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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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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	$15-30 \pm 5$	Leaves arise alternately with distinct reticulate palmate divergent venation; trailing habit noted, rudimentary tendrils may initiate.
Sapling phase	$30-48 \pm 5$	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	$55-90 \pm 10$	Active and indeterminate growth of shoot tip results in vigorous vegetative growth.
Stationary phase of growth	$90-130 \pm 10$	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	Young	Category of leaf Mature	Old	LSD (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 Young	Mature	LSD (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.)	65.27	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).

References

1. Cook O. F. 1901. The chayote: a tropical vegetable. USDA Div. Bot. Bull. 28 : 7—31.
2. Mukhia M., M. Yonzone and T. K. Sadhu. 1982. Studies on squash (*Sechium edule* Sw.) of Darjeeling district. Indian Agric. 26 : 295—299.
3. Dolui T. K. and S. Jana. 1988. Effects of phytohormones on some biochemical parameters during dark induced leaf senescence of *Sechium edule* on Darjeeling hill of the Eastern Himalayas. Biol. Plant 30 : 379—383.
4. CSIR (Council of Scientific and Industrial Research). 1972. The wealth of India: Raw materials, volume 9. PID, CSIR, New Delhi, India.
5. Arnon D. I. 1949. Copper enzymes in isolated chloroplasts : Polyphenoloxidase in *Beta vulgaris*. Plant Physiol. 24 : 1—15.
6. Lowry O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall. 1951. Protein measurement with Folin-phenol reagent. J. Biol. Chem. 193 : 265—275.
7. McCready R. M., J. Guggloz, V. Silviera and H. S. Ownes. 1950. Deterioration of starch and amylase in vegetables. Analyt. Chem. 22 : 1156—1158.
8. Cherry J. H. 1962. Nucleic acid determination in storage tissue of higher plants. Plant Physiol. 66 : 670—678.
9. Markham R. 1955. Nucleic acids, their compounds and related compounds. Pages 246—304 *in* K. Paech and M. V. Tracey, editors, Springer Verlag, Berlin, Germany.
10. Choudhuri M. A. and S. K. Chatterjee. 1970. Seasonal changes in the levels of some cellular components in the abscission zone of *Coleus* leaves of different ages. Ann. Bot. 34 : 275—287.
11. Khan A. A. and M. A. Faust. 1967. Effect of growth retardants on α-amylase production in germinating barley seeds. Physiol. Plant 20 : 673—681.
12. Snell F. D. and S. T. Snell. 1971. Colorimetric methods of analysis, volume 4. Van Nostrand Reinhold Co., New York, USA.
13. Fick N. G. and C. O. Qualset. 1975. Genetic control of endosperm amylase and gibberellin responses in standard height and short-statured wheat. Proc. National Acad. Sci., USA. 72 : 892—895.
14. Rudrapal A. B. and R. N. Basu. 1979. Physiology of hydration-dehydration treatment in the maintenance of seed viabi-

lity in wheat (*Triticum aestivum* L.). Indian J. Exp. Biol. 17 : 768—771.

15. Panse V. G. and P. T. Sukhatme. 1967. Statistical methods for agricultural workers, 2nd edition. Indian Coun. Agric. Res., New Delhi, India.
16. Davies C. R. and P. F. Wareing. 1965. Auxin directed transport of radiophosphorus in stems. Planta 65 : 139—156.
17. Mulligan D. R. and J. W. Patric. 1979. Gibberellic acid-promoted transport of assimilates in stems of *Phaseolus vulgaris* L. Localised vs. remote sites of action. Planta 145 : 233—238.
18. Bhattacharjee A. 1984. Responses of sunflower plants towards growth retardants with special reference to growth, metabolism and yield. Doctoral thesis, Burdwan Univ., India.
19. Bhattacharjee A. and M. A. Choudhuri. 1986. Chemical manipulation of seed longevity and stress tolerance capacity of seedlings of *Corchorus capsularis* and *C. olitorius*. J. Plant Physiol. 125 : 391—400.
20. Sarkar U. and M. A. Choudhuri. 1980. Glycolate content, glycolate oxidase and catalase activity in intact sunflower plant during ageing and development. Biochem. Physiol. Pflanzen. 175 : 23—28.
21. Flick G. J., F. S. Burnette, L. H. Aung, R. L. Ory and A. J. St. Angelo. 1978. Chemical composition and biochemical properties of mirlitons (*Sechium edule*) and punple, green and white eggplants (*Solanum melongena*). J. Agric. Food Chem. 26 : 1000—1005.
22. Ceccarelli N. and R. Lorenzi. 1990. In vivo gibberellin biosynthesis in endosperm of *Sechium edule* Sw. seeds. Plant Physiol. 93 : 1032—1036.
23. Aung L. H. and G. J. Flick. 1976. Gibberellins induced seedless fruit of chayote *Sechium edule* Swartz. Hort. Sci. 11 : 460—462.
24. Shil R. 1990. Some aspects of morphology, physiology and bio-chemistry of squash (*Sechium edule* Sw.) in Darjeeling Hills. M. Sc. Dissertation, North Bengal Univ., Darjeeling, India.

CHAYOTE - a boon to the hills

Projjwal.C.Lama brings to our attention Chayote known in the hills as Iskoos an extremely versatile traditional vegetable which has remained underexploited and requires more attention from both the government and NGOs.

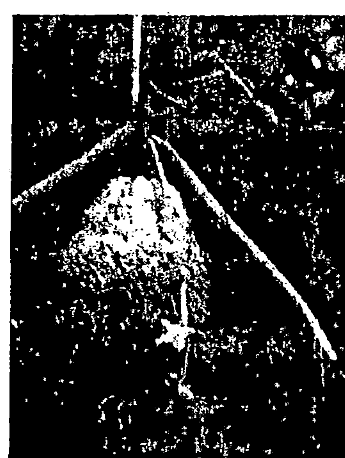
Sechium edule Sw. (family, cucurbitaceae) commonly known as Chayote (eng.), Iskoos (nepali), Quash (bengali.), is one of the most important edible vegetables for the people in the hilly regions of the Darjeeling district of West Bengal. It grows both in cultivated and wild conditions and flourishes in altitudes ranging from 500m. to 2000m. Its fruit is rich in carbohydrate and amino acids. The subterranean part of the plant is delicious and contains valuable starch. Even succulent young twigs are edible and contain amino acids and vitamin A & C. It is reportedly cultivated in tropical Central America.

The climbing plant

It is an important produce in the hilly tracts of Darjeeling along with potato, cabbage, cauliflower and ginger. This species has greatly attracted the attention of researchers and local cultivators with its three seasonally placed edible products, i.e., the "*munta*" a local name for the young twigs available during the summer time, the fruit, locally known as "*dana*", in the rainy to winter season, and roots, "*jara*", available between winter and spring, . Besides these, numerous features of its cultivation have spurred the people of the region to adopt its cultivation. First, during its cultivation, the plant requires very little manure and negligible maintenance. Secondly, there are no prominent diseases or pests which afflict this plant and thirdly, it can be stored for a longer period of time and can even be grown in fallow land. It has higher adaptability under extreme climatic conditions and lastly, insignificant dormancy.

It is a climbing herb with extra-auxiliary, single or branched tendrils and monoecious. The part above the ground dies in winter but the part underground i.e. the tuberous root is perennial. The climbing habit of the plant is mostly accelerated through tendrils. The pentagonal stem bears simple, alternate, long petiolate leaves. The fruits are single seeded with viviparous germination.

A moist but frost free atmosphere, similar to that of 'a mountainous wet temperate forest type' provides the optimum climatic condition for Chayote cultivation, though they are even cultivated in the Mountaneous-subtropics. The required annual rainfall is about 1500mm to 6200mm and the temperature of 10°C to 25°C is considered favourable. The plant can tolerate high humidity (almost upto 100 percent RH) without any ill effect.



'Dana' - the fruit

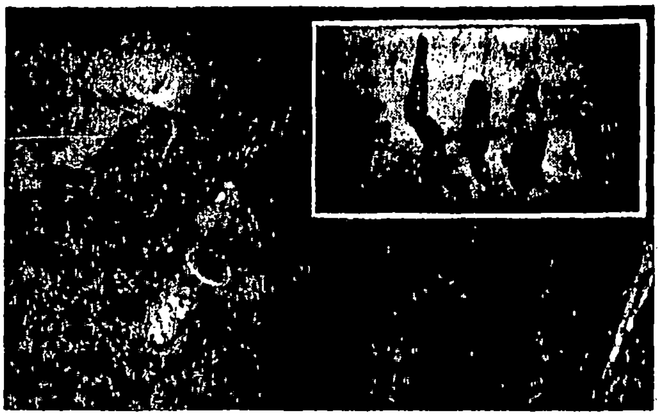
In the wild, it grows almost anywhere, in the slopes and in the plains. The species prefers soil with a rich humus for better production of quality fruits.

It is mostly cultivated in fallow and waste land. The fruit is sown in January. Nurseries of levelled beds of about 2ft X 2ft area are made. The seed bed is prepared by tilling the soil to make it loose, then decomposed organic manure is added on which the mature viable fruit is sown. The fruit is sown with the seed-part up at an angle of 30°-40°

to the ground level. The fruit should be covered by soil not more than 4 to 5 inches in thickness. Next, the decomposed organic manure is again spreaded all over the bed. The texture of soil of a particular place influences the growth and yield of the plant.

Seed of Fruit Propagation

Fruits are thus first sown in well levelled and well manured bed of 2 ft X 2 ft. In a single bed, usually five to six fruits are sown at a time as described earlier, with a distance of six to eight inches between them. Sprouting takes place within 20-30 days. After sprouting, fencing and support is essential to cater to its climbing habit. A '*macchan*' (scaffold) of five to six feet in height is built over the bed. Within five to six months the vegetative growth spreads all over the *macchan* .



Digging for 'jara', the roots.

Vegetative Propagation

The perennial underground root gives rise to new sprouts with the first showers of the next rainy season. Compared to fruit propagation the vegetative propagation gives more fruits. Its cultivation is similar to the fruit propagation system.

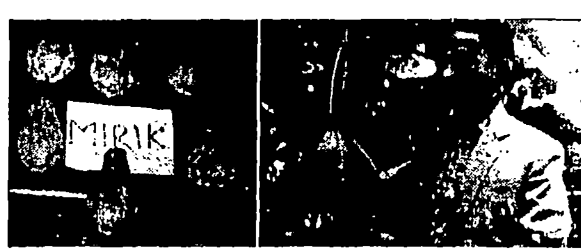
Fruiting season is from the end of June to the end of December. The main product i.e. the fruits are collected when mature. Mature fruits become available from July to the end of December when they are collected and stored in a dry place. In the Darjeeling area, two methods are used by local people for storing fruits;

(i) The fruits can be stored by keeping them under dried soil,
(ii) The fruits are stored in dried saw dust or millet husk.

The total yield of the fruit ranges from 100 to 215 tons per year per hectare (depending on the texture, type of soil, climate and environment). After the vegetative growth is complete and fruits are harvested the tuberous roots are taken out, usually during the winter season.

All the vegetative and reproductive parts of the chayote plant are useful and valuable. The young leafy twigs are used as a green vegetable. The fruit is of special significance in the hills. Simple boiled fruit is the staple food of the hill people. Chayote makes delicious curry and bhaji. It can be used for making pickles, '*channa*' (dried pieces of the sliced chayote fruit) and can replace potato in the kitchen. The unwanted leaves and vines are used as fodder for cattle, pigs, etc. The tuber of chayote is an excellent source of carbohydrate and mineral salts. It is used in curry preparation and may also be sliced into wafers, dried and ground to yield flour of high quality. On the other hand, the paper thin wafers make for good snacks when fried in oil.

Chayote plays an important role in the hill economy especially in the hills of Darjeeling and Sikkim. However, its true potential is quite under exploited. If the fallow land in the hills or the unused slopes and barren ridges are put to chayote cultivation, it will provide a tremendous boost to the hill economy. The government needs to promote its mass cultivation not only for use as a vegetable but also to yield flour for local use as well as for export to other states. Grinding mills can easily be established in the hills even in rural areas. Thus, chayote though neglected is a good source of food for the hill folks as vegetables, a staple food and fodder. Its wider cultivation would also generate new employment opportunities.



The fruit of different regions displays distinctive traits

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Biochemical Analysis on the Effect of Some Plant Growth Regulators During Dark Induced Leaf Senescence of *Sechium edule* Sw. of Darjeeling Hills

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Abstract

Plant growth regulators, coumarin, maleic hydrazide and Na-dikegulac in concentration of 100, 200 and 400 μg/ml arrested senescence by increasing the total chlorophyll, protein, soluble and insoluble carbohydrate contents over the control set in leaves of *Sechium edule* Sw. However, free amino acids and the activities of α-amylase, peroxidase and IAA-oxidase enzymes showed opposite trend with that of enhancement of catalase activity during the induction of senescence in the hill crop. Na-dikegulac exhibited maximum arrestation of senescence in leaves, followed by coumarin and maleic hydrazide.

Chayote (*Sechium edule.* Sw), a squash-like vegetable from family cucurbitaceae (1), is the most beneficial crop in Darjeeling hills of eastern Himalayas (1, 2—9). The colloquial name of the chayote is 'Eskush' among the Darjeeling hill people which is the deformative form of english name 'squash'. It is colloquially and locally known in various parts of the world as christopine, mirlinton, choko, chocho, or quash (1, 2—6).

Recently, this exotic plant in the easteren Himalayas with a good number of varieties (1) has attracted the attention of researchers and local cultivators as it provides three seasonally placed edible products (1, 7, 9), that is, the "munta" a local name for a young twig available during the summer time, the fruit, locally known as "dana" in the rainy to winter season, and roots "jara" available between winter to spring.

Considering the prospects of chayote cultivation in Darjeeling hills, a comprehensive work was undertaken keeping in mind the enhancement of crop prductivity. However, the plant has numerous plus points for cultivation (1), and there are few deleterous characters which are prominent in many cucurbitaceous plants. In the present investigation attempts were made to assess the biochemical parameters and the involvement of plant growth regulators in leaf senescence of detached leaves and to evaluate the early senescence of the contributory leaves of the plant which causes loss of production of assimilates and dirctetly or indirectly related to the crop production.

Methods

Randomized mature leaf samples (leaf age 30—40 day) from 70—75 day old plants of chayote were collected from the adjoining areas of Darjeeling town. The environmental conditions for experiment were as followes : altitude 2,134 m, temperature 20$\pm$2C and photoperiod lasted 10$\pm$2 hour.

Isolated mature leaves were surface-sterilized with 0.1% $HgCl_2$ for 30 seconds and washed thouroughly with running water. Leaves (1 g wet tissue) of *Sechium edule* Sw. (avoiding midribs and veinlets) were placed in sterilized petridishes, separately, containing 2 ml of sterile distilled water (control set) and effective doses of growth regulators, namely, coumarin

(Co), maleic hydrazide (MH) and Na-dikegulac (NaDK) of 100, 200 and 400 μg/ml respectively for 10 days in darkness at 20±2 C. In this short term senescence promoting experiment, the incubation period (10 days) has been considered as the leaves completsly senesce after that period (5). As a further precautionary measure against air-borne and epiphytic micro-organisms, streptomycin sulfhate (25μ g/ml) and Na-penicillate (25 μg/ml) were added to the experimental sets. After exposure, leaves were then washed with distilled water and different biochemical analyses we e performed.

Total chlorophyll and protein levels of leaves were estimated following the methods of Arnon (10) and Lowry et al. (11) respectively. Carbohydrate contents (both soluble and insoluble fractions) was determined following the method of McCready et al. (12). Extraction of free amino acids as done according to the method described by Dwivedi et al. (13) and estimation was done following the method of Moore and Stein (14). Extraction and estimation of enzymes α-amylase, catalase, peroxidase and IAA-oxidase were m a d according the methods of Khan and Faust (15), Snell and Snell (16) as modified by Biswas and Choudhury (17), Kar and Mishra (18) and Gordon and Weber (19) respectively. In each case of enzyme assay, value at zero time was taken as blank, and the activity of each enzyme was expressed as $(A \times Tv)/(t \times v)$ where A is the absorbance of the sample after incubation minus the absorbance at zero time; Tv is the total volume of filtrate, t is the time (min) of incubation with substrate and v is the total volume of filtrate taken in incubation. The activity of each enzyme was expressed as unit/m per g..

The data recorded in the investigation were statistically analyzed at the replication and treatment levels and the least significant(LSD) was calculated at 95% confidence level (20—22).

Table 1. Effect of plant growth regulators on changes in total chlorophyll (mg/g dry wt), soluble carbohydrate (mg/kg dry wt) and insoluble carbohydrate (mg/kg dry wt) contents in detached leaves of *Sechium edule* Sw.

Treatment	Concentration (μg/ml)	Total chlorophyll	Carbohydrate Soluble	Carbohydrate Insoluble
Control	0	2.83	44.4	90.5
Co	100	4.30	94.7	176.4
	200	4.06	104.9	182.2
	400	3.99	100.2	181.2
NaDK	100	4.72	150.8	330.6
	200	4.05	152.0	332.0
	400	3.68	145.9	264.8
MH	100	4.30	66.3	157.0
	200	4.47	119.2	194.4
	400	4.74	112.4	195.7
LSD ($P=0.05$)		0.27	2.4	3.5

Results

Table 1 showed that different concentrations of growth regulators exhibited positive response towards the arrestation of leaf senescence. Data revealed that NaDK (100μg/ml) showed maximum enhancement of chlorophyll content as compared to control set and MH and Co exhibited significant increment in chlorophyll contents. For carbohydrate level, NaDK showed significant enhancement of carbohydrate level but MH (100μg/ml) increased less amount of carbohydrate content.

Table 2 revealed the effectiveness of different plant growth regulators at different concentrations on protein and free amino acids contents. NaDK (400 μg/ml) enhanced protein contents more than other chemicals. Co

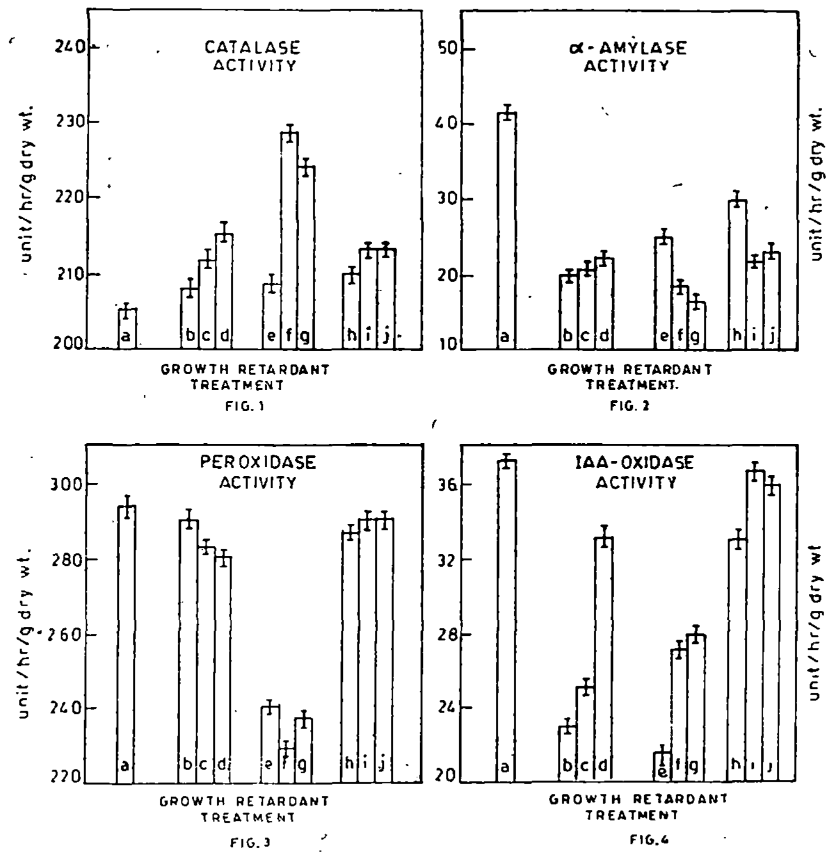

Figure 1. Effect of growth retardants on changes in different enzymes activities of detached mature leaves of *Sechium edule* Sw. (a) Control; (b) 100 (coumarin), (c) 200 (coumarin), (d) 400 (coumarin), (e) 100 (Na-dikegulac), (f) 200 (Na-dikegulac), (g) 400 (Na-dikegulac), (h) 100 (maleic hydrazide), (i) 200 (maleic hydraz de), and (j) 400 (maleic hydrazide).

(100 μg/ml) and (400 μg/ml) and MH concentrations were insignificant to that of control set. Accumulation of free amino acids in the leaf tissues were found highest in Co (100 μg/ml). Increment of free amino acid level in other chemicals was considerably slowed down.

The different enzyme activities were established from the various graphical representation. Figure 1 expressed the catalase activity in different concentrations of chemicals. The maximum activity of the enzyme was recorded in NaDK (200 μg/ml) and followed by NaDK (400 μg/ml). But Co and MH showed less significant effect on catalase activity. Further, NaDK inhibited α-amylase, peroxidase and IAA-oxidase activities in large scale. Co and MH showed non-significant inhibition in α-amylase activity as compared to that of control set. But Co showed less activities of enzy-

Table 2. Effect of plant growth regulators on changes in protein (mg/g dry wt) and free amino acids (mg/g dry wt) contents in detached leaves of *Sechium edule* Sw.

Treatment	Concentration (μg/ml)	Protein	Free amino acids
Control	0	25.95	12.75
Co	100	27.32	10.81
	2 0	29.06	9.05
	400	28.51	9.75
NaDK	100	35.30	5.98
	200	36.59	5.47
	400	37.14	4.91
MH	100	32.99	7.61
	200	31.62	8.02
	400	28.42	9.28
LSD ($P=0.05$)		2.58	4.78

me peroxidase and AA-oxidase.

Discussion

In the literature of leaf senescence in darkness, there are reports that treatments of plant with these chemicals of diverse nature can favorably inflence the leaf senescence (23—29), The results of this investigation showed that dark induced condition enhanced the leaf senescence of *Sechium edule* Sw., as evident by number of reliable biochemical parameters used in this investigation. More emphasis was paid on prolongation or expension of leaf senescence under dark phase by using different effective doses of NaDK, Co and MH. Results obtained were critically examined along with the information available on the impact of plant growth regulators on crop physiology (5, 20, 30—32). Decline of total chlorophyll, protein and carbohydrate levels in control in incubation period was checked temporarily in the presence of NaDK, Co and MH. Though the coumarin retards senescence in lesser extent in some species, the present results indicated that NaDK exposed maximum arrestation of leaf senescence by increasing or decreasing the parameters studied in the hilly plant (21, 30, 33—36). Effect of plant growth regulators on the chayote leaves during dark induced senescence was found that NaDK was superior than the other two growth regulators, that is, coumarin and maleic hydrazide.

References

1. Lama P. C. 1994. Varietal screening, developmental stages, and some physiological and biochemical parameters of *Sechium cdule* Sw. of Darjeeling hills. Environ. Ecol. 12 : 409—415.
2. Aung L. H., A. Ball and M. Kusad. 1989. Developmental and nutritional aspects of chayote (*Sechium edule*, Cucurbitaceae) Econ. Bot. 44 : 157—164.
3. CSIR. 1972. The wealth of India, raw materials, volume 9. CSIR, New Delhi, India.
4. Cook O. F. 1901. The Chayote : A tropical vegetable. USDA, Div. Bot. Bull, 28, NY, USA.
5. Dey B. K. and S. Jana. 1988. Effects of os antioxidants on dark induced changes in some biochemical parameters in detached leaves of *Sechium edule* in Darjeeling hill of the Eastern Himalayas. Environ. Ecol. 6 : 381—385.
6. Esneha K. Amrita. 1995. Iskus ko khetima prayapta labko smabhawana. (in nepali) Sunchari, July 20, 1995, Nepal.
7. Lama P. C. 1995. Chayote-*a* boon to the hills. Debacle 1 : 11—12.
8. Mukhia M., M. Yonzone and T. K. Sadhu. 1982. Studies on squash (*Sechium edule*) of Darjeeling district. Indian Agricul. 26 : 295—299.
9. Sharma N. 1993. Iskus. Journalee. 2 : 4—5.

10. Arnon D. I. 1949. Cepper enzymes in isolated chloroplasts : Polypenoloxidase in *Beta vulgaris*. Plant Physiol. 24 : 1—15.
11. Lowry O. H., N. J. Rosebrough, A. L. Farr and R. J. Randall. 1951. Protein measurement with Folin-phenol reagent. J. Biol. Chem. 193 : 265—275.
12. McCready R. M., J. Guggolz, V. Silviera and H. S. Owens. 1950. Determination of strach and amylase in vegetations, Analyt. Chem : 22 : 1156—1158.
13. Dwivedi S., M. Kar and D. Mishra. 1979. Biochemical changes in excised leaves of *Oryza sativa* subjected to water stress. Physiol. Plant 45 : 35—40.
14. Moore S. and W. W. Stein. 1948. Photometric ninhydrin method for usein the chromatography of amino acids. J. Biol. Chem. 176 : 367—388.
15. Khan A. A. and M. A. Faust. 1967. Effecte of growth terardants on α-amylase production in germinating barley seeds. Physiol. Plant 20 : 673—681.
16. Snell F. D. and C. T. Snell. 1971. Color imetric methods of analysis, volume 4. Van Nostrand Reinhold Co., New York, USA.
17. Biswas A. K. and M. A. Choudhuri. 1978. Differential behavior of the flag leaf of intact rice plant during ageing. Biochemieund Physiologic der Planazen. 173 : 220—228.
18. Kar M. and D. Mishra. 1976. Catalase, peroxidase, polyphenoloxidase activities during rice leaf senescence. Plant Physiol. 57 : 315—319.
19. Gordon S. A. and R. P. Weber. 1951. Colorimetric estimation of indole acetic acid. Plant Physiol. 26 : 192—195.
20. Bhattacharjee A. and S. Jana. 1988. Effects of dikegulac-sodium on developmental stages, senescence and yield of sunflower. Environ. Ecol. 6 : 49—52.
21. Bhattacharjee A. and R. N. Bhattacharjee. 1989. Prolongation of seed viability of *Oryza sativa*. L. cultivar Ratna by Dikegulac-Na. Seed Sci. Techn. 17 : 309—316.
22. Clarke G. M. 1969. Statistics and experimental design, Ist edition. Edward Arnold Ltd., London, UK.
23. Jana S. and M. A. Choudhuri. 1980. Senescence in submerged aquatic angiousperms : Changes in intact and isolated leaves during ageing, New Phytol. 86 : 191—198.
24. Martin C. and K. V. Thimann. 1972. The role of protein synthesis in the senescence of leaves : I. The formation of protease. Plant. Physiol. 49 : 64—71.
25. Purohit S. S. 1980. Studies with a growth regulator, dikegulac II. Effect on protein, suger and total oil contents of *Helianthus annuus* L. Camp. Physiol. Ecol. 5 : 24—26.
26. Rai A. S., D. R. Chhetri and A. Bhattacharjee. 1992. Effect of sodium-dikegulac on maintenance of viability of a few crop seeds under adverse storage conditions Environ. Ecol. 4 : 814—824.
27. Thimann K. V, 1980. The senescence of leaves I. senescence in plants. CRC Press. Inc., Florida, USA.
28. Thomas H. and J. L. Stoddart. 1980. Leaf senescence. Ann. Aev. Plant Physiol. 31 : 83—111.
29. Thimann K. V. 1985. The senescence of detached leaves of Tropaeolum. Plant Physiol. 8 : 1107—1110.

30. Bhattacharjee A. and M. A. Choudhuri. 1986. Chemical manipulation of seed longevity and stress tolerance capacity of seedlings of *Corchorus capsularis* and *C. olitorius*. J. Plant Physiol. 125 : 391—400.
31. Jana S., B. Barua and T. Dalal. 1988. Effect of dikegulac on senescence in *Canna indica* and *Coccinia cordifolia*. Environ. Ecol. 6 : 597—599.
32. Sangeeta and K. A. Varshney. 1991. Effect of gibberellic acid, maleic hydrazide and cycocel on early growth and activities of someoxidoreductase in *Avena sativa* L. : Indian J. Expl. Biol. 29 : 80—82.
33. Bhattacharjee A., S. Halder and K. Gupta. 1984. Influence of dikegulac and growth hormones on senescence and sink strength of sunflower and their impact on crop yield. Burdhawan Univ. J. Sci. 1 : 1—12.
34. Bhattacharjee A. and K. Gupta. 1984. Differential responses of sunflower (*Helianthus annuus* cv. Modern) towards high and low concentrations of dikegulac-sodium. Canadian J. of Bot. 62 : 495—500.
35. Bhattacharjee A. and R. N. Bhattacharjee. 1988. Invigoration of deteriorating sunflower seeds by chlormequat. Environ. Ecol. 6 : 9—15.
36. Bhattacharjee A. and K. Gupta. 1981. Effect of CCC on retardation of seedling growth and metabolism of sunflower (*Helianthus annuus.* L.). Sci. Cult. 47 : 266—268.