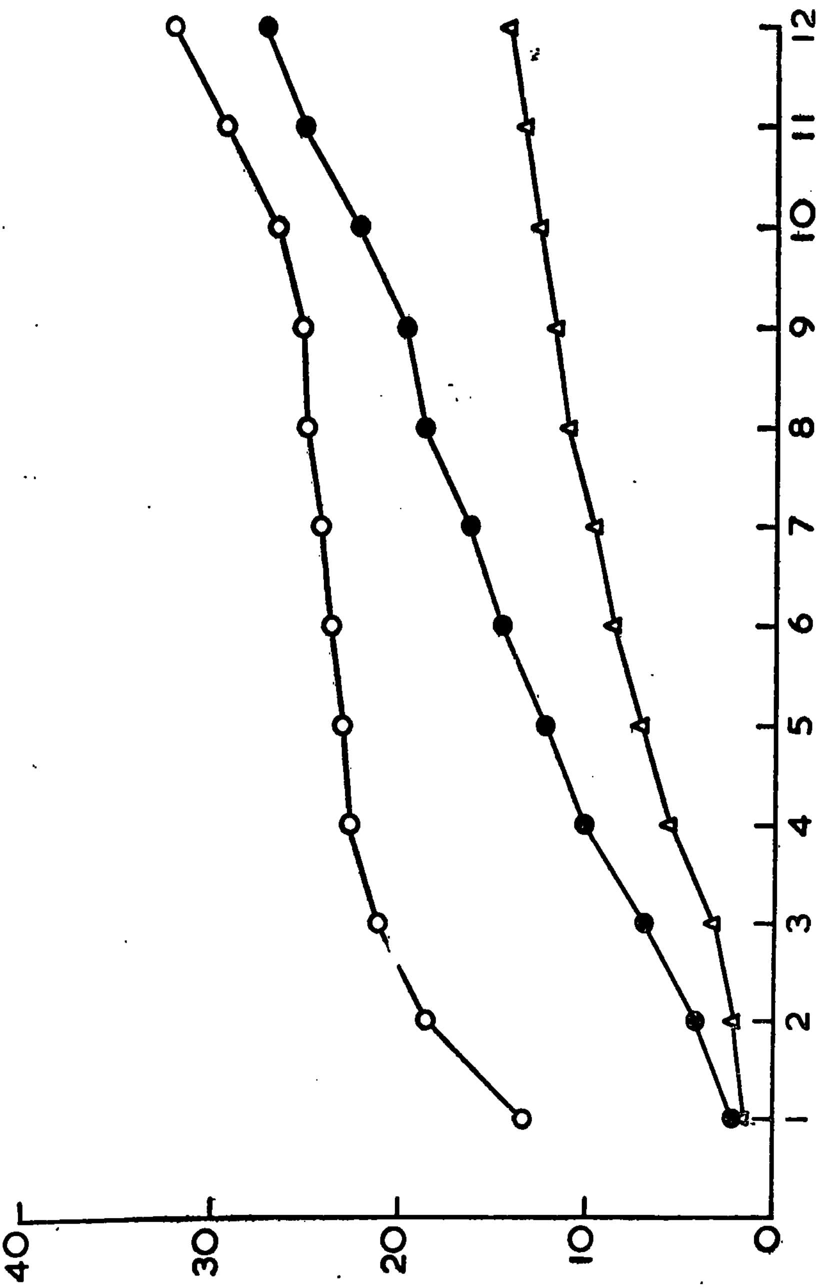

Fig. 1.—Effect of applying 0.05% IAA in hydrous Lanolin to decapitated shoots of young plants. Length of side shoots (means of 16 plants) ○ — plain lanolin ● - plain lanolin + 0.05% IAA △ — Apex intact.

TABLE 1 — *Effect of decapitation and IAA on the number of side shoots*

Treatment	Weeks 2	4	6	8	10	12
Apex intact	1.75	3.50	4.26	5.13	5.50	6.25
Plain lanolin	10.13	10.13	10.13	10.38	10.63	10.76
Plain lanolin + 0.05% IAA	2.38	4.76	6.25	7.13	7.25	7.63

Preliminary experiment to determine whether a response could be seen to the application of BA

The BA treatments did not affect the number of side shoots but increased their length with a corresponding increase in plant weight (Table 2).

TABLE 2 — *Effect of painting benzyl adenine on young tea on the mean number and length of side shoots and on dry matter production*

Treatments	*Side shoots*		*Dry weight (g)*			
	Number	*Length (cm)*	*Leaves*	*Stems*	*Roots*	*Plant*
Control	2.00	3.88	1.75	1.31	0.99	4.05
50 ppm	1.50	6.25	2.45	1.46	1.85	5.76
100 ppm	1.50	5.25	2.45	1.57	1.24	5.26
150 ppm	1.00	5.50	2.88	1.60	1.31	5.79
200 ppm	1.50	2.63	1.80	1.10	0.81	3.71
250 ppm	1.50	11.75	3.73	1.72	1.29	6.74

Effect of different concentrations of BA and fertilizer levels on growth of young tea

Activity of terminal buds averaged over the fertilizer levels

The BA treatments induced more plants to remain in the active condition from the 4th week after first spray, the effect lasting for 4 weeks (Table 3).

TABLE 3 — *Activity of terminal buds (%) of plants sprayed with different concentrations of BA averaged over the two fertilizer levels*

Treatments	*Weeks* 2	4	6	8
Control	0	37	52	31
25 ppm	0	38	56	34
75 ppm	0	49	64	25
225 ppm	0	47	63	26

Side shoot production

The BA treatments produced more and longer side shoots (Table 4). Among BA treatments longer side shoots were seen when BA was sprayed at 75 ppm.

TABLE 4 — *Effect of different concentrations of BA and level of fertilizer on side shoot production (Back-transformed numbers are given in parentheses)*

	Treatments	Side shoots: Number $\sqrt{n}$	Side shoots: Length (cm)
Between control and BA treatments	Control	0.55 (0.30)	0.78
	Treated	0.81 (0.66)	0.93
LSD (P=0.05)		0.12	0.15
Between BA treatments	25 ppm	0.86 (0.74)	0.79
	75 ppm	0.85 (0.72)	1.28
	225 ppm	0.71 (0.50)	0.73
LSD (P=0.05)		NS	0.18
Between fertilizer levels	F2	0.77 (0.59)	1.03
	F4	0.72 (0.52)	0.77
LSD (P=0.05)		NS	0.13

Longer side shoots were also seen at double the rate of fertilizer application. An interaction was noted between BA and level of fertilizer for the length of side shoots (Table 5). The BA treatments produced longer side shoots at double the rate of fertilizer application.

TABLE 5 — *Interactions of BA and level of fertilizer on number and length of side shoots (Back-transformed numbers are given in parentheses)*

Treatments	Side shoots: Number $=\sqrt{n}$	Side shoots: Length (cm)
Control F2	0.49 (0.24)	0.74
Control F4	0.61 (0.37)	0.81
25 ppm F2	0.93 (0.86)	1.00
25 ppm F4	0.79 (0.62)	0.59
75 ppm F2	0.93 (0.86)	1.56
75 ppm F4	0.77 (0.59)	1.00
225 ppm F2	0.73 (0.53)	0.79
225 ppm F4	0.69 (0.48)	0.66
LSD (P=0.05)	NS	0.13

Effect of different concentrations of ethrel on growth of young tea

Effect of different concentrations of ethrel on height and dry matter production

The 800 and 1600 ppm treatments reduced plant height from 8 weeks after first spray application (Table 6). The dry weight of side shoot stem was increased by the 1600 ppm treatment. This treatment reduced the dry weight of main stem, leaves and of plant.

TABLE 6 — *Effect of different concentrations of Ethrel on monthly height of plants and dry matter production averaged over two clones (means of 60 plants)*

Treatments	*Height (cm)*						*Dry weight (g) after 24 weeks*					
	Week						*Side shoots*					
	4	*8*	*12*	*16*	*20*	*24*	*Leaves*	*Stems*	*Leaves*	*Stems*	*Roots*	*Plant*
Control	9.60	13.97	19.34	23.10	29.42	31.74	0.37	0.10	2.00	1.49	1.03	4.99
50 ppm	9.56	13.38	18.41	21.95	27.98	30.75	0.49	0.11	1.81	1.37	0.96	4.74
100 ppm	9.74	13.28	18.15	22.42	28.98	32.36	0.46	0.11	1.91	1.52	1.00	5.00
200 ppm	9.25	13.23	18.48	22.03	27.65	31.51	0.35	0.07	1.94	1.43	0.96	4.75
400 ppm	9.22	12.00	15.40	18.90	24.17	29.42	0.37	0.10	1.97	1.26	0.99	4.69
800 ppm	9.26	10.85	12.93	16.10	21.57	26.35	0.29	0.09	1.67	1.08	0.84	3.97
1600 ppm	9.18	10.17	11.68	14.52	18.67	23.27	0.43	0.17	1.41	0.96	0.89	3.86
LSD (P=0.05)	NS	0.47	2.50	2.98	3.00	2.93	NS	0.05	0.29	0.20	NS	0.66

DISCUSSION

Apical dominance is a general term used to denote the correlative inhibition of lateral organs by the growing apex. Decapitation of stem apices usually releases some lateral buds from inhibition by the apex but this can be reimposed by the application of auxin (Thimann and Skogg, 1933, 1934).

It was seen that repeated applications of 0.05% IAA suppressed side shoot production over the duration of the experiment compared to the plants receiving plain lanolin (Table 1, Fig 1). A direct inhibition of lateral bud growth by auxins as stated above has not been able to explain many inconsistencies noted in axillary bud growth. The possibility that hormone-directed nutrient transport plays an important part in such phenomena was originally proposed by Went (1936, 1939). This theory implies a preferential movement of mineral nutrients towards areas of high auxin concentration. This has been demonstrated by several workers (Booth, Moorby, Davies, Jones and Wareing, 1962; Seth and Wareing, 1967).

A supplementary experiment (unpublished) in which decapitated shoots were treated with IAA did not reveal any accumulation of mineral nutrients in the decapitated shoots except for a slight accumulation of N at the end of 5 days. However, this aspect merits further critical study. Others, notably, Gregory and Veale (1957) have shown that the degree of apical dominance is influenced by the nutritional status of the plant. It was shown that higher levels of fertilizer, provided they were not excessive, enhanced branching and dry matter accumulation (Kathiravetpillai, Kulasegaram, Senanayake and Gunasena, 1976). This is probably associated with the effect of a high level of mineral nutrition in reducing the degree of apical dominance. A similar observation was also made earlier (Kulasegaram and Kathiravetpillai, 1972). However, Phillips, (1968) has shown that at least in the dwarf bean the inhibited buds are not starved of mineral nutrients. More recently, McIntyre, (1971) suggested that inhibition of lateral buds largely depended on the supply of water, nitrogen and carbohydrates.

Recently cytokinins have been implicated in the phenomenon of apical dominance (see review by Phillips, 1975). The preliminary experiment in this study indicated that young tea plants showed a response to BA in the range 50 to 250 ppm (Table 2). The BA treatments induced more plants to remain in the active condition (Table 3) and increased the number and length of side shoots (Table 4). It was also noted that BA at 75 ppm produced longer side shcots relative to the other concentration. Among the BA treatments increasing the fertilizer level above double the recommended rate of application gave shorter side shoots (Table 5). Kagira (1974) using a series of concentrations of adenine and kinetin on young clonal tea plants did not observe any stimulation of side shoot production. The ability of exogenous cytokinins in reducing apical dominance has been observed by many workers. Sachs and Thimann, (1964) showed that kinetin applied directly to lateral buds of Alaska pea plants released them from inhibition.

There is considerable evidence that ethylene participates in endogenous regulation of plant growth (Burg, 1962). It was shown that the higher concentration of ethrel used reduced plant height, dry weight of stems, leaves, and of plant (Table 6). Observations in other studies indicate that, at concentrations higher than that used in the present study, ethrel is a powerful defoliant. It is believed that ethylene acts primarily at the sub-apical region (Burg, 1962) where cell elongation is reduced resulting in shorter internodes. Though none of the concentrations in this study had any effect on the number of side shoots the highest concentration used increased their dry weight. Kagira and Green (1973) found that ethrel reduced height of young clonal tea plants. The depressing effect of ethrel was proportional to the concentration used. However, they did not find any consistent trend in axillary bud activity. Wickremesinghe, Perera and Munasinghe (1974) using ethrel at 300 ppm on 4-month-old tea plants at an elevation of 760 m amsl in Sri Lanka found increased shoot length and weight. However, when they thumbnailed 6-month-old tea plants and applied one drop of a range of concentrations of ethrel to the cut ends of the respective rows of plants they did not observe any stimulation of shoots.

It thus appears that there is probably a hormonal background balance present in the plant which will be modified in the regions of active hormone production and it is the resultant local balance which may be responsible for such phenomena as apical dominance (Shein and Jackson, 1971).

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REFERENCES

BOOTH, A., MOORBY, J., DAVIES, C. R., JONES, H. and WAREING, P. F. (1962). Effects of indol-3-acetic acid on the movements of nutrients within plants. *Nature, Lond.* **194**, 204-205.

BURG, S. P. (1962). The physiology of ethylene formation. *Ann. Rev. Plant Physiol.* **13**, 265-302.

GREGORY, F. G. and VEALE, J. A. (1957). A reassessment of the problem of apical dominance. *Symp. Soc. exp. Biol.* **11**, 1-20.

KAGIRA, C. N. (1974). Report of the Botany Dept. for 1973. *Ann. Rep. Tea. Res. Inst. E. Afr.* 42-65.

KAGIRA, C. N. and GREEN, M. J. (1973). Report of the Botany Dept. for 1972. *Ann. Rep. Tea. Res. Inst. E. Afr.* 31-64.

KATHIRAVETPILLAI, A., KULASEGARAM, S., SENANAYAKE, Y. D. A. and GUNASENA, H. P. M. (1976). Growth of, cuttings of tea (*Camellia sinensis (L.)* O. Kuntze) clones at varying levels of fertilizer. *J. Nat. Agric. Soc. of Ceyl.* **13**, 13-30

KULASEGARAM, S. and KATHIRAVETPILLAI, A. (1972). Effects of nutrition and hormmones on growth and apical dominance in tea (*Camellia sinensis (L.)* O. Kuntze) *J. hort. Sci.* **47**, 11-24.

MCINTYRE, G. I. (1971). Apical dominance in the rhizome of *Agropyron repens.* Some factors affecting the degree of dominance in isolated rhizomes. *Canad. J. Bot.* **49**, 99-109.

PHILLIPS, I. D. J. (1968). Nitrogen, phosphorus and potassium distribution in relation to apical dominance in dwarf bean (*Phaseolus vulgaris*, cv. Canadian Wonder),. *J. exp. Bot.* **19**, 617-627.

PHILLIPS, I. D. J. (1969). Apical Dominance. In *The Physiology of Plant Growth and Development.* (Ed. M. B. Wilkins), pp. 163-202. McGraw-Hill, London.

PHILLIPS, I. D. J. (1975). Apical dominance. *Ann. Rev. Plant. Physiol.* **26**, 341-368.

SACHS, T. and THIMANN, K. V. (1964). Release of lateral buds from apical dominance. *Nature, Lond.* **201**, 939-940.

SETH, A. K. and WAREING, P. F. (1967). Hormone-directed transport of metabolites and its possible role in plant senescence. *J. exp. Bot.* **18**, 65-77.

SHEIN, T. and JACKSON, D. I. (1971). Hormone interaction in apical dominance in *Phaseolus vulgaris L.*' *Ann. Bot.* **35**, 555-564.

SNOW, R. (1937). 'On the nature of correlative inhibition'. *New Phytol.* **36,** 283-300.

THIMANN, K. V. and SKOOG, F. (1933). 'Studies on the growth hormone of plants. III The inhibiting action of the growth substance on bud development. *Proc. nat. Acad. Sci. Wash.* **19,** 714-716.

THIMANN, K. V. and SKOOG, F. (1934). On the inhibition of bud development and other functions of growth substances in *Vicia faba. Proc. Roy. Bot. Soc.* **114,** 317-339.

WANG, T. L. and WAREING, P. F. (1979). Cytokinins and apical dominance in *Solanum andigena*: lateral shoot growth and endogenous cytokinin levels in the absence of roots. *New Phytol.* **82,** 19-28.

WENT, F. W. (1936). Algemeine Betrachtungen uber das Auxin-problem. *Biol. Zbl.* **56,** 449-463.

WENT, F. W. (1939). Some experiments on bud growth,. *Am. J. Bot.* **26,** 109-117.

WICKREMASINGHE, R. L., PERERA, K. P. W. C. and MUNASINGHE, T. A. (1974). Effects of ethephon, pure tea seed saponin and partially purified tea root saponin on the growth of tea in the nursery and the field. *Tea. Q.* **44,** 132-143.