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CULTIVATION OF *THERIOPHONUM DALZELLII* SCHOTT., A STARCH YIELDING WILD SOURCE

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Results of pot level cultivation studies on *Theriophonum dalzellii* Schott., a starch rich monsoon perennial have been described. The sprouting response was best in 1/4th cut tuber segments. Growth performance and the yield of tubers as well as starch was highest under conditions of alternate day watering and in garden soil mixed with equal proportion of farm yard manure. The growth performance decreased with decrease in watering frequency and increase in content of farm yard manure.

Key words : Cultivation, starch yielding, *Theriophonum dalzellii*.

Tubers of *T. dalzellii*, a monsoon perennial of south India are eaten in days of scarcity by local populations (Anonymous, 1976). They are rich source of starch (Mulla and Kulkarni, 1989). Results of a few pot level culture studies on this plant which form basis to bring this species under cultivation are described in this commumication.

MATERIALS AND METHODS

The tubers were collected from Mumbra hills, near Thane (Maharashtra). Sprouting response was studied by sowing entire and variously cut tuber segments in different pots filled with garden soil and watered on alternate days. Experiments dealing with fertilizer response and water requirement were conducted at pot level (30 cm diameter and depth) using sprouts obtained from 1/4 vertical cut tuber segments as sowing material. The pots were placed in full sunlight. At a time each pot was supplied 3000 ml of water through sprinkler.

To study fertilizer response the sprouts were planted in pots with increasing proportion of farm yard manure as shown below and were watered on alternate days -

Set I	-	Garden soil (GS)
Set II	-	GS + FYM = 3 : 1
Set III	-	GS + FYM = 1 : 1
Set IV	-	GS + FYM = 1 : 3
Set V	-	Farm yard manure (FYM)

In experiments designed to study watering response the pots filled with garden soil were watered differently as follows -

Set W_1	-	daily once
Set W_2	-	on alternate days
Set W_3	-	once in three days
Set W_4	-	once in week.

Each set was represented by two pots with four plants in each pot. Monthly observations were kept for phenological events and growth. Weeding was done regularly. Plants were harvested by pulling them out carefully with entire soil lump from the container. The roots were washed thoroughly in water. The observations on morphological parameters like total number of leaves per plant, leaf area, fresh weight per plant, fresh weight of the tubers etc. were made in the laboratory. The tubers and leaves were separately dried at 60°C for 48 h and the contribution of dry biomass of different organs and the total biomass was determined. Two plants were harvested per set at monthly intervals and the results were based on the average of two replicates. The experiments were terminated at the end of fourth month (Table 2).

Following physiological growth parameters were determined by using formulae employed by Radford (1967).

$$\text{Net assimilation rate (NAR)} = \frac{W_1 - W_2}{t_2 - t_1} \times \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1}$$

$$\text{Relative growth rate (RGR)} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

$$\text{Leaf area ratio (LAR)} = \frac{L_2 - L_1}{\log_e L_2 - \log_e L_1} \times \frac{\log_e W_2 - \log_e W_1}{W_2 - W_1}$$

Where,

W_1 = total dry weight at time t_1
W_2 = total dry weight at time t_2
L_1 = Leaf area at time t_1
L_2 = leaf area at time t_2.

Net producitivity was expressed in terms of gm/plant/day on the basis of dry weight. The amount and per cent of starch in tubers at final harvest stage

were determined by total starch determination method (Hoffpauir, 1949).

OBSERVATIONS

Selection of Reproductive Propagules

Table 1: Sprouting response of tubers in *T. dalzellii*

Type of Propagules	Number of propagules sown	Days required for first sprouting	Number of sprouts after 15 days	Number of sprouts after 30 days
Entire tubers	4	7	3	3
1/2 vertical tuber cuts	4	14	3	3
1/4 vertical tuber cuts	4	14	4	4

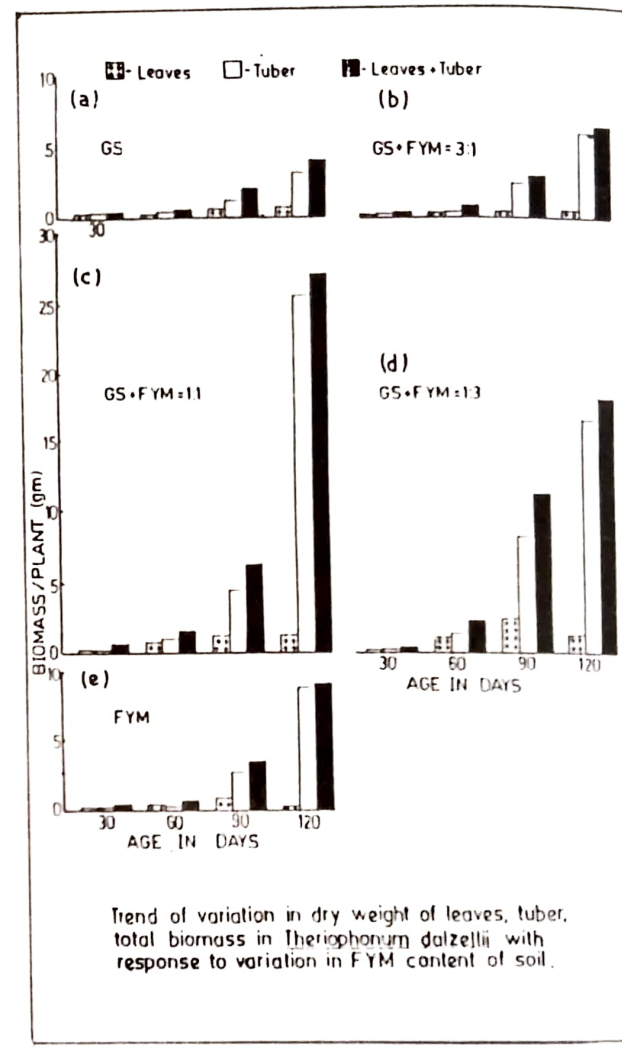
The results present in table - 1 indicate that sprouting response is as good in vertically cut tubers as in entire ones. Sowing material can be economised to maximum extent by employing 1/4 vertical cut segments.

Table 2 summarises growth performance and biomass production under various fertilizer and watering lavels.

Fertilizer response - The average number of leaves per plant in each set increased up to 3rd month and decreased in the 4th month. It increased with increase in organic matter content of the soil to certain extent. The minimum number of leaves was associated with set II during each harvest and the maximum number with set IV followed by set III and V (Table - 2). In all the sets mean leaf area increased up to 3rd month and then decreased. The mean leaf area and the total leaf area per plant were maximum in set IV followed by set III and set V.

The organic matter content of the soil influenced flowering also. In the plants of set IV flowering was initiated within 30 days of sowing; in remaining sets flowering was initiated after 90 and 120 days of sowing. The number of inflorescences per plant was 3 to 4 times higher in set III and IV than in other sets.

In all the sets fresh as well as dry weight of leaves per plant increased up to 3rd month followed by reduction in 4th month. The maximum dry weight of total leaves per plant was found in plants of set IV and followed by those of set III. There was no significant difference in values of set I, II and V (Fig. 1).



Trend of variation in dry weight of leaves, tuber, total biomass in Theriophonum dalzellii with response to variation in FYM content of soil.

Fig. 1

Dry weight of the tuber per plant in each set increased with the age as well as with increasing organic matter content of the soil to certain extent. There was not much change in this value in the first two months in different sets but steep increase was seen during 3rd and 4th months. The maximum dry weight of a tuber per plant at initial as well as final harvest stage was seen in set III followed by set IV. The dry weight of tuber was low in set V (Fig. 1).

The per centage of starch in tuber at final harvest stage was highest in set III followed by set I and set IV. Lower starch percentage was found in set V (Table - 2).

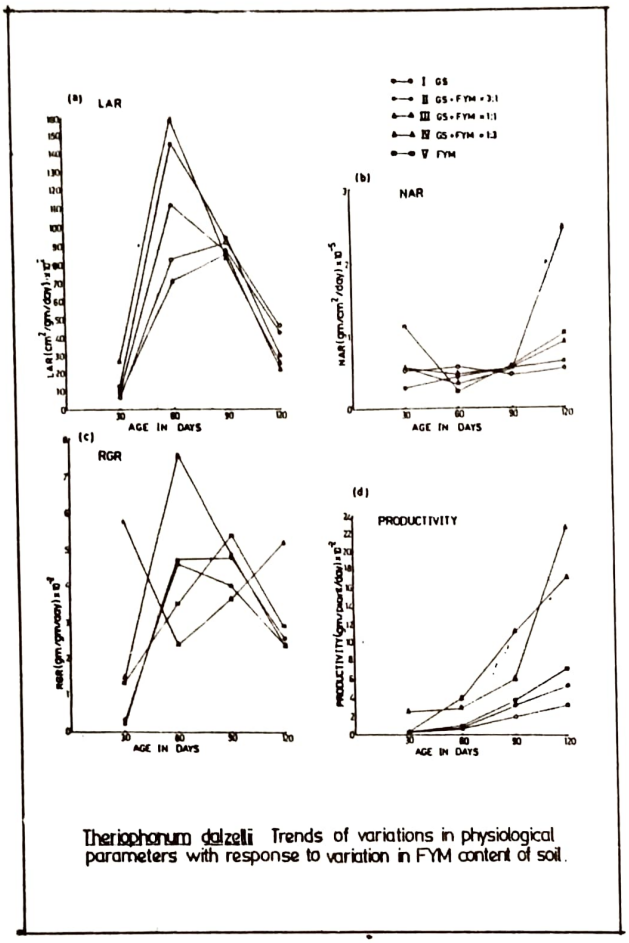
Table 2: Growth performance of vegetatively propagated *Theriophonum dalzellii* in response to variation in FYM content and watering levels of soil.

Age in days	Parameters	Fertilizer response					Watering Lavels			
		Set I	Set II	Set III	Set IV	Set V	Set W_1	Set W_2	Set W_3	Set W_4
30	No. Lvs./plant	2	2	3.12	3.42	2.42	3	2.7	2.1	1.8
	Mean leaf area (mm^2)	333.37	598.93	1239.72	775.53	702.45	606.31	425.60	422.83	
	Leaf area/plant (mm^2)	666.75	1197.87	5867.94	4524.15	1876.79	2107.35	1637.05	893.76	761.10
	Dry wt.Lvs./plant (gm)	0.04	0.03	0.30	0.12	0.07	0.06	0.20	0.06	0.05
	Dry wt.tuber/plant (gm)	0.10	0.14	0.62	0.12	0.16	0.14	0.21	0.20	0.13
	Biomass (gm)	0.14	0.17	0.92	0.24	0.23	0.21	0.41	0.26	0.18
60	No. lvs./plant	3.8	4.6	7.6	8.5	5.5	4	4	3	2.83
	Mean leaf area(mm^2)	1779.45	2300.46	2470.13	4377.78	2867.75	2051.29	2091.06	1379.38	1304.49
	Leaf area/plant (mm^2)	6767.94	10585.15	18773.01	37211.14	15199.09	8284.00	8764.16	4138.15	3691.71
	Dry wt.Lvs./plant (gm)	0.27	0.31	0.82	1.08	0.41	0.37	0.14	0.15	0.12
	Dry wt.tuber/plant (gm)	0.33	0.41	1.07	1.43	0.35	0.57	0.52	0.35	0.25
	Biomass (gm)	0.60	0.72	1.89	2.52	0.76	0.94	0.67	0.50	0.37
90	No. lvs./plant	4	5.75	10	8.75	7	5	4.25	3.25	3
	Mean leaf area (mm^2)	3939.00	3233.44	4525.17	6437.57	2649.10	3889.29	4213.20	2919.98	1978.08
	Leaf area/plant (mm^2)	15756.00	18592.32	44251.73	56328.78	18543.74	19446.45	17927.35	9489.95	5934.24
	Dry wt.lvs./plant (gm)	0.66	0.46	1.63	2.63	0.99	0.46	0.33	0.14	0.07
	Dry wt.tuber/plant (gm)	1.43	2.61	4.72	8.58	2.88	0.92	0.73	0.80	0.58
	Biomass (gm)	2.09	3.07	6.35	11.21	3.87	1.38	1.06	0.94	0.65
120	No. lvs./plant	3.5	4	4	5.5	5.5	5.5	7.5	4.5	4.5
	Mean leaf area (mm^2)	3800.37	5167.80	4651.91	4501.31	2773.90	4153.95	4793.08	4176.37	2873.62
	Leaf area/plant (mm^2)	13581.31	20671.20	18607.66	24757.24	15256.45	22846.72	35948.12	18705.50	12931.31
	Dry wt.lvs./plant (gm)	0.76	0.62	1.40	1.64	0.19	1.33	1.24	1.24	0.45
	Dry wt.tuber/plant (gm)	3.34	6.05	25.91	19.17	8.57	4.54	7.92	6.29	1.34
	Biomass	4.10	6.67	27.31	20.81	8.76	5.87	9.16	7.53	1.80
	% Starch in tubers	89	86	91	88	83	83	87	81	85

Productivity increased with increase in age of plants in all the sets. It underwent almost linear increase from first to final harvest in set IV while in other sets the increase was rapid after 60 days of growth. In set III steep increase was seen between 90 to 120 days. In general, productivity was highest in plants of set III and IV and decreased successively in sets V, II and I at each stage of harvest. Thus direct correlation between productivity and organic matter content of the soil was seen up to certain extent. However pure FYM reduced the productivity (Fig. 2d).

NAR behaved differently in different sets. In set I it did not undergo significant change from initial to final harvest stage. In set II there was marginal increasing trend from 30 to 120 days. In set III it remained almost unchanged up to 90 days but underwent steep increase during last 30 days and showed

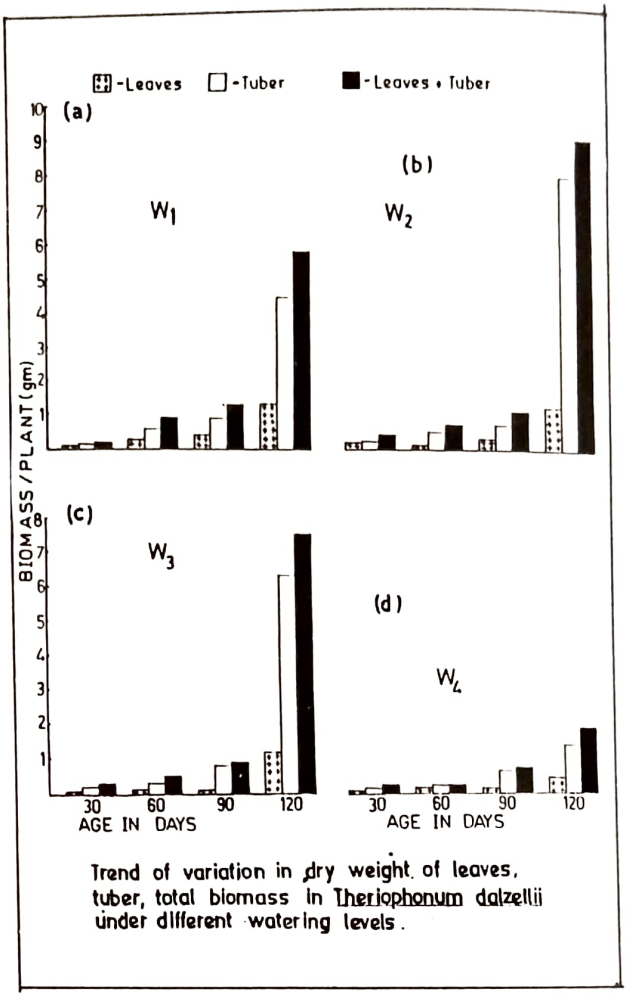
maximum value at final harvest. NAR in set IV behaved as in set III but increase in final 30 days was not that steep and showed 3rd highest value at the stage of final harvest. In set V, NAR showed highest values among different sets at 30 days but under went drastic reduction at 60 days followed by increase again up to 120 days and showed 2nd highest value at final harvest stage (Fig. 2b).



Theriophonum dalzelli Trends of variations in physiological parameters with response to variation in FYM content of soil.

Fig. 2:

In all the sets except III, the RGR values under went steep increase from 30 days reaching maximum value in set I and set IV at the end of 60 days and in set II and V at the end of 90 days followed by decrease at 120 days. In set III however RGR value was highest amongst all sets at 30 days but declined sharply to the lowest level at the end of 60 days followed by linear increase up to 120 days. Highest RGR value was associated with plants of set IV at the age of 60 days (Fig. 2c).



Trend of variation in dry weight of leaves, tuber, total biomass in Theriophonum dalzellii under different watering levels.

Fig. 3:

LAR values underwent steep increase from 30 to 60 days in set II, IV, V and up to 90 days in set I and set III followed by decrease again at 120 days. Highest values were associated with set IV followed by set V at 60 days. Even at the age of 30 days highest LAR values were associated with plants of set IV, followed by V. However at the final stage of harvest LAR values decreased in order of set I, II, V, IV and III (Fig. 2a).

Growth performance in relation to differential watering response - The average number of leaves and fresh and dry weight of leaves per plant were maximum in plants of W_2 followed by W_1 throughout

the experimental period but decreased with decrease in watering intervals in plants of set W_3 and W_4. The average leaf area was maximum in plants of both W_1 and W_2 but decreased in plants of W_3 and W_4. Fresh weight of total leaves per plant decreased with decrease in watering frequency.

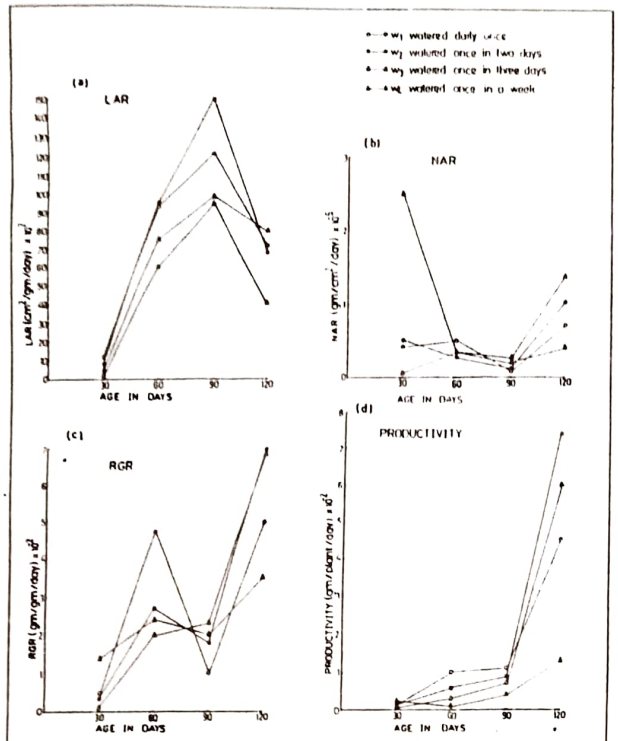


Fig 4: Theriophonum dalzellii Trends of variations in physiological parameters under different watering levels.

Fig. 4:

Growth performance in terms of dry weight of different organs as well as total biomass under different watering levels at monthly intervals is shown in Fig. 3. Under each condition of watering the dry weight of leaves per plant was less than that of tuber at each harvest stage and the values of these parameters increased successively with increase in age of the plant up to the final harvest stage at 120 days. However, contribution of leaf as well as tuber and total biomass was maximum in plants watered on alternate days (W_2) followed by those watered once in three days. It was minimum at all stages of harvest in plants watered once in a week (W_4) (Fig. 3).

Tuber starch percentage at final harvest stage was maximum in W_2 followed by W_4 and W_1 and least in W_3 (Table - 2).

Under each watering level productivity rate increased gradually from 30 to 90 days but rapidly from 90 to 120 days. The rate was highest in plants of W_2 followed by those of W_3 and W_1 set and was least in plants of W_4 (Fig. 4 d).

NAR behaved differently under different watering levels. However in all the sets there was steep increase in NAR between 90 to 120 days. During this period, the rate of increase was highest in W_3 followed by W_2, W_1 and W_3. At 60 days in W_1 and W_3 there was marginal increase in NAR but decrease in W_2 and W_4; the decrease being quite steep in W_4. The rate marginally decreased in all the sets at 90 days (Fig. 4b).

The pattern of variation in RGR was typically the same in all the sets; being least at 30 days with increase up to 60 days and decrease between 60 to 90 days followed by steep increase again during the final interval of 90 to 120 days. The fluctuations were quite marked in W_4 and W_2 conditions as compared to W_1 and W_3. At the final harvest level, highest RGR was in W_2 and W_3 followed by W_1 and W_4 (Fig. 4c).

Under all watering conditions the LAR showed steep rise from 30 to 90 days followed by fall between 90 to 120 days. The rate of rise was highest in W_2 followed by W_1, W_2 and W_3 (Fig. 4a).

DISCUSSION

In nature *Theriophonum dalzellii* reproduces both vegetatively as well as through seeds. As propagation by vegetative means maintains genetic uniformity, experiments to standardise the size of vegetative propagules to be used for cultivation purpose revealed that best sprouting response in seen when 1/4 vertically cut tubers are employed as sowing material. By employing suitably cut vegetative propagules thus, one can economise the sowing material. Kamalam *et al.* (1977) noted that of different rhizome cuts employed in *Manihot esculenta*, 1/2 node cutting was best and they could raise 647 plants from 1/2 node cuts of a single rhizome within an year. In *Costus speciosus* Sarin *et al.* (1974) obtained the yield of 1570 gms of rhizome in one growing season by employing 35 gm weight of rhizome segment as sowing material. Sharma *et al.* (1980) noted successive improvement in various growth parameters as well as yield with progressive increase

in weight of sowing material upto 120 gm. Similar investigation dealing with correlation between the size of planting material and planting rate with respect to yield of corm has been conducted by Mishra, *et al.* (1981) in *Amorphophallus campanulatus*.

T. delzellii showed good fertilizer response supplied in the form of farm yard manure. Various parameters like number of leaves per plant, total leaf area, average and total leaf weight and the number of inflorescences per plant increased with increase in proportion of FYM content of the soil to certain extent. Similar was the case with respect to physiological parameters like NAR, RGR and productivity. Dry weight of tubers and total biomass at final harvest stage was highest in plants grown in GS + FYM = 1:1, followed by those grown in GS + FYM = 1:3. However the plants grown in only FYM did not fare well. Similar fertilizer response has been observed in *Dioscorea spiculata, Xanthosoma* and *Colocasia sagittifolium* by Preston *et al.* (1964), Enyi (1968) and Jacoby (1967) respectively.

Being a monsoon perennial, active phase of life cycle of *T. dalzellii* is closely governed by moisture content of the soil. The growth performance in terms of morphological, physiological and biomass characteristics was best in plants receiving water on alternare days followed by those receiving daily. This was true even in case of starch content of tubers harvested at 120 days. Reduction in watering frequency to once in three days and once in a week successively reduced the performance. The present observation that the LAR values are maximum in plants watered daily followed by those watered on alternate days supports the finding of Ezumah (1973) who stated that in *Colocasia esculenta* the leaf area value is directly correlated with soil moisture level.

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REFERENCES

Anonymous 1976 *Wealth of India A dictionary of Indian Raw materials and Industrial Products : Raw materials*. Vol X CSIR Publication and Information Directorate New Delhi.

Enyi A C 1968 Growth of Cocoyam (*Xanthosoma sigittifolium* Schott. *Indian J Agric Sci* **38** 627-633.

Ezumah H C 1973 The growth and development of taro *Colocasia esculenta* (L) Schott. in relation to selected cultural management practices, *Diss Abstract* International B **34** 24.

Hoffpauir C L 1949 Report on starch in plants. *J of A O A C* **32** 291-294.

Jacoby T 1967 Nutrition and manuring of tropical root crops. *Green Bull* **19** 31-34.

Kamalam P, P G Rajendra & N Hrishi 1977 A new technique for the rapid propagation of Cassava (*Manihot esculenta*). *Trop Agric* **3** 213-218.

Mishra S S, S Mishra N K Choudhary & P K Ray 1981 Optimum seed size and planting rate for cultivation of *Amorphophallus campanulatus* in Bihar. *Seed Res* (New Delhi) **9** 167-171.

Mulla R M & Kulkarni A R 1989 Starches of Araceae. *Starch Starke*, (in press).

Preston W H, J R Haun J W Garvin & R J Daum 1964 Several aspects of growth, development and sapogenin yield of tubers of *Dioscorea spiculiflora*. *Econ Bot* **18** 323 - 328.

Radford P J 1967 Growth analysis formulae - their use & abuse. *Crop Sci* **7** 171-175.

Sarin Y K, K L Bedi & C K Atal 1974 *Costus Speciosus* as source of diosgenin *Curr Sci* **43** 563-570.

Sharma S N, A Singh & R S Tripathi 1980 Studies on *Costus spediosus* in relation to weight and source of the planting material. *Indian J Pharm Sci* **42** 151-153.