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Varietal Screening, Developmental Stages and Some Physiological and Biochemical Parameters of *Sechium edule* Sw. of Darjeeling Hills

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Abstract

A survey shows that there exists at least 10 different varieties of chayote (*Sechium edule* Sw.). Vegetative phase continues for more than two months and fruiting phase for 3 months. The variety available in Mirik is superior with respect to general vigor and yield of fruits to those available in Sukhia Pokhri and Darjeeling town. Both dry and fresh weight of leaves was maximum in fully expanded mature leaves and minimum in young leaves. Chlorophyll, protein, insoluble carbohydrate and RNA contents were high in mature leaves followed by young and old leaves. But soluble carbohydrate level was maximum in old leaves. The protein and insoluble carbohydrate contents were high in mature fruits, whereas soluble carbohydrate content was high in young fruits. Activities of catalase, total dehydrogenase and amylase were high in mature fruits than in young ones.

Chayote (*Sechium edule* Swartz.) belonging to the family cucurbitaceae is a squash-like vegetable. It is locally known as 'Eskush' among the Nepali speaking people, and the word 'Eskush' is a deformation of English word 'squash', which is a misnomer for chayote. Chayote is the derivative of the Aztec word 'Chayotl' meaning with thorns (1). The species is known variously as colloquial names in different parts of the world. In Louisiana, it is called mirliton ; In Florida, vegetable pear : and in Japan, cho-cho.

In recent years, this species with a number of varieties has attracted researchers because it seems to be a highly promising dietary vegetable crop (2, 3). The underground part is delicious and is a good source for carbohydrate and some vitamins. The fruit contains carbohydrate, protein and some essential amino acids. The young shoots including the tendrils are rich source of vitamin A (4). The recent acceptance of this species by local cultivators as an ideal hilly vegetable crop are : minimum cost of maintenance in the field ; less susceptibility towards fatal diseases, except some animal pests which appear during flowering ; considerably higher productivity even in fallow land ; considerable food value in all plant parts ; higher storage potential of fruits and tubers at ambient conditions for a long period ; insignificant dormancy and minimum storage deterioration of propagules ; and higher adaptibility towards various climatic hazards.

Considering the prospects of chayote cultivation in Darjeeling hills, a comprehensive work was undertaken keeping in mind enhancement of crop productivity. However, in this investigation attempts were made in the follo-

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wing lines : varietal screening of the plant growing in various altitudes of Darjeeling hills ; phenological studies to know important events in the life cycle and analysis of some physiological and biochemical parameters of the Variety growing in Darjeeling town. As literature on chayote research is scanty, the results of this preliminary work are reported in this paper as basic information.

Methods

Varietal screening of chayote (*Sechium edule* Sw.) was done from the fruits of the wildly grown plants of Darjeeling hills available at altitudinal ranges from 500 to 2200 m. For phenological studies, the plants were developed from sprouted fruits and grown in the experimental field of Darjeeling Government College campus. The experimental field was divided into eight subplots each having an area of 3×3 m. The sprouted fruits were sown at a spacing of 1.5×1.5 m. after adequately supplying the plots with cowdung and compost manures. Each sprouted fruit was kept embeded at least 15 cm into the soil and watered at 5-day intervals until seedlings develop.

Some physiological and biochemical analyses were done taking samples from leaf and fruit tissues of the field grown chayote plants. Dry matter content of leaves was determined by ovendrying method (at 70 C for 7 days). Chlorophyll and protein levels of leaves were estimated following the methods of Arnon (5) and Lowry et al. (6); respectively. Carbohydrate levels (both soluble and insoluble fractions) were determined following the method of McCready et al. (7). Extraction of RNA was done after the method described by Cherry (8) and estimation was done according to the method of Markham (9) modified by Choudhuri and Chatterjee (10). Extraction and estimation of the enzymes catalase and amylase were made following the methods of Khan and Faust (11) and Snell and Snell (12), respectively. For the assay of these enzymes the blank was taken as zero time control. The activity of each enzyme was expressed as $\Delta A \times TV/(t \times v)$, where ΔA is the absorbance of the sample after incubation minus the absorbance of the zero time control. Tv is the total volume of the filtrate, t is the time (minutes) of incubation with the substrate and v is the volume of the filtrate taken for incubation (13). The activity of total dehydrogenases was measured according to the method of Rudrapal and Basu (14).

The physiological and biochemical data recorded in this investigation, were statistically analyzed at the replication and treatment levels and the least significant difference (LSD) was calculated at 95% confidence limits (15).

Results

Table 1 shows varietal differences of *Sechium edule* growing in various altitudes of Darjeeling hills. Altogether 10 varieties were established and they are named alphabetically. As it was difficult to identify the varietal types on the basis of vegetative characters, here the types were made on the basis of the stable morphological characters of mature fruits, namely, size, weight and color of fruits and also on the basis of density, length and mode of distribution of hairs on fruit surface.

Important events during the life cycle of a chayote plant are depicted in Table 2. The above ground part of chayote is monocarpic in nature and the leafy plant survives more than 5 months. Vegetative phase continues more than two months and fruiting phase continues for 3 months.

Table 3 shows a few vegetative and reproductive characters of chayote growing in three

Table 1. Varietal differences of *Sechium edule* on the basis of morphological characteristics of mature fruits. Data were recorded from 10 mature fruits of each variety and the average values were incorporated in the Table.

Variety	Length (cm)	Breadth (cm)	Girth (cm)	Weight (g)	Color	Hair density (per cm)	Hair length (mm)	Pattern of distribution
A	12.2	8.6	19.0	469.5	Greenish white			
B	15.5	8.9	22.8	570.8	Green			
C	14.0	8.2	20.9	425.0	Yellow green	10	3	Evenly distributed on the whole surface
D	8.7	7.2	14.8	208.9	Yellow green	22	5	hairs coarse, uniformly distributed
E	7.4	4.5	11.2	105.7	Yellow green	6	3	arranged on the longitudinal surface of the fruit
F	10.9	7.0	15.9	292.9	Yellow green	12	4	randomly scattered over the whole surface
G	11.8	6.8	16.0	327.7	Yellow green	4	2	arranged around the vertical notches
H	9.1	5.8	14.0	140.5	Greenish white	Only a few per fruit	2	evenly distributed around the apical notch
I	11.9	8.8	19.0	370.2	Whitish green	4	2	sparsely distributed over the whole surface
J	10.0	8.9	17.7	290.5	Yellow green	0		
LSD (P=0.05)	1.02	0.68	1.28	14.0		0.35	0.19	

separate altitudinal zones of Darjeeling hills. The type growing in Mirik was superior in all respects, particularly on yield of fruits.

Data on fresh weight, dry weight, chlorophyll, protein, soluble carbohydrate, insoluble carbohydrate and RNA levels of three categories of leaves (young, mature and old) have been incorporated in Table 4. Maximum fresh weight and dry weight were noted in mature leaves which was followed by old and young leaves. Chlorophyll, protein, RNA and insoluble carbohydrate contents were maximum in mature leaves and minimum in old leaves. But soluble carbohydrate content increased with the progress of leaf ageing, and the amount was found maximum in old leaves.

Biochemical data of fruits have been represented in Table 5. As compared to young fruits, protein and insoluble carbohydrate levels were found high in mature fruits. But soluble carbohydrate remained at low level in mature fruits. On the other hand, enzymes such as catalase, dehydrogenase and amylase showed their maximum activity in mature fruits.

Discussion

Data show that out of the 10 varieties avai-

Table 2. Important phases occurring in the life cycle of *S. edule*. Data were recorded from five uniformly grown plants, developed from five uniformly sprouted fruits.

Phases in life cycle	Days required after sowing	Remarks
Field emergence phase	15±5	Sprouting takes place from the apical notches of the propagating fruit.
First leaf emergence phase	21±3	First leaf emerges from the tip of the tender epicotyl without tendrillar initiation.
Seedling phase	15–30±5	Leaves arise alternately with distinct reticulate palmate divergent venation; trailing habit noted, rudimentary tendrils may initiate.
Sapling phase	30–48±5	Branched tendrils appear, plants start climbing holding a support.
Flower initiation phase	68±7	Male and female flowers appear at leaf axils; female flower solitary per node with short pedicel; male flowers (20-30) appear on long peduncle.
Fruit formation phase	77±7	Single fruit with apical notch and vertical crevices appear in nodes; surface hairs prominent.
Log phase of growth	55–90±10	Active and indeterminate growth of shoot tip results in vigorous vegetative growth.
Stationary phase of growth	90–130±10	Active apical growth retarded; fruit production maximum.
Senescence phase	135±8	Leaf yellowing starts, overall vigour reduced, underground tubers maximally developed.
Death phase	160±8	Above ground part dies, underground part remains fully viable with abundant starchy storage.

lable in Darjeeling hills, the variety B growing in Mirik zone is superior in respect to fruit size (Table 1) and some vegetative and reproductive characters including crop yield (Table 3). It seems likely that in the past this exotic species of tropical America had been introduced and not acclimatized in these hilly regions and subsequently experienced ecological variations due to differential temperature, humidity photoperiod, and soil types at various altitudes. These probably resulted in various ecotypes as observed in the present investigation after long years (Table 1). Phenological studies (Table 2) reveal that during log phase and

Table 3. Some vegetative and reproductive characteristics of three different varieties of *S. edule* collected from three different altitudinal places of Darjeeling hills. Data were recorded from five uniformly grown mature plants of each locality.

Locality	Length of main vine (cm)	Total number of leaves per plant	Total number of flowers per plant		Total yield per plant (kg)
			Female	Male	
Mirik	965	422	272	6690	95.5
Sukhia Pokhri	770	307	210	5125	82.5
Darjeeling Town	550	255	182	3645	70.7
LSD (P=0.05)	55.28	28.19	15.92	298.40	7.50

Table 4. Fresh weight, dry weight, chlorophyll, protein, soluble carbohydrate, insoluble carbohydrate and RNA content of young, mature and old leaves of *S. edule*.

Parameter	Category of leaf			LSD
	Young	Mature	Old	(P=0.05)
Fresh weight (g)	1.28	14.05	10.82	0.25
Dry weight (g)	0.57	2.53	1.53	0.09
Chlorophyll (mg/g fr. wt.)	1.40	2.50	0.95	0.12
Protein (mg/g fr. wt.)	40.08	67.95	32.25	4.52
Soluble carbohydrate (mg/g fr. wt.)	3.85	4.50	10.95	0.42
Insoluble carbohydrate (mg/g fr. wt.)	21.75	40.70	15.07	1.92
RNA (μg/g fr. wt.)	872.52	1109.80	597.24	65.88

stationary phase of the species maximum fruiting occurs. But even after death phase of the vine, the underground part remains fully viable and store food for future generation. In fact, during log phase the contributory leaves of the vine serve as active source leaves and transport photosynthetes to the fastly developing reproductive sinks, that is, to the growing fruits developing from the fertilized female flowers. After saturating these apical sinks the contributory leaves start transporting the assimilates to the basipetal direction possibly from the end of the stationary phase and consequently cause the development of the tuberous underground roots (the basal sinks). These roots gradually grow in size in a couple of seasons with full potential for regeneration, indicating its perennial mature. This source-sink relationship and mobilization of assimilates have been reported (16, 17). Fresh weight, dry weight, chlorophyll, protein, insoluble carbohydrate and RNA levels were found maximum in mature leaves (Table 4). This is because the synthetic machinery becomes active at the full-grown stage of the leaf. And in old leaves the macromolecules are degradated or synthesized to a minimum extent. In fact, synthesis of these are accelerated in young leaves, the process reaches its climax in fully expanded mature leaves and starts declining in senescing leaves. However, high level of soluble carbohydrate in old leaves may be attributed to the higher degradation of insoluble carbohydrate releasing increased soluble forms. These results are in conformity with the reported observations (18). In mature fruits, protein, insoluble carbohydrate contents and activities of catalase, dehydrogenase and amylase enzymes remained at high level in comparison to young fruits (Table 5). This result indicates that attainment of maximum vigor and potential of the fruits took place at their full-grown stage probably due to strong and balanced activity of source and sink. Higher activity of enzymes such as catalase and dehydrogenase in high vigor and high potent plants or plant parts have been reported (19, 20). However, lower level of soluble carbohydrate in mature fruits may be due to higher conversion rate of soluble carbohydrate into insoluble form at advanced stage of growth of the fruits.

From this study and available literature (1, 4, 21, 22) it can be concluded that a scientific approach on improvement of this promising vegetable crop may make it a profitable cash crop of Darjeeling hills. Owing to increased awareness on food value and economic feasibi-

Table 5. Protein, soluble carbohydrate and insoluble carbohydrate contents and catalase, dehydrogenase and amylase activities in young and mature fruit tissues of *S. edule*.

Parameter	Category of fruit		LSD
	Young	Mature	(P=0.05)
Protein (mg/g fr. wt.)	18.20	25.85	2.06
Soluble carbohydrate (mg/g fr. wt.)	28.72	10.24	1.20
Insoluble carbohydrate (mg/g fr. wt.)	85.27	105.72	9.28
Catalase (units/g fr. wt./hr)	280.80	337.59	30.52
Dehydrogenase (units/g fr. wt./hr)	60.19	85.27	7.51
Amylase (units/g fr. wt./hr.)	2.85	12.60	0.29

lity, this so called wild-grown plant has now attracted the attention of researchers for crop improvement by breeding, increasing feminity of flowers, producing ideotypic plant, hormonal manipulations, tissue cultures, and cultural practices (23, 24).

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