STUDIES ON BIOLOGY OF *SECHIUM EDULE* SW. IN DARJEELING HILLS : 1. IMPROVEMENT OF CROP PRODUCTIVITY 2. SURVEY OF ANIMAL PESTS

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This is to certify that the research work of Sri Satyabrata Roy, M. Sc. Assistant Professor in WBES. embodied in the present thesis entitled, "**Studies on biology of *Sechium edule* Sw. in Darjeeling hills : 1. Improvement of crop productivity 2. Survey of animal pests**" has been carried out under our supervision. Sri Roy has followed the rules and regulations as laid down by North Bengal University for the fulfilment of requirements for the award of the degree of Doctor of Philosophy (Science). The results incorporated in the thesis have not been submitted for any other degree or diploma. The help and sources of information availed during the course of this investigation have been duly acknowledged.

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Contents

Summary

SUMMARY

Different germplasms of chayote (*Sechium edule* Sw., Cucurbitaceae) were collected and ten varietal types (named alphabetically A to J) were recorded after a thorough exploration of different chayote growing altitudinal regions Darjeeling hills. Unlike other cucurbits the above ground leafy plant is annual and underground tuberous part of the plant is perennial and all parts e.g. tuberous roots, fruits and tender shoots are used as human food. Phenological studies showed that the leafy plant survives around 160 days and within its life span it shows some distinct developmental phases which include : field emergence phase, first leaf emergence phase, seedling phase, sapling phase, flower initiation phase, fruit formation phase, senescence phase and death phase. Each phase is clearly distinguished by a few key features. Plantation of different varietal types of chayote starts from February, vigours vegetative growth and fruiting takes place during the monsoon months of June and July and harvesting of fruits is completed by October each year.

A plant growth retardant Atrinal or Na-dikegulac (2,3 : 4-6-di-O-isopropylidene-α-L-xylo-2 hexalofuranosate), was applied at three different stages of chayote plant viz., at sprouting stage of fruits (intact or defleshed fruit treatment), at sapling stage (30-day-old plants) and at preflowering stage (60-day-old plants). The chemical-induced changes on growth, metabolism and yield were analysed at different developmental stages of the plant. Atrinal-treated plants at the preflowering stage were given a supplementary treatment with GA_3 (100 μg/ml) or kinetin (100 μg/ml) at the flowering stage of plant development (70-day-old). Effect of such combined treatments on vegetative as well as reproductive growth, metabolism and crop yield were analysed at fruiting and senile stages of plant development.

Intact or defleshed fruit treatment at sprouting stage : Treatment of intact or defleshed sprouting fruits with Atrinal (500, 1000 and 2000 μg/ml), resulted in significant increase of chlorophyll and protein contents in leaves at the seedling and sapling stages only, and subsequent changes recorded at preflowering, fruiting and senile stages were statistically insignificant. Almost an identical trend of changes were noted when soluble carbohydrate, insoluble carbohydrate, RNA and DNA levels in leaves were analysed at the different developmental stages. Corresponding changes in the activities of catalase and peroxidase

enzymes in leaves were recorded. The growth retardant, irrespective of its concentrations, enhanced the activities of these two enzymes at the two initial observation periods i.e., at seedling and sapling stages, and thereafter the chemical effect was nullified. Conversely, activities of IAA-oxidase and RNase enzymes were suppressed by Atrinal treatment at the seedling stage only, and this inhibitory action did not persist at subsequent analyses done at preflowering, fruiting and senile stages.

Atrinal-induced biochemical changes in leaves were associated with the changes of growth parameters like vine length and stem circumference. Regardless of concentrations Atrinal retarded vine length and increased stem circumference, and the effects were found significant up to sapling stage only.

Yield attributes recorded in terms of fruit number, fruit weight and tuberous root weight as well as days to onset of plant senescence remained unchanged by the retardant treatment given at the sprouting stage of fruits.

Atrinal treatment was found to be equally effective or ineffective in case of plants raised from intact or defleshed fruits as in both the cases the chemical-induced effects were significant at seedling and sapling phases of plant development. At subsequent analyses Atrinal-induced changes were found to be ineffective in both kinds of plant samples raised either from intact fruits or defleshed fruits.

Thus, in case of fruit (intact or defleshed) treatment the retardant could render only a transient effect on the growth and metabolism of chayote plants and such changes were not at all reflected in yield attributes.

Foliar treatment at sapling stage : Foliar application with the same concentrations of the growth retardant at the sapling stage (30-day-old plants) caused a significant reduction of chlorophyll, protein, soluble and insoluble carbohydrates as well as DNA and RNA levels in leaves at the initial observation period of sapling stage on 40-day-old plants. The inhibitory effects were found transient and the chemical subsequently augmented the levels of these cellular components.

Activities of the enzymes catalase and peroxidase were declined shortly after foliar application of the Atrinal but this retardation effect was not only alleviated quickly but the activities were found even higher at Atrinal-treated plant samples analysed at fruiting and senile stages. A reverse change in the activities of IAA-oxidase and RNase was recorded where the retardant-induced transient increase in the enzyme activities were followed by a consistent decrease till senile stage. Unlike the retardant-induced differential biochemical changes with respect to growth stages of the plant, vine length was retarded and stem circumference was increased by Atrinal treatment and such retardation or enhancement effects were found to be maintained throughout the observation periods.

Atrinal showed a tendency towards deferring leaf senescence of chayote plants but among all the concentrations Atrinal 1000 and 2000 µg/ml showed significant senescence deferral effect. Again a significant increase of yield components like fruit weight and tuberous root weight per plant was recorded in Atrinal treated plants.

Thus, unlike fruit (intact or defleshed) treatment, effect of foliar treatment with the growth retardant was found to fairly persist till senile stage and the changes of the growth and biochemical parameters were associated with a substantial increase of yield components.

Foliar treatment with Atrinal at preflowering stage and Atrinal followed by hormonal treatment of flowering stage : Atrinal, irrespective of its concentrations, resulted in increase of chlorophyll, protein, soluble carbohydrate, insoluble carbohydrate, RNA and DNA levels in leaves of chayote plants at both fruiting and senile stages. However, the retardant-induced increases were further augmented by GA_3 and kinetin treatments at flowering stage.

Like the changes of the above biochemical parameters, almost identical trend of changes was recorded in catalase and peroxidase activities, and GA_3- as well as kinetin-induced additive effect was found to be very prominent. Changes of IAA-oxidase and RNase activities were found to be reverse to that of peroxidase and catalase. Here the retardant-induced decrease of IAA-oxidase and RNase activities were reduced to a further extent in supplementary treatments with GA_3 and kinetin.

Atrinal-induced reduction of vine length was overcome to some extent by the second treatment with GA_3 and kinetin. On the other hand, the retardant increased stem circumference and the effect was found additive in supplementary treatments with kinetin. Atrinal showed a tendency towards deferring of leaf senescence and senescence deferral effect was found significant in the single treatment with Atrinal (1000 and 2000 µg/ml) and in combiend treatments with Atrinal and kinetin. Yield attributes like fruit weight and tuberous root weight were augmented by the retardant treatment and this augmentation was much more remarkable in combined treatments particularly with kinetin. Atrinal, however, failed to increase particularly the number of female flowers per plant while combiend treatments with GA_3 and kinetin remarkably increased both female and male flowers. Again, the combined treatment with Atrinal and GA_3 exerted the best response on increasing female flowers than such treatment with Atrinal and kinetin..

Regulatory action of the growth retarding chemical Atrinal and its promising role on augmentation of crop yield are discussed.

Review of the Literature

REVIEW OF THE LITERATURE

Review work of this investigation is dealt under two major captions: 1. On the biology and prospects of chayote (*Sechium edule* Sw.)-the experimental plant and, 2. On Atrinal (Sodium dikegulac) – the key plant growth regulant.

1. ON THE BIOLOGY AND PROSPECTS OF CHAYOTE (*SECHIUM EDULE* SW.) THE EXPERIMENTAL PLANT

Botanical Characters

The chayote suggests the cucumber rather than any other of the cultivated plants of the same family, but is a larger and more vigorous plant, climbing widely by means of numerous branched tendrils. The leaves are strongly three-angled or lobed, with the broadly cordate base also showing two or four sharp corners. The leaves as they stand in nature are deeply concave, with the apex sharply decurved. The surface is rather rough, but there are scracely any hairs, and the color is a deep, fresh green. The whitish veins are rather conspicuous.

The pistillate flowers are solitary, but otherwise not greatly different in general appearance from the much more numerous staminate blossoms. The latter are borne on special branches, which are often described as "short whorled, long-stalked, axillary racemes," though it is not clear that they are either racemes or whorled, the actual structure consisting merely of single small clusters at the nodes of a shortened and leafless, branch. Both filaments and styles are connate into a central column, of which the anthers appear as lobes, while the stigmas are more closely set together to form a small head. The ratio of male and female flowers per flowering leaf axial becomes roughly 25:1. Pollination occurs by bees or insects, pollen grains are polycolpate, 8-9 colporate, oblate, 52-55 µm, spiniferous; chromosome complemant is n=14.

The ovary is always one-celled, with a single ovule. It is mealy-pubescent when young, becoming spiny with maturity in some varieties. The mature fruits are more or less compressed, as though built over the large flat seed. They are also, in general, pear shaped, in that they are narrower near the point of attachment and broader toward the apex. In addition to the spines, which, however, are not always present, the surface of the fruit is usually more or less uneven, and has, in addition, several deep longitudinal grooves or channels, more pronounced toward the ends, and in some varieties nearly obliterated near the middle. In different varietal types of chayote found in Darjeeling hills the shape, size, colour, texture varies.

Vitality of the Fruit

The fruit of the chayote presents unique physiological and morphological adaptations. It is comparable, perhaps, with that of the mangrove (*Rhizophora*), though the similarity extends only to the fact that germination may take place before the seed falls from the parent plant. The fruit of the mangrove is adapted for taking root in the soft mud, into which it penetrates by means of the long, pointed radicle, but in the chayote, which must fall upon drier ground, a projecting radicle would be broken off. Instead of putting forth a radicle, the apex of the mature seed is extruded from the fruit only far enough to expose the tip of the hypocotyl, from which arises a tuft of small roots. The plumule escapes laterally from between the cotyledons, which are not further drawn out or separated from the fruit, and the latter, instead of drying up or decaying at maturity, or before the germination of the seed. Unlike other cucurbitaceous members the fruits of chayote are hardy and can withstand adverse environmental situations. By virture of having such uniue property they can be safely stored for a prolonged period without losing the quality and food value (Lama, 2000).

That such an adaptation should arise in the Cucurbitaceae is even more strange than it would have appeared in many other families, owing to the well-known perishability, or at least limited vitality, of the fruits of this group. The chayote constitutes, as it were, the antithesis of the balsam-apple (Momordica), the flesh of which opens and begins to disintegrate, almost by deliquescence, as soon as the apical seeds have matured, and while those at the base of the fruit are still far from ripe.

The Seed and Germination

The chayote further deviates from the normal type of the Cucurbitaceae in its one-seeded character, and in the fact that the seed coats are obsolete or very imperfectly differentiated. At maturity the seed is embedded in the middle of the fruit and entirely enclosed. But before germination the seed grows so that the apex of the cotyledons is pushed further toward the base of the fruit, while the hypocotyl emerges from the apex and gives rise to several rootlets. In the middle of the outer faces of the cotyledons, there is a considerable surface, representing the original area of the seed, which remains closely in contact with the fleshy and undifferentiated seed coats. It is in this area of the cotyledons, presumably, that the absorption of the nutritive material from the fruit into the seedling takes place (Cook, 1901).

In the chayote a whole fruit functioning as endosperm during an extended period in which it is capable of general vegetative activity. Possibly, however, the nutritive aspect of its utility may be equaled or even exceeded by its importance as a means of storing moisture to assist in carrying the young plant through periods of drought. The large tuberous roots which meet this requirement for the more mature plant are said not to be formed until the second season. A third posible advantage of the species is that by being able to send out without delay a vine several feet long, seedlings of the chayote might be able to make connection with the soil without the seed or fruit having come in contact with the ground at all. Such as adaptation would be of obvious utility in permitting a large-fruited species to maintain an existence where the ground is covered with tangled masses of vegetation (Cook, 1901, Mukhia *et al*, 1982).

The keeping qualities of fleshy fruits and vegetables are dependent upon the vitality of the protoplasm of the cells. Many fruits can be kept for considerable periods under favourable conditions and the time can be artificially extended by cold storage. In nature, the chayote seems to furnish the instance of a fruit which normally continues alive even after the germination of the contained seed and after separation from the parent plant. The readiness with which the seed of the chayote germinates is probably be the only obstacle to its exploitation as a commercial product. What determines the germination is not exactly known, and it may be found that if kept sufficiently dry and cool condition there will be no difficulty from this source. In Mexico, according to Dr. Edward Palmer, it is considered an easy matter to preserve the fruits indefinitely by packing them in dry sand. It is customary to allow the seeds to germinate before planting the fruits being placed for this purpose on the shelves of living rooms or in other sheltered places. About New Orleans a similar practice is followed, fruits kept for planting being wrapped in paper and laid away in cool dark cellars or storerooms during the winter. Chayotes shipped from Algeria to the markets of Paris and London are said to bear shipment well, even when eight or ten days on the journey, and to remain for a long time in good condition (Cook, 1901). In Darjeeling hills the local cultivators, after harvest, keep fruits in dry air for 15-30 days and then store in dry sawdust or millet husk in dark and cool place (Shil, 1990, Lama, 2000).

Varieties of Chayote

Cook (1901) and others reported the existence of two very distinct varieties of *Sechium edule*, the first with green colored fruit and the other with white one. There exists differential flower colors of the varieties i.e., the white variety has green colored flowers and large in size than the green variety with white and small flowers. Cook (1901) also reported that in Porto Rico, there were five varieties of the plant and one of the white kinds being as small as any of the green variety of the two varieties grown in Madeira, the cream colored or white variety was larger in size. Engels (1983) reported eleven varieties of chayote from Central America. Lama et al (1994) reported ten varieties of chayote from Darjeeling hills.

Chemical and nutritional composition

The most ancient literature on chemical composition of chayote plant as searched by the present worker is the work of Cook (1901) who analysed the composition of edible storage tuberous roots of chayote. In 100 parts of the tuber, he estimated, 71% water 20% starch, 0.2% ether soluble resinous material, 0.32% sugars, 0.43% albumen, 5.60% cellulose, 2.25% minerals. Aung *et al.* (1976; 1990; 1991; 1992) found that the storage roots of a light-green type of chayote contain 0.6% soluble sugars and 13.6% starch on wet weight basis. Thus the ratio of starch : sugar in the tuberous root is 23 : 1. Again, they found 0.3% soluble sugar and 0.7% starch in young apical shoots. Analysis of the chayote fruit flesh showed 3.3% soluble sugar and 0.2% starch, in the seed 4.2% soluble sugar and 1.9% starch was found on wet weight basis. They observed that fruit contains 15 and 25 time more soluble sugar than tuberous root and apical shoots respectively whereas starch content is very much less. Aung and his associates (1976; 1978; 1990; 1991; 1992) further recorded that the carbohydrates in chayote consist of fructose, glucose, sucrose, sorbitol, raffinose, stachyose and starch. In the vegetative shoot, the fructose content was four times and glucose content was two times greater than sucrose or sorbitol. In the male flower, 79% of the soluble sugars consisting of fructose and glucose were found in the floral disc nectaries. In the androecium, sucrose content was 1.2 times greater than fructose or glucose. The fruitlet was found to contain six times more fructose and glucose than sucrose. In the immature fruit, the starch content was higher in the seeds (85 $\mu g.mg^{-1}$ dry wt.) than the flesh (75 $\mu g.\ mg^{-1}$ dry wt.) Lama *et al.* (1994) reported that among the three chayote types growing in three different altitudinal zones of Darjeeling hills, the type growing in Mirik was superior in all respects, particularly in yield attributes.

As compared to young fruits, protein and insoluble carbohydrate levels were found high in mature fruits. But soluble carbohydrates remained at low level in mature fruits. On the other hand, catalase, dehydrogenase, and α-amylase showed maximum activities in mature fruits. Flick *et al.* (1978) reported that chayote fruit contain high moisture and low nitrogen and about 0.4% crude fibre on the whole fruit. The seed of the chayote was considerably higher in all 18 amino acids than the flesh. Methionine was detectable in seed but not in the flesh. Of the total nitorgen 59.9% was protein nitrogen. The activities of different enzymes like ATPase, F-1,6 dipase, G-6-Pase and G-1-Pase were observed in chayote. ATPase and G-1-Pase were observed in chayote. ATPase and G-1-Pase showed highest and lowest in seed and flesh respectively. ATP substrate introduction accelerated phosphatase activities more than Glucose-1-6-phosphate. The other activities decreased in the following order : F-1-6-dipase, α-glycerol phosphatase, G-6-Pase and phytase. Skin of the fruit showed maximum phosphatase activities than the seed.

Apart from the work of Aung, Ceccarelli and Lorenzi (1982, 1983, 1990, 1992) variously documented the endogenous hormonal regulation on chayote seed and its germination. Ogawa (1966) reported the first existence of 'water soluble' gibberellin like substances in developing chayote seeds. Albone *et al.* (1984) reported the presence and localization of gibberellin catabolites in the testa. It is reported that the immature fruits of chayote contained very high levels of growth regulators, particularly gibberellins and cytokinins (Lorenzi, 1988; Cecarelli, 1992). A thorough investigation on the endogenous gibberellins and cytokinins in chayote seed revealed that the endosperm tissues of the chayote seed contained maximum gibberellins than other plant parts.

It has been demonstrated that endosperm and cotylendons synthesized gibberellins simultaneously in the seed, which can be directly proved by the work with cell-free systems. Endosperm and cotyledons of *Sechium edule* at different stages of seed development were found to contain three novel GA conjugates namely a glucoside of 16-

17 dihydro-16-hydroxy-GA_{15}, the 3-propyl-or 3-acetyl-GA_4, the 3-propyl or 3-acetyl-GA_{15}, the 3-propyl-or 3-acetaly-GA_4, the 3-propyl or 3-acetyl-GA_7. The function of these conjugates are not well understood. The *S. edule* GA glucoside is biologically active in the lettuce and rice bioassay. In GA glucoside, the aglycone resulting eventually from enzymatic hydrolysis would not bear structural characteristics assuring biological activity thus it seems reasonable to hypothesize that the observed biological activity would result from its further metabolism. This suggested that GA conguates act as a transporter or storage form of *S. edule*. The endosperm of chayote contains high amount of GAs both free and conjugated *in vivo*. The lower ABA concentration in pollinated ovules than unpollinated ovule suggested that the pollination accelerated the ovule growth in faster rate which caused dilution of ABA level continuously. Apart from these two hormones, Gibberellins and ABA, *S. edule* seeds contain significant amount of cytokinins like zeatin, riboside, ribotide and O-glucoside. Vansuÿt and Zinsou (1986) reported that agatine, the immediate decarboxylation product of L-arginine in floral buds and apical part of the leaves accumulated more agmatine than basal part. The accumulation of agmatine during the flowering stage considered as a good biochemical marker for cell division in chayote. Vozari-Hampe *et al.* (1992) suggested that the exudate of *S. edule* fruit contained lectin which was rich in glycine, leucine, asparagine/aspartic acid, glutamine/glutamic acid and serine residue, without detectable amount of methionine and hydroxyproline. The purified chayote lectins were non-specific towards human erythrocytes of A,B or O groups. Besides the above-mentioned chemical composition of chayote, MacLeod (1990) reported different, volatile components of chayote. A total of 61 components were identified and four were partially characterized and these are represented in the following table.

Volatile components of the chayote : (DB5 column GC-MS)

Components	Rt (min)	Kovats Index	%RA (relative abundance)	Odour
Butanedione (i.e., diacetyl)	7.43	575	0.1	Sweet, creamy, buttery
Hexane	7.71	600	6.1	
2-methylbutan-2-ol	9.77	-	0.1	
3-methylbutan-al	10.64	649	0.7	fresh green, fragrant, chemical solvent
Cyclohexane	11.08	677	0.2	stale green, chemical solvent
2-methylbutanal	11.24	651	0.3	sweet, rotting fruit
Pent-1-en-3-ol	12.33	673	0.3	green, buttery
Pentane-2, 3-dione	13.25	681	0.2	buttery, caramel, toffee
Pyridine	17.05	695	0.4	stale grass,chemical solvent
2,4-Dimethylhexane	18.79	-	0.1	
Toluene	19.12	765	tr.	chemical solvent
3-methylheptane	19.44	-	0.6	
A dimethylcyclohexane	19.99	-	0.3	sap-like, fragrant.
Octane	21.83	800	0.6	oily/fatty, sweety, rancid
Hexanal	21.94	780	1.3	green,grassy,fragrant, oily/fatty
2-Furaldehyde/furfural	24.82	815	tr.	oily/fatty,caramel, roasted
(E)-Hex-2-enal	26.89	832	0.1	green, grassy, beany, fragrant.
(Z)-Hex-3-en-1-ol	27.16	847	10.1	fresh cut grass,green
Hexan-1-ol	28.25	858	1.1	green, grassy, fragrant, earthy, oily
Benzaldehyde	37.18	947	tr.	nutty, almonds
Oct-1-en-3-ol	38.46	968	10.4	green,grassy,earthy, musty, mouldy, cucumber like
2-Pentylfuran	39.71	983	0.2	green, hay, rubbery
(E,E)-Hepta-2, 4-dinal	41.39	989	0.1	oily/fatty,putty,green, cucumber-like

Contd...

4-iso Propyl-1 methylbenzene (i.e.-p-cymemne)	42.30	1020	tr.	fragrant
Limonene	43.24	1022	3.0	sweet,fragrant,lemongrass
Phenylacetaldehyde	44.65	1024	0.1	floral,fragrant,roses, hyacinth
Decan-2-one	56.72	1176	0.1	fragrant,caramel
Napthalene	57.30	1172	tr	fragrant, camphoraceous
Benzothiazole	60.31	1202	tr.	
2-Methoxy-4-vinylphenol (i.e.,p-vinylguaiacol)	66.60		0.2	stale,musty,cooked beans,cloves
1-methylnaphthalene	67.10	1298	tr.	roasted cereal,hay like
2-vinylnaphthalene	71.82		0.1	sweet, fragrant.
Diethyl phthalate	85.78	1565	0.1	
Tetradecanoic acid	94.97		1.4	slightly oily,waxy
Octadecane	97.14	1800	0.6	musty/mouldy,cereal like.
Phenanthrene	98.33		tr.	
Di(2-methylpropyl) phthalate	102.14		0.9	
Nonadecane-1-ene	102.30		2.2	
Nonadecane	103.22	1900	1.3	fragrant
Hexadecanoic acid	108.12		7.2	
Eicos-1-ene	108.66		0.3	
Dibutyl phthalate	109.09	1922	8.2	
Eicosane	110.99	2000	2.5	
An aliphatic acid	113.39		2.0	
Heneicosane	121.15	2100	1.1	
Octadeca-9, dienoic acid (i.e. linoleic acid)	127.84	16.4		
Docos-1-ene	134.63	1.1		
Docosane	138.49	2200	10.9	musty/mouldy,leathery.
Tricosane	147.45		0.6	
Tricosane	153.21	2300	1.8	sweet
Tetracosane	178.37	2400	1.2	
Pentacos-1-ene	212.87		0.9	
Pentacosane	227.05	2500	0.8	
Dioctyl phthalate	234.66		0.5	

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* Adopted from "Volatile components of chayote" by G.MacLeod, 1990.

Distribution

The chayote is a popular and an important home grown food in tropical and subtropical regions of the New World. It is well spread and cultivated in West Indies, throughout Southern Europe, Southern United States and Russia, East Indies, Australia. In Asian countries, it is cultivated in Sri Lanka, Mascarene Islands, Malayasia, Nepal, Philippins, India and so on. In India it is mostly cultivated as vegetable in the hills of India. In the state of Megalaya, Sikkim, Uttar Pradesh, Himachal Pradesh, West Bengal, Karnataka and Maharastra of India this crop is grown luxuriantly in temparate and subtropical regions (Chakravorty 1973). The crop can be grown with relative ease due to its adaptability to a wide range of climatic conditions. Louis and others reported the existance of the plant in areas at sea level to regions with altitudes between 4000 to 7500 ft. The crop can tolerate cold but succumbs to prolonged hard forst and hence it can be grown even in high altitudes.

Common and scientific names of chayote

Unlike other plants, this plant has many common names. Although it is not very widely distributed, it has a lot of localized names. Cook (1901) assumed that variable names of the plant was due to slow and gradual introduction in new communities of the world. And the name has forgotten before the fruit had obtained standing in the markets and thus required a popular designation. In India, the differential naming of the plant is due to varied regional languages. A list of common names of chayote is given herewith (Cook, 1901).

CAHIOTA – Recorded in Lowe's " Flora of Madeira".
CAMOCHAYOTE – A mexican name for the edible root of the chayote.
CHAHIOTA – Another Madeira name.
CHALLOTE – Recorded by Seeman from the Isthmus of Panama. In a subsequent mention the more correct form, chayote is used.
CHAYOTA – A West Indian form of the following, used by Jacquin and others.
CHAYOTE – The modern Mexican and now generally preferable name of which several others are more corruptions.

CHAYOTE FRANCES – According to Jacquin, this name was applied in Cuba to a small, smooth variety of the chayote, but Maza associates it with the Sponse gourd (Luffa).

CHAYOTE PELON – A mexican name, evidently for a smooth variety. " pelon" meaning bold.

CHAYOTESTELE – A mexican name, for the edible root of the chayote.

CHAYOTITO – A mexican name for a variety of chayote (Herrera).

CHAYOTITO GACHUPIN – A mexican variety of chayote, "gachupin means "fine" or "elegant".

CHAYUTLI – The ancient Aztec name as recorded by Hernandez in the sixteenth century. This is said to signify a " head bristling with spines" or a " squash covered with throns".

CHINCHAYOTE – A mexican name for the edible root of the chayote.

CHIOTIE – Used in Belt's Naturalist in Nicaragua.

CHOCHO – The prevalelnt name in the British West Indies and in Australia.

CHOKO – A Queensland variation of the preceding.

CHOU – CHOU – Recorded by Mr. Faichild as in use among the creoles of Louisiana.

CHOUCHOUTE – From the French colonies particularly Reunion; evidently a compromise between the preceding and 'chayote'.

CHOW – CHOW – An English rendering chou-chou.

CHRISTOPHINE – Reported from the French West Indies and France.

CHUCHU – The Brazilian name; evidently a further corruption of 'chocho'.

MIRLITON – In use among the creole population of Louisiara.

ONE – SEEDED CUCUMBER – Apparently inverted by the English-speaking residents of New Orleans.

PERINELLAN – Madeira (Lowe).

TALLOTE – Known only from Porto Rico.

TAYOTE – The Porto Rico modification of the name chayote.

UPOPO – A Mexican variety of chayote (Herrera).

VEGETABLES PEAR – British West Indies (Grisebach).

Apart from the above, there are several common names for chayote in different parts of India, which are listed hereunder :

ESKUSH - Indian name for the varieties of chayote which is the corruption of English world for 'squash'. This name is common in Darjeeling hills.
QUASH – A Bengali name for chayote and it is also the corruption of English word 'squash'.
SOH-KWASH – Name used by Khasi – hill people for chayote of eastern India.
SEEMA – KATTIRIKKAI – South Indian name, designated by Tamilnadu people.
SEEMA – BADAIVE – Name for chayote, in the Karnataka state.

Scientific Name :

In 1760, Jacqlin proposed the first botanical name '*Sicyos edulis*' to the chayote under the binomial system of nomenclature. Later in 1780, the same author changed the above name and called it by the latinized form of the native name, *Chayota edulis*. After 20years Swartz used the name, proposed by Patrick Browne in 1756, *Sechium*. This name was not employed under the binomial system until the time of Swartz. There are three opinions as to nomenclature of the plant; the first one emphasises the binomial name proposed by Swartz, that is, *Sechium edule*; the second one gives importance on Jacquin's name as the oldest acceptable binomial designation, while third opinion would favour Sechium simply because older as a generic name than *Chayota* or *Sicyos* without regard to the binomial system. In 1763 Adanson had also proposed to replace Brown's name *Sechium*, with the vernacular chocho, but this name was not popularised.

Economic importance and Commercial Prospects

Chayote has immense economic potential and commercial prospect as a vegetable crop in many countries of the world including India. This is mainly because of its easy cultivation procedure, considerable food value of all its plant parts like fruits, tuberous roots and leafy shoots, prolonged storage capacity of its fruits and tuberous roots. It is often called a zero management crop with high yield potential.

The chayote is one of the most important of the indigenous economic plants of Mexico, and that it is the superior of the potato in the quality and quantity of its products. Its culture is rapidly increasing in Mexico and it is one of the most important of cultivated plants since it furnishes palatable and wholesome foods which can be produced with extreme cheapness. The single seeded character of the fruit is a serious impediment to its rapid introduction and multiplication in culture (Cook, 1901). In tropical America, France, Cuba, Australia, North Africa the cultivation of this vegetable crop is being popularized gradually.

In Algeria, although chayote was introduced as early as 1845, and highly recommended in 1860 by M. Hardy, the then director of the experimental garden of Algeria, it has increased in popularity very slowly for many years, and now it has become a commercial product of serious importance. Bulk export of chayote takes place from Algeria to different countries. Its utility as a substitute for the base of the true artichoke in high-priced dishes is a suggestion that it will find other places in the elaborate cuisine of Paris and other large cities of Europe.

Endogenous hormonal levels of chayote

Maturing seeds of *Sechium edule* Sw. contain very high levels of free and conjugated gibberellins throughout seed development; both free and conjugated gibberellic acids (GAs) are abundantly present also at the completion of seed development. Various studies regarding the identity and the endogenous levels of seed GAs have been published. In 1983, Cecearelli and Lorenzi first reported on the structure and concentration of biologically active GAs in the endosperm and cotyledons of seeds at different developmental stages. A detailed analysis of the GAs present in the different seed components of *Sechium edule* Sw. was also reported by Albone *et al.* (1984). Biosynthessis of major endogenous GAs was also shown in cell-free systems prepared from both endosperm and cotyledons of maturing seeds (Ceccarelli and Lorenzi, 1983). The purification and identification of the conjugated GAs present in the seed were reported (Lorenzi and Ceccarelli, 1986). These conjugates were biologically active in the standard GA bioassays (lettuce hypocotyl and dwarf rice). Consequential to the studies Cecearelli and Lorenzi (1992) investigated the hormonal relationship between fruits, developing seeds and the mother plant and between the mature seed and the derived plantlet. The authors showed that removal of fruit and seed teguments was ineffective on plantlet growth while the removal of cotyledons arrested growth under short days. They suggested that the control of early plantlet growth by cotyledons under short day conditions may be mediated by GAs.

Immature seeds of *Sechium edule* Sw. are a rich source of GAs, the structure and approximate concentration of the different GAs present in seed tissues have been determined (Lorenzi and Ceccarelli, 1983; Albone, et al., 1984; Lorenzi and Ceccarelli, 1986). Previous work (Ceccarelli and Lorenzi, 1983) has demonstrated that cell-free systems prepared from endosperm and cotyledons of immature seeds are able to convert MVA to the endogenous C_{19}-GAs present in the tissues.

Seeds of *Sechium edule*, a viviparous species, contain high levels of gibberellins and cytokinins throughout seed growth and development (Lorenzi and Ceccarelli, 1983; Lorenzi, et al., 1988). Endogenous levels of ABA in the same seeds have been also investigated (Gnagnarini and Lorenzi, 1985), and absence of hormone accumulation in coincidence with the maximal seed growth as observed in other species (King, 1982; Ackerson, 1984), has been noticed. Paolo, et al, (1989) reported on the quantification of ABA in integuments and nucellus of pollinated and unpollinated *Sechium* ovules. They showed that in unpollinated ovules ABA concentration was higher in comparison to that in pollinated ovules of *Sechium*.

2. On Atrinal (sodium dikegulac) – the key plant growth regulant

In agricultural and horticultural practices manipulation of growth and development is an absorbing area of research by the plant physiologists. People of even prehistoric times learned to check excess vegetative growth of crop plants simply by detopping or by incapacitating them to uptake adequate nutrients and water from soil i.e. by rendering them to experience some sort of artificial starvation. In recent years a new class of organic chemicals has appeared with the special characteristics that they can retard or defer growth processes in plants, and these are termed ‘growth retarding chemicals’ or ‘growth retardant’ (Cathey, 1964). Dikegulac-sodium (sodium 2,3: 4,6-di-O-isopropylidene-α-L-xylo-2-hexalofuranosate) or ATRINAL (trade name), has established itself as a potent chemical belonging to this group. Since its first report by Bocion *et al.*, (1975) from Dr. R. Maag Ltd., Switzerland, a considerable volume of work on different aspects of grwoth, development, metabolism and yield of a number of plant species has been accumulated (de Silva *et al*, 1976; R zee *et al.*, 1977; Malstrom and McMeans, 1977; Sanderson and Martin, 1977; Hield *et al.*, 1978; Zilkah and Gressel, 1980; Wilson and Nell, 1983; Purohit and Chandra, 1983; Jaafar, 1984; Bhattacharjee *et al* 1986). Particularly due to its chemical pinching property, the chemical evokes attention of quite a good number of horticulturists in different countries of the world. It is now being used as a very good substitute of manual pinching by arborists, highway maintenance divisions and landscape contractors for woody and herbaceous perennials.

Dikegulac, produced as an intermediate product in the commercial synthesis of L-ascorbic acid, is a sugar hormone which is monosaccharide in nature and of the different salts, sodium-linking to it was found to be most effective with respect to exhibiting the hormonal activity. Hence sodium-dikegulac (or dikegulac-sodium) was recommended as a potent synthetic growth hormone. On the basis of physiological responses elicited by dikegulac, it seems that the chemical is close to morphactins.

Among other growth retardants, it has also some resemblance with cycocel (CCC) and Alar (SADH) with respect to their common biological action although structurally the chemical is quite different from them (Bhattacharjee *et al* 1986). Arzee *et al.* (1977) demonstrated that it works counter to auxins or to gibberellins but it is neither an anti auxin or an antigibberellin in true sense. The chemical possesses extremely low bee, fish and mammalian toxicity; it is not irritant to eyes and skin (de Silva *et al.*, 1976). Physically it is white, odourless, solid with a m.p. 300°C and does not exhibit photosensitivity. Na-dikegulac is stable in aqueous solutions at pH 7 and above, highly soluble in water, methanol and ethanol and less soluble in chloroform, acetone, cyclohexane and hexane.

A thorough literature search revealed that since its first report in 1975 over 200 publications have appeared on dikegulac covering various research fields. The present review is based on the reports of some of the experimental works available with this chemical during the last decade or more investigation.

Seed germination and hypocotyl growth

A few reports are available on the effect of dikegulac on the germination behaviour of seeds. Dikegulac does not significantly alter germination percentage of sunflower (Purohit, 1979; 1980a; 1980b) or *Brassica campestris* (Purohit 1980c) seeds but it specially inhibits the radicle and hypocotyl elongation at the low concentration range (50 to 250 µg/ml) of the chemical tested. Using a higher concentration range of 500 to 1000 µg/ml, Bhattacharjee and Gupta (1985) reported that dikegulac slowed down the process of seed germination of sunflower but did not affect the final germination percentage i.e. the inhibitory effect was merely transient. However, hypocotyl length was markedly reduced irrespective of the concentrations used. Results obtained with different crop plants (*Helianthus annuus, Brassica campestris, Glycine max, Zea mays and Allium cepa*) revealed that the reduction in hypocotyl and radicle lengths was concentration dependent. The radicle turned brown and became curved, stunted and swollen (Purohit 1979; 1980b,c; Purohit and Chandra, 1981). There are some reports that loss of germinability of jute (Bhattacharjee *et al.*, 1986), sunflower (Bhattacharjee and Gupta, 1985) and rice (Bhattacharjee and Bhattacharyya, 1989) seeds under conditions of accelerated ageing treatment was found higher in dikegulac-pretreated seeds. Hypocotyl length of 6-day-old sunflower seedlings, raised from seeds pretreated with dikegulac was found to be reduced to 29.1%, 16.8% and 11.6% over control seedlings at 2000, 1000 and 500 µg/ml respectively (Bhattacherjee, 1984).

Along with seed germination, associated biochemical changes in cotyledons of germinating sunflower seeds were found to occur during the process of germination (Bhattacharjee, 1984; Bhatacharjee and Gupta, 1985). He observed low level of soluble carbohydrate in cotyledons of dikegulac-pretreated seeds up to 96 h after seed-soaking, while an inverse picture was noted as to the changes of insoluble carbohydrate level. Free amino acid content as well as DNA and RNA levels were found to be low up to 72h of seed germination, while in later observation periods a clear increasing trend was apparent. Dikegulac distinctly reduced α-amylase activity at the initial observation period but this inhibitory effect was erased subsequently. All such observations can explain the temporary inhibitory action of dikegulac on germinability of sunflower seeds. The author suggested that owing to subdued availability of soluble carbohydrate, amino acids, nucleic acids as well as α-amylase, transient hindrance of seed germination was apparent in sunflower.

Seedling growth and metabolism

There are reports in the literature that dikegulc influences seedling growth and metabolism of a good number of plant species (Bocion and de Silva, 1976; Arzee *et al.*, 1977; Shemy, 1978; Purohit, 1979, 1980a,b and c). Arzee *et al.*, (1977) showed that the overall seedling growth of zinnia, sunflower and chrysanthemum was affected with regard to the shortening of internodes, abnormal growth of leaves and disruption of apical dominance. The authors showed that in zinnia axillary shoots were also developed as a result of 750µg/ml dikegulac application and intervascular chlorosis of leaves was apparent. However, in all the three species dikegulac-induced convoluted and chlorotic leaves later regreened. Histoautoradigraphic studies showed that DNA synthesis was inhibited in the apical meristem, and normal cytohistologic zonation was no longer apparent. In their investigation, they also showed by whole plant autoradiography that dikegulac moved towards acropetal direction and triggered its physiological action from the shoot tips. The authors suggested from their data that dikegulac acted selectively on meristematic cells in the apex and developing leaf primoridia, and a minute amount of the chemical was sufficient to effect changes in the apical development. Shemy (1978) reported that *Citrus* seedlings, which were treated with up to 0.3 µg dikegulac per seed, elongated their shoot 20% more than the control seedlings. He found some gibberllin-like activity of dikegulac at its low concentration on rice, lettuce and cucumber seedlings. The author, however, stated that dikegulac had distinct inhibitory effect at concentrations higher than 10^{-3} M. Several reports revealed that dikegulac reduced the seedling growth of sunflower (Purohit, 1979, 1980a,b), *Avena sativa* (Purohit and Chandra, 19800, *Brassica campestris* (Purohit, 1980c), or *Glycine max* (Purohit and Chandra, 1980) and the effect was found to be concentration dependent. Purohit (1979, 1980a,b) reported that concomitant with the reduction of seedling growth, dikegulac adversely affected chlorophyll biosynthesis, reduced protein and sugar contents, inhibited the growth of primary as well as lateral roots. The authors also showed that dikegulac-induced inhibition of growth and chlorophyll biosynthesis in *Avena* could be effectively overcome by GA_3 treatment. They also noted that 50 to 100 µg/ml dikegulac was sufficient enough to cause chlorotic effects in cotyledonary leaves of *Helianthus annuus* seedlings.

Bhattacharjee (1984) studied the developmental behaviour as well as metabolism of seedlings, raised from dikegulac-pretreated seeds. He showed that dikegulac-inhibited height, leaf area and dry weight of 14-day-old sunflower seedlings. A proportional shift in seedling metabolism was also noted after seed pretreatment with dikegulac. Results showed that chlorophyll and protein levels as well as catalase activity in leaves of seedlings were found to be low, whereas activities of IAA-oxidase and protease enzymes were high in dikegulac-treated samples. He also showed from this experiment that when observation was made on 28-day-old plants all such deleterious effects on growth and metabolism were erased.

There are reports that growth retardants temporarily exert an inhibitory effect on growth and metabolism (Cheema *et al.*, 1975; Ben Gad *et al.*, 1979). It is presumed that owing to dikegulac-induced impairment of nucleic acid, chlorophyll and protein biosynthesis, seedling growth was adversely affected. However, after an initial set back, the seedlings restored their normal functional life by antagonizing the initial deleterious plant processes, as was evident from complete revival of growth and metabolism of sunflower at later observation periods.

Stress Tolerance/Avoidance

Some sporadic reports are available on the regulation of stress tolerance/avoidance capacity of dikegulac. Bhattacharjee and Choudhuri (1986) using two cultivars of jute (*Corchorus capsularis* L. cv. JRC 212, and *C. olitorus* L. cv. JRO 632) showed that dikegulac-treated seedlings gained some potential for withstanding unfavourable environmental stress. It was shown from this experiment that the health of seedlings, which experienced water-stress treatment after having a prior pretreatment with dikegulac, was superior to seedlings which underwent same stress treatment but without any seed treatment. Results showed that after 7 days of water-stress treatment by immersing the root system of jute seedlings in PEG-6000 (Polyethyleneglycol) solution for 48 h, both height and dry matter content were higher in seedlings, which were raised from dikegulac-pretreated seeds. They also noted that chlorophyll and protein contents in leaves of the untreated and dikegulac-pretreated seedlings increased after 7 days of water-stress treatment but the increases were much more remarkable in seedlings developed from dikegulac-pretreated seeds. Such changes were associated with higher activities of catalase and superoxide dismutase enzymes in leaves of seedlings raised from dikegulac-pretreated seeds. Higher activity of these scavenger enzymes (Fridovich, 1976) are indicative of higher plant potential rendering plants tolerant against environmental stresses. Hence, these are regarded as reliable indices for evaluation of stress tolerance capacity of a plant. Elstner (1982) reported that free radicals participate, chiefly in the form of activated O_2 species such as superoxide (O_2) or H_2O_2, in several electron transfer reactions of normal cell metabolism and are usually controlled by the appropriate protective mechanisms, such as superoxide dismutase, catalase and peroxidases. There are also reports that catalase and superoxide dismutase activities of detached wheat and rye leaves decline with concomitant decrease of chlorophyll and protein during ageing (Kar and Feieraband, 1984). In fact, adaptive responses of plants towards environmental stresses are indicative of their high vigour and these are reflected in metabolism through gene expression (Hochachka and Somero, 1973). Thus from the available information on the growth and metabolic behaviour of seedlings, raised from dikegulac-pretreated seeds, it seems quite apparent that dikegulac strengthened the defence mechanism by stimulating the activities of the free-radical scavengers which consequently resulted in substantial alleviation of the damaging effects of environmental stress. Biswas and Choudhuri (1986) reported that pretreatment of *Vigna* seedlings with dikegulac through root systems significantly improved water status, maintained membrane integrity, chlorophyll and protein levels of water stressed seedlings. Water stress-induced proline accumulation in *Vigna* was also significantly inhibited by this treatment. From their observation they came to the conclusion that dikegulac acts as a potential hardening agent against water stress.

Dikegulac as a Chemical Pinching Agent

Perhaps the most important and well-established property of dikegulac, so far known, is its effect on pinching and stimulating branch initiation of a good number of plant species. The chemical quickly reduces or disrupts apical dominance of plants being mobilized to the shoot apex within a short period after treatment, and thus strongly retards plant growth (Bocion *et al.*, 1975; Arzee *et al.*, 1977). Its effect on the production of profuse axillary branches of many ornamental plants is amply documented (Bocion and de Silva, 1976; Sanderson and Martin, 1977; Malstorm and McMeans, 1977; Hield *et al.*, 1978; Larson, 1978; Agnew and Campbell, 1983; Arnold and Aldrich, 1983).

Sachs *et al.* (1975) demonstrated inhibition of shoot elongation and axillary bud-break on many shrubs and trees like *Xylosma congestrum, Pyracantha coccinea, Callistemon citrinus, Cotoneaster pannosa and Nerium oleander.* Green-house trial with *Eucalyptus globulus, Fraxinus uhdei* and *Ulmus parviflora* indicated that dikegulac is a useful inhibitor for landscape trees. Bocion *et al* (1977, 1978) found that dikegulac is effective as a growth retardant and pinching agent for *Gerbera jamesonii, Cyclamen persicum, Fuchsia, Pachystachis lutea* and *Begonia elatior.* These plants were of uniform and compact shape after dikegulac treatment. Sanderson and Martin (1977) reported that in 4 varieties of *Rhododendron, sps.*, dikegulac at the concentration range of 3000 to 6000 μg/ml inhibited shoot elongation, produced more side shoots than untreated plants, but the number of flowers did not increase. However, in *Gerbera jamesonii* production of profuse axillary branches were associated with formation of increased number of flower. Treated leaves reduced in size and also malformed a little. Three months after application, normal size as well as appearance were restored and plants looked more compact and green. DeSilva *et al.*, (1976) found that foliar application with 0.4 to 0.6% dikegulac was effective as a pinching agent under commercial growing conditions on all the azalea cultivars tested. They noted that within 4 weeks after treatment, the axillary shoots began to elongate, stem diameter was also increased in all the cultivars except 'R Ambrosius'. Information of Orson and Kofranek (1978) revealed that foliar spray of dikegulac effectively pinched most of the varieties of

Rhododendron tested which include : 'California Sunset', 'Chimes', 'Dogowood', 'Golris', 'Kaute Erwin' and 'Rose Queen', and the pinching was very effective under certain environmental conditions. The resultant shoots greatly diminished at the highest concentration of the chemical. Although dikegulac was found to be phytotoxic to immature leaves near the growing point, this did not detract from the quality of the plants. Malstrom and McMeans (1977) showed that foliar application of dikegulac after bud break stopped shoot growth and caused chlorosis of many leaflets in pecan trees, but application before leaf-fall delayed bud growth and promoted lateral shoot development.

Heursel (1975), Bocion *et al.*, (1975) and Bocion and de Silva (1976) demonstrated that an aqueous solution of dikegulac is very effective as a pinching agent on azalea (*Rhododendron simsii*). They observed that one to two weeks after application of dikegulac, slight chlorotic some times necrotic spots appeared on the upper leaves of the shoots. Axillary shoot elongation was initiated after four weeks of dikegulac application, and chlorosis began to disappear and foliage regained its dark colour about eight weeks after treatment. A better pinching effect was obtained with higher spray volumens but it depends upon the growth stage of azalea (Bocion *et al.*, 1975). Wise and Fonteno (1980) working with *Petunia hybrida* reported that when seedlings were given foliar application with 400 μg/ml *Atrinal*, greatest number of branches were found within acceptable foliar toxicity limits. Greater and lesser concentrations produced fewer branches and higher concentrations also produced more toxic effects. In *Capscum annum* both hand pinching and chemical pinching with dikegulac increased branching in all the three cultivars tested (Mattia, 1983; 1984). Arnold and Aldrich (1983) reported that when peach plants were applied by handgun with 500, 1000, 1500 and 2000 μg/ml. dikegulac, tree height and width decreasded but lateral branching increased with increasing concentrations of dikegulac. Barua and Gupta (personal communication) have used dikegulac on safflower at sapling stage and found that the chemical of the concentration of 500 μg/ml significantly increased the number of secondary branches along with reduction in plant height. In Wing bean dikegulac altered the plant habit and dwarfing effect was very significant (Das Gupta *et al.*, 1985). From all such reports, it has been well established that dikegulac is a suitable chemical pinching and shoot-inducing agent. Hence, it is recently being effectively used as a substitute of hand prunning and thus save manual labour.

Plant Growth and Metabolism

Growth : Effect of dikegulac on the alteration of plant growth has been studied by a number of workers (Bocion *et al.*, 1975; deSilva *et al.*, 1976; Hield *et al.*, 1978; Orson and Kofranek, 1978; Bhattacharjee, 1984; Bhattacharjee and Gupta 1984a,b; Mattia 1984). Bocion *et al.*, (1975) reported that dikegulac retarded the growth of a wide range of plant species which included cereals, cultivated as well as weed grasses and woody plants. Morphological observations revealed that dikegulac produced some toxic effects on the shoot apex and on the young growing leaves of sunflower, zinnia and chrysanthemum which was evidenced from the convoluted nature, yellowing and narrowing of leaf lamina along with the appearance of some necrotic spots (Arzee *et al.*, 1977). Similar observations on morphological abnormalities of some other plant were noted by Purohit (1980c), Kawabata and Criley (1982), and Bhattacharjee *et al.*, (1984).

Using a tall and a dwarf sunflower cultivar Bhattacharjee (1984) reported that when foliar application was made just before head initiation stage of sunflower plant height was reduced in both the tall and dwarf varieties at the higher concentration of 500 and 750 µg/ml. Dikegulac at 100 µg/ml reduced the height of tall cultivar only, and the magnitude of inhibition was low in dwarf cultivar. He also showed that such effect of dikegulac is more pronounced over two other height shortening agents CCC and SADH. Production of leaves was equally affected in both the cultivars at the two higher concentrations. Results also showed that stem circumference was significantly increased at 100 and 500 µg/ml regardless of cultivars concerned, while 750 µg/ml was found to be ineffective in this regard. Leaf area was decreased at all the concentrations in case of tall cultivar, but interestingly in dwarf cultivar this was increased at 100 µg/ml dikegulac. When application of dikegulac was made at the seed or seedling stage of the the two cultivars, retardation of growth was found merely transient, because when observations were made beyond head initiation stage of sunflower retardation effect was completely erased, and dikegulac-treated plants looked as good as control ones. So, attempt to check excess plant growth by dikegulac application at seed and seedling stages became futile. From such observations, it seems quite apparent that growth retardation of sunflower becomes effective, in terms of persistence of retardation effect, only when application was made before head initiating stage of sunflower. It might be mentioned in this context that the unbalanced plant type of this photoneutral, oil-yielding crop renders the plants susceptible to lodging particularly during rainy season. This is mainly due to (i) shallow and sparsely branched root system in comparison to the heavy foliage – and massive capitulum – bearing aerial part (ii) extremely strong apical dominance rendering plants tall (iii) weak and herbaceous stem (iv) less developed secondary tissues in stem causing subdued mechanical strength. All these deleterious plant characteristics are responsible for the reduction of crop yield, and hence this crop needs the modification of its unbalanced plant type for higher productivity. The author showed from his investigation that dikegulac can substantially alleviate some of these disadvantageous features by chemical manipulation with dikegulac. But selection of the appropriate stage of application and that of the optimum concentration of the chemical are the important criteria for obviating the handicaps in case of sunflower. In fact, log phase of plant growth in sunflower starts just before head initiation stage (Dorrel, 1973). Hence, plant growth was successfully manipulated by dikegulac application at this particular stage by disrupting its log phase. On the other hand, application of the chemical at lag phase of plant growth is of no worth, because after an initial set back when plants reach their log phase the chemical effect was completely erased and consequently plants started growing vigorously.

Shulmann and Lavee (1983) reported that growth of grapevine and olive shoots was inhibited by dikegulac-sodium. Concentrations of 500 to 6000 μg/ml were effective in grapevine 'Perlettle', while only 3000 or 6000 μg/ml inhibited the growth of 'Manzanillo' olive shoots. They showed that the chemical reduced the size of young leaves and clusters; mature leaves, however, were not affected. Application to dormant grapevine buds caused delayed bud opening, weak growth and deformed shoots. At 3000 and 6000 μg/ml dikegulac induced shortening of internodes and swelling of nodes of olive shoots. Adriansen and Andersen (1983) showed that *Atrinal* reduced shoot length of *Aeschynanthus hildebrandii* about 26 cm. Making a more suitable plant height and in case of *A. speciosus* reduction of shoot length occurred up to 32 cm. In *Rieger begonio* dikegulac, chlormequat as well as hand pinching effectively reduced internode length but did not affect oveall height, stem diameter, visual quality or d-ry weight (Agnew and Campbell, 1983). Working with 4 cultivars of greenhouse-forcing azaleas (*Rhododendron spp)* Shu and Sanderson (1979) reproted that dikegulac decreased shoot length and increased shoot number but the chemcial did not have a long term depressive effect on azalae shoot growth and development, because 6 weeks after treatment shoot growth increased normally. Kawabata and Criley (1982) found that dikegulac effectively suppressed the growth of *Murraya paniculata* in the spring but not in winters and the hedge did not show regrowth in summer. They further showed that spraying of dikegulac at one day after the trimming or at the budbreak mainly inhibited the first flush, and spraying at the expansion of the first leaves mainly inhibited the second flush. Jaffar (1982, 1984) from his experiment on a commercial rubber plant (*Hevea brasiliensis*) concluded that in spite of manipulation of plant growth dikegulac may be promising new growth substance for releasing dormancy of buds in budded stumps and maxi stumps.

Metabolism : There exists a number of reports that dikegulac, like other growth retardants, also exerts influence on plant metabolism (Bocion and deSilva, 1976; Gressel and Cohen, 1977; Zilkah and Gressel, 1978; 1979, 1980; Purohit and Chandra, 1981; Bhattacharjee and Gupta, 1981a,b and 1984a). With histoautoradiographic studies of the shoot apex Arzee et al. (1977) showed that in the apical meristematic zone of zinnia, sunflower and chrysanthemum DNA synthesis was strongly inhibited. Inhibition of DNA synthesis by dikegulac occurred on *Spirodela* and plastidial RNA was found to be more susceptible to dikegulac than cytoplasmic RNA (Gressel and Cohen, 1977).

Bhattacharjee (1984) reported differential action of dikegulac with respect to the changes of metabolic activity in directly treated and newly expanding leaves of a tall and a dwarf sunflower cultivar. Because, anabolic activity was highly impaired and catabolic activity was much more augmented in newly expanding leaves having actively dividing cells in comparison to those in the maturing leaves which received direct treatment.

There are, however, reports which indicate that dikegulac acts differentially on dividing and stationary cells as the former ones are extremely susceptible to dikegulac, while latter ones are hardly inhibited even at relatively high concentrations (Zilkah and Gressel, 1978, 1980).

In pot experiments, Bhattacharjee (1984) noted that after foliar application of dikegulac at the preheading stage chlorophyll level in the directly treated leveas was reduced over initial content irrespective of cultivar at 500 and 750 µg/ml after 7 days of treatment. In dwarf cultivar however, reduced chlorophyll level started reviving after 14 days of treatment which was not apparent in case of the tall cultivar at least up to 21 days after treatment. Interestingly, in dwarf cultivar the low concentration of 100 µg/ml enhanced chlorophyll content over control at later sampling periods, while the tall culvtivar remained inert in this respect. As regards the changes of protein and dry matter content in the treated leaves, almost identical trends were noted. Both soluble and insoluble carbohydrate contents remained in low level over control values at 500 and 750 µg/ml dikegulac treatment in case of tall cultivar, while in dwarf cultivar soluble carbohydrate increased at 500 µg/ml and insoluble carbohydrate increased at 100 µg/ml. Both DNA and RNA contents in treated leaves declined regardless of sunflower cultivars and the effect was found to be concentration-dependent. On the other hand, RNase and protease activities were greatly stimulated and catalase activity was inhibited at the two higher concentrations in the treated leaves of the two cultivars. In contrast to the dikegulac-induced biochemical changes in treated leaves, in newly expanding leaves, a drastic impairment of such metabolic variables were noted. Because, in such leaves the inhibition of anabolic activities and promotion of catabolic activities were much more pronounced than treated leaves and even the lowest concentration of 100 µg/ml was found inhibitory. Thus, it seems quite apparent from this investigation that dikegulac exerts differential action depending upon the nature of tissues and the tall cultivar appears to be more sensitive to this chemical. This is quite in conformity with some other reported observations as well (Bocion and de Silva, 1976; Bhattacharjee and Gupta, 1981 a,b). In aseparate study under field condition, Bhattacharjee and Gupta (1984a) and

Bhattacharjee et al (1984) showed that all such metabolic variable, which were affected as a result of dikegulac application, [illegible] of dikegulac application, revived completely at later periods of plant growth. This is indicative of the fact that dikegulac-induced inhibitory effects on plant metabolism does not perpetuate for longer duration.

Chlorophyll Degradation/Inhibition

Inhibition of chlorophyll biosynthesis has been studied in *Zinnia, Chrysanthemum* and *Helianthus* (Arzee et al., 1977), *Azalea* (Bocion and de Silva, 1977a), *Helianthus annuus* (Purohit, 1979) and ***Brassica campestris*** (Purohit, 1980b). Purohit and Chandra (1980b) observed inhibition of linear growth of primary leaf in *Avena sativa* when the seedlings were kept in solutions of different concentrations of dikegulac (10 to 60 mg/1). Such inhibitory effects of dikegulac could be overcome when GA_3 was applied along with dikegulac. This reveals that GA_3 neutralizes the adverse effects of dikegulac by bringing about growth and chlorophyll biosynthesis to control level.

It is known that presence of GA_3 is essential for retention of chlorophyll in isolated leaf discs of *Rumex* (Whyte and Luckwill, 1966). At the molecular level dikegulac inhibits GA-induced DNA synthesis (Arzee *et al.*, 1977). Studies on dikegulac-induced modulation of plastidial nucleic acid synthesis have indicated that in axenically cultured *Spirodela*, dikegulac depressed uridine incorporation into both plastidial and cytoplasmic ribosomal RNAs. GA_3 stimulted percursor incorporation into organeller DNA, was found to supressed by dikegulac.

Sabater and Rodriguarz (1978), Purohit (1982a,b) studied degradation of chlorophyll during senscence of detached leaves of *Avena sativa* and *Helianthus annuus*. They indicated that chlorophyllase enzyme is responsible for such loss (Sabater, 1984). Similarly, Shimokawa (1983) observed enhancement of chlorophyllase activity after ethylene treatment in *Citurs unshiu*. Ethylene level increases after dikegulac treatment and kinetin interacts with dikegulac (Bocion and de Silva, 1977a). Purohit and Chandra (1980 d) also observed, while studying dikegulac-kinetin intraction, that chlorophyllase activity showed an increase in detached leaves of *Avena sativa* after dikegulac treatment. They indicated that chlorophyllase is involved in the protective effects of kinetin against chlorophyll loss and correlation between chlorophyll retention and chlorophyllase level is highly significant. Therefore, dikegulac may directly enhance chlorophyllase activity or indirectly increase ethylene level which in turn would enhance the enzyme activity.

Combining together all the reports of various workers cited above, Purohit and Chandra (1980b) have proposed a model pertaining to the possible mode of actions of dikegulac on degradation/inhibition of chlorophyll biosynthesis in leaves. The model suggests that dikegulac may act either by inhibiting endogenous hormonal (GA, IAA and cytokinins) activity by interacting with hormonal-induced other growth regulatory activities related to chlorophyll biosynthesis (Arzee et al., 1977; Bocion and deSilva, 1977a) or by suppressing rRNA incorporation into plastid nucleic acid and its synthesis (Gressel and Cohen l 1977) or by inhibiting GA-dependent DNA biosynthesis which decrease protein content necessary for chlorophyll biosynthesis (Arzee et al., 1977) and in addition by its direct involvement in increasing chlorophyllase synthesis and or activity induced by ethylene because the level of ethylene increases to six-fold after dikegulac-treatment (Bocion and de Silva, 1977a). Purohit and Chandra (1981) observed reversal of dikegulac-sodium induced chlorophyll degradation and chlorophyllase activity in *Helianthus annuus* by urea.

Changes of Endogenous Hormones

A few reports are available which support that dikegulac affects the levels of some endogenous homrones like IAA, GA, ABA and ethylene in plants (Bocion and deSivla, 1976, 1977; Purohit and Chandra 1981b; Bhattacharjee, 1984). Bocion and de Silva (1976) reported that at 10^{-3} M concentration dikegulac enhanced endogenous ethylene level of pea seedlings up to 6 times of the control value. Level of trypotophan, a precursor of IAA, declined gradually with the increasing concentrations of dikegulac and concomitantly IAA-oxidase activity steadily increased (Purohit and Chandra, 1981).

In pot experiments, Bhattacharjee (1984) reported that when foliar application of dikegulac was made for three consecutive days at the preheading stage of sunflower GA-like substances was reduced to a considerable extent just after 5 days of treatment. Such a low level of GA was found to be maintained up to the observation periods of 25 days in case of 500 μg/ml dikegulac, while at 100 μg/ml after an initial fall, revival was recorded after 15 days of treatment. Unlike GA, ABA-like substances increased almost steadily up to 15 days of treatment and then a declining trend was noted. 500 μg/ml was found to be more stimulatory than 100 μg/ml in this regard. However, at the final observation, the changes of ABA level was found to be statistically insignificant. In field experiments, an interesting pattern of the hormonal (GA and ABA) changes were noted when the data were recorded at the three developmental stages of sunflower viz, head developmental stage, 50% anthesis stage and preharvest stage after foliar application of dikegulac at the preheading stage. Results showed that GA-like substances were found to be low, with respect to control value, at the head developmental stage; at 50% anthesis stage such inhibitory effect tended to be nullified and at preharvest stage the hormonal level was found to be higher in dikegulac-treated samples than in control ones. So far the changes of ABA-like substances were concerned with respect to these developmental stages the result was found to be almost inverse to that of GA.

Arzee et al (1977) assumed that the action of dikegulac may cause reduction in GA as well as GA-induced DNA synthesis. Gressel et al. (1977) speculated that dikegulac reduces auxin level or counteract the action of auxin because it reverses apical dominance, which is maintained by endogenous auxin level in plants. Like other growth promoters, dikegulac at its low concentration has been shown to produce a synergistic mode of promotion with GA_3 on the callus growth of tomato (Bocion and de Silva, 1976). Shemy (1978) reported that low concentration of the chemical promoted the growth of *Citrus* seedlings, and some gibberellin-like activity was also noted by him in experiments with rice, lettuce and cucumber seedlings, Bhattacharjee (1984) noted a stimulatory action of dikegulac at 100 μg/ml on growth and metabolism of sunflower. Hence, a proposition of dikegulac (low concentration) mediated production of growth hormones involving in synergistic action may not be ruled out. Thus, from the available information, it seems apparent that dikegulac, as its short-term effect, generally reduces the levels of growth promoters and enhances the level of growth inhibitors. But under certain instances, at low concentration it acts synergistically with some other growth promoters and may stimulate growth possibly by increasing the endogenous hormonal level.

Stem Anatomy and Lignification

Although growth retardant-induced changes of stem anatomy (Halfacre and Barden, 1968; Smolinski et al, 1972; Tezuka et al., 1980, Phelps *et al.*, 1980) and lignification (Kaplya and Moroz, 1976; Munnich and Koschuchowa, 1977; Hrebinskyi *et al.*, 1978; Khamis *et al.*, 1979) are amply documented, dikegulac-induced modification of stem anatomy and lignification is scanty in the literature. Bhattacharjee and Gupta (1984a) made such a study after foliar application of dikegulac at the preheading stage of a dwarf sunflower cultivar (*Helianthus annuus* L. cv. Modern). They showed that after 30 days of treatment dikegulac altered anatomy of sunflower stem mainly by stimulating the growth and development of secondary tissues. At the low concentration (100 µg/ml) of dikegulac cambial activity in the stem of treated plants was noted to be higher than that of untreated ones. This was evidenced from well-developed vascular tissues in each bundle as well as from the appearance of a good amount of vascular tissues both in fascicular and interfascicular regions. The activity of fascicular cambium seemed to be more pronounced than that of interfascicular ones, which resulted in disproportionate thickening of vascular tissues. But the identity of the individual bundles was more or less maintained. At the higher concentration (500 µg/ml) of dikegulac, development of mechanical tissues was found more profuse. Here, activities of both the fasciular and interfascicular cambia were more or less uniform, thereby producing a continuous thick band of secondary tissues. In contrast to low concentration, more cell layers were found in the cortical zone. Detailed observations further revealed that in treated sampels the number of rows of vessels, particularly of tracheids, were increased. At 500 µg/ml, the average number of rows of trachied and vessels were 27 and 8 respectively and at 100 µg ml these were 12 and 6 respectively; in contrast, in untreated controls there were 8- and 4-seriate tracheids and vessels, respectively.

Bhattacharjee (1984) reported that along with the changes of stem anatomy, lignin content in sunflower stem was also higher in dikegulac-treated plants. Using three different concentrations (100, 250, 500 µg/ml) of the chemical, the author showed that in contrast to control value lignin level was increased to 39.6%, 31.0% and 16.8% at 500,250 and 100 μg/ml dikegulac treatment respectively. He conclusively proved his findings from a separate experiment by measuring O.D. values of the pooled safranine of the stained, untreated and treated samples. However, as to the details of anatomical modification as well as the mechanism of controlling the process, there is much to be learned. Phelps *et al.*, (1980) reported that thickening and anatomical changes of *Salix* stem as a result of morphactin application were brought about by the synergistic effect of morphactin and endogenous hormones which greatly stimulated cambial activity. Tezuka *et al.*, (1980) noted remarkable development of xylem and phloem in the internodes of primary shoots of grapes by CCC application which, according to them, was cytokinin-mediated. Because, along with growth reduction, CCC treatment has been shown to increase the levels of substance with cytokinin activity (Skene, 1968, 1969). Infact, cytokinin-like substances are found to increase in plants as a result of reduction of apical dominance by decapitation (Satoh *et al.*, 1977). Dikegulac-induced disruption of apical dominance and suppression of plant growth have been well-established. Therefore, for enhancing the cambial activity and consequent enhancement of radicle growth in sunflower, the question of involvement of dikegulac-stimulated cytokinin, might not be ruled out. Whatever might be the actual mechanism, it seems apparent that dikegulac possesses the property of anatomical modification in stem chiefly because of their effect on suppression of vertical growth of plants.

Translocation of Assimilates

Hormone-directed translocation of assimilates is a well-established phenomenon (Davies and Wareing, 1965; Mulligan and Patrick, 1979; Patrick, 1979). It is generally accepted that actively growing meristems and developing organs are the potential sinks for photosynthetically produced assimilates, and that promotion or repression of apical sink may result in corresponding changes in growth patterns (Moorby, 1977; Wareing and Patrick, 1975). Growth retardants generally act through suppressing the apical sink by reducing the hormonal levels therein and consequently by hindering the acropetal mobilization of assimilates (Monselise and Luckwill, 1974; Hoad and Monselise, 1976;

Ben-Gad *et al.*, 1979). However, reports, on dikegulac-induced mobilization of assimilates are rare in the literature.

Bhattacharjee (1984) made a critical study on the translocation pattern of radiorctive phosphorus (^{32}P) after foliar application of dikegulac on sunflower and this is indicative of the chemical-induced assimilate translocation in plants. He recorded the data after feeding ^{32}P to the head (capitulum) and also to the topmost leaves, but promoted it to the basal leaves and roots, the effect being concentration dependent. It is this clear that dikegulac reduces acropetal modilization but induces basipetal mobilization of assimliates, However, acropetal mobilization was greatly stimulated by IAA, Kinetin and GA_3 (100 µg/ml each) appliction to the head at 50% anthesis stage following dikegulac (100 µg/ml) application at the preheading stage of sunflower. This is evidenced from greater accumulation of the radioactive phosphorus both in the central and perepheral regions of sunflower capitulum.

Lovett and Orchard (1976) reported from their experiment with radioactive carbon that in sunflower photosynthetic rate and assimilate translocation were reduced by CCC treatment in the upper leaves. However, greater accumulation in CCC-treated plants was noted in the roots. Monselise and Luckwill (1974) demonstrated that acropetal translocation of assimilates was hindered by SADH beginning almost immediately after treatment. Thus, from the reported observations, it may seem that like other growth retardants dikegulac probably hindered acropetal mobilization by weakening the apical sink of sunflower, and this allowed the root sinks to become capable of accepting the surplus assimilates. That such an inhibitory effect of dikegulac is hormone-mediated, can be proved from higher mobilization of phosphorus in sunflower heads when IAA, Kinetin and GA_3 were applied on the head at 50% anthesis stage. This is indicative of the fact that repression of apical sink by dikegulac was overcome by hormonal application of apical sink by dikegulac mobilization force resulting in greater ^{32}P accumulation in the capitulum of sunflower.

Flowering, Fruiting and Harvest Delay

Wise and Fonteno (1980) showed that at the concentration range of 200 to 1200 µg/,l dikegulac delayed flowering in *Petunia hybriaa* from 1 to 10 days compared to controls. Using 3 cultivars of *Capsicum annum*, Mattia (1983) reported that both hand pinching and Atrinal (at 14.8 ml/plant) delayed the first harvest by 9 days. He also showed that Atrinal decreased yield of all cultivars at all concentrations. However, Arnold and Aldrich (1983) noted no effect of dikegulac on the changes of flowering date of peach trees, Adriansen and Anderson (1983) reported that Atrinal delays the flowering in *Aeschynanthus hildebrandii*, but it has no effect on the flowering time in *A. speciosus*.

Flowering and fruiting are markedly inhibited by dikegulac in *Alix crenata* when the plants were sprayed at the mid of the post flowering stages (deSilva *et al.*, 1976). However, the chemical stimulated flower development and flower number in *Cyclamen persicum* and *Gerbera jamesonii* (Bocion *et al.*, 1978). Foliar spray of dikegulac on *Helianthus annuus* (Purohit 1980d) before flowering hastened flowering and the effect was found to be inversely proportional to 100 and 250 µg/ml concentrations. Beyond these concentrations delay in flowering was directly proportional to the concentrations. A very peculiar abnormality was recorded in some of the flowers developed on the plants sprayed with 250 µg/ml dikegulac. The abnormality was decreased significantly with increasing concentrations of dikegulac. The seeds in treated plants were light brown and slightly elongated whereas in untreated plants they were dark brown in colour. Bhattacharjee (1984) noted distinct distortion of sunflower capitulum at the two higher concentrations (500 and 750 µg/ml) of dikegulac, which was evidenced from blunt as well as necrotic apices of the bracts of capitulum which extended inwardly and covered a large part of disc floret zone. Moreover, the thalamus never assumed the normal plate-like appearance and ray-florets failed to emmerge. However, such anomalies were not apparent at 100 µg/ml dikegulac as well as in CCC and SADH treatments. Dikegulac-induced changes in size and shape of sunflower seeds was noted and compared with two other growth retardants (CCC and SADH) after foliar application of the chemicals at the preheading stage. At 100 µg/ml dikegulac, sunflower seed were found to be rather bold, and the size seemed to be increased a little over control. On the other hand, at 500 µg/ml although seeds apparently look bold, they were partially filled, light and tend to appear roundish.

Bhattacharee (1984) made a study on the changes of times of occurrence of some important events in the life cycle of the dwarf sunflower cultivar after dikegulac application at seed, seedling and preheading stages of the plant. Data showed that the schedule times of ray-floret opening, head yellowing and harvest of sunflower were not deviated when treatments were made both at seed and seedling stages of sunflower. However, a little delaying effect on the incidence of head initiation only was noted. On the other hand, when dikegulac was treated at the preheading stage delaying effects on the incidence eof head initiation only was noted. On the other hand, when dikegulac was treated at the preheading stage delaying effects on head initiation, rayfloret opening, head yellowing and harvest of sunflower was found to be very conspicuous, and at 500 µg/ml of the chemical harvest was delayed up to 15 days. It was further noted that seed yield remained almost unaffected when the chemical was applied at seed and seedling stages but when treatments were made at preheading stage, yield was found to be positively or negatively influenced at 100 and 500 µg/ml dikegulac treatment respectively.

Study on development of parthenocarpic fruit by dikegulac application was made on *Lycopersicum esculentum* (Bocion *et al.*, 1975) and *Pyrus communis* (Bocion and deSilva, 1977a). Foliar application of 300 µg/ml dikegulac twice at 20 day intervals resulted in more fruits than single application. Bocion *et al.*, (1975) also showed that dikegulac stimulates fruit ripening. Available information, thus, reveals that in additioin to the influencing effect of dikegulac on some aspects of growth, development and metabolism of plants, the chemcial has some role the alteration of reproductive behaviour of plant species.

Senescence and Abscission

Although there are reports that dikegulac influence the greening of leaves and rejuvenate treated plants after a transient degreening (Sanderson and Martin, 1977), reports on dikegulac-induced changes of senescence and abscission are rare in the literature. Bocion et al. (1975) showed that dikegulac induces petiole abscission of a good number of plant species. Jana *et al.*, (1986) studied the effects of dikegulac concentrations (100, 500, 1000, 1500 and 2000 µg/ml) on some senescence variables in leaves of *Canna indica and Coccinia cordifolia* under detached condition. They noted that treatmetns of 100, 500 and 1000 µg/ml increased hill activity, chlorophyll and protein contents, dry matter percentage in biomass and decreased tissue permeability over control. The inhibitory effects of dikegulac on leaf senescence were markedly pronounced with the treatments of 1000 µg/ml in *Canna* and 500 µg/ml in *Coccini* during dark-induced senscence. However, at concentrations beyond 1500 µg/ml all such senescence variables were impaired indicating that dikegulac at low concentrations is a potent inhibitor of leaf senescence, while at higher doses it promotes leaf senescence at least in case of *Canna and Coccinia*. Bhattacharjee *et al.*(1984) studied the effects of dikegulac on leaf senescence of sunflower under attached condition. They reported that dry matter, chlorophyll and protein contents as well as activity of catalse enzyme of contributory leaves (Johnson, 1972) were remarkably reduced at 500 and 750 µg/ml dikegulac, when analysis were made at head development stage. At 50% anthesis stage, these adverse effects were overcome and at preharvest stage all such senescence variables were found remarkably high over control plants. All these are indicative of the fact that after an initial adverse effect, dikegulac-treated plants steadily rejuvenated and this was maintained for a longer duration. Thus, dikegulac may be a potential chemcial for a monocarpic plant like sunflower with regard to arrestation of leaf senescence. Such senescence deferral effect of dikegulac was conclusively proved by Bhattacharjee and Gupta (1984a) in a separate study.

As regards the mechanism of dikegulac-induced deferment of leaf senescence nothing is clarly known. However, it is speculated that such effect may be cytokinin-mediated. Because, there are reports that endogenous cytokinin level icnreases in CCC-treated grape vines which consequently maintain higher chlorophyll level per unit leaf area (Skene, 1968, 1969). Available reports also indicate that sometiems growth retardants are much more effective than exogenous cytokinin application in delaying senescence (Weaver, 1972), and retardant-induced deferral of senescence of isolated leaf segments (Beevers and Guernsey, 1967; Kessler *et al.*, 1967; Knypl, 1967; Harada,

1968) or of intact plants (Appleby *et al.*, 1966; Halevy and shilo, 1970; Guardia *et al.*, 1974; Orchard and Loevit, 1976) has been widely reported, Again , dikegulac-induced enhancement of growth promoter and inhibition of growth inhibitor levels at preharvest stage of sunflower is also known (Bhattacharjee, 1984). Thus from reported observations it may be likely that dikegulac triggered the delaying of senescence of attached leaves by manipulating the hormonal level, particularly of cytokinin at later stages of plant growth, (Purohit and Chandra, 1983).

Lodging Behaviour and Yield

Serious impairment of yield of many monocarpic crops often occurs as a result lodging, specially when such crops are grown in extremely fertile soils and they attain a certain height with the subdued mechanical strength of stem. As dikegulac is a potent height shortening agent of plants, the efficacy of this chemical on alleviation of this handicap was tested by Bhattacharjee (1984) on a tall and a dwarf sunflower cultivar during monsoon period when maximum incidence of loding occurs. Results showed that dikegulac regardless of its concentrations, reduced the severity of head lodging in both the cultivars. The tall cultivar was found to be extremely susceptible to lodging and dikegulac was most successful on this variety with respect to arrestation of lodging and consequently of improvement of the yield attributes like per cent filled seeds and average yield per plant. However, such effect of dikegulac on the lodging behaviour and yield attributes of sunflower was noted only when application of this chemcial was made at the long phase of plant growth i.e. at preheading stage, and no such effect was apparent when dikegulac application was made at seed and seedling stage of the sunflower cultivars. Working on 3 cultivars of *Capsicum annuum* (Sandia, Espanol 1 and NM_6), Mattia (1983) reported that though dikegulac application increased branching in all the 3 cultivars, it decreased yield in all of them, and dikegulac at 104 ml per plant resulted in no yield. Menhenett and Hanks (1983) showed that dikegulac was most effective chemcial with respect to restriction of post-flowring extention growth of late season-tulip and checks the lodging tendency. But as to its role on qualitative flower dikegulac was proved most unsuitable because it increased flower bud blasting and gave rise to abnormally coloured perianth segments.

Effect of dikegulac on the alleviation of and consequent enhancement of yield can be expalined by its effect on suppression of apical dominance (Bocion *et al.*, 1975) rendering plants short statured and on production of profuse mechanical tissues in stem (Bhattacjaree and Gupta, 1984a) and enhancement of lignin as well (Bhatacharjee, 1984) strengthening the stem of sunflower. Such a role of dikegulac is suggestive of the fact that whatever might be its effect on direct modification of crop yield, the chemical may enhance yield atleast in those crops where reduction of yield occurs due to incidence of lodging.

Sprouting of Tubers

A comparative study of the effect of dikegulac and GA_3 on potato sprouting reveal that dikegulac (25 to 400 µg/ml) delayed sprouting emergence and inibits further growth of shoot while GA_3 has hastened the same (Purohit, unpublished data). Such delay caused by dikegulac may be due to antagonistic action of this chemical on endogenous GA level which consequently inhibits growth activities (sprouting) induced by GA_3.

Callus Growth

Promotion of callus growth by dikegulac at 10^{-6} M in *Lycopersicum esculentum* ws observed by Bocion and deSilva (1977a). Higher concentration of dikegulac (10^{-3}M0 in culture medium caused death of the callus. Such inhibitory effects of dikegulac at 10^{-3}M could only be counteracted by similar concentration of GA_3. When dikegulac (10^{-6}M0 was used in combination with GA_3 (10^{-7} or 10^{-6}M) the growth was found to be stimulated than that of GA_3 alone. These results therefore, suggests that dikegulac and GA_3 when used in combination, the effect remains additive while it is antagonistic at higher concentrations.

Summary and Conclusion

The foregoing review thus clearly indicates that since the discovery and establishemnt of dikegualc as a potent growth rgulator in 1975 by Bocion et al., a comprehensive work in diverse fields of research has been accumulated through two decades and a half. From the numerous experimental results available to date, a light could be thrown on the problems and prospects of this novel growth regulator, and some new and promising approaches of research problems could also be designed out of these poineering works. On the basis of available literature, the promising roles of dikegulac enabling to open commercially prospective research avenues are briefed, and a few possible suggestions of its fruitful utilization have been mentioned (Bhattacharjee *et al.*, 1986).

1. Dikegulac may be commercially exploited for maintaining seed vigour and viability, and thus the practice of conventional methods of seed storing may be improved with this chemcial with a view to delaying storage deterioration which poses a serious problem to the crop growers.

2. As dikegulac shows encouraging results with respect to rendering plants tolerant towards adverse environmental stresses, the commercial feasibility of exploiting such an effect of dikegulac could be tested on a wide range of crop plants and be suitably utilized for agricultural practices.

3. Property of chemical pinching and consequent production of profuse axillary branches of dikegulac is promising for horticulturists and florists.

4. Dikegulac seems to be promising for monocarpic plants like sunflower, safflower etc. because the chemical, if applied at proper stage of plant growth, can produce some alterations in growth and metabolism of plants which are conducive to yield imporvement. In fact, short-statured plants, enhanced mechanical strength in stem, deferment of senescence and prolongation of seed filling period are general characteristics of such treatments which are encouraging for monocarpic plants like sunflower and safflower.

5. Dikegulac-induced improved plant vigour and higher potential, particularly at later stages of sunflower growth could be efficiently exploited through hormonal application at the active seed-filling period. Such a strategy of yield improvement in sunflower, by treatments of dikegulac followed by hormones, may be tested in some other monocarpic crops.

6. Dikegulac may be potentially used on those crops which often prone to lodging resulting in serious loss of yield.

All such achievements appeared to be encouraging for agricultural and horticultural practices in addition to the academic interest of dikegulac. Hence, testing the commercial feasibility of dikegulac in conjuction with some other hormones in raising ideotype plant for higher productivity may be an attractive proposition. However, the criteria like selection of the optimum stage of application, concentrations of the chemical, exploitation of the imposed plant vigour through hormonal manipulation at the critical period of grain-filling etc. are the important determinants for obtaining covetable result.

Introduction

INTRODUCTION

Sechium edule Swartz (family : Cucurbitaceae, tribe : Scyoideae) commonly known as chayote (English), Iskoos (Nepali), Quash (Bengali), is one of the important vegetable crops for the people in the hilly regions of the Darjeeling district of West Bengal. State in India (Mukhia *et al.*, 1982, Dey and Jana, 1988). It is also grown profusely in tropical America (Cook, 1901). It grows both in cultivated and wild conditions and flourishes in altitudes ranging from 500m to 2000m around Darjeeling hills. This hilly plant species is perennial; the above ground part die in winter but the tuberous roots thrive and new sprouts arise in the next rainy season. Fruiting time is from September to December. Tuberous roots, fruits as well as young leafy shoots of the plant are edible and are used as delicious table items. In recent years, this species has attracted cultivators as well as researchers because it seems to be highly dietary vegetable crop requiring no cumbersome field management and for its scope for developing ideal plant type for higher productivity by scientific manipulation, (Lama, 1988; Dolui and Jana, 1989; Shil, 1990; Lama, 2000).

The crop has a lot of plus points for its enthusiastic acceptance by the local cultivators of Darjeeling district as an ideal vegetable crop. These are : (1) minimum cost of maintenance in the field, (2), less susceptibility towards diseases, (3) higher productivity in the agroclimatic conditions of Darjeeling hills, (4) higher responsiveness towards organic manures and vigo[illegible]growth of the plant even in fallow land, (5) considerable food value of all its parts, (6) Strong storage potential of fruits and tuberous roots under ambient climatic condition of storage prevailing in Darjeeling, (7) significant resistance capacity towards various climatic hazards, particulary against high relative humidity and biotic hazards particularly against fungi and bacteria (Lama, 2000).

Considering the prospects of cultivation of *Sechium edule* in Darjeeling hills, an attempt was made in the present investigation to produce an ideotypic plant having higher productivity by chemical manipulative agents, using plant growth regulators. Like other cucurbitaceous plants, there are some problems as to the higher productivity of chayote plants. Firstly, unwanted excess plant vigour and strong apical dominance, particularly during log phase of growth, cause impairment of crop yield. Secondly, in some varieties higher (even 50 : 1, Lama, 2000) ratio of male to female flowers causes lower yield of fruits, as male flowers function as pollen donors and are ineffective with respect to increasing fruit numbers. Thirdly, early senescence of the contributory leaves results in reduced supply of assimilates to the active reproductive sinks and the consequence is the smaller size of fruits and reduction of total yield. Fourthly, attack by some animal pests on the foliage, inflorescence and stem of the plant particularly during assimilate filling phase, renders the growing fruits less saturated or unsaturated sinks thereby resulting in smaller size of fruits and consequent impairment of crop yield. Even the life cycle of the plant is terminated shortly, and in case of severe infection yield becomes negligible or nil. Lastly, yield of the underground tuberous root is often reduced by some animal pests and soil nematodes which hinder tuberization process. Considering the above-mentioned problems of chayote cultivation, attempts were made to obviate or to reduce the degree of some of these deleterious features of the plant by chemical manipulative methods using plant growth regulators of one retardant class (Atrinal) and two prometer class (GA_3 and kinetin). To get rid of the undesired profuse vegatative growth, the selected growth retardant Atrinal is supposed to act the preferred instrument. There are ample reports in the literature that a number of growth retarding chemicals including the present one can successfully check unwanted excess plant vigour causing subdued plant growth (Knypl, 1979; Monselise, 1974; Bhattacharjee, 1984. The efficacy of the retardant on lowering plant vigour was determined by analysing the growth and metabolic status of the chayote plant. An attempt was made to increase the number of female flowers per plant by foliar application of kinetin, GA_3 and

IAA which are supposed to have some role on flowering as well as on sex expression in many cucurbits (Leopold and Kriedemann, 1975; Ghosh and Basu, 1982, 1983). The deleterious feature of the onset of earlier sonescence of the active assimilate transporter leaves, was tried to overcome by using senescence deferral agents like kinetin and Atrinal which is reported to keep the foliage green even before preharvest stage of many monocarpic crops (Bocion et al., 1975, Nooden and Leopold, 1978; Bhattacharjee, 1984). The efficacy of these chemical manipulants was analysed through several established and reliable physiological and biochemical senescence evaluation indices. Thus, the prime objective of the present investigation was to obtain an ideotypic chayote plant for higher productivity after possible obviation of the deleterious features, as mentioned, by chemical manipulative methods.

Materials and Methods

MATERIALS AND METHODS

Plant material :

Experiments of this investigation were performed with a promising vegetable crop chayote (*Sechium edule* Sw.), a squash like climbing plant of the family Cucurbitaceae under the tribe Sicyoideae. The plants are luxuriantly grown in Darjeeling hills of Eastern Himalayas at altitudinal ranges of 500 to 2500 meters (M) under cultivated as well as wild condition. After varietal screening of the species it was found that the varietal type available in Mirik (1850M) was superior to others growing in Sukhia Pokhri (1900M) and Darjeeling Town (2134 M) with respect to general vigour and yield of fruits (Vide Table 3). Detailed experiments were carried out with a specific varietal type (I, Vide Table 1) growing in and around Darjeeling town.

Chayote is a perennial species; the above ground parts die in winter but the tuberous roots thrive and new sprouts arise from the tuberous roots in the following season. The above ground part of the plant is monocarpic in nature and survives more than five months. Vegetative phase continues more than two months and fruiting phase persists for three months. Varieties growing in various altitudes of Darjeeling hills were recorded and altogether ten varietal types were screened and named alphabetically (A,B, C,D, E,F,G, H, I and J) mainly on the basis of morphological characters of fruits (Table 1). Important events during the life cycle of the plant were determined from the average data of four planting seasons i.e., 1992, 1993, 1994 and 1995 (Vide Table 2 and also Diagram 1). The underground tuberous part is perennial, enriched with carbohydrates and is highly potential for giving new plants under favourable situations.

Soil preparation and method of sowing :

The whole experimental plot was divided in subplots each having an area of 3x3 M for raising plants of different treatments. The main plot was ploughed 3-4 times, cowdung and organic composts were amended with the soil before sowing the fruits, the main propagating unit of this species. The ~~sporued~~ Sprouted mature healthy fruits were sown at a distance of 1.5M (plant-to-plant as well as row-to-row).

Owing to delay of field emergence, possibly because of occurrence of some inhibitors in fruit flesh, the mode of sowing was of two different kinds. Sowing of intact fruits and sowing of defleshed fruits. Sprouted fruits (intact or defleshed) were sown at the depth of 15 cm into the soil in a slight oblique manner placing the sprouted part towards the upperside and the propagules were watered at five-day intervals until seedlings developed.

Meteorological Data :

Meteorological data viz., temperature, relative humidity and rainfall during the experimental years of 1992 to 1995 were procured monthwise from the Principal Office of Agriculture, Govt. of West Bengal, Darjeeling. The data were incorporated in Tables 4,5,6 and 7.

Design of Experiments :

In this investigation experiments were designed under the following directions to analyse the effects of an agrihorticulturally promising and less explored growth retarding chemical sodium dikegulac (Na-dikegulac) or Atrinal (2,3:4-6-di-O-isopropylidene-α-L-xylo-2 hexalofuranosate) with a view to obtaining higher productivity. Keeping in mind some beneficial effects of raising chayote plants from defleshed fruits, with respect to quicker field emergence and maintaining higher plant potential (Lama 1990, personal communication), plants were developed from both intact fruits and defleshed fruits.

1. Analyses of the effects of fruit (intact or defleshed) treatment with Atrinal on growth, metabolism and crop yield (Section 1).

2. Analyses of the effects of Atrinal treated at sapling stage on growth, metabolism and crop yield (Section 2).

3. Analyses of the effects of Atrinal treated at preflowering stage on growth, metabolism and crop yield (Section 3).

4. Analyses of the effects of Atrinal treated at preflowering stage followed by GA_3 and kinetin application at flowering stage on growth, metabolism and crop yield (Section 4).

1. Analyses of the effects of fruit (intact or defleshed) treatment with Atrinal on growth, metabolism and crop yield :

A screening experiment was initially performed to observe the effects of quantum of fruit flesh removal (25%, 50%, 75% and 100%) for better development of chayote plants. It was found that plants raised from 50% defleshed fruits stand well in the field (data not shown) and hence experiments were done with 50% defleshed fruits (hereinafter called defleshed fruits) or intact fruits.

Healthy, sprouted fruits (intact or defleshed) of chayote were thoroughly sterilized with 0.1% $HgCl_2$ for 90 seconds and then air-dried. Subsequently, the fruits were presoaked with aqueous solutions of Atrinal (500, 1000 and 2000 µg/ml) for 24 hours and then sown in the experimental field in the month of February. Fruits (intact or defleshed) treated with distilled water for 24 hours served as the control set. From the field grown plants phenological, growth, biochemical and yield data were recorded.

Phenological analysis :

Important events during the life cycle of chayote plant were determined from the verage data recorded in four planting seasons of the years 1992, 1993, 1994 and 1995 Table 2 and also Diagram 1). The phases recorded include : field emergence phase, first af emergence phase, seedling phase, sapling phase, flower initiation phase, fruit formation hase, senescence phase and death phase.

Growth analyses :

For study of growth attributes of the plants raised from pretreated fruits (intact or defleshed) investigation was carried out from the date of sowing with the first field emergence as the initial phase of life cycle. Growth parameters like vine length and stem circumference (cm) of plants were recorded from each plot-grown plants of different ages (days, d) at specific stages viz., seedling stage (20-d), sapling stage (40-d), preflowering stage (60-d), fruiting stage (80-d) and senile stage (140-d). Data were recorded from the mean values of 5 uniformly grown plants, developed from the 5 uniformly sprouted fruits for each treatment. Stem circumference was recorded from the 10th, 11th and 12th internods of each plant. Further, the data on number of days (plant age) required for the inception of leaf senescence of plants were recorded and the results were represented with yield data like fruit number fruit weight and tuberous root per plant.

Biochemical analyses :

Biochemical analyses were carried out taking samples from leaves at five important phases of chayote plants viz., seedling phase, sapling phase, preflowering phase, fruiting phase and senile phase which correspond to 20-, 40-, 60, 80- and 140-days of plant age respectively.

Chlorophyll :

Leaf tissues (100 mg) of each treatment were immersed in 5 ml methanol in test tubes and kept in freeze for 48 hours. The supernatant was decanted off and leaf samples were rinsed repeatedly with a little volume of methanol until they were completely free from green colour. Thus, the final volume of methanol was made to 10 ml and the intensity of the green colour was measured at 650 nm in spectrophotometer. The chlorophyll content was stimated following Arnon's (1949) principle.

Protein :

The chlorophyll free above leaf samples were crushed with 80% ethanol and centrifuged at 6000 g for 10 min. to make the pellet free from phenol. It was washed successively with 10% (w/v) cold trichloroacetic acid TCA, twice), ethanol (once), ethyl alcohol; chloroform (3:1, v/v, once), and finally with solvent ether as per the method of Kar and Mishra (1976). The pellet was then evaporated to dryness. The protein was solubilised by treating with 0.5 N NaOH at 80°C for 1 h. A definite volume (4 ml) was made with the extraction medium. It was then estimated by reacting the protein solution with Folin-phenol reagent and measuring the O.D. values spectrophotometrically at 650 nm according to the method of Lowry *et al.* (1951). The quantitative determination was made by comparing the O.D. values of a standard curve previously prepared using bovine serum albumin (BSA, Fraction-V powder, Sigma Chemical Co., USA).

Carbohydrates :

Carbohydrate levels (both soluble and insoluble fractions) were determined following essentially the method of McCready *et al* (1950) with minor modifications. Fifty mg leaf samples of each treatment were homogenized with boiling 80% ethanol, and centrifuged at 6000 g for 15 min. The supernatant was taken in a watch glass. This was repeated thrice, and the pooled supernatant was then evaporated to dryness. Trace of chlorophyll, if any, adhering on the surface of the watch glass were carefully removed using solvent ether. The remaining material in watch glass was taken in test tubes by washing them several times with 80% ethanol and the volume was made up to 10 ml. This was kept as a source of soluble carbohydrate. For the analysis of insoluble carbohydrate, the residue after centrifugation of the sample was digested with 5 ml 25% H_2SO_4 at 80°C in a water-bath for 30 min. The extracted material after suitable dilution was taken as a source of insoluble carbohydrate.

For quantitative measurement of both the carbohydrate fractions, 1 ml of the source sample from each was taken in a test tube and to it added 4 ml freshly prepared, precooled 0.2% anthrone reagent (200 mg anthrone in 100 ml concentrated analar H_2SO_4). After 15 minutes, the intensity of green colour was measured spectrophotometrically at 610 nm. Actual contents were determined from the standard curve with glucose.

Nucleic acids :

Extraction of nucleic acids (both RNA and DNA) was made from 100 mg leaf samples of each treatment following the method of Cherry (1962), and the estimation was done as per the method of Markham (1955) modified by Choudhuri and Chatterjee (1970).

Extraction process of RNA and DNA was done as outlined below :

Plant tissue

Homogenized in 2 ml cold methanol, washed the insoluble pellet thrice with 2 ml methanol and centrifuged

Supernatant
Methanol-soluble phosphate
(discarded)

Residue
Extracted with 4 ml of cold 0.2 M perchloric acid (PCA) and centrifuged

Supernatant
Acid soluble phosphate
(discarded)

Residue
Extracted with 4 ml ethanol and centrifuged

Supernatant
Ethanol soluble phosphate
(discarded)

Residue
Extracted with 5 ml ethanol : ether (2:1) at 50°C for 30 minutes and centrifuged

Supernatant
Lipid soluble phosphate
(discarded)

Residue
Extracted with 5 ml 5% PCA at 70°C for 40 minutes (Refrigeration overnight aids in clarification)

Supernatant
RNA and DNA were estimated using this supernatant as the extracted source sample of nucleic acids.

Residue
(discarded)

For the estimation of RNA 3 ml diluted extract (in 5% perchloric acid) in test tube was treated with an equal volume of freshly prepared orcinol reagent (1 gAR grade orcinol dissolved in 100 ml concentrated HCl containing 100 mg 0.1% $FeCl_3$, $6H_2O$), and boiled in a water bath for 20 min. with glass marble at the mouth of the test tube. The mixture was then cooled, and the intensity of the blue green colour was measured at 700 nm. The blank used contained a mixture of 3 ml distilled water and 3 ml orcinol reagent, which were treated in an identical manner. RNA level was calculated from O.D. values from a standard curve prepared with yeast RNA.

For the estimation of DNA 1ml of nucleic acid extract in a test tube was mixed with 5 ml freshly prepared diphenyl amine reagent (100 ml glacial acetic acid BDH. AR+ 2.7 ml H_2SO_4 + Ig AR grade diphenyl amine. The mixture was boiled in a water bath for 30 min with a glass marble at the top. After cooling, intensity of bluish colour was measured at 610 nm in the spectrophotometer. DNA level was quantified from the O.D. values of a standard curve prepared with herring sperm DNA.

Catalase activity :

Leaf tissues (500 mg) of each treatment were homogenized with 8 ml of chilled 0.1 M phosphate (Na_2HPO_4/NaH_2PO_4) buffer (pH 6.8). The homogenate was centrifuged in the cold at 3000 g for 15 min followed by 10,000 g for 20 min. the volume of the supernatant was made up to 10 ml with the same buffer, and this was used as crude enzyme source. The activity of the enzyme catalase was assayed following the method of Snell and Snell (1971) modified by Biswas and Choudhuri (1978). The reaction mixture for catalase consisted of 1 ml of the above extract and 1 ml of H_2O_2 (0.005 M), incubated together at 37°C for 2 min. The reaction was stopped by adding 2 ml 0.1% titanyl sulphate in 25% H_2SO_4 (V/V), and the mixture was centrifuged at 6000 g for 15 min. The intensity of yellow colour was measured at 420 nm. The blank was prepared by inactivating the enzyme with the addition of titanyl sulphate prior to H_2O_2 addition.

Peroxidase :

Leaf tissues (500 mg) of each treatment were homogenized in cold 0.05 M sodium phosphate buffer (pH 6.5). The homogenate was centrifuged at 10,000 g for 10 min. The filtrate was used as enzyme source.

Activity of this enzyme was assayed following the method of Kar and Mishra (1976) with slight modification. Five ml of the assay mixture containing 300 µM of sodium phosphate buffer (pH 6.8), 50 µM catechol, 50 µM H_2O_2 and 1 ml of crude enzyme extract. After incubation at 25°C for 5 min, the reaction was stopped with the addition of 1 ml of 10% H_2SO_4. The colour was read at 430 nm. In case of blank sample, the enzyme was first inactivated with the addition of H_2SO_4.

IAA-oxidase activity :

Extraction of this enzyme was made from 100 mg leaf tissue with 12ml of cold 0.2M sodium phosphate (pH 6.1). The activity of IAA oxidase was assayed following the method of Gordon and Weber (1951) as modified by Ramadas (1968). The reaction mixture contained 1ml (1mM) of 2.4-dichlorophenol, 1ml of MnCl 1mM, 0.6ml of 0.03M sodium citrate buffer (pH 4.5) and 1ml of enzyme extract. This was incubated for 50 min at room temperature and then the reaction was stopped by pouring 1ml of 20% $HClO_4$ to the mixture. One ml of the assay mixture was reacted with 3ml of Salkowski reagent (50 ml of 35% $HClO_4$ + 1ml 0.5 N $FeCl_3$), and the reading was taken at 525 nm in the spectrophotometer.

RNAse activity :

Fresh leaves (100 mg) were homogenized with 5ml of 0.1M sodium phosphate buffer (pH 6.4) at 0°C and centrifuged at 10,000g for 20 min. The supernatant was made up to 10ml with the same buffer solution and this was used as crude enzyme source. Assay was made as per the method described by Biswas and Choudhuri (1978).

The reaction mixture for RNAse consisted of 1ml of the enzyme extract and 1ml of yeast RNA (1mg/ml) dissolved in 0.1M sodium phosphate buffer (pH 5.7). The mixture was then incubated for 30min at 37°C, and the reaction was stopped by adding 0.2ml perchloric acid (70%). After centrifugation at 6000g, the supernatant was mixed with 5ml of BSA (0.5μg/ml) dissolved in 0.1M sodium acetate buffer (pH 4.0). After 5 min the turbidity developed was stabilised with 2ml of 0.1% gelatine and measured at 420 nm. Activity of this enzyme was expressed following the principle of Fick and Qualset (1975).

In each case of enzyme assay, value at zero time was taken as blank, and the activity of each enzyme was expressed as (ΔAxTv)/(txv), where ΔA is the absorbance of the sample after incubation minus the absorbance at zero time. Tv is the total volume of the filtrate, t is the time (min) of incubation with substrate and v is the total volume of the filtrate taken for incubation (Bhattacharjee, 1984). The activity of each enzyme was expressed as unit/ fresh weight/h.

Yield analyses :

After senile stage yield data were analysed in terms of the production of fruits and underground tuberous roots and yield attributes recorded include : total number of mature fruits per plant, total weight (kg) of fruits per plant and total weight (kg) of tuberous roots per plant.

2. Analyses of the Effects of Atrinal treated at Sapling Stage on Growth, Metabolism and Crop Yield.

Foliar application with aqueous solutions of Atrinal (500, 1000 and 2000 μg/ml) containing Teepol (surfactant) were given at around 9 am each day for three consecutive days on thirty-day-old field grown saplings raised from intact or defleshed fruits. Saplings treated with distilled water served as control set. From the field grown plants growth, biochemical and yield data were recorded.

Growth analyses :

After foliar application with Atrinal growth data, measured in terms of vine length and stem circumference, were recorded at four developmental stages of the plant viz., sapling stage, preflowering stage, fruiting stage and senile stage which correspond to 40-, 60-, 80- and 140-days of plant age respectively. Like fruit treatment (intact or defleshed) data were analysed from the mean values of 5 uniformly growing plants, and here also plant age (days) to inception of leaf senescence was recorded.

Biochemical analyses :

For biochemical analyses samples were taken from leaves of plants, which experienced foliar treatment with Atrinal or distilled water. Methods for extraction and estimation of biochemical parameters like chlorophyll, protein, carbohydrate, nucleic acids (RNA and DNA), catalase, peroxidase, RNase and IAA-oxidase were described earlier in section 1 (Fruit treatment).

Yield analyses :

Yield attributes analysed are the same as in Section 1 i.e., total number of fruits per plant as well as total fruit weight (kg) and tuberous root weight (kg) per plant.

3. Analyses of the Effects of Atrinal Treated at Preflowering Stage on Growth, Metabolism and Crop Yield :

Sixty-day-old field grown plants, raised from intact and defleshed fruits, were foliarly sprayed with Atrinal (500, 1000 and 2000 µg/ml) or distilled water containing Teepol (surfactant) at around 9 am each day for three consecutive days. From the field grown plants growth, biochemical and yield data were recorded.

Growth analyses :

Growth data recorded in this experiment were the same as done in case of fruit (intact or defleshed) and sapling treatments mentioned in Sections 1 and 2 respectively. Here data were recorded at two stages of plant development i.e., fruiting stage and senile stage, which correspond to 80- and 140- days of plant age respectively.

Biochemical analyses :

Biochemical analyses were done taking samples from leaves of the plants, raised from intact and defleshed fruits, at fruiting and senile stages of plant development. The parameters analysed were the same as done in case of fruit and sapling treatments and the methods of extraction and estimation were described in Section 1.

Yield analyses :

Yield attributes recorded in this experiment are the same as done in Sections 1 and 2.

4. Analyses of the Effects of Atrinal Treated at Preflowering Stage Followed by GA_3 and Kinetin Application at Flowering Stage on Growth Metabolism and Yield.

In this experiment, foliar treatment with Atrinal (1000 µg/ml) or distilled water containing Teepol was given the preflowring state of sixty-day-old field grown plants, raised from intact and defleshed fruits, for three consecutive days. Such plants were subsequently sprayed with GA_3 (100 µg/ml) or kinetin (100 µg/ml) for further three consecutive days starting from 70-day-old plants. Growth, biochemical and yield data were recorded like previous experiments. In addition, here total number of male and female flowers per plant was counted. Considering the most effective concentration of Atrinal (1000 µg/ml), in this experiment only single dose of Atrinal was used.

Growth analyses :

Like previous experiments as mentioned in Sections 1,2 and 3 growth data were recorded from plants raised from intact and defleshed fruits. And data on vine length and stem circumference were taken at fruiting and senile stages as in experiments mentioned in Section 3.

Biochemical Analyses :

Biochemical parameters and methodologies of analyses were the same as done in Section 1. Here samples were taken from leaves of plants which experienced foliar treatment with Atrinal (1000 µg/ml) at the preflowering stage or from plants which received Atrinal treatment at preflowering stage followed by GA_3 and kinetin (100 µg/ml each) treatment at flowering stage.

Yield Analyses :

Yield data recorded in this experiment are the same as done in previous experiments. Here in addition to the effect of Atrinal (1000 µg/ml) effects of supplementary treatments (GA_3 and kinetin) on modifying crop yield was analysed.

Statistical Analyses :

All the growth, biochemical and yield data recorded in this investigation, were statistically analysed at the treatment and replication levels. In the tables LSD (least significant difference) values at 95% confidence limits were incorporated (Panse and Sukhatme, 1967).

Results

RESULTS

Table 1 shows varietal differences of *Sechium edule* growing in various altitudes of Darjeeling hills. Altogether 10 varietal types have been established on the basis of morphological characters on mature fruits viz., length, breadth, girth, weight and colour of fruits as well as on the basis of density, length and mode of distribution of hairs on the surface of fruits. Among the categories the types A,B, and J produce hairless fruits and the type H produce fruits with scanty hairs. Other varietal types yield fruits with hairs of specific nature and they show specific mode of distribution on fruit surface.

Important events during the life cycle of the experimental chayote plant have been depicted in Table 2 and Diagram 1. The leafy above ground part of chayote is monocarpic in nature and the data reveal that the plant survives more than 5 months with prolonged duration of log phase and stationary phase of growth. The underground tuberous part is perennial and survives for several years. Meteorological data at the experimental station (Darjeeling) during the experimental years of 1992, 1993, 1994 and 1995 (monthwise) are represented in Table 4, 5 6 and 7 respectively. As planting of chayote starts from late February maximum vegetative growth takes place during the months of April, May and June, and harvesting of fruits is completed by October each year, it seems apparent that during plantation comparatively low temperature, low relative humidity and low rainfall are ideal climatic factors. Vigorous plant growth and fruit maturation takes place during the monsoon months of June and July when maximum rainfall, fairly high relative humidity and moderate temperature are recorded.

While undertaking extensive survey programme of different altitudinal areas of Darjeeling hills three distinct chayote growing localities at different altitudes were identified. There are Mirik (1850 M). Sukhia Pokhi (1900M) and Darjeeling Town (2134M). Plants are distinctly different with respect to their vegetative (vine length, leaf number), reproductive (female and male flowers) and yield (fruit weight) characters (Table 3). Data showed that the varietal type growing in Mirik was superior in all respects, particularly on yield of fruits.

Analyses of the Effects of Fruit (intact or defleshed) Treatment with Atrinal on Growth, Metabolism and Crop Yield

Changes in chlorophyll and protein Levels (Table 8) :

Results showed that pretreatment of both intact and defleshed fruits with Atrinal increased chlorophyll and protein contents in leaves of chayote plants when data were recorded at seedling and sapling stages of plant development. However, subsequent changes observed at preflowering, fruiting and senile stages were statistically insignificant. Data further revealed that chlorophyll and protein levels were comparatively high in leaves of plants raised from defleshed fruits. Among the three concentrations of Atrinal used 1000 µg/ml was found to be most effective in this regard.

Changes in soluble and insoluble carbohydrate levels (Table 9) :

Pretreatment of the fruits (both intact and defleshed) with Atrinal, irrespective of its concentration, resulted in significant increase of soluble and insoluble carbohydrate levels in leaves of chayote. However, such increase was found to be transient and did not persist beyond sapling stage of plant development. Here also, the carbohydrate levels were found higher in leaves of plants raised from defleshed fruits.

Changes in RNA and DNA levels (Table 10) :

After a transient increase of DNA content at the seedling stage only Atrnial-induced changes of DNA levels failed to attain statistical significance at the subsequent sampling periods of sapling, preflowering, fruiting and senile stages. The changes of RNA level followed the same trend as found in the changes of DNA level but here Atrinal-induced promotive effect persisted up to sapling stage.

Changes in catalase and peroxides activities (Table 11) :

Activities of both catalase and peroxidase enzymes were stimulated in leaves as a result of pretreatment of intact and defleshed fruits with 500, 1000 and 2000 µg/ml Atrinal. Here also, the chemical-induced stimulatory activities of the enzymes were not recorded at the preflowering, fruiting and senile stages of plant development. This table clearly revealed the best response of Atrinal at 1000 μg/ml. Between the two different modes of plant development, plants raised from defleshed fruits showed higher activity of both the enzymes and such results are fairly uniform regardless of treatments at all the development stages.

Changes in IAA-oxidase and RNase activities (Table 12) :

Unlike the changes of catalase and peroxidase activities, IAA-oxidase and RNase activities were found significantly low in leaves of chayote plants, raised from Atrinal pretreated fruits (both intact and defleshed). However, the chemical-induced subdued activities of the enzymes were observed only at seedling and sapling stages of plant development and the changes recorded beyond sapling stage failed to attain statistical significance.

Changes in vine length and stem circumference (Table 13) :

Biochemical changes in leaves were found to be associated with the changes of growth parameters like vine length and stem circumference of chayote plant as a result of fruit pretreatment with the three different concentrations of Atrinal. Data revealed that vine length was significantly reduced by Atrinal and such effect was found to be strictly concentration dependent. On the other hand, stem circumference was found to increase in plants which were raised from the chemical pretreated fruits. However, Atrinal-induced retardation of vine length and enhancement of stem circumference was found to persist only up to sapling stage of plant development. Data also showed that plants raised from defleshed fruits were apparently superior to the plants raised from intact fruits.

Changes in number of days required for inception of plant senescence, fruit number, fruit weight and tuberous root-weight per plant (Table 14) :

Atrinal-induced transient changes of growth and biochemical parameters did not alter yield attributes, recorded in terms of fruit number, fruit weight and tuberous root weight per plant as well as the time (days of plant age) for onset of plant senescence, determined by observing the yellowing of leaves. The data inserted in this Table are fairly uniform regardless of treatments as well as the modes of plant development and all the changes were noted to be statistically insignificant.

Analyses of the Effects of Atrinal Treated at Sapling Stage on Growth, Metabolism and Crop Yield

Changes in chlorophyll and protein levels (Table 15) :

Foliar application with Atrinal (500,1000 and 2000 µg/ml) for three consecutive days at the sapling stage of chayote plants, raised from both intact and defleshed fruits, resulted in significant reduction of chlorophyll and protein levels in leaves of all samples analysed at the sapling stage only. After a transient set back the chemical-treated plants were not only found to retain the normal levels of chlorophyll and protein but such levels were recorded to be even higher than control plants at least at the fruiting and senile stages of plant development. Such effects were found true in case of plant samples raised from both intact and defleshed fruits.

Changes in Soluble and Insoluble Carbohydrate Levels (Table 16) :

Almost an identical change like that of chlorophyll and protein, was observed when the Atrinal-induced changes of soluble and insoluble carbohydrate levels were analysed. Here also, the chemical exerted an inhibitory effect which was merely transient and recorded only at the sapling stage. The inhibitory effect of Atrinal was found to overcome at the subsequent stage (preflowering) of plant development. At fruiting and senile stages levels of both soluble and insoluble carbohydrate contents were found higher in the chemical treated samples.

Changes in RNA and DNA levels (Table 17) :

Atrinal–induced changes of RNA and DNA levels in chayote leaves were found distinctly inhibitory at the initial observation period i.e. at sapling stage. Such inhibitory action of the chemical was nullified at the preflowering stage, as the changes observed were not significant at all the concentrations of the chemical used. Interestingly, the chemical action was found promotive when data were recorded at the fruiting and senile stages of plant development, and the effect of 1000 µg/ml Atrinal treatment was found most efficient in this regard.

Changes in catalase and peroxidase activities (Table 18) :

Activities of both the enzymes were suppressed by all the concentrations of Atrinal when data were recorded at the sapling stage. Like other biochemical changes recorded earlier this retardation effect was erased quickly and at the fruiting and senile stages of plant development activities of the enzymes in Atrinal-treated samples were found higher than distilled water treated (control) samples. Here also, Atrinal 1000 µg/ml showed the best response, and plants raised from defleshed fruits showed comparatively higher potential with respect to maintenance of higher activities of such enzymes.

Changes in IAA-oxidase and RNase activities (Table 19) :

Unlike the changes in the activities of catalase and peroxidase enzymes, a reverse trend of changes in that of IAA-oxidase and RNase were recorded. Data clearly revealed that all the concentrations of Atrinal more or less suppressed the activities of these enzymes after a transient increase of the enzyme activities at the sapling stage only.

Changes in vine length and stem circumference (Table 20) :

Biochemical changes were associated with the changes of growth parameters like vine length and stem circumference. Results showed that Atrinal significantly reduced the length of vine at all the concentrations used and this inhibitory effect was found to be maintained throughout the observation periods i.e., till senile phase. On the other hand, stem circumference was found to increase in all the plants which underwent foliar treatment with the three concentrations of Atrinal. The chemical-induced changes of vine length and stem circumference was found to be strictly concentration dependent and thus 2000 µg/ml Atrinal was most effective for inhibiting vine length and enhancing stem circumference.

Changes in Number of Days Required for Inception of Plant Senescence, Fruit Number, Fruit Weight and Tuberous Root Weight Plant (Table 21) :

At least at the two higher concentrations of Atrinal (1000 and 2000 μg/ml) delaying of senescence of chayote plants was recorded. The chemical was found to be ineffective for significant enhancement of fruit number at any of the concentrations used. However, plants raised from defleshed fruits showed higher fruit numbers than the plants raised from intact fruits. Fruit weight was significantly increased at the two lower concentrations (500 and 1000 μg/ml) and the root weight was found to increase significantly at the two higher concentrations (1000 and 2000 μg/ml) of Atrinal.

Analyses of the Effects of Atrinal Treated at Preflowering Stage on Growth, Metabolism and Crop Yield

Changes in chlorophyll and protein levels (Table 22) :

Foliar treatment with Atrinal at the preflowering stage resulted in significant increase of chlorophyll and protein levels in leaves of plants raised either from intact fruits or defleshed fruits and such increase was found to persist till senile stage. Best response was recorded at 1000μg/ml Atrinal treatment.

Changes in soluble and insoluble carbohydrate levels (Table 23) :

Atrinal-treated plant samples significantly augmented the levels of soluble and insoluble carbohydrates in leaves of chayote plant. Here also, stimulatory activity was found most significant at 1000 μg/ml Atrinal treatment.

Changes in RNA and DNA levels (Table 24) :

The changes of RNA and DNA levels in leaves as a result of foliar treatment with Atrinal was found to be identical with that of chlorophyll, protein and carbohydrates recorded in leaves of plants which underwent foliar treatment with Atrinal at the preflowering stage.

Changes in catalase and peroxidase activities (Table 25) :

Like sapling treatments, foliar treatment of chayote plants with the three concentrations of Atrinal at the preflowering stage efficiently enhanced the activities of both the enzymes and such effect was true both in case of plants raised from intact fruits or defleshed fruits.

Changes in IAA-oxidase and RNase activities (Table 26) :

A reverse picture was noted when the changes in the activities of IAA-oxidase and RNase enzymes were compared with that of peroxidase and catalase enzymes. Here, activities of both IAA-oxidase and RNase enzymes were found to decline significantly in the leaves of plants which received foliar treatment with Atrinal at the preflowering stage.

Changes in vine length and stem circumference (Table 27) :

Atrinal-induced changes of biochemical parameters were associated with remarkable change of vine length and stem circumference. Data revealed that the chemical, irrespective of its concentrations, significantly retarded vine length and enhanced stem circumference at both the observation periods i.e., fruiting stage and senile stage of plant development.

Changes in Number of Days Required For Inception of Plant Senescence, Fruit Number, Fruit Weight and Tuberous Root Weight Per Plant (Table 28) :

Atrinal (1000 and 2000 µg/ml) caused significant deferment of plant senescence in both the plant samples developed from intact or defleshed fruits. The low concentration (500 µg/ml) effect was found to be insignificant in this regard. However, the chemical at all its concentrations failed to induce any significant change with regard to the enhancement of total fruit numbers per plant. Fruit weight and tuberous root weight per plant was found to increase significantly at the two higher concentrations of Atrinal (1000 and 2000 µg/ml).

Analyses of the Effects of Atrinal Treated at Preflowering Stage Followed by GA_3 and Kinetin Application at Flowering Stage on Growth, Metabolism and Crop Yield

Changes in chlorophyll and protein levels (Table 29) :

Data clearly revealed that foliar treatment with Atrinal (1000 µg/ml) resulted in significant enhancement of chlorophyll and protein levels and such enhancing effect of Atrinal was augmented when the chemical treated plants were further treated with kinetin (100 µg/ml). However, the supplementary treatment with GA_3, on Atrinal treated plants, was found to be ineffective and such effect was found true in case of plants raised from both intact and defleshed fruits.

Changes in soluble and insoluble carbohydrate levels (Table 30) :

Here also, Atrinal-induced stimulatory effect on the levels soluble and insoluble carbohydrate was found additive when foliar treated plants with Atrinal (1000 µg/ml) at the preflowering stage was further experienced a foliar treatment with kinetin (100 µg/ml) at the flowering stage of plant development. GA_3-induced effects (either on control or Atrinal-treated plants) were insignificant in this regard.

Changes in RNA and DNA levels (Table 31) :

The results of supplementary treatments with GA_3 or kinetin at the flowering stage on Atrinal-pretreated plants were found to be identical with the changes of chlorophyll, protein and carbohydrate levels recorded from leaves of plants which underwent Atrinal followed by the hormonal treatments.

Changes in catalase and peroxidase activities (Table 32) :

Results of this Table revealed the effective supplementary treatments i.e. kinetin treatment given at the flowering stage of the plants which were previously treated with 1000 µg/ml Atrinal. Such effect of kinetin was found true in both the plant samples raised from intact as well as defleshed fruits.

Changes in IAA-oxidase and RNase activities (Table 33) :

Atrinal-induced retardation action of IAA-oxidase and RNase enzymes was augmented to a further degree when the chemical treated plants was further experienced foliar treatment with kinetin (100 μg/ml) only. Thus, the level of the enzymes in Atrinal plus kinetin treated sample was found to be even lower than Atrinal minus kinetin treated plant samples.

Changes in vine length and stem circumference (Table 34) :

GA_3 significantly increased vine length and Atrinal-induced retardation of vine length was overcome by supplementary treatments with GA_3. Kinetin was found to be least effective or almost ineffective in this regard. On the other hand, GA_3 failed to enhance stem circumference either singly or in combination with Atrinal treatments while kinetin effect was found to be slightly promotive in this regard.

Changes in number of days required for inception of plant senescence, fruit number, fruit weight and tuberous root weight per plant (Table 35) :

Atrinal-induced deferral of plant senescence was found additive when plants received supplementary treatment with kinetin only. Data revealed that onset of senescence occurs at the plant age of 155 days in case of Atrinal-treated plants as against 142 days of control plants. And in Atrinal plus kinetin treated plants onset of senescence was delayed to a further extent (162 days of plant age). But fruit number per plant was found to increase significantly only in GA_3- treated samples either as single treatment or as follow-up treatment after Atrinal. Kinetin was found to be almost ineffective on enhancing fruit number. However, fruit weight per plant was found to increase both in GA_3 and kinetin treatments either as single treatment or as supplementary treatment i.e. Atrinal + GA_3 or Atrinal + kinetin. GA_3, however, failed to enhance tuberous root weight per plant.

Changes in the number of female and male flowers per plant (Table 36) :

Results revealed that GA_3 efficiently enhanced both female and male flowers per plant either as single treatment or as supplementary treatment (Atrinal 1000 + GA_3) after pretreatment of the plants with Atrinal at the preflowering stage. However, kinetin effect was found to be differential with respect to changes of two sexes of flower. Kinetin, particularly as supplementary treatment (Atrinal 1000 + kinetin 100), was effective for enhancement of female flowers per plant but kinetin-induced enhancement of male flowers was not found significant at least in case of plant samples which were raised from defleshed fruits.

Discussion

DISCUSSION

Influence of growth retarding chemicals on modification of growth, metabolism and yield have been extensively studied and a comprehensive report has been incorporated in an excellent review by Cathey (1964). Atrinal or sodium dikegulac, the key plant growth regulator used in this investigation, was first reported by Bocion *et al* (1975) and since then its effects on the changes of different aspects of growth and metabolism have been studied by a number of workers (Arzee *et al.*, 1977; Hield *et al.*, 1978; Bhattacharjee, 1984; Bhattacharjee *et al*, 1986; Maity *et al.*, 2000). Keeping in mind a balanced growth retardation effect of this chemical particularly in case of plants having a strong apical dominance (Arzee *et al*, 1977) like members of cucurbitaceae, an attempt was made to modulate plant growth and crop yield of an agrihorticulturally promising crop *Sechium edule* (chayote).

Many cucurbitaceous vegetable crop plants growing in India suffer from the drawback of having undesired excessive vegetative growth which often cause serious impairment of crop yield and thus in many occasions vigorous plant growth and higher productivity becomes inversely correlated (Shil, 1990). The present experimental plant chayote was also not found to be an exceptional species showing this generalized behaviour of cucurbits. Keeping in mind this prime negative yield attributing characters of chayote plant an attempt was made to increase crop yield simply by restraining the undue vigour using Atrinal which had been established as potent suppressor of vegetative growth of many agricultural and horticultural plants. We are now quite aware of the fact that yield impairment is resulted in many crop plants owing to their unwanted excess vigour which consequently deprive the reproductive sinks of their optimum need of assimilates (Weaver, 1972; Bhattacharjee *et al.*, 1984; Milthrope and Moorby, 1988).

After initial screening of varietal types and selecting of optimum concentration range of Atrinal suitable for this plant, applications were timed at three different developmental stages of the plant viz., sprouting stage of fruits, sapling stage and preflowering stage of the plant. The chemical induced changes of some growth and biochemical parameters were analysed at different developmental stages of the plant and reflection of such changes on yield attributes were recorded. Again supplementary treatments with Atrinal followed by plant hormones like GA_3 and kinetin were given at the flowering stage of plant growth, and changes in modification of growth, metabolism and yield were analysed. Considering the beneficial effects of plant development from defleshed fruits, experimental plants were raised both from intact and defleshed fruits. The results obtained in this investigation were discussed at length from the available literature in this field and allaied fields of research.

The present investigator and his associates after a thorough exploration in the chayote growing regions of Darjeeling hills, reported the existance of ten varietal types (Table-1) which somewhat differ among themselves with respect to their productivity, morphological characters of mature fruits, vine length and branching pattern (Lama *et al.*, 1994). Important events in the life cycle of this varietal type were analysed and found that vigorous vegetative growth starts around 50 days of plant age and continue up to active fruiting phase and this was determined as the log phase of plant growth (Table 1 and Diagram 1).

Results on intact on defleshed fruit treatment with Atrinal revealed that the chemical, irrespective of its concentrations, failed to induce any permanent effect on modification of growth, metabolism and yield of chayote plant. Data on biochemical changes in leaves showed that Atrinal-induced increase in chlorophyll and protein (Table 8), soluble and insoluble carbohydrate (Table 9), RNA and DNA (Table 10) levels were recorded at the seedling and sapling stages of plant development were transient and subsequent changes were found to be statistically at par with that of control values. Likewise, activities of catalase-peroxidase enzymes (Table 11) remained high in the Atrinal-treated samples only up to sapling phase, and activities of the catabolic enzymes IAA-oxidase and RNase (Table 12) remained subdued up to sapling stage. Growth parameters like vine length was reduced and stem circumference was increased (Table 13) by the Atrinal treatments up to sapling stage and thereafter all changes were found insignificant.

Such results are indicative of the fact that Atrinal possibly hindered the biosynthetic processes of the macromolecules which actively occur at the early stage of plant development, but with the progress of plant age the inhibitory effects were nullified because of diminished action of the retardant and consequent revival of the biosynthetic machinery of the cellular components. The resultant biochemical changes were correspondingly reflected in the plant growth as evident from the reduced vine length and enhanced stem circumference recorded at seedling and sapling stages only.

Reports exist in the literature that growth retardant temporarily exert inhibitory effects on seedling growth and metabolism (Knypl and Chylinska, 1972; Ben-Gad *et al.*, 1979; Bhattacharjee, 1984; Bhattacharjee *et al.*, 1986b. Ben-Gad *et al* (1979) observed that elongation of *Citrus* seedlings was initially retarded by SADH treatment but vigorous growth was resumed thereafter. Similar retardant-induced transient inhibition followed by rapid growth was also observed by Monselise *et al.* (1966), Sachs and Mock (1975), Bhattacjarjee (1984) and many others who reported such effect using conventional retardants like CCC, SADH, 2,4-DNC, AMO 1618, MH morphactin etc, but reports with Atrinal are rather scanty.

There are reports in the literature that Atrinal affect,seedling growth and metabolism of a good number of plant species (Bocion and De Silva, 1976; Arzee *et al.*, 1977; Purohit, 1979; 1980a,b,c; Bhattacharjee and Gupta 1981a,b; Bhattacharjee *et al.*, 1986b. Arzee *et al.* (1977) showed that the overall seedling growth of zinnia, sunflower and chrysanthemum was affected with regard to the shortening of internodes, abnormal growth of leaves and disruption of apical dominance. Several reports revealed that Na-dikegulac reduced the seedling growth of sunflower (Purohit, 1979, 1980a,b), *Avena sativa* (Purohit and Chandra, 1980), *Brassica campestris* (Purohit, 1979, 1980c) or *Glycine max* (Purohit and Chandra, 1981) and the effect was found to be concentration dependent. Purohit (1979, 1980a,b) also reported that concomitant with the reduction of seedling growth, Atrinal adversely affected chlorophyll biosynthesis and reduced protein as well as sugar contents.

The results of this investigation was thus in conformity with the reported observations with Atrinal or some other growth retardants on some other plants. Initial retardation of growth and metabolism in chayote plant followed by alleviation of such inhibitory effects might be explained considering the proposition made by Ben-Gad *et al.* (1979). From their experiments on the distribution of ^{14}C labelled assimilates in SADH-treated plants, the authors concluded that assimilates and growth substances accumulated during the period of inhibition. Such accumulated materials and growth hormones were utilized fully during the subsequent periods when normal growth and metabolism and consequent rejuvenation of the plants resumed. In fact, such accumulatin of growth substance during the periods of inhibition by growth retardants was also found in several studies (Frydman and Wareing, 1974; Kuo and Pharis, 1975; Fillipovich and Rowe, 1977). Arzee *et al* (1977) using Atrinal showed that overall seedling growth of zinnia, sunflower and chrysanthemum was affected with regard to the shortening of internodes, abnormal growth of leaves, disruption of apical dominance, inhibition of DNA synthesis and chlorosis of leaves. In their investigation, the authors showed by whole plant autoradiography that the chemical moved towards acropetal direction and triggered its physiological action from the shoot-tips. They further reported that the adverse effects were later overcome and in all the three species convoluted and chlorotic leaves were regreened after a transient degreening.

The temporary inhibitory effect, as observed in the present study, as a result of fruit (intact or defleshed) treatment at the sprouting stage, might therefore be the effect of the growth retardant in the arrestation of the activities of overall biochemical machinery within the plant tissue and these cumulatively resulted in subdued plant metabolism and consequent shortening of vine length as well as increased radial growth of stem.

Results of Atrinal-induced fruit (intact or defleshed) treatment at the sprouting stage also revealed that yield components of chayote, recorded in terms of fruit number, fruit weight and tuberous root weight per plant as well as days for inception of plant senescence (Table 14) remained unchanged at all the concentrations of the chemical. This result can be substantiated from the normal behaviour of growth and metabolism as well as unchanged potential of the plants during flowering, fruiting and senile stages after a transient initial adverse effect. In fact, as yield components and senescence inception time were recorded at the advanced stage in the life cycle of the plant, the initial adverse effects of the retardant were totally nullified leaving their no residual influence on modulating the yield components and senescence.

The present observation on the futile effect of Atrinal on modifying yield attributes can be corroborated from the findings of Lovett and Orchard (1976) who reported that CCC could augment yield alongwith inducing morphological and anatomical changes of sunflower when applied at log phase of plant growth only, and its application at lag phase was ineffective. Similar observation was recorded by Dorrel (1973). In sunflower Bhattacharjee (1984) reported that seed treatment or early seedling treatment with some growth retardants neither impaired or stimulated productivity. In the present study with chayote the results thus accord with reports of previous workers.

In the present investigation, results on foliar treatment with Atrinal at the sapling stage (30-day-old plants) revealed that the retardant-induced changes in chlorophyll and protein (Table 15), soluble and insoluble insoluble carbohydrate (Table 16), RNA and DNA (Table 17), levels as well as activities of catalase and peroxidase (Table 18) enzymes in leaves were inhibitory only at the initial observation period of 40-day-old plants. Such inhibitory effects were erased shortly, and the levels of the biochemial variables were higher than control values that persisted till the senile stage of the plant. Again after a fleeting increase of IAA-oxidase and RNase (Table 19) activities, a consistent decrease in the activities of the enzymes were recorded till senile stage of the plant. Atrinal–induced shortening of vine length and increase of stem circumference (Table 20) were however recorded throughout the observation periods.

Results of foliar application of the retardant at the sapling stage of 40-day-old plants thus indicate that higher levels of chlorophyll, protein, insoluble carbohydrate and RNA as well as enhanced activities of the anabolic enzymes like catalase and peroxidase in the retardant-treated plants maintained vital functional life of the plant for longer duration. Thus, after experiencing a transient set-back with respect to potential performance of the species at sapling stage, all the retardant-treated plants revealed higher metabolic status and showed enhanced plant potential throughout its life span. However, the initial inhibitory effect may be justified by an immediate strong retardation action of Atrinal on plant metabolism which started relinquishing with the progress of plant age. The adverse effects thus did not at all persist for a longer duration. A perpetuating retardation action of the chemical at later stages of plant development was clearly reflected on the overall growth of the chayote plant as evident from the reduction of vine length and enhancement of radial growth of stem which persisted till the senile stage of plant growth.

Retardant-induced reduction in plant height is amply documented (Cathey, 1964; Lovett and Campbell, 1973; Guardia *et al.*, 1974; Clark and Fedak, 1977; Bhattacharjee, 1984; Bhattacharjee and Gupta, 1984) Cathey (1964) in his review lucidly reported the work of many workers on various physiological roles of growth retardants and the very common and significant visible effect of the chemicals is the shortening of plant height. Whitehead (1965) showed that both shortening and xeromorphism could be induced in sunflower through CCC application. Guardia *et al* (1974) observed that CCC and SADH efficiently reduced plant height and produced thicker as well as stronger stem in sunflower. Bhattacharjee (1984) reported that in sunflower shortening of plant height and increase of stem circumference were associated with profuse development mechanical tissues and enhanced lignification in stem. Effect of Atrinal on the alteration of plant growth and metabolism was studied by a number of workers (Bocion et al. 1975; De Silva *et al.* 1976; Hield et al 1978; Orson and Kofranek, 1978; Bhattacharjee and Gupta, 1984; Bhattacharjee et al. 1986,Mattia, 1984). Bocion *et al.* (1975) reported that Atrinal retarded the growth of a wide range of plant species which included cereals, cultivated as well as weed grasses and woody plants. Atrinal-induced inhibition of growth was observed by Shulmann and Lavee (1983) in grapevine and olive shoots. A number of reports exist in the literature that Atrinal like other conventional growth retardants, exert influence on plant metabolism (Bocion and De Silva, 1976; Gressel and Cohen, 1977; Zilkah and Gressel, 1978; 1979; 1980; Bhattacharjee and Gupta, 1981a,b and 1984). Inhibition of chlorophyll biosynthesis has been studied in *Zinnia, Chrysanthemum* and *Helianthus* (Arzee et al. 1977), Azalea (Bocion and De Silva, 1977a) *Helianthus annuus* (Purohit, 1979).

The existing literature pertaining to the retardant-induced effects on the changes in growth and metabolism thus, corroborate the overall findings of this investigation done with a different plant species.

In this study, Atrinal resulted in a significant increase of yield components like fruit weight as well as tuberous root weight per plant. The retardant also showed a tendency towards deferring plant senescence (Table 21). Increased crop yield as well as senscence delaying effect of Atrinal can be substantiated from the enhanced plant potential as evident from the biochemical analyses of this investigation. Unlike intact or defleshed sprouting whole fruit treatment, foliar treatment with the growth retardants at the sapling stage enhanced the levels of vital cellular components like chlorophyll, protein, carbohydrate, nucleic acids as well as the activities of the scavenger enzyme catalase and peroxidase particularly at the fruiting and senile stages of the plant. During active fruiting phase or assimitate filling phase of plants, developing fruits or grains function as reproductive sinks which show a strong sink demand and thus accumulate assimlates from the source leaves or contributory leaves (Bhattacharjee *et al*, 1984; Milthrope and Moorby, 1988). Prolonged assimilate transport due to strong sink demand enhance plant capital, and delaying of the senescence of plants cause augmentation of yield in many plants (Bhattacharjee 1984; Bhattacharjee *et al.* 1986; Kumar and Purohit, 1997; Biswas and Ghosh 1999). In the present investigation, it seems apparent that increased crop yield in chayote is possibly due to maintenance of vital functional life of the source leaves by delaying of senescence which in turn efficiently transported assimilates for a longer duration.

Whatever might be the mechanism of senescence in this monocorpic vegetable crop, it seems quite likely that Atrinal-induced enhanced plant potential, deferred plant senescence, desired plant type modification and possibly prolonged assimitate transportation during fruit development cumulatively resulted in a substantial enhancement of yield. Some authors critically analysed scientific crop production as well as source-sink relationship in various crop plants including a few vegetable crops and came to the conclusion that a balanced source-sink relationship is an important determinant for crop yield (Thakur, 1975; Milthrope and Moorby, 1988; Biswas and Ghosh, 1999). Retardants, in general, delay the onset of senescence in plants (Orchard and Lovett, 1976; Weaver, 1972; Bhattacharjee, 1984; Bhattacharjee et al; 1986). Retardant-induced delaying of seed senescence and consequent enhancement of seed potential in some species have been established (Bhattacharjee and Gupta, 1985; Bhattacharjee and Choudhuri, 1986; Chhetri et al., 1993; Basu, 1994; Rai et al. 1995; Bhattacharjee et al., 1999; Rai 2010 Maity et al. 2000). Deferral of senescence in vegetables, cut flowers and even in mushroom and the resultant longevity have also been documented (Halevy, and Wittwer, 1966). While studying the processes of monocarpic senescence Nooden et al (1979) concluded that the prevention of the internally programmed degeneration might open a way to yield improvement. In the present study thus the augmented yield in the treated plants can be justified from the reported observations with respect to manipulation of source-sink, senescence as well as plant type.

Experiment on foliar treatment with growth retardants at preflowering stage and retardant followed by hormone treatment at the flowering stage seemed to be more interesting. In this experiment Atrinal, regardless of its concentrations, caused to increase the levels of chlorophyll and protein (Table 22) soluble and insoluble carbohydrates (Table 23), RNA and DNA (Table 24) as well as the activities of catalase and peroxidase (Table 25) enzymes. Such increases were further enhanced as a result of GA_3 and kinetin application at flowering stage (Tables29,30,31 and 32) . Again Atrinal-induced decrease in IAA-oxidase and RNase activities (Table 26) was decreased to a further extent in the GA_3- and kinetin-treated samples (Table 33). Biochemical changes in leaves were associated with the changes in vine length and stem circumference (Table 27). While the retardant-induced reduction of vine length was substantially overcome in combined treatments with GA_3 and kinetin, stem circumference in the chemical treated plants was found to increase steadily throughout the observation periods in kinetin-treated plants (Table 34), and thus combined treatmens were found more effective.

Unlike the results of foliar treatment of Atrinal at sapling stage, the consistent increase of chlorophyll, protein, soluble and insoluble carbohydrate, RNA and DNA levels as well as the activities of catalase and peroxidase enzymes indicate that their application at the preflowering stage (active log phase of growth) resulted in a steady and unfailing enhancement of plant potential which persisted till senile stage. Further potentiation of the retardant-treated plants by GA_3 and kinetin, as evident from the biochemical changes and rejuvenated plant growth, is indicative of the fact the plants under combined treatment could successfully defer the inevitable internally programmed degeneration occurring during senescence. The data of this investigation thus prove the senescence deferral property of the chemicals.

In the physiology of plant senescence, it is now well established that senescence is accompanied by the decrease of chlorophyll and protein levels and/or increase of their degradation (Osbrone, 1967; Leopold and Kriedemann, 1975; Van Staden et al. 1988; Biswas and Ghosh, 1999). There are reports that the activities of enzymes like protease and IAA-oxidase increase and catalase activity decrease during senescence (Biswas, 1978; Bhattacharjee, 1984) and alteration of such senescence indices by growth retardants indicate their senescence deferral action. While studying the processes of monocarpic senescence in soybean Nooden et al (1979) concluded that prevention of the internally programmed degeneration might open a way for strengthening plant potential and consequent enhancement of yield. Whatever might be the mechanisms of senescence (Thomas and Stoddart, 1980; Thimann, 1980; Nooden and Leopold, 1988; Engvild, 1989; Nooden et al., 1997) it is now well documented that deferral of plant senescence results in a enhanced plant vigour and such invigouration in many occasions is associated with enhanced productivity (Biswas and Choudhuri 1978; Nooden et al. 1979; Bhattacharjee et al. 1984; Biswas and Ghosh 1999).

Results of yield analysis along with senescence of plants (Tables 28, 35) and flower productivity (Table 36) using growth retardants and growth promoters respectively at preflowering and flowering stages, as observed in the present investigation, seemed to be more encouraging. Strong senescence deferral action in conjunction with higher productivity particularly in combined treatments (Atrinal + GA_3 or Atrinal +Kinetin) can be explained by the enhanced potential of the plants by the growth retardant Atrinal and effective utilization of the potentiated vigour by stimulating the sink demand using GA_3 or kinetin at the appropriate stage i.e. flowering stage of plant development. Again, a significant increase of flower numbers (Table 36). Particularly female flowers, in combined treatments (specially in Atrinal +GA_3) showed an additive effect to the enhanced productivity. In fact, higher number of female flowers resulted in corresponding increase of fruit numbers and consequent increase of total yield of fruits per plant. Now the question arises why tuberous root weight and also weight of fruits per plant increased both in single (Atrinal only) and in combined treatments although the increase was distinctly differential in single and combined treatments. This observation can be well explained from the available literature on source-sink and translocation system relationship of plants and particularly that of monocarpic plants where a balance relationship of soruce, sink and translocation system plays a crucial role for optimum productivity.

In crop plants physiological basis of yield was demonstrated and it was shown that enhanced plant potential becomes futile if plants fail to exploit vigour by efficiently drawing assimilates to the reproductive sinks during fruiting (Evans, 1975; Bjattacharjee, 1984; Bhattacharjee et al. 1984; Milthrope and Moorby, 1988). In the present investigation at least two systems were vitalized i.e. source and sink, while translocation system remained unexplored. Potentiation of source system was well documented in this work where the treated plants got rejuvenated as evident even by visual appearance and this was biochemically substantiated by analysing some senescence variables like enhancement of chlorophyll, protein, carbohydrate, nucleic acids as well as activities of catalase and peroxidase enzymes and supression of deleterious enzymes like IAA-oxidase and RNase during active fruit development and senile stages. Efficiency of the reproductive sinks was supposed to be enhanced by the hormonal (GA_3 and kientin) treatments during flowering stage where endogenous hormone-induced sink stimulation was further augmented by exogenous application of the hormones at the appropriate assimilate filling stage.

Hormone-directed translocation of assimilates is an well established phenomenon (Audus, 1959; Davies and wareing, 1965; Thomas, 1985). It is generally accepted that actively growing meristems and reproductive organs are the potential sinks for photosynthetically produced assimilates, and that activation or repression of apical sink and/or reproductive sinks may result in corresponding changes in growth and yield of plants

(Moorby, 1977). Growth retardants generally act through suppressing the apical sinks by reducing the hormonal levels therein and consquently by hindring the acropetal mobilization of assimilates (Cathey, 1964; Monselise and Luckwill, 1974; Hoad and Monselise, 1976; Ben-Gad et al., 1979). Bhattacharjee (1984) using ^{32}P showed that feeding of ^{32}P through contributory leaves of sunflower of some retardant treated plants resulted in a strong hindrance of ^{32}P mobilization to the upper leaves and reproductive sinks of the capitulum. He further observed that concomitant with such hindered mobilization of ^{32}P at the apical region basipetal mobilization was stimulated in the retardant treated plants.

Thus, from all the reported observations, it seems likely that in this investigation Atrinal induced positive factors of productivity like suppression of excess vigour and invigouration of plants but induced a negative factor for fruit production in chayote i.e. lowering of acropetal mobilization of assimilates, However this was overcome by exogenous application of GA_3 and kinetin which possibly compensated or even enhanced sink demand. So, enhanced plant vigour in conjunction with activated reproductive sink resulted in a substantial increase of fruit yield. Again, enhanced yield of tuberous roots can be explained by the reported observation that during retardant-induced basipetal mobilization the tuberous roots acted as the alternate potential sinks at least till the growth promoters are applied at the flowering stage of the plant causing diversion of assimilates to the reproductive sinks. In the present investigation, thus Atrinal alone caused to enhance root yield, and combined treatments with Atrinal followed by growth promoters (GA_3 and kinetin) caused to improve fruit yield. It has been demonstrated by many workes (Lorenzi *et al.* 1988, Ceccarelli and Lorenzi, 1990; Piaggesi *et al.*, 1997) that in chayote plant hormones like IAA, cytokinin and GA_3 appear during fruiting and developing fruits yield a considerable amount of the hormones. Thus enhancement of the levels of these hormoens by their exogenous application, as done in the present experiment, resulted in a remarkable enhancement of fruit yield.

Hormonal regulation of sex expression as well as flowering and fruit development in many plants including some cucurbits are well documented (Ghosh and Basu, 1982; 1983; 1984; Banerjee and Basu, 1991; 1992). Banerjee and Basu (1992) reported that GA_3 and ethrel enhance female flower production, stimulate fruit setting and fruit development in a monoecious cucurbit, *Momordica charantia*. Enhancement of both male and female flowers per plant by GA_3 application was demonstrated by Prakash (1977) in the same cucurbit. GA_3, IAA and HMO, an oxidation product of IAA promoted female flowers in *Momordica* which resulted in yield improvement (Ghosh and Basu, 1983). Influence of Atrinal and IAA in increasing female flower production, decreasing the percentage of abortive female flowers and consequent augmentation of fruit yield was reported by Banerjee and Basu (1991).

In this observation with a different cucurbit (*Sechium edule*) masculinizing and feminizing effect of GA_3 and kinetin and corresponding enhancement of fruit yield is thus in agreement with reported results. In this investigation this floral stimulation property of the growth promoters was efficiently utilized after modifying plant growth and potentiating the chayote plants by prior application of the growth retardant Atrinal. Thus retardant and promoter-induced selective dual action on the plants caused significant augmentation of crop yield in this study.

Thus, it is concluded that selective concentrations of Atrinal might be used with a view to increasing crop yield of chayote plant, but selection of the optimum stage of the chemical application and exploitation of the imposed higher vigour through hormonal manipulation at a critical stage of plant growth are the important determinants for obtaining the most covetable result.

Survey of Animal Pests

SURVEY OF ANIMAL PESTS

INTRODUCTION

By simple definition, pests are insects or any other living being whose population increases to such an extent as to cause economic losses to crops or a nuisance and health hazard to man and his livestock. As a process of civilisation, cultivation of crops led to a concentration of host plants providing easily available food to enable the insects to flourish. Deforestation, as another factor, necessitated by man's need for greater cultivation, habitation etc made forest insects migrating to fields and becoming pests of such plants and which they otherwise would have not cared for. In fact, insects and other beings are designated as pests only when they are sufficiently numerous to cause economic losses. Many factors are tied with the problems of pest outbreaks in the agricultural fields. Favourable weather conditions may lead to a rapid multiplication of an insect and the same condition may turn out to be unfavourable to its natural enemies giving an added impectus for the growth of the pest to cause an outbreak. Secondly, large scale mono culture of crops may be suitable for specific insects to thrive.

Existing literature on the animal pests of cucurbetaceous plants reveals that there occurs a number of vexatious pests which cause extensive damage to the whole plants. Leaves of plants attacked by certain pests rapidly wilt as if the sap flow had been cut or poisoned. Presence of permicious borer may destroy 25 per cent or more of the crop. Some worms whose larvae mature later in the season may even totally destroy late maturing pest populations results in extensive damage of chayote plants. Like other cucurbits, one of the severe problems as to the maximum productivity of chayote plants is attack by some animal pests on the foliage, inflorescence and stem of the plant particularly during assimilate filling phase, rendering the growing fruits less saturated or unsatured sinks thereby resulting in smaller size of fruits and consequently serious impairment of crop yield. Even the life cycle of the plant is terminated shortly and yield becomes negligible or nil under severe infection. Again yield of the underground tuberous root is sometimes reduced by some animal pests and soil nematods. To get rid of such biotic hazards in higher productivity, the population dynamics of animal pests appearing on the plants have to be ecologically analysed, the study of which is totally lacking in the literature. The present study therefore has been aimed to 1) identify and document different pestiferous populations on the stem, foliage and inflorescence 2) record the population fluctuations of different species in different months of the year in relation to climatology as well as growth phase of the plant 3) analyse such fluctuations in order to assess the ecological status of the agroecosystem and 4) to compare between wild and cultivated areas of plants growth. Although information are available on different pests in general on cucurbitaceous plants (Dhillon and Sharma, 1987) in India, specific and detailed information on chayote pests in Darjeelling hill areas are yet to be documented. Existing literatures also indicate that pest infectations to crop may be controlled by natural mortality factors like weather, hyperparasitism etc. (Walker et al., 1984, Soteres *et al.*, 1984 ; Williamson *et al.,* 1985 and Singh *et al.*, 1991). Such factors acting on chayote pests provide effective natural control in wild areas.

MATERIALS AND METHODS

Area of Study : The study area was located at Darjeeling, West Bengal, India at an altitude of 2100 m (approx). Two sites, were selected, one remained as uncared area of chayote plantation, herein referred to as 'wild' and another was a cultivated area by a farm herein referred to as 'cultivated'. For this study, 1000 m^2 area of both the sites were earmarred for sampling of pest populations on the said plantations. In the wild, the plants needed no extra maintenance but were naturally provided with good drainage, sandy loamy soil with rich humus. The cultivated area was a waste land where the fruit was sown in the month of January, in the levelled bed. The seed bed was prepared by filling the soil to make it loose and then decomposed organic manure (cowdung or compost) was added, on which the mature viable fruit was sown, slightly obliquely facing the seeded part towards the upperside, making an angle of 30°-40° with ground level. The fruit was covered with soil not exceeding 4 inches to 5 inches in thickness. Next, the decomposed organic manure was again spread all over the bed, propagation of the plant may either be through seed or fruit or vegetative propagation through the perennial underground tuberous roots.

3 Methodologies for population study :

In order to study the pestiferons population on *S. edule*, weekly observations were made from the very beginning of sprouting time of the plant. Juvenile and adult morphs of different pestiferous populations invading the crop were collected and maintained in the laboratory under preservation for identification. The population density of different species was enumerated both in wild and cultivated fields. The feeding nich of each population was observed carefully throughout the study period to ascertain species interactions if any. To estimate the population density and dynamics of different pest species a unit of 10 infested plants were considered (mostly the aerial parts were observed i.e. stem, leaves and reproductive parts) both in wild and cultivated fields. Meterological data with respect to precipitation (ie rainfall, snow etc), temperature and relative humidity were collected throughout the study period to analyse their impact on the pest species.

RESULTS AND DISCUSSION

In the present study, the following pestiferous populations were collected throughout the life cycle of plant, *Sechium edule.*

1. Hadda Beetle :- *Epilachna demurili*
   (Coleoptera : Coccinelhidae)
2. Red pumpkin Beetle :- *Rabphidopalpa foveicollis*
   (Coleoptera : Chrysomelidae)
3. Pickleworm :- *Diaphania nitidalis*
   (Lepidoptera : Pyralididae)
4. Squash bug :- *Anasa tristis*
   (Hemiptera : Coreidae)

The snail,

5. *Macrocalamys* sp :- Phylum Mollusca
   Class – Gastropoda.

The objective of this study was to throw light on the following characteristics of the community.

1. Comparative survey of the abundance of various population in Wild and Cultivated areas.
2. Total community structure in every month of plant life as regards populations of different species and a comparison between wild & cultivated areas.
3. Dominance Diversity curve for study in species importance at each month of plant's occurrence.

Comparative survey of each population in wild and cultivated areas : The results of this study has been depicted in Figs 1 to 5 .

In the Fig 1, abundance of *Epilachna demurili* on *Sechium edule* has been shown. The population is represented by large number of individuals both in wild and cultivated areas during the month of July and dwindles to certain extent in August. Then onwards, the population is shown to steadily decrease and in maintained at low level.

Fig 2 shows the abundance of *Diaphania nitidalis* during the months of occurrence. It shows that in cultivation, the population increases exponentially in August and then declines steadily over time. However, in the wild the population increase is not as great as that in cultivation and was maintained at a comparatively low levels to go to dormant phase during December.

Similar trends were also observed for *Rabphidopalpa foveicollius* (Fig 3) In the cultivated men from an initial low level in July, population increased from August but started to decline after October to a sudden low population density in December. The population showed slightly higher rate of increase in the cultivated than in wild, in which, notable population increase took place only during October, maintained at equilibrium till November and then sharply declined to a dormant level in December.

In the case of *Anasa tristis* (Fig, 4) , population growth in the cultivated areas increases exponentially from August and reaches its peaks in October but a population crash is obtained afterwords as evident from a steadily debilitating population in November and December. In the wild, population increase is however not as rapid as in the cultivation but a rising trend is maintained till October, after which the population decline following a short interval of equilibrium.

The population of *Macrocalamys* sp, has shown a fluctuating trend as seen in Fig 5. In the cultivated area, it shows an initially higher rate of growth in August and grows rapidly in September but falls to a low level in October. It again rises in November to finally decline in December. In the wild, similar fluctuations are observed although, the rate of growth is lower than that in the cultivation.

Explanations : Although variations in the abundance of different species are evident, yet a general trend is still existing. The changes in the population density can firstly be correlated with the metrological factors viz. rainfall, humidity, temperature & photoperiod and the life cycle of the plant itself. Fruiting of the plant is from the end of June to and of December and the incidence of pest population has also been recorded during this phase only.

The climatic factors during this period ensures a moist but frost free atmosphere with good rainfall to about 1500 – 6257 mm and temperature from 10^0c to 25^0c which is the most favourable for the plant growth and thereby associated pestiferous population. A relative humidity (RH%) averaging 80-90% has been very much favourable and 100% RH can be tolerated by the plant.

Hence, with the atmospheric factors for plant growth being favourable, the plant life is spanned from end of June to end of December and peals of propagation during August to October. During July to September both the cultivated and wild field get maximum abundance of pestiferous populations belonging to species *Epilachna demurilii* and *Diaphania nitidalis.* During September to November the most abundant populations of pests belong to *Rabphidopalpa foveicollis* , *Anasa tristis* and *Macrocalamys.*sp. Therefore both the periods (i.e July to September and September to November) need intensive observation to reduce the crop productions by the pests.

Monthwise Community structure of pest populations both in cultivated and wild fields:

The results of this study have been shown in Fig (6 –7). Among the reorded five pestiferous species. *Epilachna demurili* showed maximum abundance in July both in cultivated and wild fields, with a gradual decline upto December. *Diaphania nitidalis, Macrocalamys* sp and *Raphidopalpa foveicollis* had peak abundance during August to October in cultivated field. The senerio is to some extent different in case of wild field for these pest species. According to the magnitude of abundance of population, the pest species may be ordered, from highest to lowest, *Epilachna demurili, Diaphania nitidalis, Macorcalamys,*sp. *Rabphidopalpa foveicollis. Anasa tistis* in cultivated condition. The order is more or less similar in case of wild condition.

Explanations : *Sechium edule* supports a large number of pestiferous species with different degrees of manifestations. The recorded five species had a seggregated status trophic (feeding) niche, for example, defoliator, Sucker, scraper, barer etc. Such a vast range of invasion pattern is a serious concern with regards to crop cultivation. The whole pesteferous community was very much static and stable one as all the thriving species were mutually exclusive with regards to their feeding as well breeding niches. Therefore, all the species need individual attention for the controlling programme taken, if any.

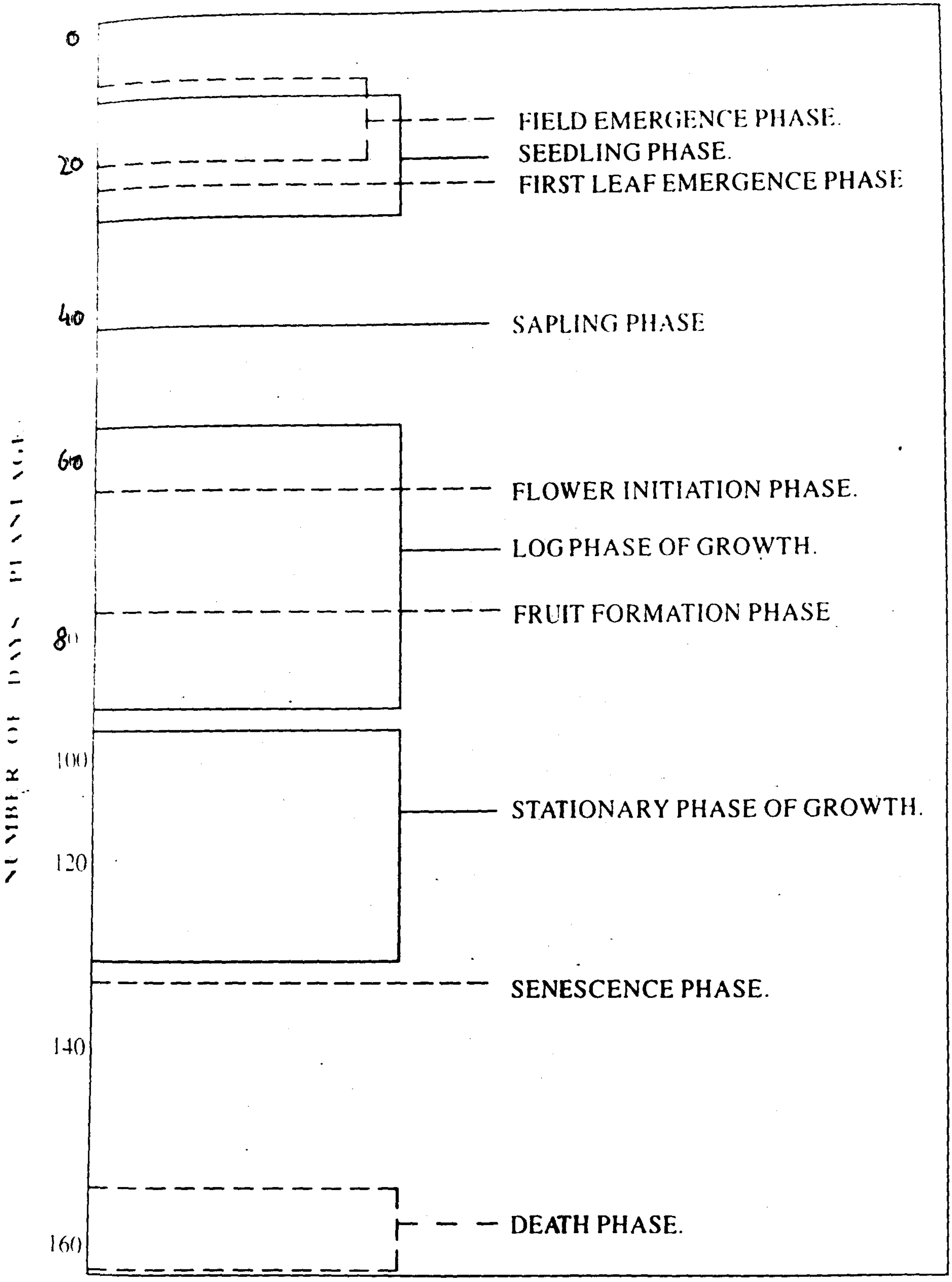
Month wise Dominance diversity of pestiferous species populations.

The results of this study has been shown in the figs (8 to 19).

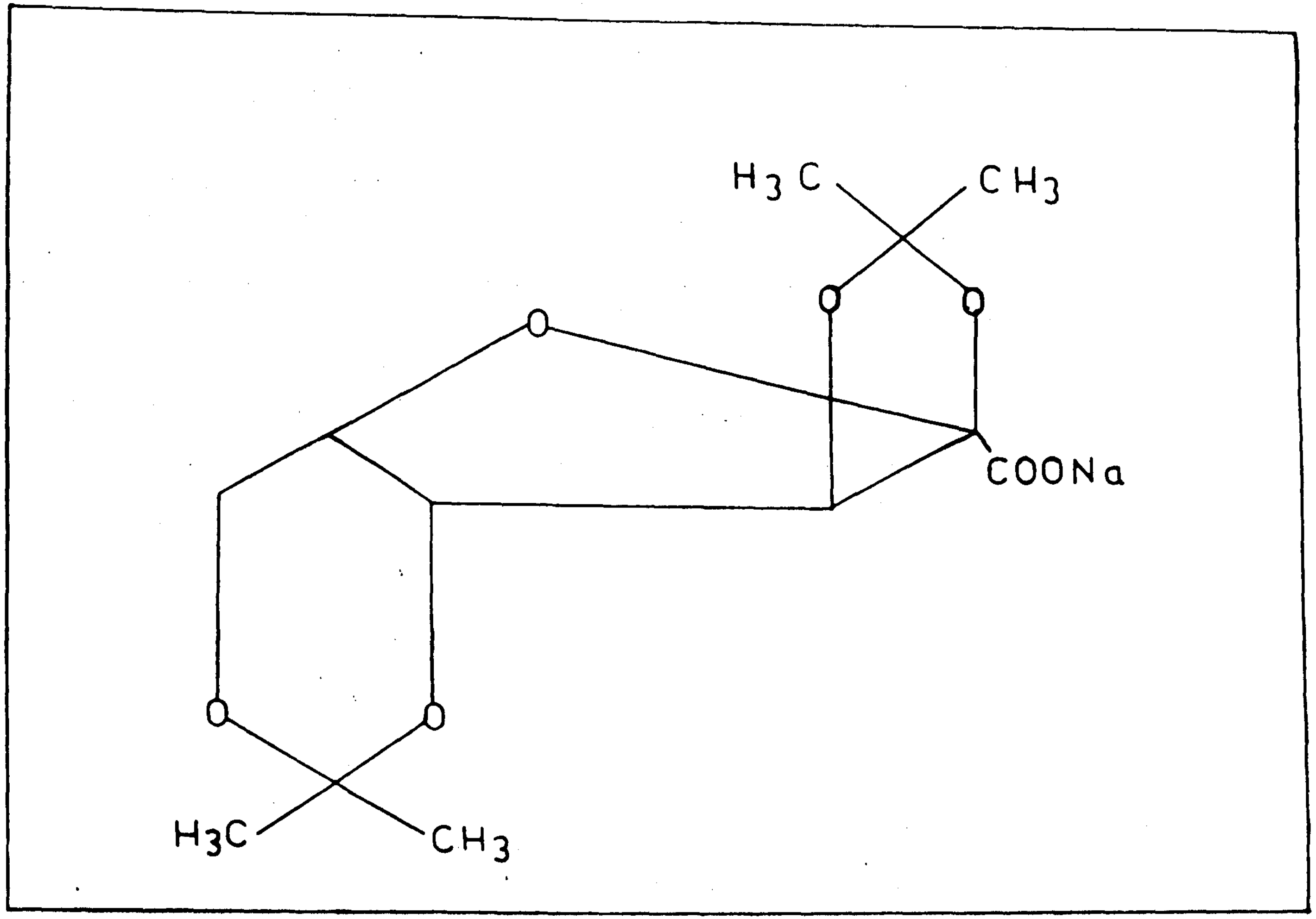
The species *Epilachna demurili* is represented as 'A' , *Diaphania nitidalis* is 'B', *Rabphilopalpa foveicollis* is 'C' *Anasa tristis* is 'D' and *Macrocalamys* sp. is 'E' for convenience. In August, the species dominance in order of magnitude, 'A', 'B', 'E', 'C', 'D' both in cultivated and wild conditions. September witnessed the same as 'A', 'B', 'E', 'C', 'D' in cultivated condition and 'A', 'B', 'E', 'C', 'D' in wild condition. October had the sequence as 'B', 'A', 'D','E', 'C', in cultivated condition and A', 'B', 'D', 'C' 'E', in wild condition. November showed 'B', 'E', 'A', 'D', 'C' sequence in cultivated and 'A', 'E', 'B', 'D', 'C' in wild conditions. Finally December witnessed the species sequence as 'B', 'A', 'E', 'D', 'C' in cultivated condition and A', 'B', 'E', 'D;', 'C', in wild condition. 'A' and 'B' appears to be the most dominant species.

Explanations : From the study it appears that in all month of study period 'A', 'B', 'E' are the most dominant pestiferous species amongst the five except in October, when first three dominant species are 'A' 'B' 'D'. Therefore, 'A', 'B', 'D', 'E' may be considered as first four dominant species during the study period. This result is equally reflected in all the parameters of this study under consideration. Hence, the whole survey reveals that 'A', 'B', 'D', 'E' i.e. *Epilachana demurili, Diaphania nitidalis, Anasa tistis, Macrocalamys* sp. are the most prominent pests of *Sechium edule* throughout the study period with the some less important pest species. Therefore, all these species need intensive surveillance for the better production of *Sechium edule* crop.

Diagram

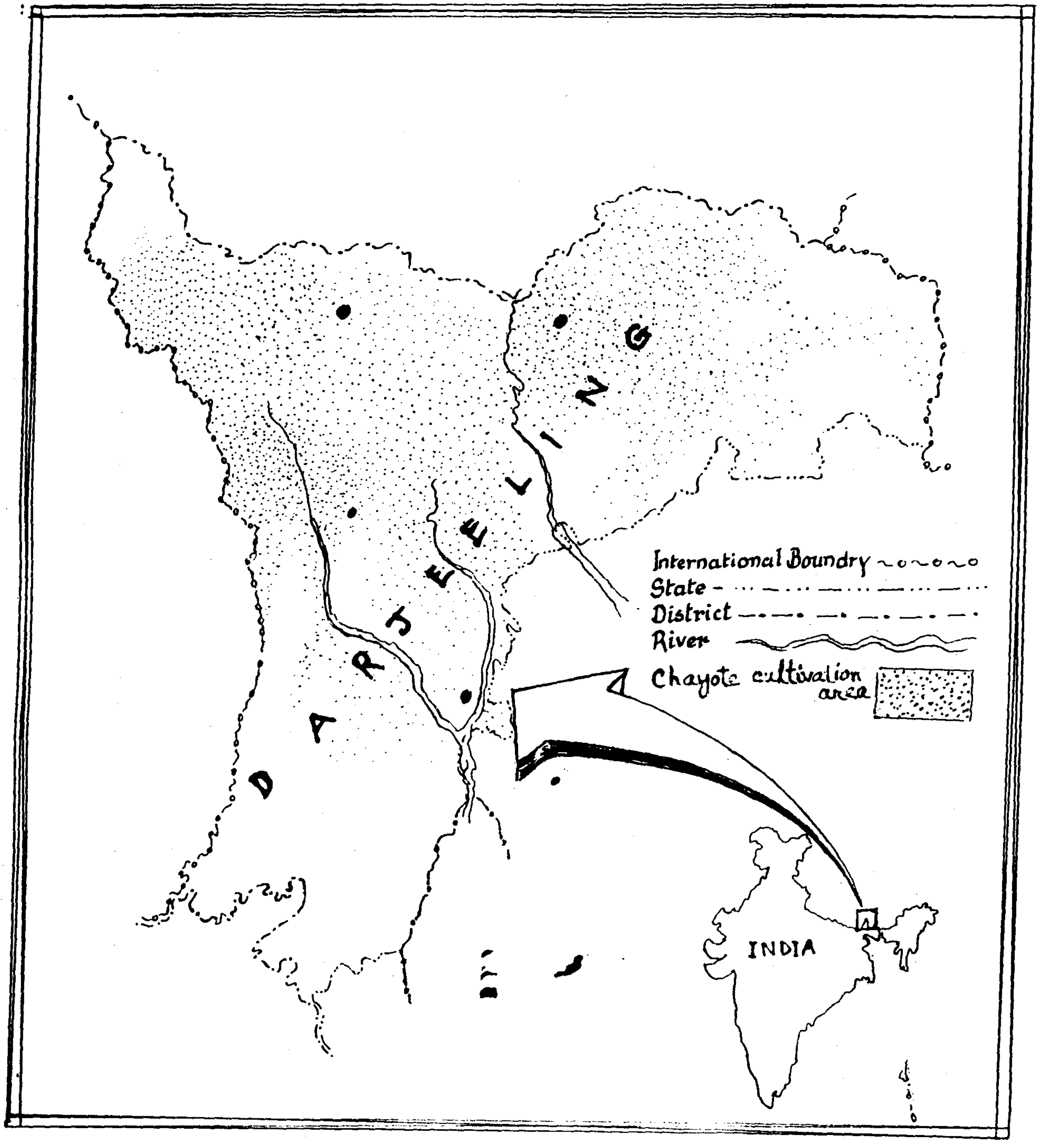


Dia 1 GRAPHICAL REPRESENTATION OF THE LIFE CYCLE OF *Sechium edule*.



Structure of sodium dikegulac

Dia 2



Dia 3 A map of Darjeeling district showing chayote cultivation area

Tables

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

Varietal type	Length (cm)	Breadth (cm)	Girth (cm)	Weight (g)	Colour	Hair density (per cm)	Hair length (mm)	Pattern of distribution
A	12.2	8.6	19.0	469.5	Greenish white	0	-	Hairless fruits
B	15.5	8.9	22.8	570.8	Green	0	-	Hairless fruit
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
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
H	9.1	5.8	14.0	140.5	Greenish white	Only a few per fruit	2	Evenly distributed 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	-	Hairless fruits
LSD (P=0.05)	1.02	0.68	1.28	14.0		0.35	0.19	-

Table 2. Important phases occurring in the life cycle of *Sechium 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 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 several deep longitudinal groves or channels, more pronounced toward the ends; 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.

Table 3. Some vegetative and reproductive characteristics of three different varieties of *Sechium 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 fruit 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. Summary of meteorological observations during the year 1992 at Darjeeling*

MONTH	**TEMPERATURE(^{0}C)**		**RELATIVE HUMADITY (%)**		**TOTAL RAINFALL mm**
	MEAN MIN	**MEAN MAX.**	**8.30 HRS.**	**17.30 HRS.**	
JANURAY	7.11	9.28	83.71	85.27	NIL
FEBRUARY	8.96	11.72	85.88	89.21	43.0
MARCH	9.72	12.78	72.81	75.75	54.0
APRIL	14.28	18.77	82.11	83.87	132.0
MAY	19.70	20.08	83.11	85.57	252.6
JUNE	20.70	22.00	86.47	87.83	607.10
JULY	20.34	22.85	94.78	97.17	859.0
AUGUST	19.50	20.00	85.70	87.44	84.0
SEPTEMBER	20.00	23.34	93.28	95.70	309.2
OCTOBER	19.35	20.00	85.70	87.44	84.0
NOVEMBER	14.78	17.67	84.03	85.91	NIL
DECEMBER	9.23	11.78	80.78	82.98	NIL
AVERAGE	15.30	17.58	85.77	87.16	T = 2704.40

*Longitude : 88°12′E Place : Darjeeling Town Altidue : 2134M Latitude : 26°55′N

Table 5. Summary of Meteorological observations during the year 1993 at Darjeeling*

MONTH	TEMPERATURE°C		RELATIVE HUMADITY (%)		TOTAL RAINFALL mm
	MEAN MIN	MEAN MAX.	8.30 HRS.	17.30 HRS.	
JANURAY	7.07	7.07	83.78	84.50	48.0
FEBRUARY	8.78	12.98	85.21	86.71	6.0
MARCH	13.48	17.22	72.11	73.25	25.5
APRIL	17.17	19.20	80.12	81.23	39.0
MAY	19.15	20.88	84.88	84.90	281.0
JUNE	18.77	19.88	86.77	90.11	587.0
JULY	20.78	21.74	93.77	97.11	594.0
AUGUST	20.58	22.44	96.77	98.38	651.4
SEPTEMBER	20.95	21.75	94.22	95.71	532.5
OCTOBER	17.75	19.28	85.70	86.29	2.0
NOVEMBER	15.19	17.00	82.17	83.21	NIL
DECEMBER	10.01	12.78	80.11	82.28	9.0
AVERAGE	15.80	17.68	85.46	86.97	T = 2775.4

*Longitude : 88°12′E Place : Darjeeling Town Altidue : 2134M Latitude : 26°55′N

Table 6. **Summary of** Meteorological **observations** during the year 1994 at Darjeeling*

MONTH	**TEMPERATURE(^{0}C)**		**RELATIVE HUMADITY (%)**		**TOTAL RAINFALL mm**
	MEAN MIN	**MEAN MAX.**	**8.30 HRS.**	**17.30 HRS.**	
JANURAY	6.14	10.17	73.44	75.81	NIL
FEBRUARY	7.01	13.18	78.71	79.71	28.5
MARCH	10.11	16.44	75.81	76.71	NIL
APRIL	15.35	21.19	80.88	83.73	95.0
MAY	16.78	23.12	84.55	86.93	109.5
JUNE	18.84	24.19	86.17	89.90	313.9
JULY	20.18	24.78	94.27	96.39	725.5
AUGUST	21.15	25.00	96.88	98.22	517.5
SEPTEMBER	20.98	25.15	92.11	94.17	288.0
OCTOBER	17.17	21.78	84.22	85.15	68.0
NOVEMBER	13.18	18.77	82.12	83.11	NIL
DECEMBER	10.00	12.33	77.11	80.01	3.4
AVERAGE	14.74	19.67	83.85	85.82	T = 2149.3

*Longitude : 88° 12′E Place : Darjeeling Town Altitude : 2134M Latitude : 26°55′N

Table 7. Meterological data recorded during tye year 1995 at Darjeeling*

MONTH	TEMPERATURE(^{0}C)		RELATIVE HUMADITY (%)		TOTAL RAINFALL mm
	MEAN MIN	MEAN MAX.	8.30 HRS.	17.30 HRS.	
JANURAY	7.12	12.05	64.45	86.59	0.00
FEBRUARY	8.59	13.85	75.88	64.85	07.0
MARCH	10.38	15.09	78.59	70.77	21.5
APRIL	12.87	20.28	72.85	80.69	33.5
MAY	14.36	22.06	92.29	91.33	97.0
JUNE	16.01	20.08	89.75	100.00	613.0
JULY	18.15	19.57	90.88	100.00	806.0
AUGUST	19.75	20.08	91.66	91.57	520.0
SEPTEMBER	20.21	18.17	82.77	100.00	398.0
OCTOBER	16.90	17.28	77.84	69.21	032.7
NOVEMBER	14.01	15.36	89.63	67.95	142.0
DECEMBER	8.14	14.01	68.21	77.66	20.8
AVERAGES	13.87	17.32	81.23	83.38	T=2691.49

*Longitude : 88° 12′E Place : Darjeeling Town Altitude 2134M Latitude : 26°55′N

Table 8. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 μg/ml) on intact and defleshed fruit of chayote on chlorophyll (Chl, mg/g fresh weight) and protein (Pr, mg/g fresh weight) contents in leaves at different developmental stages of the plant.

Sprouting fruits (intact or defleshed) were pretreated with the test solutions or distilled water for 24 hours and then sown in the experimental field. Data were recorded at 5 developmental stages i.e., seedling stage, sapling stage, preflowering stage, fruiting stage and senile stage which correspond to 20-, 40-, 60-, 80- and 140 days of plant age respectively.

Pretreating Sample	Concn. of Atrinal (μg/ml)	Developmental Stages									
		Seedling		Sapling		Preflowering		Fruiting		Senile	
		Chl	Pr	Chl	Pr	Chl	Pr	Chl	Pr	Chl	Pr
Intact Fruit	0	2.49	22.50	3.10	65.51	3.55	74.20	2.81	62.50	0.32	19.80
	500	2.72	35.75	3.45	78.55	3.61	80.71	2.88	65.01	0.35	21.70
	1000	3.05	38.80	4.02	84.25	3.65	80.25	2.94	66.45	0.35	21.01
	2000	2.75	33.70	3.50	70.69	3.52	75.50	2.85	63.10	0.34	20.50
	LSD (P=0.05)	0.210	3.50	0.28	6.15	NS	NS	NS	NS	NS	NS
Defleshed fruit	0	2.78	28.75	3.40	75.05	3.85	85.70	3.05	66.01	0.49	25.55
	500	2.95	40.50	3.88	85.40	3.98	88.76	3.20	70.81	0.58	25.95
	1000	3.25	46.65	4.60	90.30	4.02	92.38	3.25	72.60	0.58	27.01
	2000	2.68	40.15	3.35	80.12	3.70	86.01	3.25	67.11	0.62	26.15
	LSD (P=0.005)	0.19	3.50	0.30	6.69	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 9. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 µg/ml) on intact and defleshed fruit of chayote on soluble (Sol, mg/g fresh weight) and insoluble (Insol, mg/g fresh weight) carbohydrate contents in leaves at different developmental stages of the plant.

Treatments and recording of data are the same as in Table 8

Pretreating Sample	Concn. of Atrinal (µg/ml)	Developmental Stages									
		Seedling		Sapling		Preflowering		Fruiting		Senile	
		Sol	Insol	Sol	Insol	Sol	Insol	Sol	Insol	Sol	Insol
Intact Fruit	0	5.47	60.18	7.23	75.70	10.90	81.10	8.01	52.71	4.35	25.15
	500	6.70	72.75	10.90	86.70	11.15	83.65	8.20	51.90	4.35	25.00
	1000	7.20	75.80	12.25	90.39	11.72	85.80	8.65	55.01	4.40	26.25
	2000	5.89	68.85	10.05	78.18	11.88	78.01	7.78	52.41	4.32	25.20
	LSD (P=0.05)	0.75	6.19	1.08	6.90	NS	NS	NS	NS	NS	NS
Defleshed fruit	0	6.50	67.10	8.50	83.20	12.95	86.69	8.38	54.15	5.05	30.08
	500	8.20	79.67	10.25	92.15	13.05	90.01	8.40	57.10	5.10	32.05
	1000	8.66	78.35	12.05	98.72	13.60	92.40	8.52	58.91	5.25	33.19
	2000	7.58	76.66	9.98	94.50	12.99	88.20	8.44	55.36	5.10	30.95
	LSD (P=0.005)	0.70	5.90	0.89	7.10	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 10. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 µg/ml) on intact and defleshed fruit of chayote on RNA (µg/g fresh weight) and DNA (µg/g fresh weight) contents in leaves at different developmental stages of the plant.

Treatments and recording of data are the same as in Table 8.

Pretreating Sample	**Concn. of Atrinal (µg/ml)**	**Developmental Stages**									
		Seedling		**Sapling**		**Preflowering**		**Fruiting**		**Senile**	
		RNA	**DNA**	**RNA**	**DNA**	**RNA**	**DNA**	**RNA**	**DNA**	**RNA**	**DNA**
Intact Fruit	0	470.5	70.5	535.8	82.7	548.7	78.6	515.9	60.9	288.7	38.7
	500	5.60.8	85.2	633.9	85.0	580.8	82.7	528.5	63.0	307.2	40.1
	1000	590.2	90.8	649.8	88.5	585.5	85.0	540.7	65.5	310.9	41.5
	2000	550.9	80.6	598.9	84.6	557.2	82.8	520.5	61.8	297.5	38.9
	LSD (P=0.05)	38.80	8.50	48.05	NS	NS	NS	NS	NS	NS	NS
Defleshed fruit	0	520.2	77.0	578.9	88.9	88.9	601.5	85.6	543.2	60.6	50.6
	500	570.6	88.0	645.7	92.0	92.0	635.1	88.7	560.5	63.3	52.0
	1000	629.8	92.9	666.9	95.8	95.8	639.5	90.0	569.9	64.8	52.5
	2000	588.7	84.5	630.4	91.3	91.3	633.6	87.7	556.1	60.9	49.8
	LSD (P=0.005)	42.95	7.05	50.75	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 11. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 µg/ml) on intact and defleshed fruit of chayote on catalase (Cat, unit/g fresh weight/h) and peroxidase (Per, unit/g fresh weight/h) activities in leaves of chayote plant.

Treatments and recording of data are the same as in Table 8.

Pretreating Sample	Concn. of Atrinal (µg/ml)	Developmental Stages									
		Seedling		Sapling		Preflowering		Fruiting		Senile	
		Cat	Per	Cat	Per	Cat	Per	Cat	Per	Cat	Per
Intact Fruit	0	120.7	30.5	139.5	78.2	146.5	85.9	130.7	96.7	60.6	25.6
	500	140.8	45.7	165.9	84.8	150.5	86.9	132.2	96.7	63.3	25.8
	1000	158.6	52.2	177.6	92.7	153.5	90.0	134.5	100.1	65.0	26.2
	2000	137.0	38.9	159.0	90.1	149.5	88.8	128.7	96.9	61.7	27.0
	LSD (P=0.05)	10.52	4.01	12.05	6.50	NS	NS	NS	NS	NS	NS
Defleshed fruit	0	140.5	38.5	157.6	90.0	159.9	97.1	139.5	100.8	77.9	36.5
	500	154.9	45.9	177.0	97.9	162.0	101.0	141.7	98.9	77.5	37.0
	1000	166.9	56.7	187.5	114.7	165.2	105.2	148.0	103.0	82.5	37.1
	2000	153.4	43.8	180.2	98.8	158.9	99.5	142.8	98.5	80.8	36.9
	LSD (P=0.005)	11.80	4.05	13.80	8.15	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 12. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 µg/ml) on intact and defleshed fruit of chayote on IAA-oxidase (IAAox, unit/g fresh weight) and RNase (unit/g fresh weight) activities in leaves of chayote plant.

Treatments and recording of data are the same as in Table 8.

Pretreating Sample	Concn. of Atrinal (µg/ml)	Developmental Stages									
		Seedling		Sapling		Preflowering		Fruiting		Senile	
		IAA ox	RNase	IAAox	RNase	IAAox	RNase	IAAox	RNase	IAAox	RNase
Intact fruit	0	24.50	80.75	29.10	93.01	69.35	170.11	80.69	215.52	96.40	292.70
	500	18.01	72.72	25.01	89.90	70.16	162.51	81.15	210.80	94.25	288.15
	1000	16.50	60.59	22.50	80.98	67.95	161.80	77.90	206.10	92.29	282.75
	2000	19.90	66.40	27.25	85.54	68.80	169.50	80.05	213.22	96.20	285.65
	LSD (P=0.05)	1.50	6.90	2.01	6.98	NS	NS	NS	NS	NS	NS
Defleshed fruit	0	22.70	77.34	25.91	87.90	61.82	150.90	70.24	198.72	86.85	244.44
	500	16.95	68.75	22.01	80.14	60.15	148.34	68.80	190.31	85.50	238.14
	1000	15.80	65.05	19.95	77.33	58.90	144.90	66.88	188.90	84.19	232.92
	2000	18.40	70.15	23.14	78.75	59.75	149.11	70.01	193.75	86.05	240.70
	LSD (P=0.005)	1.48	6.01	2.04	7.05	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 13. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 µg/ml) on intact and defleshed fruit of chayote on vine length (V.L., cm) and stem circumference (S.C., cm) at different developmental stages of the plant.

Treatments and recording of data are the same as in Table 8.

Pretreating Sample	Concn. of Atrinal (µg/ml)	Developmental Stages									
		Seedling		Sapling		Preflowering		Fruiting		Senile	
		V.L.	S.C.	V.L.	S.C.	V.L.	S.C.	V.L.	S.C.	V.L.	S.C.
Intact fruit	0	52.7	1.05	131.5	1.98	319.2	3.66	530.9	5.58	550.4	5.70
	500	45.8	1.45	112.9	2.40	312.9	3.85	528.5	5.70	542.7	5.78
	1000	43.6	1.59	108.4	2.52	309.8	3.88	520.7	5.75	538.6	5.85
	2000	38.5	1.64	100.7	2.60	305.2	3.90	510.1	5.75	532.9	5.92
	LSD (P=0.05)	4.01	0.13	10.52	0.20	NS	NS	NS	NS	NS	NS
Defleshed fruit	0	58.6	1.25	148.9	2.30	340.5	3.89	562.8	5.90	505.9	6.10
	500	50.1	1.53	132.7	2.60	338.7	3.98	548.7	5.98	585.2	6.21
	1000	45.9	1.60	125.8	2.66	335.9	4.05	540.2	6.18	579.8	6.30
	2000	40.9	1.68	120.3	2.74	326.5	4.08	536.9	6.24	568.7	6.33
	LSD (P=0.005)	4.20	0.15	12.50	0.21	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 14. Effect of pretreatment with Atrinal (0, 500, 1000 and 2000 µg/ml) on intact and defleshed fruit of chayote on changes in number of days required for inception of leaf senescence (Senes. days) total fruit number (Fruit No.), total fruit weight (Fruit wt.) and total tuberous root weight (Root wt.) per plant.

Treatments and recording of data are the same as in Table 8. Data were recorded from 5 uniformly grown plants of each treatment.

Pretreating sample	Concn. of Atrinal (µg/ml)	Senes. days	Fruit No.	Fruit wt. (kg)	Root wt. (kg)
Intact fruit	0	142	155	57.5	13.0
	500	145	157	60.0	13.0
	1000	145	158	58.9	13.5
	2000	142	155	57.0	12.9
	LSD (P=0.05)	NS	NS	NS	NS
Defleshed fruit	0	142	165	63.5	14.5
	500	143	167	65.2	15.0
	1000	139	167	66.0	14.2
	2000	143	166	62.9	14.7
	LSD (P=0.05)	NS	NS	NS	NS

NS = Not significant

Table 15. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 μg/ml) at the sapling stage of the plant on chlorophyll (Chl, mg/g fresh weight) and protein (Pr, mg/g fresh weight) contents in leaves of chayote.

Thirty-day-old field grown saplings raised from intact and defleshed fruits, were sprayed with Atrinal or distilled water for 3 consecutive days. Data were recorded at 4 developmental stages i.e, sapling stage, preflowering state, fruiting stage and senile state which correspond to 40-, 60-, 80- and 140 days of plant age respectively.

Plants raised from	Concn. of Atrinal (μg/ml)	Developmental Stages							
		Sapling		Preflowering		Fruiting		Senile	
		Sol	Insol	Sol	Insol	Sol	Insol	Sol	Insol
Intact fruit	0	7.19	71.90	10.05	79.15	8.20	52.90	4.32	24.88
	500	6.05	62.50	10.50	77.90	11.20	70.12	6.52	33.70
	1000	5.90	58.90	11.01	77.88	12.72	75.90	7.90	38.90
	2000	5.82	56.69	10.05	75.05	10.90	65.70	6.23	33.05
	LSD (P=0.05)	0.40	5.04	NS	NS	0.80	5.25	0.48	2.90
Defleshed fruit	0	8.45	82.21	12.82	85.90	8.25	53.86	4.98	29.75
	500	6.25	69.50	11.99	86.28	11.57	73.05	7.05	36.95
	1000	5.99	66.29	12.50	88.20	12.85	76.45	9.05	44.80
	2000	5.90	62.50	11.98	82.01	11.05	68.51	7.10	38.80
	LSD(P=0.05)	0.48	6.60	NS	NS	0.92	5.65	0.45	3.01

NS = Not significant

Table 16. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the sapling stage of the plant on soluble (Sol, mg/g fresh weight) and insoluble (Insol, mg/g fresh weight) carbohydrate contents in leaves of chayote.

Plant development and treatments are the same as in Table 15. Data were recorded at 4 developmental stages as metioned in the same Table.

Pretreating Sample	Concn. of Atrinal (µg/ml)	Developmental Stages							
		Sapling		Preflowering		Fruiting		Senile	
		Chl	Pr	Chl	Pr	Chl	Pr	Chl	Pr
Intact fruit	0	3.07	63.79	3.50	72.58	2.80	60.80	0.32	20.15
	500	2.43	57.59	3.82	70.57	3.25	68.50	0.48	28.28
	1000	2.30	54.10	3.90	73.90	3.66	75.58	0.66	35.75
	2000	2.18	52.25	3.75	69.95	3.15	67.19	0.40	27.80
	LSD (P=0.05)	0.20	5.01	0.24	NS	0.28	6.05	0.03	NS
Defleshed fruit	0	3.41	72.90	3.83	86.77	3.12	67.31	0.52	26.88
	500	3.02	62.90	4.20	82.50	3.49	76.10	0.70	36.75
	1000	2.95	58.85	4.35	81.95	3.78	80.80	0.85	40.90
	2000	2.90	55.99	4.09	79.80	3.48	75.20	0.69	35.95
	LSD(P=0.05)	0.29	6.11	0.35	NS	0.30	6.20	0.05	3.01

NS = Not significant

Table 17. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the sapling stage of the plant on RNA (µg/g fresh weight) and DNA (µg/g fresh weight) contents in leaves of chayote.

Plant development and treatments are the same as in Table 15. Data were recorded at 4 developmental stages as metioned in the same Table.

Plants raised from	Concn. of Atrinal (µg/ml)	Developmental Stages							
		Sapling		Preflowering		Fruiting		Senile	
		RNA	DNA	RNA	DNA	RNA	DNA	RNA	DNA
Intact fruit	0	528.9	78.8	550.8	77.8	511.3	62.1	285.5	39.0
	500	460.5	61.6	530.1	76.8	570.1	70.1	360.8	55.9
	1000	440.9	56.9	518.9	72.9	592.7	75.2	395.1	62.0
	2000	426.2	51.8	515.2	70.9	561.6	69.5	352.7	58.8
	LSD (P=0.05)	38.75	5.95	NS	NS	42.50	5.80	25.95	4.16
Defleshed fruit	0	577.5	85.9	595.2	85.0	548.4	64.7	340.1	53.8
	500	522.6	70.0	579.0	82.5	601.4	70.6	398.9	62.7
	1000	511.3	64.2	564.8	80.9	640.0	76.9	440.7	69.8
	2000	480.5	59.5	560.9	80.5	592.7	71.8	407.5	60.9
	LSD(P=0.05)	42.80	6.08	NS	NS	45.5	5.34	32.95	5.00

NS = Not significant

Table 18. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 μg/ml) at the sapling stage of the plant on catalase (Cat, unit/g fresh weight/h) and peroxidase (Per, unit/g fresh weight/h) activities in leaves of chayote.

Plant development and treatments are the same as in Table 15. Data were recorded at 4 developmental stages as metioned in the same Table.

Plants raised from	Concn. of Atrinal (μg/ml)	Developmental Stages							
		Sapling		Preflowering		Fruiting		Senile	
		Cat	Per	Cat	Per	Cat	Per	Cat	Per
Intact fruit	0	138.9	81.8	142.6	85.7	128.6	94.9	92.0	27.1
	500	110.7	65.2	138.7	82.5	148.7	112.7	76.8	38.8
	1000	101.5	60.7	135.2	80.8	160.8	119.8	88.9	49.6
	2000	92.8	57.9	132.9	79.6	142.7	103.5	77.1	40.9
	LSD (P=0.05)	9.01	5.98	NS	NS	10.95	8.57	6.05	3.00
Defleshed fruit	0	154.9	91.6	159.0	98.1	137.6	97.5	78.4	37.8
	500	109.8	78.1	152.7	95.5	156.8	120.7	89.7	48.6
	1000	102.5	76.0	149.8	93.7	167.2	128.1	108.7	54.9
	2000	95.8	70.9	147.9	92.5	149.9	115.9	92.8	45.5
	LSD (P=0.05)	9.14	6.66	NS	NS	11.90	9.01	7.50	3.95

NS = Not significant

Table 19. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 μg/ml) at the sapling stage of the plant on IAA-oxidase (IAAox, unit/g fresh weight/h) and RNase (unit/g fresh weight/h) activities in leaves of chayote.

Plant development and treatments are the same as in Table 15. Data were recorded at 4 developmental stages as metioned in the same Table.

Plants raised from	Concn. of Atrinal (μg/ml)	Developmental Stages							
		Sapling		Preflowering		Fruiting		Senile	
		IAAox	RNase	IAAox	RNase	IAAox	RNase	IAAox	Rnase
Intact fruit	0	30.90	92.50	68.75	174.70	78.80	210.7	94.50	288.75
	500	38.76	107.50	60.10	162.62	64.05	182.6	81.90	230.60
	1000	44.10	111.35	57.25	153.74	59.90	171.8	73.49	201.59
	2000	45.90	118.05	61.10	163.81	65.81	185.5	85.81	236.95
	LSD (P=0.05)	3.01	8.98	5.01	9.05	5.20	15.50	7.10	19.90
Defleshed fruit	0	23.88	88.24	59.50	152.72	66.99	196.65	84.50	241.18
	500	35.70	98.90	50.02	138.51	56.05	172.70	69.90	195.80
	1000	40.02	108.70	47.59	125.91	52.18	153.61	58.50	172.05
	2000	46.15	117.35	53.01	141.01	58.10	167.90	68.88	198.80
	LSD (P=0.05)	3.05	8.10	4.90	10.50	4.80	14.90	6.00	16.19

Table 20. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the sapling stage of the plant on vine length (V.L., cm), and stem circumsference (S.C., cm) at different developmental stages of chayote.

Plant development and treatments are the same as in Table 15. Data were recorded at 4 developmental stages as metioned in the same Table.

Plants raised from	Concn. of Atrinal (µg/ml)	Developmental Stages							
		Sapling		Preflowering		Fruiting		Senile	
		V.L.	S.C.	V.L.	S.C.	V.L.	S.C.	V.L.	S.C.
Intact fruit	0	128.6	2.01	314.7	3.61	524.8	5.65	546.7	5.65
	500	110.9	2.28	287.6	4.05	475.5	5.98	489.5	5.92
	1000	103.7	2.78	275.9	4.38	460.2	6.60	460.7	6.62
	2000	93.9	2.90	266.7	4.49	439.8	6.78	445.8	6.78
	LSD (P=0.05)	9.01	0.20	23.08	0.35	40.55	0.50	35.51	0.49
Defleshed fruit	0	145.5	2.35	337.2	3.86	554.9	6.10	612.8	6.10
	500	126.2	2.78	283.6	4.38	468.7	6.44	571.0	6.42
	1000	105.9	3.01	264.8	4.75	451.0	6.68	536.5	6.78
	2000	95.8	3.20	250.1	4.86	443.7	6.80	518.9	6.96
	LSD (P=0.05)	9.00	0.27	25.09	0.30	40.50	0.40	58.25	5.01

Table 21. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the sapling stage of the plant on chages in number of days required for inception of leaf senescence (Senes. days), total fruit number (Fruit No.), total fruit weight (Fruit wt.) and total tuberous root weight (Root wt.) per plant.

Plant development and treatments are the same as in Table 15. Data were recorded from 5 uniformly grown plants of each treatment.

Plants raised from	Concn. of Atrinal (µg/ml)	Senes. days	Fruit No.	Fruit wt. (kg)	Root wt (kg)
Intact fruit	0	142	155	57.9	12.8
	500	148	158	62.5	13.9
	1000	154	160	65.4	14.8
	2000	159	159	58.5	14.5
	LSD (P=0.05)	10.01	NS	4.00	1.20
Defleshed fruit	0	142	165	64.0	13.8
	500	168	168	69.8	14.9
	1000	175	175	73.8	16.2
	2000	163	163	64.5	15.7
	LSD (P=0.05)	11.80	NS	4.50	1.10

NS = Not significant

Table 22. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the preflowering stage of the plant on chlorophyll (Chl, mg/g fresh weight) and protein (Pr, mg/g fresh weight) contents in leaves of chayote.

Sixty-day-old field grown plants, raised from intact and defleshed fruits, were sprayed with Atrinal or distilled water for 3 consecutive days. Data were recorded at 2 developmental stages i.e., fruiting stage and senile stage which correspond to 80- and 140-days of plant age respectively.

Plants raised from	Concn. of Atrinal (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		Chl	Pr	Chl	Pr
Intact fruit	0	2.85	63.15	0.33	21.07
	500	3.38	76.10	0.58	37.14
	1000	3.75	80.01	0.80	47.10
	2000	3.26	72.19	0.49	36.01
	LSD (P=0.05)	0.21	5.90	0.03	2.15
Defleshed fruit	0	3.05	67.15	0.52	27.01
	500	3.55	88.95	0.83	42.27
	1000	3.92	99.01	0.98	48.98
	2000	3.54	82.54	0.77	39.90
	LSD (P=0.05)	0.28	6.20	0.05	4.01

Table 23. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the preflowering stage of the plant on soluble (Sol, mg/g fresh weight) and insoluble (Insol, mg/g fresh weight) carbohydrate contents in leaves of chayote.

Plant development and treatments are the same as in Table 22. Data were recorded at 2 developmental stages as mentioned in the same Table.

Plants raised from	**Concn. of Atrinal (µg/ml)**	**Developmental Stages**			
		Fruiting		**Senile**	
		Sol	**Insol**	**Sol**	**Insol**
Intact fruit	0	8.20	52.50	4.41	26.01
	500	11.98	82.50	7.58	38.95
	1000	13.88	86.80	8.95	48.80
	2000	12.15	77.29	7.80	39.50
	LSD (P=0.05)	0.90	5.15	0.45	3.05
Defleshed fruit	0	8.38	55.01	5.02	31.18
	500	13.01	87.10	8.25	44.05
	1000	14.50	89.90	11.37	53.80
	2000	12.80	77.58	8.05	42.04
	LSD (P=0.05)	0.98	6.10	0.52	3.18

Table 24. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the preflowering stage of the plant on RNA (µg/g fresh weight) and DNA (µg/g fresh weight) contents in leaves of chayote.

Plant development and treatments are the same as in Table 22. Data were recorded at 2 developmental stages as mentioned in the same Table.

Plants raised from	Concn. of Atrinal (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		RNA	DNA	RNA	DNA
Intact fruit	0	510.5	59.5	301.1	37.6
	500	595.7	75.1	397.9	62.8
	1000	623.8	82.7	436.8	73.4
	2000	588.5	76.6	378.6	66.6
	LSD (P=0.05)	40.54	4.01	28.29	3.50
Defleshed fruit	0	545.8	61.7	335.8	52.0
	500	648.5	76.9	438.7	69.5
	1000	701.0	85.2	486.9	78.8
	2000	639.8	72.8	442.2	65.4
	LSD (P=0.05)	45.80	50.95	30.04	4.95

Table 25. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 µg/ml) at the preflowering stage of the plant on catalase (Cat, unit/g fresh weight/h) and peroxidase (Per, unit/g fresh weight/h) activities in leaves of chayote.

Plant development and treatments are the same as in Table 22. Data were recorded at 2 developmental stages as mentioned in the same Table.

Plants raised from	Concn. of Atrinal (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		Cat	Per	Cat	Per
Intact fruit	0	130.5	95.0	62.1	26.5
	500	162.7	126.3	85.1	42.6
	1000	175.9	139.5	96.9	57.0
	2000	157.8	120.6	85.9	45.9
	LSD (P=0.05)	12.05	9.50	6.14	2.50
Defleshed fruit	0	136.9	98.6	79.1	35.8
	500	171.0	132.2	96.9	56.8
	1000	185.8	147.8	122.7	66.7
	2000	160.9	130.5	101.6	54.9
	LSD (P=0.05)	12.80	8.98	6.69	3.05

Table 26. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 μg/ml) at the preflowering stage of the plant on IAA-oxidase (IAAox, unit/g fresh weight/h) and RNase (unit/g fresh weight/h) activities in leaves of chayote.

Plant development and treatments are the same as in Table 22. Data were recorded at 2 developmental stages as mentioned in the same Table.

Plants raised from	Concn. of Atrinal (μg/ml)	Developmental Stages			
		Fruiting		Senile	
		IAAox	RNase	IAAox	RNase
Intact fruit	0	78.25	211.75	94.90	296.50
	500	67.25	185.80	75.95	226.40
	1000	61.19	166.65	65.70	188.55
	2000	68.25	182.59	82.01	224.24
	LSD (P=0.05)	6.50	15.05	6.42	16.60
Defleshed fruit	0	69.95	201.75	88.01	241.75
	500	52.01	162.74	61.25	162.74
	1000	44.75	135.71	45.45	140.92
	2000	52.96	157.10	57.92	170.54
	LSD (P=0.05)	5.01	15.57	4.50	12.44

Table 27. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 μg/ml) at the preflowering stage of the plant on vine length (V.L., cm) and stem circumference (S.C., cm) of chayote.

Plant development and treatments are the same as in Table 22. Data were recorded at 2 developmental stages as mentioned in the same Table.

Plants raised from	Concn. of Atrinal (μg/ml)	Developmental Stages			
		Fruiting		Senile	
		V.L.	S.C.	V.L.	S.C.
Intact fruit	0	525.8	5.49	554.9	5.65
	500	462.7	6.02	478.7	6.15
	1000	451.9	6.75	455.9	6.80
	2000	430.6	6.80	436.7	6.80
	LSD (P=0.05)	35.25	0.48	35.80	0.50
Defleshed fruit	0	567.7	5.85	598.9	6.05
	500	455.9	6.50	542.7	6.58
	1000	437.5	6.72	520.8	6.80
	2000	432.7	6.80	505.8	6.88
	LSD (P=0.05)	38.32	0.48	45.10	0.55

Table 28. Effect of foliar treatment with Atrinal (0, 500, 1000 and 2000 μg/ml) at the preflowering stage of the plant on changes in number of days required for inception of leaf sencscence (Senes. days), total fruit number (Fruit No.), total fruit weight (Fruit wt.) and total tuberous root weight (Root wt.) per plant.

Plant development and treatments are the same as in Table 22. Data were recorded from 5 uniformly grown plants of each treatment.

Plants raised from	Concn. of Atrinal (μg/ml)	Senes. days	Fruit No.	Fruit wt. (kg)	Root wt. (kg)
Intact fruit	0	142	155	56.8	12.9
	500	150	158	63.0	13.8
	1000	155	162	66.8	15.0
	2000	155	158	59.99	14.7
	LSD (P=0.05)	9.98	NS	5.05	1.20
Defleshed fruit	0	143	165	62.0	14.2
	500	150	170	70.1	15.0
	1000	156	178	74.0	16.8
	2000	156	165	65.8	15.9
	LSD (P=0.05)	11.01	NS	6.05	1.35

NS = Not Singnificance

Table 29. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 μg/ml) at the preflowering stage followed by GA_3 (100 μg/ml) and kinetin (Kin, 100 μg ml application at the flowering stage of the plant on changes in chlorophyll (Chl, mg/g fresh weight) and protein (Pr, mg/g fresh weight) contents in leaves of chayote.

Sixty-day-old field grown plants, raised from intact and defleshed fruits, were sprayed with Atrinal or distilled water for 3 consecutive days at the preflowering stage. Such plants were subsequently treated with GA_3 or kinetin for 3 consultive days at the flowering stage (70-day-old). Data were recorded at fruiting stage and senile stage which correspond to 80- and 140 days of plant age respectively.

Plants raised from	**Treatments (μg/ml)**	**Developmental Stages**			
		Fruiting		**Senile**	
		Chl	**Pr**	**Chl**	**Pr**
Intact fruit	Atl. 0	2.85	63.15	0.33	21.07
	Atl 0 + GA_3	2.86	65.10	0.33	22.90
	Atl 0 + Kin	3.80	73.80	0.86	32.10
	Atl 1000	3.75	80.01	0.80	47.10
	Atl 1000 + GA_3	3.75	83.05	0.85	50.20
	Atl 1000 + Kin	4.05	92.80	1.20	55.65
	LSD (P=0.05)	0.20	5.08	0.04	3.08
Defleshed fruit	Atl. 0	3.05	67.15	0.52	27.01
	Atl 0 + GA_3	3.12	69.55	0.52	26.98
	Atl 0 + Kin	3.95	75.41	0.98	39.80
	Atl 1000	3.92	99.01	0.98	48.98
	Atl 1000 + GA_3	3.95	98.59	0.99	49.05
	Atl 1000 + Kin	4.33	120.69	1.35	60.25
	LSD (P=0.05)	0.30	6.01	0.50	3.05

Table 30. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 µg/ml) at the preflowering stage followed by GA_3 (100 µg/ml) and kinetin (Kin application at the flowering stage of the plant on changes in soluble carbohydrate (Sol, mg/g fresh weight) and insoluble carbohydrate (Insol, mg/g fresh weight) contents in leaves of chayote.

Plant development, hormonal treatments and recording of data are the same as in Table 29.

Plants raised from	Treatments (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		Sol	Insol	Sol	Insol
Intact fruit	Atl. 0	8.20	52.50	4.41	26.01
	Atl 0 + GA_3	8.30	54.01	4.45	27.50
	Atl 0 + Kin	8.41	62.10	5.05	36.96
	Atl 1000	13.88	86.80	8.95	48.80
	Atl 1000 + GA_3	14.05	85.06	8.95	49.05
	Atl 1000 + Kin	15.80	98.75	10.15	58.90
	LSD (P=0.05)	0.72	5.88	0.50	2.90
Defleshed fruit	Atl. 0	8.38	55.01	5.02	31.18
	Atl 0 + GA_3	8.44	56.55	5.05	31.10
	Atl 0 + Kin	9.95	78.77	8.01	42.18
	Atl 1000	14.50	89.90	11.37	53.80
	Atl 1000 + GA_3	15.05	90.50	12.01	55.05
	Atl 1000 + Kin	17.56	122.75	14.50	72.95
	LSD (P=0.05)	0.80	5.98	0.60	3.99

Table 31. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 µg/ml) at the preflowering stage followed by GA_3 (100 µg/ml) and kinetin (Kin, 100 µg/ml) application at the flowering stage of the plant on changes in RNA (µg/g fresh weight) and DNA (µg/g fresh weight) contents in leaves of chayote.

Plant development, hormonal treatments and recording of data are the same as in Table 29.

Plants raised from	Treatments (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		RNA	DNA	RNA	DNA
Intact fruit	Atl. 0	510.5	59.5	301.1	37.6
	Atl 0 + GA_3	522.7	61.8	315.9	38.5
	Atl 0 + Kin	598.9	75.5	370.8	50.7
	Atl 1000	623.8	82.7	436.8	73.4
	Atl 1000 + GA_3	633.5	84.4	445.9	76.6
	Atl 1000 + Kin	705.8	95.6	502.8	88.50
	LSD (P=0.05)	40.66	5.16	28.33	
Defleshed fruit	Atl. 0	545.8	61.7	335.8	52.0
	Atl 0 + GA_3	557.9	66.0	242.9	54.1
	Atl 0 + Kin	601.8	75.8	408.8	69.5
	Atl 1000	701.0	85.2	486.9	78.8
	Atl 1000 + GA_3	702.5	85.9	477.6	79.90
	Atl 1000 + Kin	782.9	98.9	438.9	87.99
	LSD (P=0.05)	50.18	5.99	30.69	5.05

Table 32. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 µg/ml) at the preflowering stage followed by GA_3 (100 µg/ml) and kinetin (Kin, 100 µg/ml) application at the flowering stage of the plant on changes in catalase (Cat, unit/g fresh weight/h) and peroxidase (Per, unit/g fresh weight/h) activities in leaves of chayote.

Plant development, hormonal treatments and recording of data are the same as in Table 29.

Plants raised from	Treatments (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		Cat	Per	Cat	Per
Intact fruit	Atl. 0	130.5	95.0	62.1	26.5
	Atl 0 + GA_3	132.7	94.0	62.2	28.7
	Atl 0 + Kin	156.1	115.8	86.1	42.8
	Atl 1000	175.9	139.5	96.9	57.0
	Atl 1000 + GA_3	180.2	144.7	95.0	57.0
	Atl 1000 + Kin	209.5	176.5	138.5	72.9
	LSD (P=0.05)	11.88	9.01	6.05	2.15
Defleshed fruit	Atl. 0	136.9	98.6	49.1	35.8
	Atl 0 + GA_3	138.5	100.5	78.5	36.6
	Atl 0 + Kin	166.9	128.7	96.9	58.8
	Atl 1000	185.8	147.8	122.7	66.7
	Atl 1000 + GA_3	182.5	152.9	127.0	69.5
	Atl 1000 + Kin	235.8	177.8	154.9	105.9
	LSD (P=0.05)	12.79	9.90	6.85	4.05

Table 33. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 µg/ml) at the preflowering stage followed by GA$_3$ (100 µg/ml) and kinetin (Kin, 100 µg/ml) application at the flowering stage of the plant on changes in IAA-oxidase (IAAox, unit/g fresh weight/h) and RNase (unit/g fresh weight/h) activities in leaves of chayote.

Plant development, hormonal treatments and recording of data are the same as in Table 29.

Plants raised from	Treatments (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		IAAox	RNase	IAAox	RNase
Intact fruit	Atl. 0	78.25	211.75	94.90	296.50
	Atl 0 + GA$_3$	75.10	207.85	90.70	288.95
	Atl 0 + Kin	69.95	178.52	81.01	245.05
	Atl 1000	61.19	166.62	65.70	188.55
	Atl 1000 + GA$_3$	62.90	164.92	65.05	182.90
	Atl 1000 + Kin	50.05	143.25	51.20	149.66
	LSD (P=0.05)				
Defleshed fruit	Atl. 0	69.95	201.75	88.01	241.75
	Atl 0 + GA$_3$	68.68	189.80	85.20	236.80
	Atl 0 + Kin	56.65	162.75	63.74	168.78
	Atl 1000	44.75	135.71	45.45	140.92
	Atl 1000 + GA$_3$	42.79	130.88	45.00	143.19
	Atl 1000 + Kin	31.75	109.70	33.79	125.01
	LSD (P=0.05)	6.05	12.75	4.88	13.08

Table 34. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 µg/ml) at the preflowering stage followed by GA_3 (100 µg/ml) and kinetin (Kin, 100 µg/ml) application at the flowering stage of the plant on changes in vine length (V.L., cm) and stem circumference (S.C., cm) of chayote.

Plant development, hormonal treatments and recording of data are the same as in Table 29.

Plants raised from	Treatments (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		V.L.	S.C.	V.L.	S.C.
Intact fruit	Atl. 0	525.8	5.49	554.9	5.65
	Atl 0 + GA_3	598.9	5.49	639.5	5.62
	Atl 0 + Kin	544.7	5.89	593.9	5.93
	Atl 1000	451.9	6.75	455.9	6.80
	Atl 1000 + GA_3	530.7	6.80	565.7	6.87
	Atl 1000 + Kin	470.6	7.29	508.9	7.36
	LSD (P=0.05)	40.05	0.52	42.88	0.55
Defleshed fruit	Atl. 0	5.67.7	5.85	598.9	6.05
	Atl 0 + GA_3	6.51.9	5.92	663.8	5.98
	Atl 0 + Kin	609.8	6.20	615.9	6.35
	Atl 1000	437.5	6.72	520.8	6.80
	Atl 1000 + GA_3	495.0	6.75	578.8	6.82
	Atl 1000 + Kin	472.7	7.38	501.9	7.48
	LSD (P=0.05)	45.01	0.53	45.72	6.62

Table 35. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 µg/ml) at the preflowering stage followed by GA_3 (100 µg/ml) and kinetin (Kin, 100µg/ml) application at the flowering stage of the plant on changes in number of days required for inception of leaf senescence (Senes. days), total fruit number (Fruit No.), total fruit weight (Fruit wt.) and total tuberous root weight (Root wt.) per plant.

Plant development, hormonal treatments and recording of data are the same as in Table 29.

Plants raised from	Treatments (µg/ml)	Developmental Stages			
		Fruiting		Senile	
		Senes. days	Fruit No.	Fruit wt. (kg)	Root wt. (kg)
Intact fruit	Atl. 0	142	155	56.8	12.9
	Atl 0 + GA_3	145	168	62.16	12.8
	Atl 0 + Kin	154	160	64.05	13.9
	Atl 1000	155	162	66.8	15.0
	Atl 1000 + GA_3	153	175	65.01	15.0
	Atl 1000 + Kin	152	164	68.20	16.4
	LSD (P=0.05)	9.87	10.01	4.01	1.10
Defleshed fruit	Atl. 0	143	165	62.0	14.2
	Atl 0 + GA_3	144	178	69.5	14.0
	Atl 0 + Kin	156	170	70.5	15.5
	Atl 1000	156	178	74.0	16.8
	Atl 1000 + GA_3	155	188	75.0	16.4
	Atl 1000 + Kin	166	176	78.5	17.8
	LSD (P=0.05)	9.78	11.90	5.42	1.25

Table 36. Effect of foliar treatment with Atrinal (Atl, 0 and 1000 μg/ml) at the preflowering stage followed by GA_3 (100 μg/ml) and kinetin (Kin, 100 μg/ml) application at the flowering stage of the plant on changes in total number of female and male flowers per plant.

Plant development and hormonal treatments are the same as in Table 29. Data were recorded from 100-day-old plants.

Plants raised from	Treatments (μg/ml)	No. of female flowers per plant	No. of male flowers per plant
Intact fruit	Atl. 0	182.0	3645.8
	Atl 0 + GA_3	215.8	4347.5
	Atl 0 + Kin	199.8	3980.7
	Atl 1000	180.5	4480.1
	Atl 1000 + GA_3	225.9	4598.0
	Atl 1000 + Kin	210.8	4272.9
	LSD (P=0.05)	16.75	300.95
Defleshed fruit	Atl. 0	182.5	4050.3
	Atl 0 + GA_3	228.6	4581.9
	Atl 0 + Kin	198.5	39966.6
	Atl 1000	183.7	3674.4
	Atl 1000 + GA_3	239.5	4795.1
	Atl 1000 + Kin	211.8	4195.3
	LSD (P=0.05)	17.20	328.87

Figures

Series -1 Cultivated
Series - 2 Wild

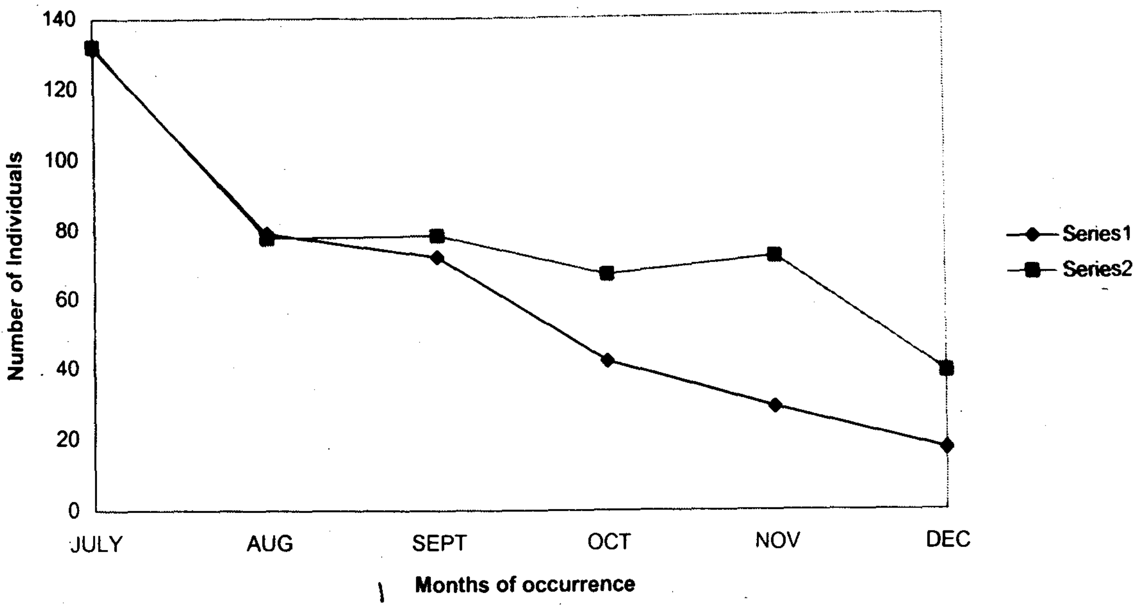


Fig - 1 Abundance of *Epilachna demurili* on *Sechium edule*

Series - 1 Cultivated
Series - 2 Wild

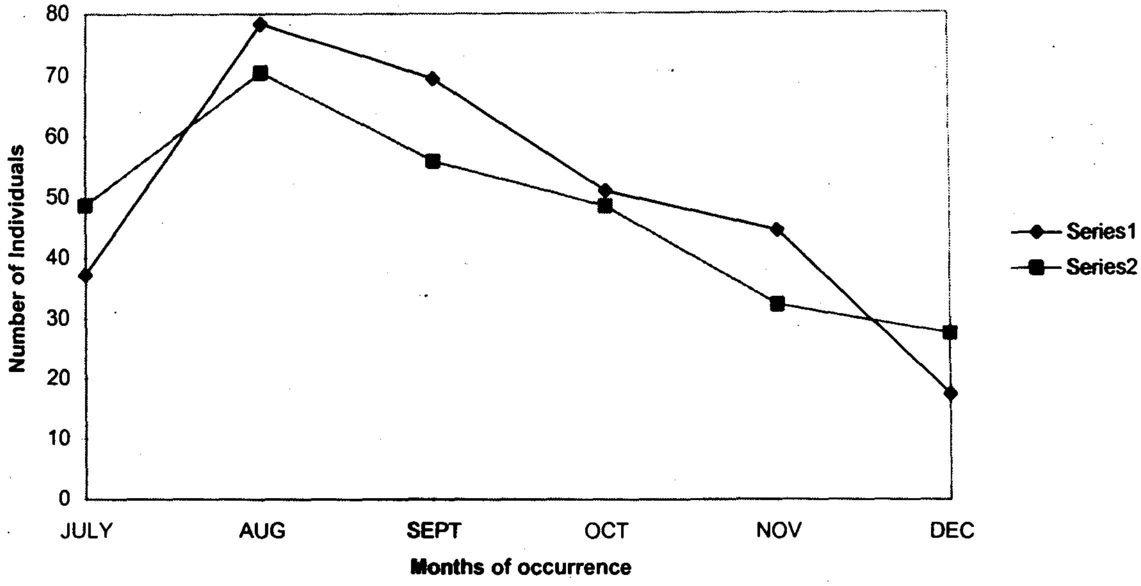


Fig - 2 Abundance of *Diapharia nitidalis* on *Sechium edule*

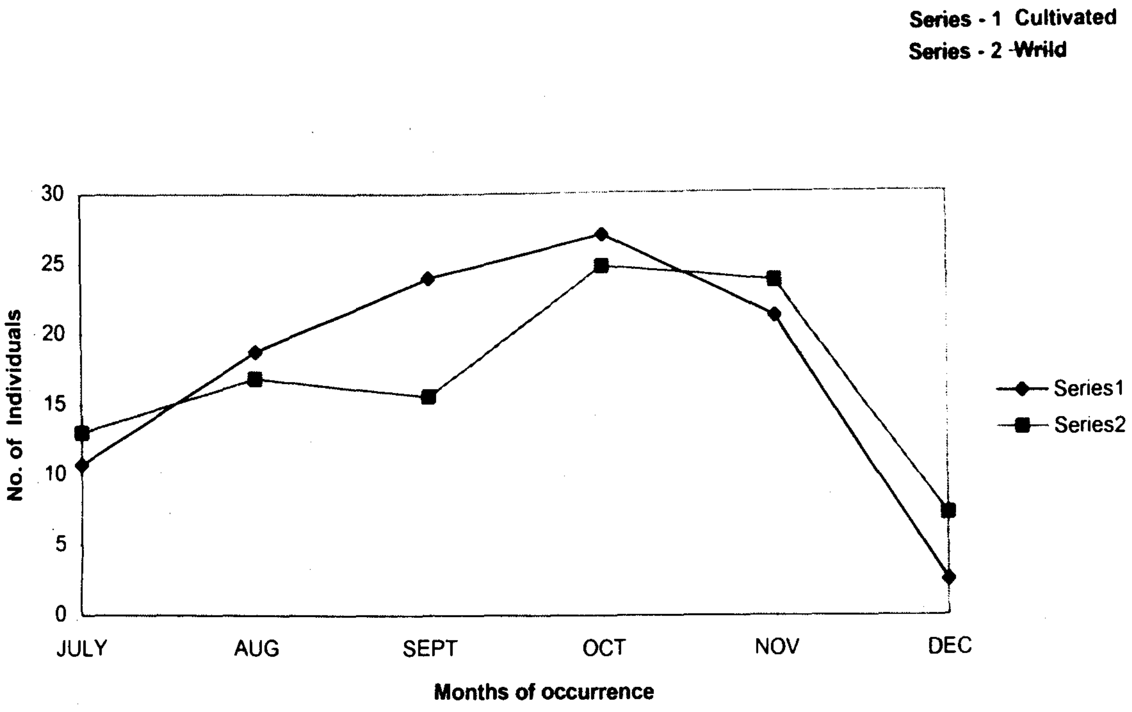


Fig - 3 Abundance of *Rabphidopalpa foveicollis* on *Sechium edule*

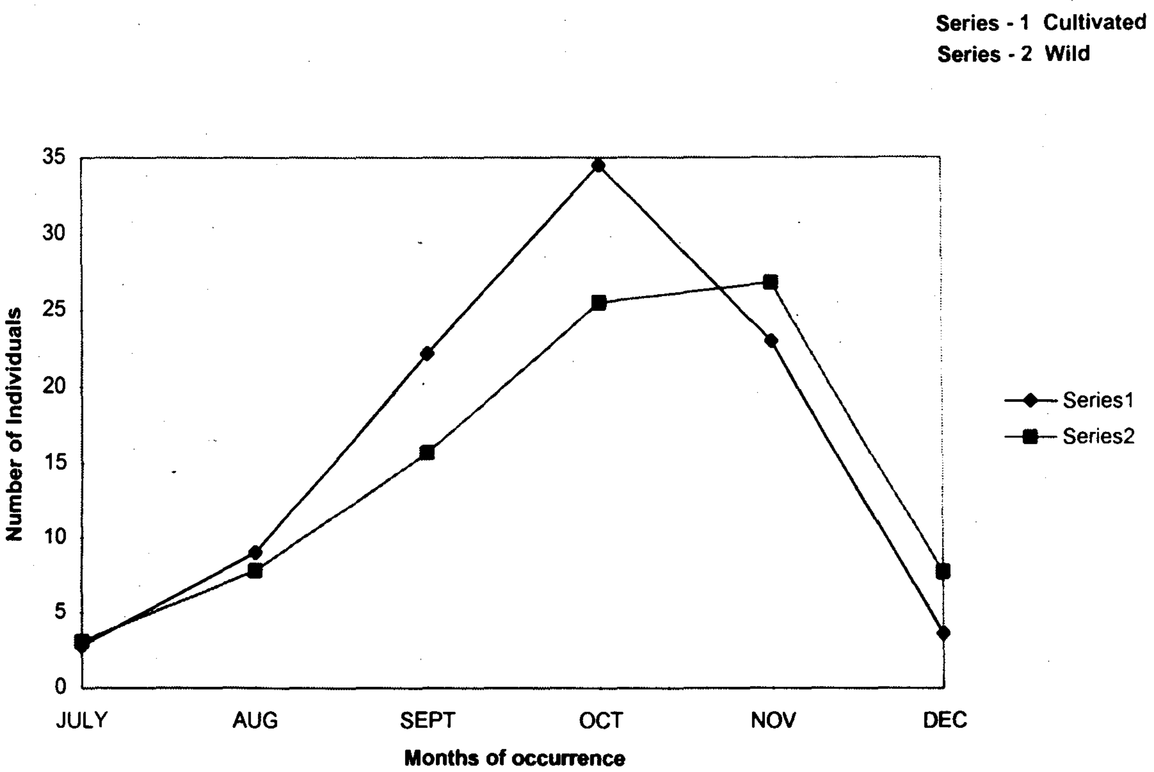


Fig - 4 Abundance of *Anasa tristis* on *Sechium edule*

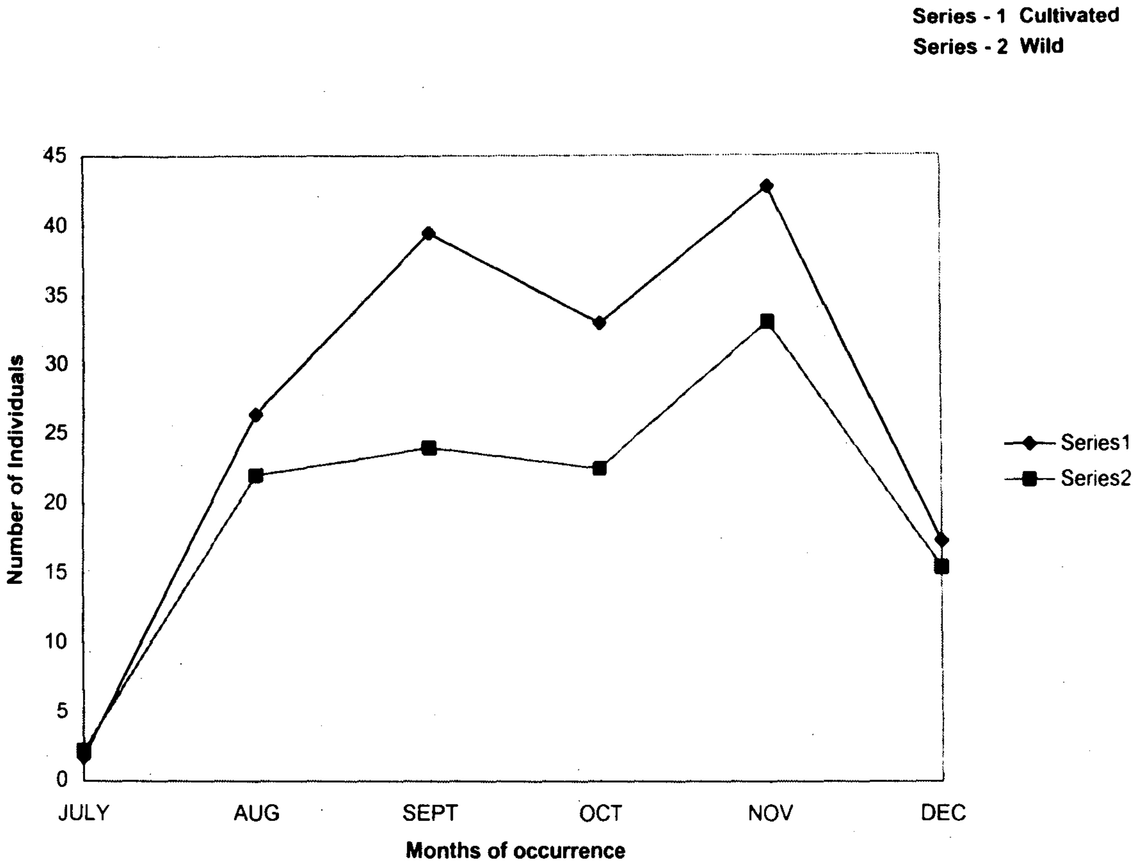


Fig - 5 Abundance of *Macrocalamys sp* on *Sechium edule*

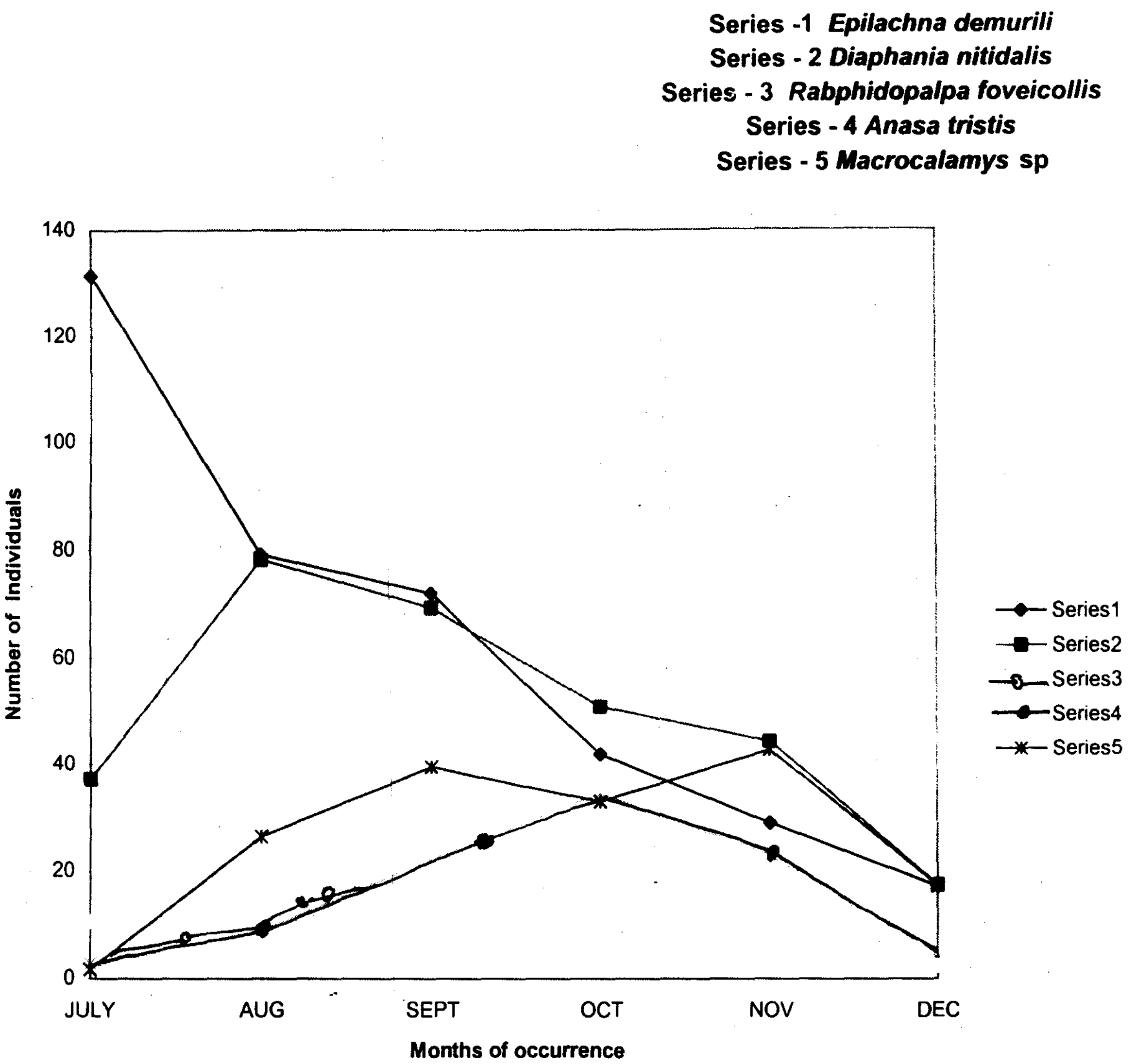


Fig - 6 Species abundance of pestiferous populations on *Sechium edule* in cultivation

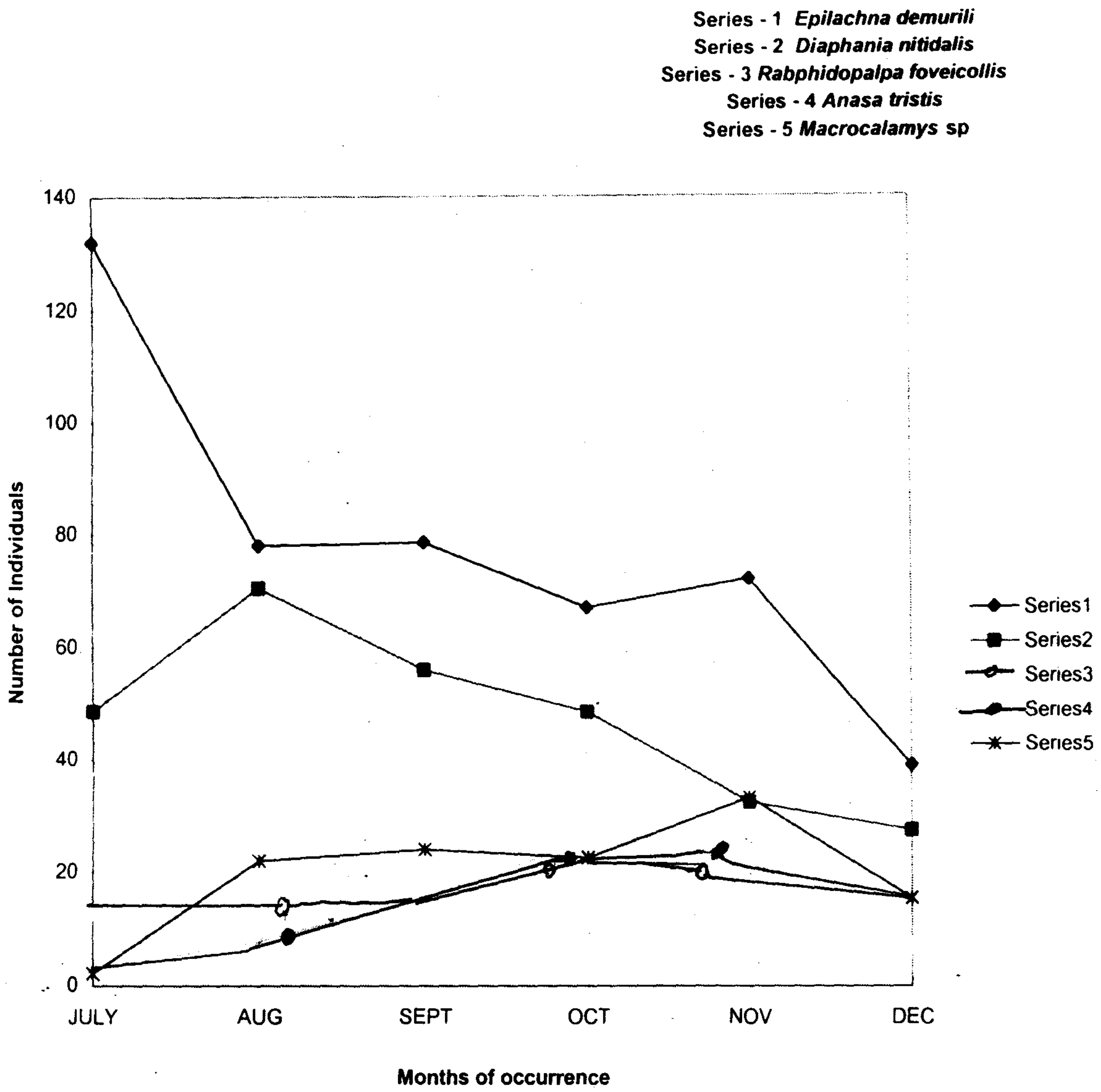


Fig - 7 Species abundance of pestiferous populations on *Sechium edule* in Wild

Fig. Dominance Diversity Curve of some Pestiferous invertebrate species on *Sechium edule* (SW)

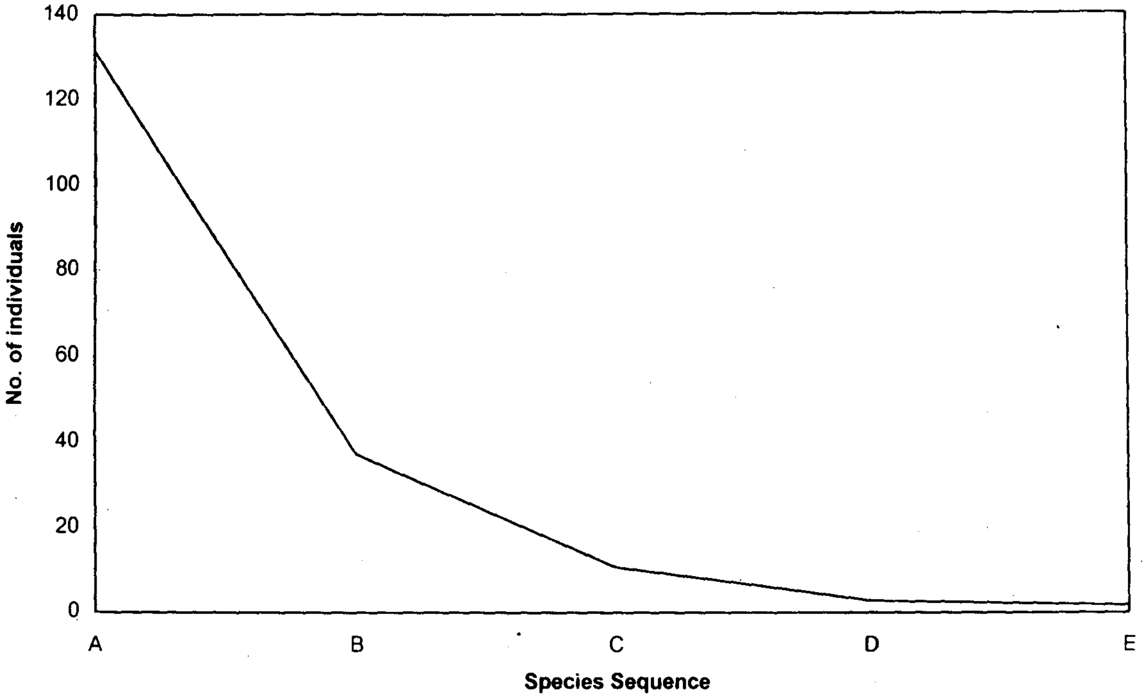


Fig - 8 July 1993 (Cultivated)

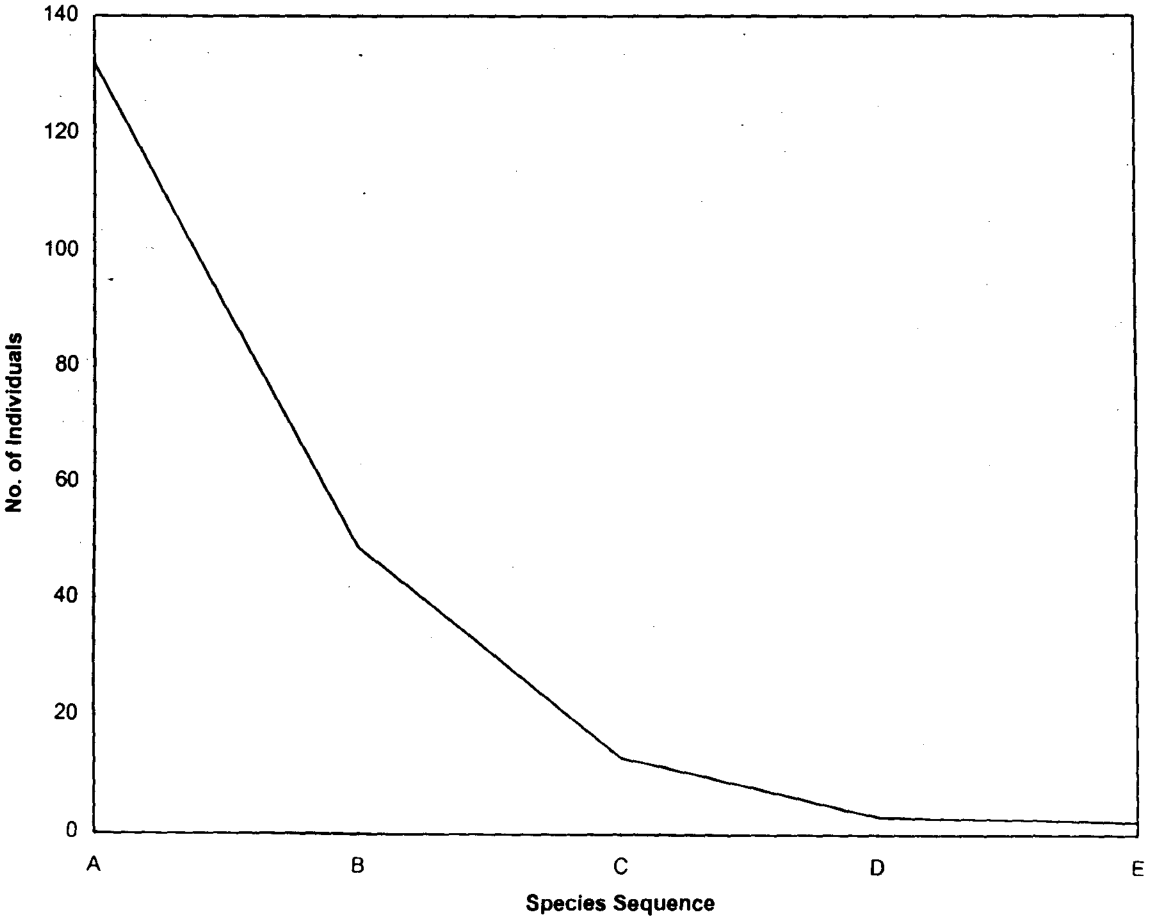


Fig - 9 July 1993 (Wild)

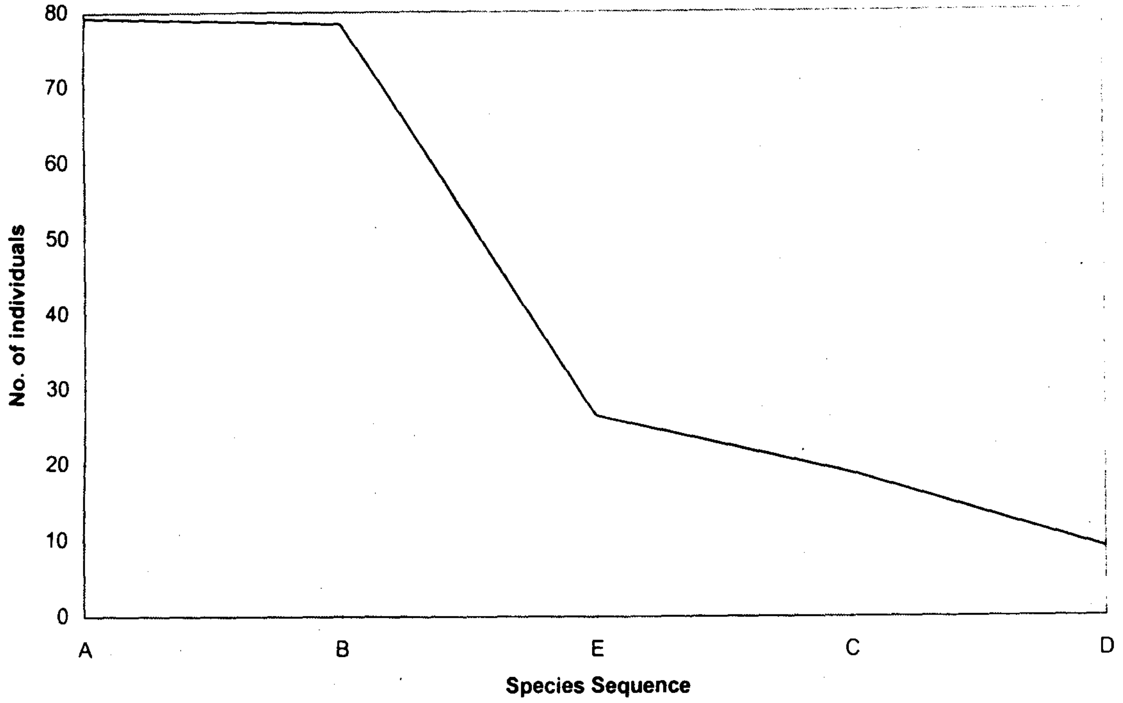


Fig - 10 August 1993 (Cultivated)

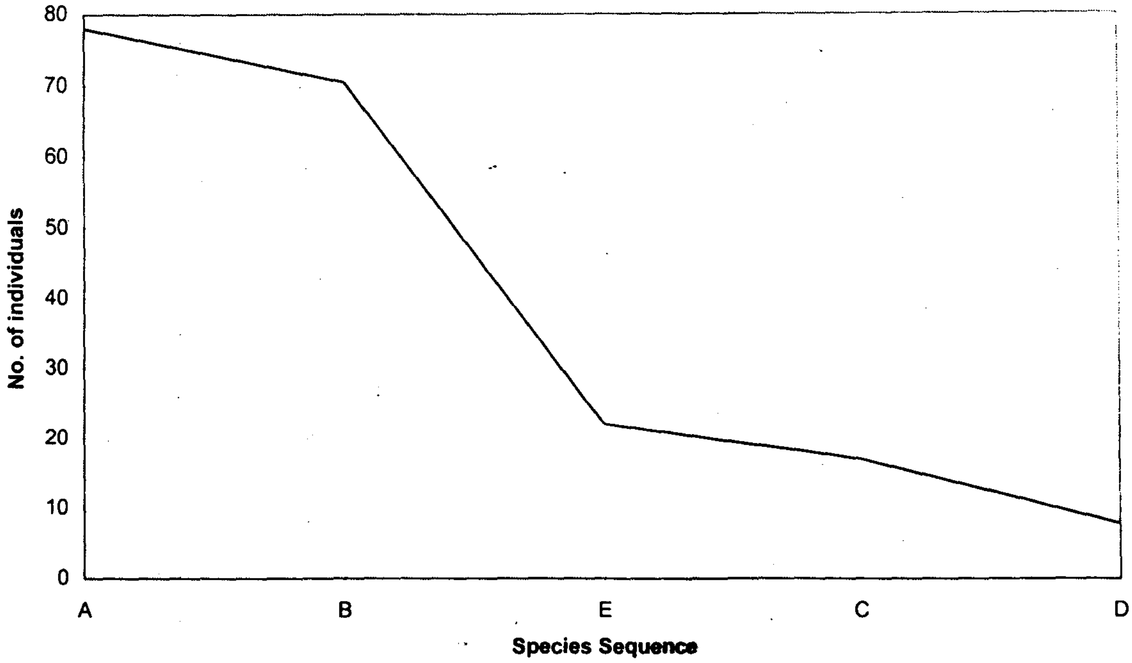


Fig - 11 August 1993 (Wild)

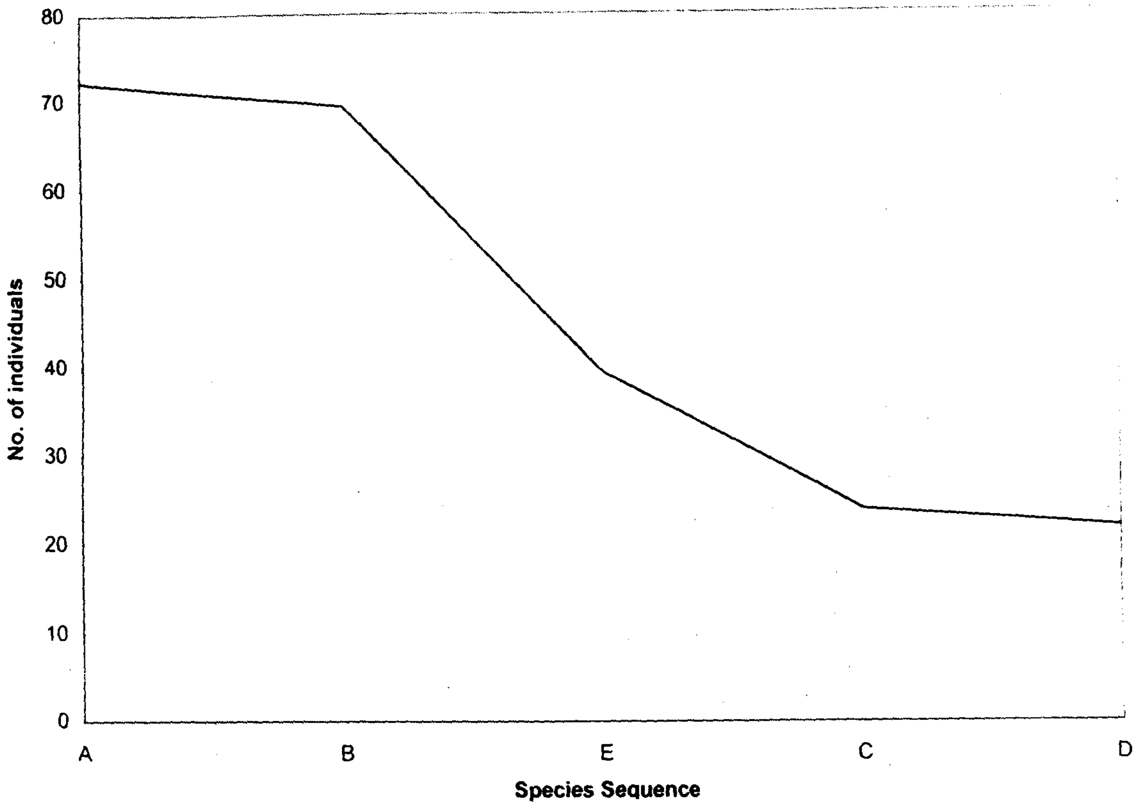


Fig - 12 September 1993 (Cultivated)

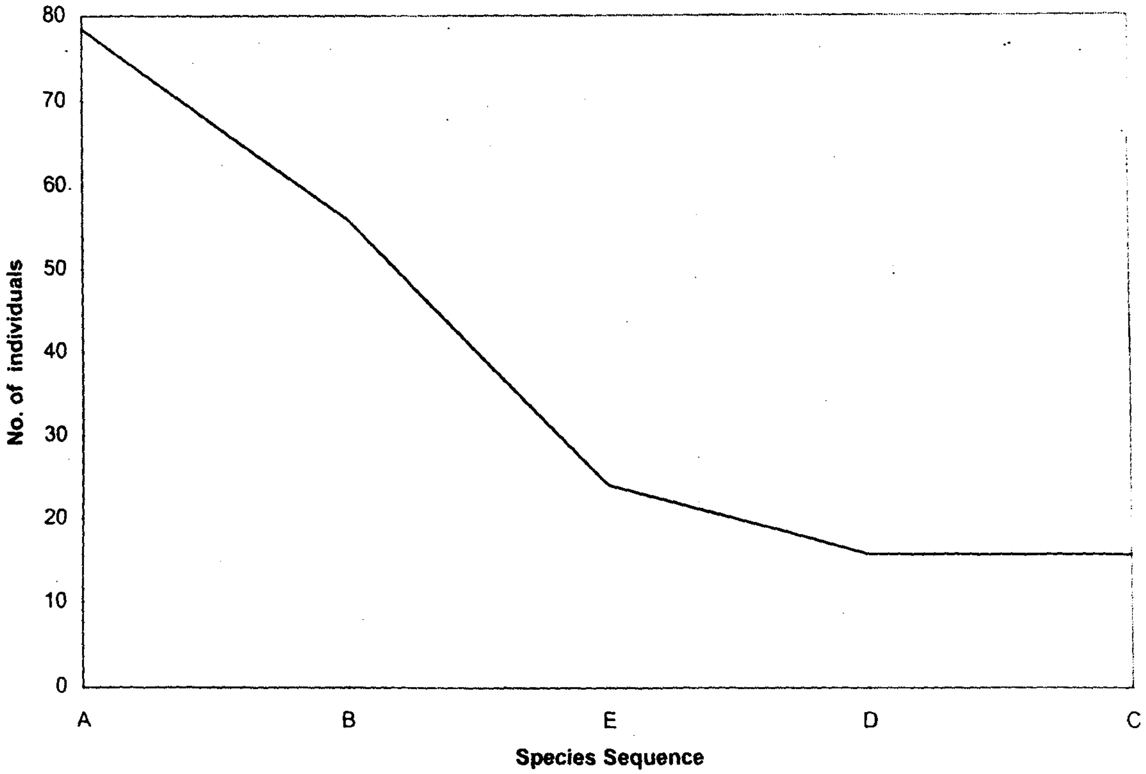


Fig - 13 September 1993 (Wild)

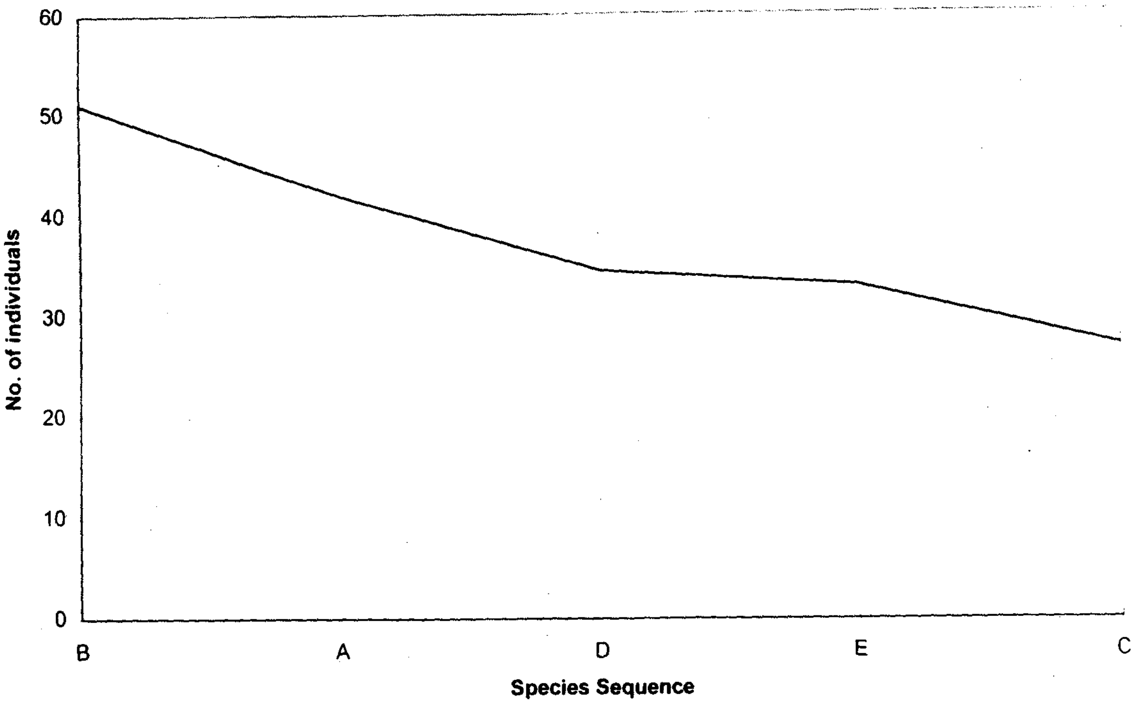


Fig - 14 October 1993 (Cultivated)

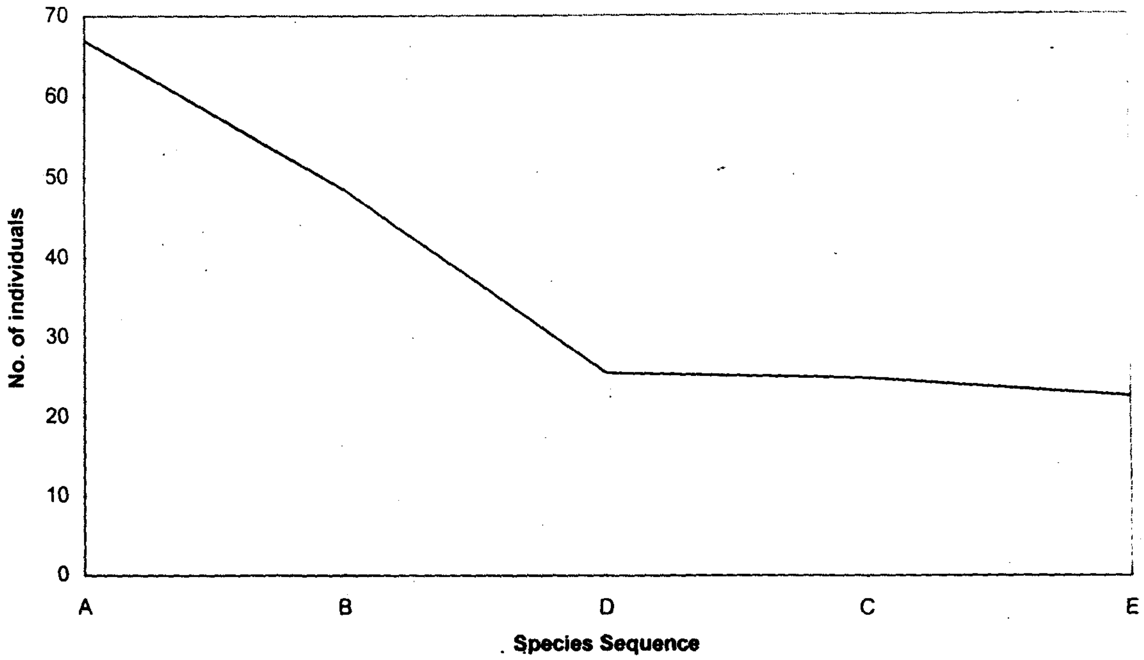


Fig - 15 October 1993 (Wild)

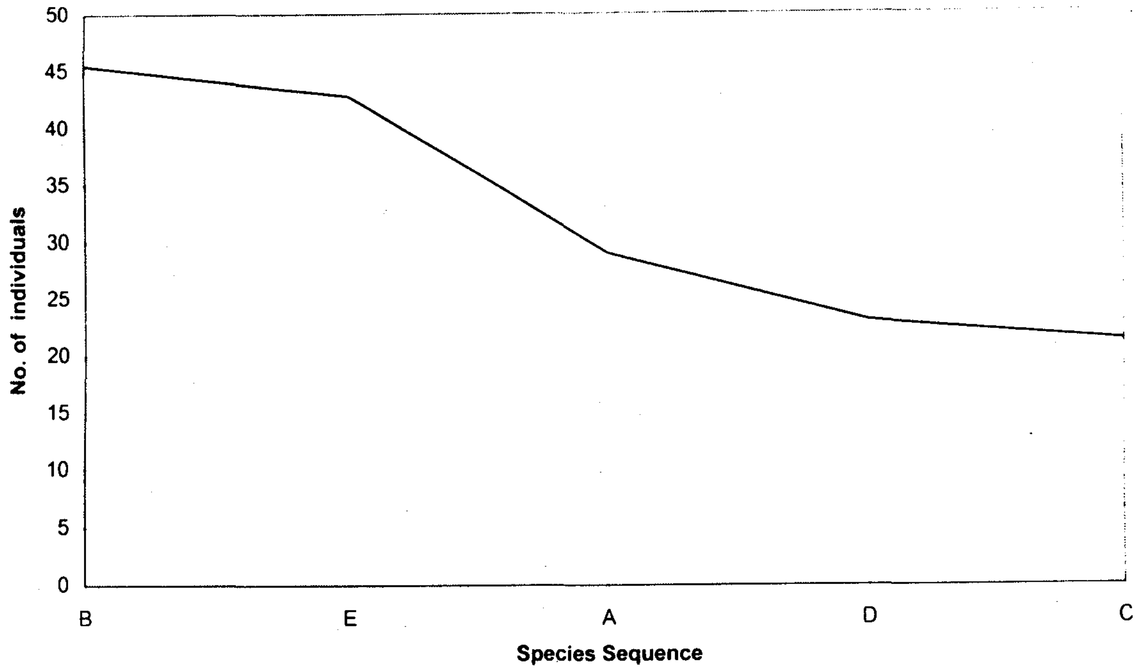


Fig - 16 November 1993 (Cultivated)

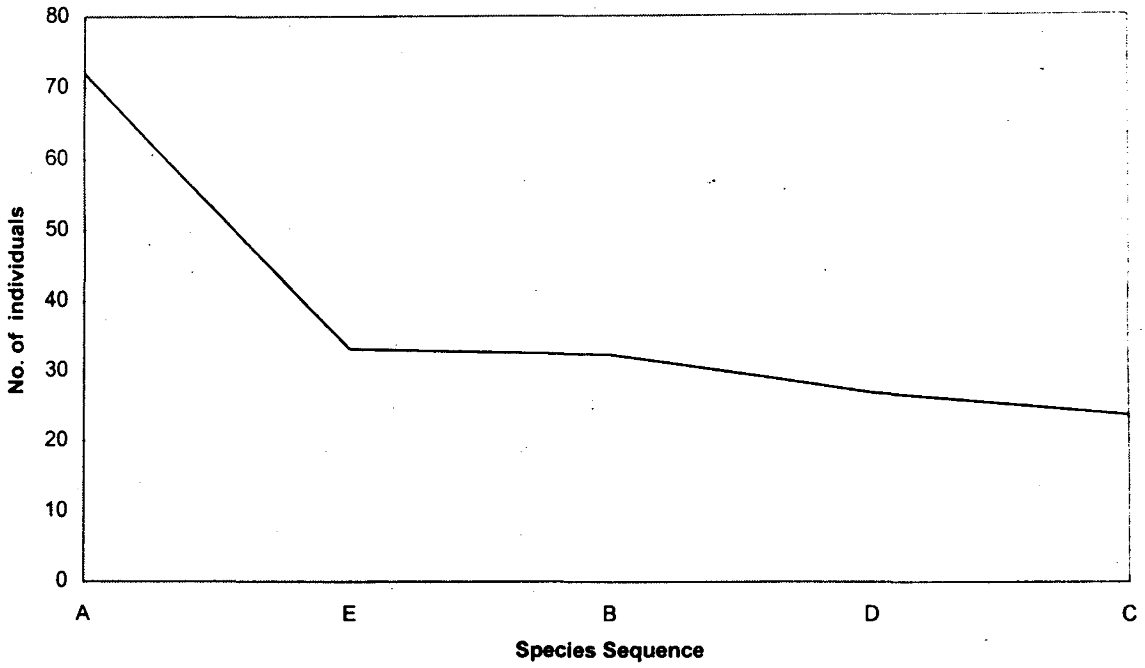


Fig - 17 November 1993 (Wild)

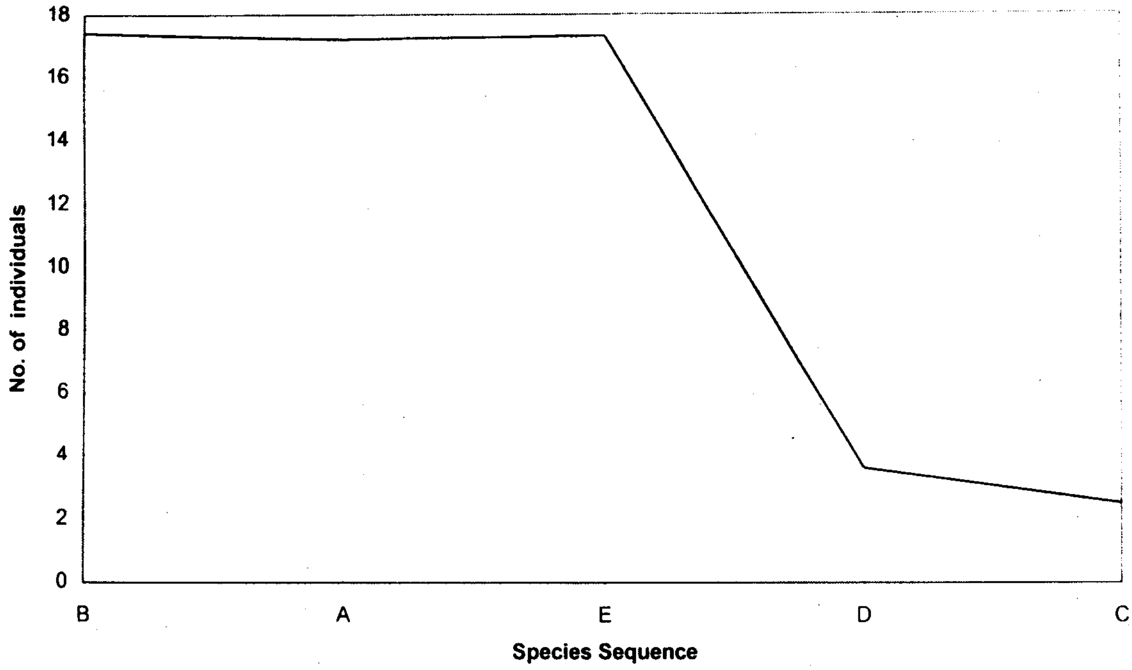


Fig - 18 December 1993 (Cultivated)

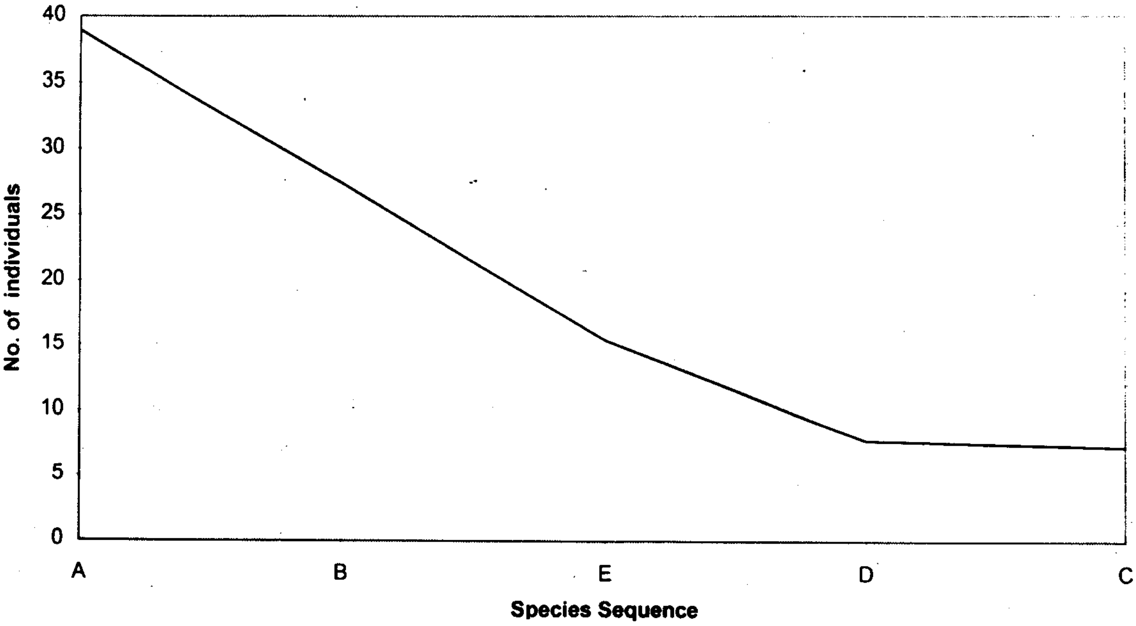


Fig - 19 December 1993 (Wild)

Photograps

Plate 1. A mature spiny sprouting fruit. The fruit reveals several distinct longitudinal grooves or channels and sprouting is found to develop from the distal part of the fruit.

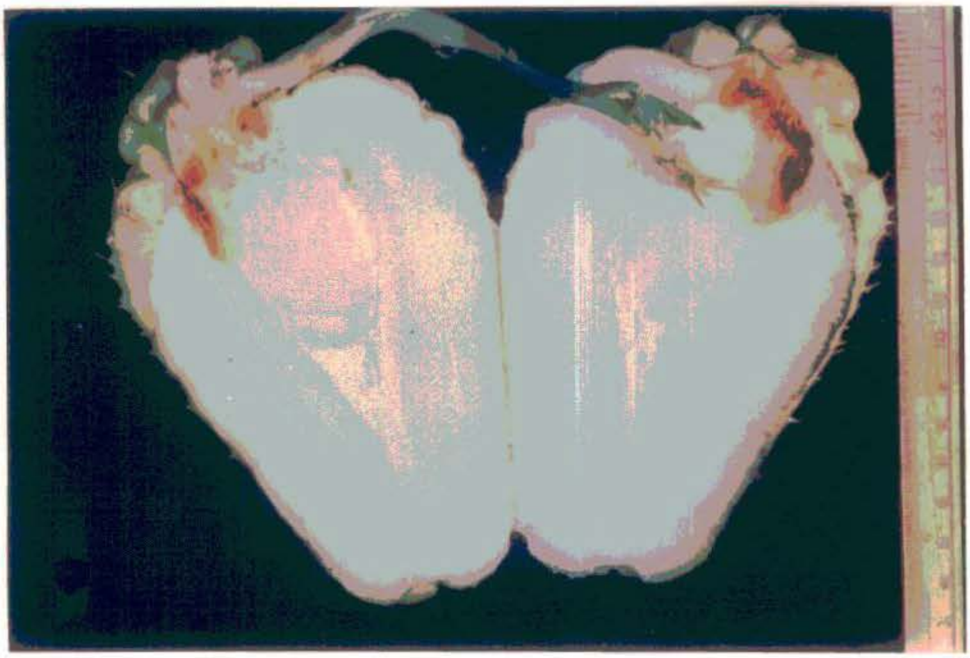


Plate 2. A longitudinally dissected sprouting fruit with distally located single large and abundant fruit flesh.

Plate 3. Developing chayote seedling with newly developing branched tendrils. Several plantlets are developed from a single pit.

Plate 4. A chayote vine is seen growing over a scaffold (machan) in the experimental field at Darjeeling Govt. College campus.

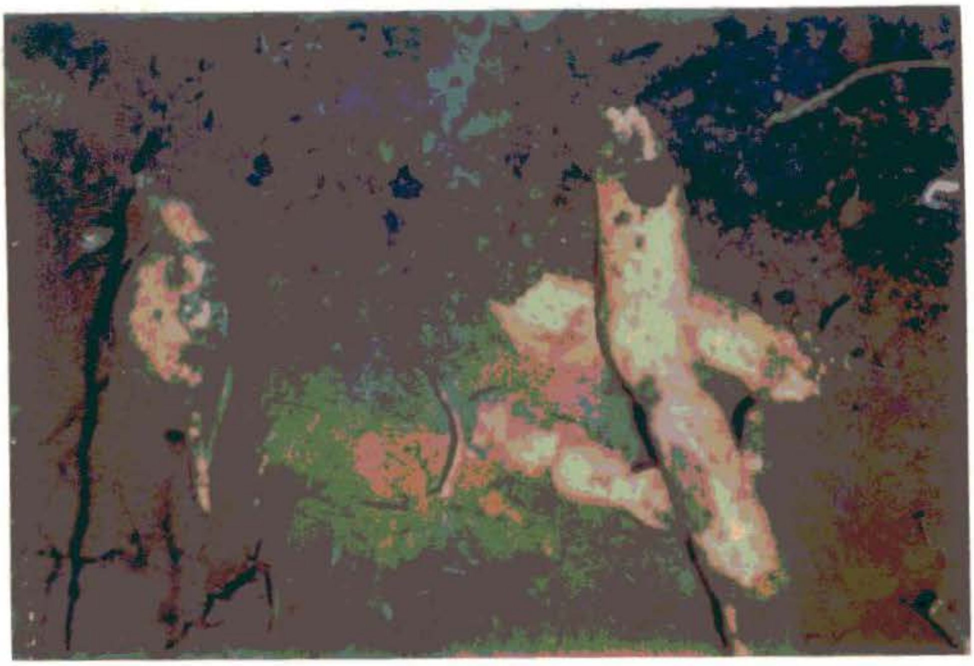


Plate 5. This plate shows tuberous underground roots. Unlike other cucurbits such tuberous roots with abundant carbohydrate reserve are unique in chayote.

Plate 6. A chayote vine with reproductive phase showing a long peduncle with a number of whitish male flowers. The infloresence arises from leaf axils.

Plate 7. This plate clearly reveals a female flower developing singly from leaf axils. Female flowers have inferior ovary surmounted by calyx and corolla. Calyx tube is hemispherical with 5 lobes, corolla rotate, deeply 5-partite.

Plate 8. A chayote vine is seen under fruiting condition. From leaf axil an young spiny fruit is found hanging beside a long-stalked peduncle with a few male flowers.

Plate 9. A spineless whitish variety of fruit with long stalk is developing from the leaf axil adjacent to a long peduncle with male flowers.

Plate 10. This plate reveals a freak of nature. Two fruits are developed from a single female flower. They are seen united at the proximal part, and the distal part tend to diverge.

Plate 11. A female flower is seen pollinated by insects which are attracted by nectors produced profusely in nectaries

Plate 12. A leaf plucked from a chayote vine is seen heavily infected with beetle. Scattered necrotic spots with chlorotic leaf lamina are characteristic of beetle attack on growing vine.

Plate 13. A voracious caterpillar is seen to defoliate chayote plant causing a strong impairment of crop yield.

Plate 14. Under severe infection young leaf twigs are seen to be eaten-up by caterpillars. Surviving leaves get convoluted and degreened.

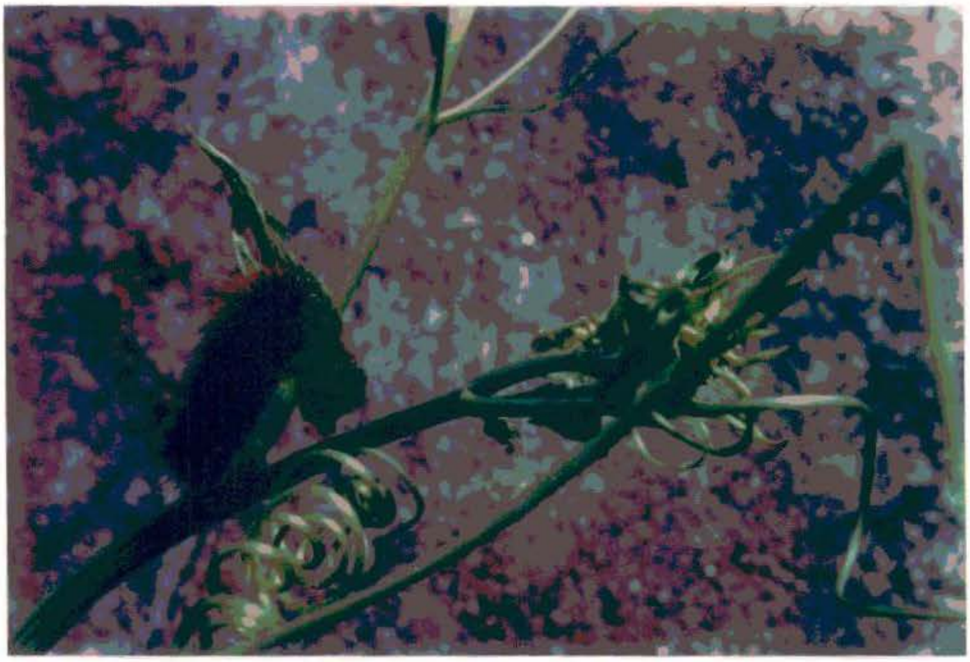


Plate 15. This plate shows crumpling of tendrils as well as tender twigs of chayote vine as a result of infection by caterpillars.

Plate 16. Golden bettle-induced leaf infection is seen in this plate. Such infection causig leaf chlorosis and leaf shot hole.

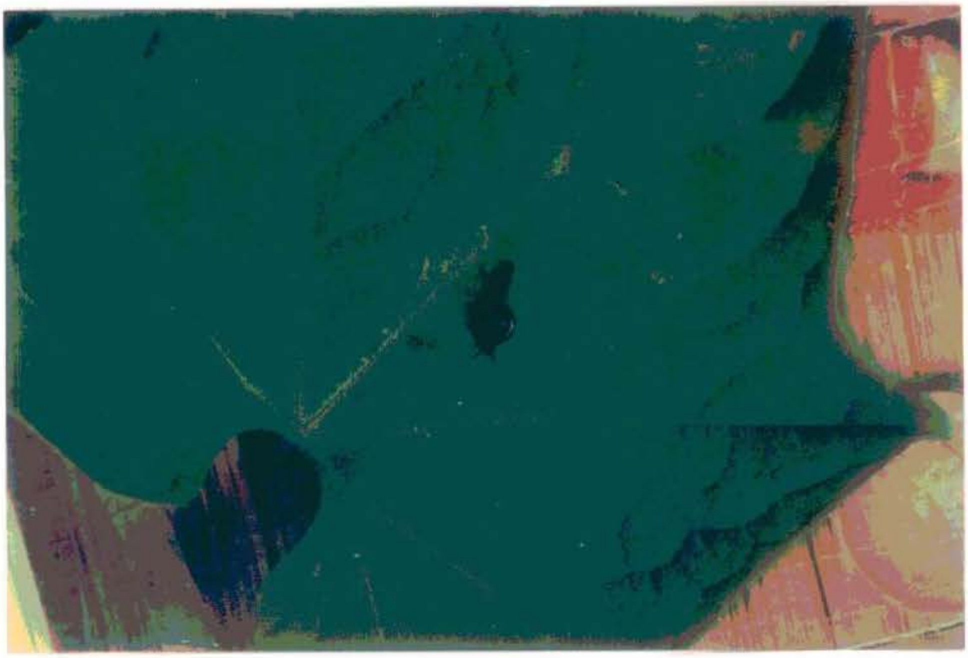


Plate 17. *Macrocalamys sp.* a Molluscan member is seen to thrive on leaf lamina of chayote. This attack is reported to be much less injurious.

Plate 18. An Insect is found to harbour on fleshy tuberous roots of chayote. Under severe infection this type of beetle is reported to rapidly exhaust carbohydrate reserve.

Plate19. Chayote fruits are often attacked by some insects which cause necrosis of fruits both under attached condition or under storage condition.

Plate 20. Some insects are seen which are reported to suck leaf juice and cause localized degreening and consequent damage.

References

REFERENCES

Adriansen, B. and H. Andersen. 1983 . Atrinal application on rooted nodal cuttings from *Aeschynanthus hildebrandii* and *Aeschynanthus speciosus. Tidsskr. Planteavl.* 87 : 597-604.

Agnew, W. H. and R. W. Campbell, 1983. Growth of *Begonia X hiemalis* as influenced by hand-pinching, dikegulac and chlormequat. *Hort Sci.* 18 : 201-202.

Albone, K.S. Gaskin, P. MacMilan, J. and Sponsel, V.M. 1984. Identification and localization of gibberellins in maturing seeds of the cucurbit *Sechium edule,* and a comparison between this cucurbit and the legume *Phaseolus coccineus.* Planta 162 : 560-565.

Appleby, A. P., W.B. Kronstad and C. D. Rohde. 1966. Influence of 2- chloroethyltrimethyl ammonium chloride (CCC) on wheat (*Triticum aestivum*L.) when applied as a seed treatment. *Agron. J.* 58 : 435-437.

Arnold, C. E. and J. H. Aldrich. 1983. Peach responses to dikegulac. *Hort. Sci.* 18 : 474-476.

Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta Vulgaris. Plant Physiol.* 24 : 1-15.

Arzee, T., H. Langenauer and J. Gressel. 1977. Effects of dikegulac a new growth regulator on apical growth and development to three compositate *Bot. Gaz.* 138 : 18-28.

Audus, L.J. 1959. In *Plant Growth Substances.* Wiley (Interscience), New York.

Aung, L.H. and Flick, G.J. 1976. Giberellins induced seedlins induced seedless fruit of chayote *Sechium edule* Swartz. *Hort. Sci.* 11 : 460-462.

Aung, L.H. Fouse, D.C. and Kushad, M. 1991. The distribution of carbohydrates in the organs of *Sechium edule* Sw., J. Hortic. Sci. 66(2) : 253-257.

Banerjee, S. and Basu, P.S. 1991. Hormonal regulation of flowering and fruit development : I. effect of dikegulac and indole acetic acid on flowering and fruit development of *Trichosanthes dioica* 53 : 171-177.

Banerjee, S. and Basu, P.S. 1992. Hormonal regulation of flowering and fruit development : Effect of gibberellic acid and ethrel on fruit setting and development of *Momordica charantia* L. 34 : 63-70.

Beevers, L. and F. S. Guernsey. 1967. Interaction of growth regulators in the senescence of nasturtium leaf discs. *Nature.* 214 : 941-942.

Ben-Gad, D.Y., A. Altman and S. P. Monselise. 1979. Interrelationships of vegetative growth and assimilate distribution of *Citrus limettioides* seedlings in response to root-applied GA_3 and SADH. *Can J. Bot.* 57 : 484-490.

Bhattacharjee, A and K. Gupta. 1981a. Effect of dikegulac on growth and correlative biochemical changes in leaves of sunflower (*Helianthus annuus* L. cv. EC 68414). *Biochem. Physiol. Pflanzen.* 175 : 305-313.

Bhattacharjee, A. and K. Gupta. 1981b. Effect of dikegulac on plant growth and biochemical changes in treated and newly formed leaves of sunflower (*Helianthus annuus* L.cv. Modern). *Indian J. Exp. Biol.* 19 : 481-486.

Bhattacharjee, A. 1984. Responses of sunflower plants towards growth retardants with special reference to growth, metabolism and yield. Ph.D. thesis. Burdwan University, India.

Bhattacharjee, A. and K. Gupta. 1984a. Differential responses of sunflower (*Helianthus annuus* cv. Modern) towards high and low concentrations of dikegulac-sodium. *Can. J. Bot.* 62 : 495-500.

Bhattacharjee, A. and K. Gupta.. 1984b. Effect of CCC, SADH and dikegulac on growth modification of a sunflower cultivar and its impact on yield. *J. Indian Bot. Soc.* 63 : 335 – 340.

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 corp yield. *Burdwan Univ. Jn. Sci.* 1 : 1-12.

Bhattacharjee, A. and K. Gupta. 1985. Effect of dikegulac-sodium a growth retardant. on the viability of sunflower seeds. *Seed Sci. & Technol.* 13 : 165-174.

Bhattacharjee, A., S. Roychowdhury and M. A. Choudhuri. 1986. Effects of CCC and Na-dikegulac on longevity and viability of seeds of two jute cultivars. *Seed Sci. & Technol.* 14 : 127-139.

Bhattacharjee, A. and M. A. Choudhuri. 1986. Chemical manipulation of seed longevity and stress tolerance capacity of seedlings of *Corchorus capsular* is and *C. olitorius. Z. Pflanzenphysiol* 125 : 391-400.

Biswas, A.K. 1978. Studies on the mechanism of senescence in rice (Oryza sativa L. cv. Java) : Hormonal and nutritional control of the process and its influence on yield. Ph.D. Thesis, Burdwan University, India (1978).

Biswas, A.K. and Choudhuri, M.A. 1978. Differential behaviour of the flag leaf of intact rice plant during ageing. *Biochem. Physiol. Pflanzen.* 173 : 220-228.

Biswas, A. K. and M. A. Choudhuri. 1986, Dikegulac sodium-a potential water stress hardening agent. *Indian. J. Exp. Biol.*

Biswas, A.K. and Ghosh, A.K. 1999. *Regulation of Senescence in Various Plants* Emkay Publications, Delhi, India.

Bocion, P. F., W. H. de Silva, G. A. Huppi and W. Szkrybalo. 1975. Group of new chemicals with plant growth regulatory activity. *Nature.* 258 : 142-144.

Bocion, P. F., W. H. de Silva. 1976. Some effects of dikegulac on the physiology of whole plants and tissues : Interactions with plant hormones. 9th *Int. Conf. on Plant Growth Substances.* Lausanne, Switzerland. Pp. 189-198.

Bocion, P. F. and W. H. de Silva. 1977. Some effects of dikegulac on the physology of whole plants and tissues : Interactions with plant hormones. *Plant Growth Regulation.* 9th Int. Conf. on Plant Growth Substances. P. E. Pilet (ed.) Springer Verlag, Berlin. pp. 189-198.

Bocion, P. F., W. H. de Silva, H. R. Walther and H. R. Graf. 1977. Versuche mit Atrinal bei Gerbera, Cychamen, Begonien and Fuchsien. *Gartnerborse and Gartenwett.* 27 : 634-636.

Bocion, P. F., W. H. de Silva, H. R. Walther and H. R. Graf. 1978. The effects of dikegulac on the flowering and growth of some ornamentals. *Proceedings Joint BCPC and BPGRG Symposium* – Opportunities for Chemical Plant Growth Regulation. Pp. 195—201.

Cathey, H.M. 1964. Physiology of growth retarding chemicals. *Ann. Rev. Pl. Physiol.* 15 : 271-202.

Ceccarelli, R. and Lorenzi, R. 1982. Biosynthesis of GA_9 in a Cell-free system of *Sechium edule* S. Z. Planzenphysiol. Bd. 108 : 447 – 479.

Ceccarelli, N. Lorenzi, R. 1983. Gibberlins biosynthesis in endosperm and cotyledons of *Sechium edule* se edds. Phytochemistry. 22 : 2203-2205.

Ceceraelli, N. and Lorenzi, R. 1990. In vivo gibberellin biosynthesis in endosperum of *Sechium edule* Sw. seeds Plant Physiol. 93 : 1032-1036.

Ceccarelli, N. Lorenzi, R. 1992. Role of Cotyledons and Gibberelllins in the Early Growth of *Sechium Edule* Sw. Plantlets. J. Plant Physiol. 140 : 190-194.

Cherry, J.H. 1962. Nucleic acid determination in storage tissue of higher plants. *Plant Physiol.* 37 : 670-678.

Cheema. S. S., R. Singh, J. Singh and O. P. Malhotra. 1975. Effects of meteorological conditions on the response of barley to cycocel under limited moisture conditions. Indian J. Ecol. 2 : 146-150.

Chakravarty, H.L. 1973. Fasicles of Flora of India FASC II Cucurbitaceae pp . 100-101.

Choudhuri, M.A. and Chatterjee, S.K. 1970. Seasonal changes in the levels of some cellular components in the abscission zone of *Coleus* leaves of different ages. *Ann. Bot.* 34 : 275-278.

Cook, O.F. 1901. The chayote : a tropical vegetable. USDA Div. Bot. Bull. 28 : 7-31.

CSIR (Council of Scientific and Industrial Research). 1972. The wealth of India : Raw materials, volume 9. PID, CSIR, New Delhi, India.

Davies, C. R. and P. F. Wareing. 1965. Auxin directed transport of radiophosphorus in stems. *Planta* 65 : 139-156.

Das Gupta, P. K., D. Chakravorty, D. A. Konar and P. Das Gupta, 1985. Ageing in Wing bean. Abst. Published in symp.vol. of National Seminar on physiology of Ageing Burdwan on Dec 13th & 14th 1985.

Dey, B.K. and Jana, S. 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. Evniron, Ecol. 6 : 381-385.

De Silva, W. H., P. F. Bocion and H. R. Walther. 1976. Chemical pinching of azalea with dikegulac. Hort. Sci. 11 : 569-570.

Dorrel, D. G. 1973. Controlling plant height in sunflowers with growth retardants. *Can J. Plant. Sci.* 53 : 417-418.

Dhilon, N.P.S. and Sharma, B.R. 1987. Genetics of resistance to red pumpking beetle (*Aulacophora foveicollis*) in summer squash (*Cucurbita pepo* L.). Theor Appl. Genet 73, 711-715.

Dolui, T.K. and Jana, S. 1988. Effects of phyto, hormones on some biochemical parameters during dark induced leaf senescence of *Sechium edule* on Darjeeling hill of the Eastern Himalayas. Biol. Plant 30 : 379-383.

Elstner, E. F. 1982. Oxygen toxicity. *Ann. Rev. Plant Physiol.* 33 : 73-98.

Engvild, K.C. 1989. The death hormone hypothesis. Physiol Plantarum 77 : 282-285.

Evans, L.T. 1975. The Physiological basis of crop yield. In : Crop Physiology. (L.T. Evens, ed.) pp. 327-335. Cambridge Univ. Press, London.

Fillipovich, S.D. and Rowe, R.N. 1977. Effect of succinic acid 2, 2-dimethylhydrazide (SADH) on starch accumulation in young apple trees. *J. Hort. Sci.* 52 : 367-370.

Flick

[illegible]l, G.J., Burnette, F.S. Aung, L.H. Ory, R.L. and St. Angelo, A.J. 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.

Fridovich, I. 1976. Oxygen radical, hydrogen peroxide and oxygen toxicity. In : *Free radicals in biology* (ed. W. A. Prior) Vol. 1,pp. 239-277. Academic Press, New York.

Frydman, V.N. and Wareing, P.F. 1974. Phase change in *Hedera helix*. III. The effects of gibberellins, ABA and growth retardants on juvenine and adultivy. *J. Exp. Bot.* 25 : 420-429.

Ghosh, S. and Basu P.S. 1982. Effect of some growth regulators on sex expression of Momordica charantia L. Scientia Hortic. 17 : 107-112.

Ghosh, S. and Basu, P.S. 1983. Hormonal regulation of sex expression in *Momordica charantia* ; Physiol. Plant 57 : 301-305 (Copenhagen).

Ghosh, S. and Basu, P.S. 1984. Hormonal regulation of sex expression and some physiological and Biochemical changes in *Luffa acutangula* Roxb. Biochem. Physiol. Pflanzen. 179 : 277-287.

Gordon, S.A. and Weber, R.P. (1951). Colorimetric estimation of IAA. *Plant Physiology.* **26**, 192-195.

Gressel, J. and N. Cohen. 1977. Effects of dikegulac, a new growth regulator, on RNA synthesis in Spirodela. *Plant & Cell Physiol.* 18 : 255-259.

Guardia, M. D. D. L., L. G. Tornes and J. Berengena. 1974. Effects of growth regulators on sunflowers in the greenhouse and in field plots. *Proc. 6th Int. Sunflower Conf.*, Bucharest, Romania. Pp. 161-166.

Jaafar, H. B. 1982. Release of bud dormancy in budded stumps and maxi stumps using growth substances. J. Rubber Res. Ins. Malaysia. 32 : 73-81.

Halevy, A.H. and Wittwer, S.H. 1966. Effect of growth retardants on longevity of vegetables, mushrooms, and cut flowers. *Proc. Am. Soc. Hort. Sci* . 88 : 582-580.

Halevy, A. H. and R. Shilo. 1970. Promotion of growth and flowering and increase in content of endogenous gibberellins in *Gladiolus* plants treated with growth retardant CCC. Physiol. Plant. 23 : 820-827.

Halfacre, R. G. and J. A. Barden. 1968. Anatomical responses of apple leaf and stem tissues to succinic acid 2, 2-dimethyl hydrazide (Alar). Proc. Am. Soc. Hort. Sci. 93 : 25-32.

Haque, R. and Lama, P.C. 1996. *Envioron, Ecol.* 14 : 949-954.

Harada, H. 1968 . Retardation of the leaf senescence of *Rumex obtusifolius* L. leaves by growth retardants. Plant & Cell Physiol. 7 : 701-703.

Heursel, J. 1975. Results of experiments with dikegulac used on azaleas (*Rhododendron simsii* Planch) Medelingen Faculteit Land Bouwwetenschappen Gent. 40 : 849-467.

Hield, H., R.M. Sachs and S. Hemstreet. 1978. Foliar spray and bark banding with dikegulac for ornamental tree growth inhibition. Hort. Sci. 13 : 440-442.

Hoad, G.V. and s.P. Monselise, 1976. Effects of succinic acid 2, 2-dimethyl hydrazide (SADH) on the gibberellin and abscisic acid levels in stem tips of M_{26} apple rootstocks. Scientia Horticulturae 4 : 41-47.

Hochachka, P.W. and G.N. Somero. 1973. Strategies of biochemical adaptation. P.1, Saundery Press, Philadelphia.

Hrebins'kyi, S.O., L.K. Horb, Y.I. Baran, O.V. Vasyleiyo and T.M. Merchuk. 1978. Effect of chlorocholine chloride on growth and lignification of shoots of ornamental tree species in the city of Lvov (USSR). Ukr. Bot. Zh. 35 : 322-325.

Kar, M. and Mishra, D. 1976. Catalase, peroxidase, polyphenol oxidase activities during rice leaf senescence. *Plant Physiol.* 57 : 315-319.

Kessler, B., S. Spiegel and Z. Zolotov. 1967. Control of leaf senescnece by growth retardants. Nature 213 : 312.

Khamis, M.E. W.A., T. Holubozicz and Z. Skowronski. 1979. Influence of foliar application of some growth regulators on frost hardiness of one-year-old peach shoots. II., Influence of shoot-lignification. *Fruit Sci. Rep.* 6 : 101-106.

Kawabata, O. and R.A. Criley. 1982. Growth retardation of *Murraya Paniculata* (L) Jack by dikegulac-sodium. *Hort. Science.* 17 : 1.

Kaplya, A.V. and T.A. Moroz. 1976. Direction of growth processes and certain aspects of metabolism in fruit plants treated with chloro-choline chloride. *Fiziol. Biokhim. Kul't Rast.* 8 : 44-48.

Knypl, J.S. 1967. Inhibition of chlorophyll disappearance in senescing leaf tissues by coumarin and growth retardants. *Acta Soc. Bot. Pol.* 36 : 589-603.

Knypl, J.S. & Chylinska, K.M. 1972. Chlorophyll accumulation and protein synthesis in lettuce cotyledons treated with growth retardants, gibberellin and benzylaminopurine. *Z. Pflanzenphysiol.* 66 : 297-306.

Kumar, A. and Purohit, S.S. 1997. ***Plant Physiology* : *Fundamentals and applications*,** Agro Botancia, Bikaner, India.

Kuo, C.G. and Pharis, R.P. 1975. Effects of AMO-1618 and B_{995} on growth and endogenous gibberellin content of *Cupressus arizonica* seedlings. *Physiol. Plant.* 34 : 288-292.

Lama, P.C., Shil, R. Roy, S. and Bhattacharjee, A. 1994. Varietal screening, developmental stages and some physiological and biochemical parameters of *Sechium edule* Sw. of Darjeeling Hills. 12 : 409-415.

Lama, P.C. 2000. Studies on Biology of *Sechium edule* Sw. in Darjeeling : Influence of plants growth regulators on modification of growth, metabolism and yield. Ph.D Thesis, North Bengal University.

Larson, R.A. 1978. Stimulation of lateral branching of azaleas with dikegulac-sodium (Atrinal). *J. Hort. Sci.* 53 : 57-62.

Leopold, A.C. and Kriedemann, P.E. 1975. *Plant Growth and Development*. McGraw Hill, USA.

Lorenzi, R., Vernieri, P. and Ceceareli, N. 1988. Cytokinins om emdps[er, pf *Sechium edule* Sw. Seeds. *J. Plant Physiol.* 133 : 310-315.

Lovett, J.V. and Campbell, D.A. 1973. Effects of CCC and moisture stress on sunflower. *Expl. Agric.* 9 : 329-336.

Lovett, J. V. and P.W. Orchard. 1976. Morphological and anatomical changes induced in sunflower by chlormequat and their possible significance. *Proc. 7th Int. Sunflower Conf.* Krasnodar, USSR. pp. 323-331.

Lorenzi, R. Verneri, P. and Ceccarelli, N. 1988. Cytokinins in Endosperm of *Sechium edule* Sw. Seeds. 133 : 310-315.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with Folin phenol reagent. *J. Biol. Chem.* 193: 265-275.

MacLeod, G. 1990. Volatile components of chayote. Phytochemistry, 29 : 197-200.

Maity, S., Banerjee, G., Roy, M., Pal, C., Pal, B., Chakrabarti, D. and Bhattacharjee, A. 2000. Chemical induced prolongation of seed viability and stress tolerance. capacity of Mungbean seedlings. Seed Sci and Technol 28·155.162

Malstrom, H.L. and J.L. McMeans. 1977. A chemical method of prunning young pecan trees. *Hort Sci.* 12 : 68-69.

Markham, R. 1955. Nucleic acids, their compounds and related compounds. In : *Modern Methods of Plant analysis.* Vol. IV (K. Paech and M.V. Tracey, eds.) pp. 246-304, Springer-Verlag, Berlin.

Mattia, F.B. 1983. Effects of Atrinal concentrations on transplants of three chile pepper cultivars, *Capsicum annuum. Hort. Sci.* 18 : 170.

Mattia, F.B. 1984. Response of chili pepper transplants to greenhouse and field applied dikgulac-sodium sprays. *Hort.Sci.* 19 : 585.

McCready, R.M. Gaggloz, J., Silviera, V. and Owens, H.S. 1950. Determination of Starch and amylase in Vegetables. *Analyt. Chem.* 22 : 1156-1158.

Menhenett, R. and G. Hanks, 1983. Comparison of a new triazole retardant- pp 333 with ancymidol and other compounds on pot-grown tulips. *Plant. Growth Regulation.* 1 : 161-173.

Milthrope, F.L. and Moorby, J. 1988. An Introduction to Crop Physiology (2^{nd} ed), Cambridge Univ. Press, Cambridge.

Monselise, S.P. Goren, R. & Halvey, A.H. 1966. Effect of E_9, cycocel and benzothiazole oxyacetate on flower bud induction of lemon trees. *Proc. Am. Soc. Hort. Sci.* 89 : 195-200.

Monselise. S.P. and L. C. Luckwill. 1974. Effects of succinic acid 2, 2-dimethyl hydrazide (SADH) on the translocation of assimilates in apple. *Scientia Hort.* 2 : 185-192.

Moorby, S. 1977. Integration and regulation of translocation within the whole plant. In : Integration of activity in the higher plant. *Soc. Exp. Biol. Symp.* 31 : 425-454.

Mukhia M., Yonzone M. and Sadhu, T.K. 1982. Studies on squash (Sechium edule Sw.) of Darjeeling district. Indian Agric. 26 : 295-299.

Mulligan, D.R. and J.W. Patrick. 1979. Gibberellic acid-promoted transport of assimilaces in stems of *Phaseolus vulgaris* L. Localised vs. remote sites of action. *Planta,* 145 : 233-238.

Munnich, H. and S. Koshuchowa. 1977. Influence of chlorocholine chloride (CCC) on lignification of plant organs. *Biol. Rundsch* 15 : 186-188.

Nooden, L.D., Khanak, G.M. and Okatan, Y. 1979. Prevention of monocarpic senescence in soybeans with auxin and cytokinin : an antidote for self-destruction. *Science* 206 : 841-843.

Nodden, L.D. and leopold, A.C. 1988. Senescence and Aging in Plants. Academic Press, San-Diego.

Ogawa, Y. 1966. Acid, neutral and "Water Soluble" gibberllin like substances occuring in developing seed of *Sechium edule* Bot. Maz. (Tokyo) 79, 1-6.

Orchard, P.W. and J.V. Lovett. 1976. Chlormequat induced drought avoidance in sunflower. Proc. 7th Int. Sunflower Conf. Krasnodar, USSR, pp. 332-343.

Orson, P. and A. M. Kofranek. 1978. Dikegulac-sodium as a pinching agent for evergreen azaleas *J. Am. Soc. Hort. Sci.* 103 : 801-804.

Osbrone, D.J. 1967. Hormonal regulation of leaf senescence. In Woolhouse 1967, 305-321.

Panse, V.G. and Sukhatme, P.T. (1967). *Statistical methods for Agricultural Workers.* 2nd edition, pp. 150-157. *Indian Council of Agricultural Researchy,* New Delhi. India.

Patrick, J.W. 1979. An assessment of auxin-promoted transport in decapitated stems and whole shoots of *Phaseolus vulgaris L. Planta,* 146 : 107-112.

Phelps, J.E., E.A. McGinnes, M. Saniewski, J. Pieniazek and M. Smolinski. 1980. Some anatomical observations on the effects of morphactin IT 3456 and ethrel on wood formation in *Salix fragilis* L. *IAWA Bulletin.* 1 : 76-82.

Piggesi, A., Picciarelli, P., Ceccarelli, N. and Lorenzi, R. 1997. Cytokinin biosyntesis in endosperm of *Sechium edule* Sw. *Plant Science,* 129, 131-140.

Prokash, G. 1977. Plant growth regulators and sex expression in flower buds of *Momordica charantia in vitro- Curr. Sci.* 46 : 10.

Purohit, S.S. 1979. Studies with a new growth regulator dikegulac-sodium I. Effects on seed germination, seedling growth and chlorophyll biosynthesis. *Comp. Physiol. Ecol.* 4 : 264-266.

Purohit, S.S. 1980a. Studies with a new growth regulator : Dikegulac sodium II. Effects on protein, sugar and total oil content of *Helianthus annuus* L. Comp. Physiol. Ecol. 5 : 24-26.

Purohit, S.S. 1980b. Studies with a new growth regulator : Dikegulac sodium VI. Influence on some morphological parameters of *Brassica campestris. Comp. Physiol. Ecol.* 5 : 83-85.

Purohit, S.S. 1980c. Studies with a new growth regulator : Dikegulac-sodium III. Effects on root growth and negative geotropic response of *Helianthus annuus* L. *Curr. Sci.* 49 : 403-404.

Purohit, S.S. and K. Chandra. 1981. Effects of dikegulac-sodium on negative geotropic response, endogenous tryptophan and IAA-oxidase activity in *Glycine max* roots. Experientia. 37 : 148-149.

Rai, A.S. 2000. An investigation into the problems of maintenance of seed vigour and viability under adverse climatic conditions of Darjeeling hills. Ph.D. Thesis, North Bengal University.

Ramadas, V.S., Rao, J.V.S. and Rao, K.N. 1968. Changes in endogenous growth regulators during fruit development in *Citrullus colocynthis*. In *Proceeding of International Symposium on Plant Growth Substances*, Calcutta (ed. S.M. Sircar), 41-46.

Sabater, B. and M.T. Rodriguez. 1978. Control of chlorophyll degradation in detached leaves of Barley and Oat through effect on Kinetin on chlorophyllase level. *Physiol Plant.* 43 : 274-276.

Sachs, R.M. and Mock, T. 1975. Growth retarding activity of foliar applied daminozide (SADH) in relation to its concentration in three species. *J. Am. Soc. Hort. Sci.* 100 : 210-212.

Sachs, R.M., H. Hield and J. Debie. 1975. Dikegulac : a promising new foliar applied growth regulator for woody species. Hort. Sci. 10 : 367-369.

Sanderson, K.C. and W.C. Martin. 1977. Effects of dikegulac as a postsheraing shoot-inducing agent on azaleas, *Rhododendron* spp. *Hort. Sci.* 12 : 337-338.

Satoh, M., P.E. Kriedemann and B.R. Loveys. 1977. Changes in photosynthetic activity and related processes following decapitation in mulberry trees. *Physiol. Plant.* 41 : 203-210.

Shemy, A. 1978. Chemical regulation of Citrus growth-influence of sodium dikegulac. M.Sc. (Ag) Thesis, Hebrew Univ.

Shil, R. 1990. Some aspects of morphology, physiology and biochemistry of (*Sechium edule*) in Darjeeling hills. M.Sc. dissertation, North Bengal University.

Shimokawa, K. 1983. Role of Ethylene in fruit ripening. In : *Aspects of Physiology and Biochemistry of Plant Hormones*. S.S. Purohit (ed.) Kalyani Publishers. New Delhi. India pp. 175-200.

Shu, L.J. and K.C. Sanderson, 1979. Comparisons of several chemical pinching agents on azaleas. Proc. SNA Res. *Conf.* 24 : 201-202.

Shulmann, G.N.Y. and S. Lavee. 1983. Effects of dikegulac on the vegetative development of grapevine (*Vitis vinifera*) and olive (*Olea europea*) shoots, Scientia Hort. 21 : 147-153.

Singh, K., Nema, J.K.K. and Singh, O.P. 1991. Seasonal incidence, nature of damage and biology of podborer, *Adisura atkinsona* (Lepidoptera, Noctuidae) on pigeoapea (*Cajanus cajan*) in Madhya Pradesh (India). India Agric. Sic. 61(1) 65-69.

Skene, K.G.M. 1968. Increase in the leaves of cytokinins in bleeding sap of *Vitis vinifera* L. after CCC treatment. *Science*. 159 : 1477-1478.

Skene, K.G.M. 1969. A comparison of the effects of cycocel and topping on fruit set in *Vitis vinifera* L. Aust. *J. Biol. Sci.* 22 : 1305-11.

Smolinski, M., M. Saniewski and J. Pieniazek. 1972. The effect of morphactin IT 3456 on cambial activity and wood differentiation in *Picea excelsa*. Bull. *Acad. Polon. Sci. Ser. Sci. Biol.* 20 : 431-435.

Snell, F.D. and Snell, G.T. 1971. Colorimetric Methods of Analysis. Van Nostrand Reinhold Co., New York. IV AAA, 7-145.

Soteres, K.M., Berberet, R.C. and R.W. 1984. Parasitic insects associated with lepidopterous herbivores on alfalfa (*Medicago* stiva) in Oklahoma (U.S.A.) Environ. Entromol., 13(3), 787-793.

Tezuka, T., H. Sekiya and H. Ohno. 1980. Control of elongation and thickening growth of primary shoots and primary lateral shoots in 'Kyoho' grapes by CCC. *J. Japan Soc. Hort. Sci.* 49 : 8-14.

Thakur, C. *Scientific cropproduction,* Metropliton Book Co. Pvt Ltd., Delhi, India. 1975.

Thimann, K.V. 1980. Senescence in plans. CRC press, Boca Raton, Florida.

Thomas, H. and Stoddart, J.L. 1980. Leaf senescence. Annu. Rev. Plant Physiol. 31 : 83-111.

Thomas, T.H. 1985. Hormonal conrol of assimilate movement and compartmentation. In : Plant Growth substances 1985 (M. Bopp, ed.) pp. 350-359. Springer-Verlag, Berlin, Heidelberg, 1986.

VanStaden, J., Cook, E.L. and Nooden, L.D. 1988. Cytokinins and Senescence. In : Senescence and Aging in Plants (L.D. Nooden and A.C. Leopold, eds.) 281-328. Academic Press, New York.

Vansuyl, G. and Zinsou, C. 1986. Accumulation of agmatine in chayote (*Sechium edule*) leaves during development. *Physiol. Plant.* 64 : 592-597.

Walker, G.P., Nault, L.R. and Simonet, D.E. 1984. Natural mortality factors acting on potatos aphid (*Macrosiphum euphorbiae*) populations in processing tomat fields in Ohio (USA). Environ. Entomol. 13(3), 724-732.

Wareing, P. F. and J.W. Patrick. 1975. Source-Sink relations and the partition of assimilates in the plant. In *Photosynthesis and productivity in different environments* (ed. J.P. Cooper). Cambridge Univ. Press, Cambridge, pp. 481-499.

Weaver, R. J. 1972. Plant Growth Substances in Agriculture. Freeman & Co., Sanfransisco.

Whitehead, F.H. 1965. Phenotypic adaptation in wind plants. *Sci. Hort.* 17 : 31-39.

Wise, F.C. and W.C. Fonteno. 1980. Response of *Petunia hybrida* cv. Happinness to Atrinal applications. Hort. Sci. 15 : 440.

Wilson, M.R. and T.A. Nell. 1983. Foliar applications of BA increase branching of 'Welkeri' Dieffenbachia. *Hort. Sci.* 18 : 447-448.

Williamson, d.L., Vaggas, R.I. and Harris, E.J. 1985. Status of 3 pestiferous fruitfly (Distera : Tephritidae) populations Kanai Hawai VSA foleswing Hurricane IWA. *Proc. Hawau, Entomol.* Soc. 25. 145-154.

Zilkah, S. and J. Gressel. 1978. Differential inhibition by dikegulac of dividing and stationary cells in *in vivo* cultures. Planta, 142 : 281-285.

Zilkah, S. and J. Gressel. 1979. Cell suspensions for kinetic studies of inhibitor action : The rapid initial action of dikegulac on membrane properties on sito.. *Planta* 145 : 273-278.

Zilkah, S. and J. Gressel. 1980. Multistage disruption of protoplasts by dikegulac. Planta. 147 : 274-276.

Missing References (Addendum)

Ackerson, R.C. 1984. Abscisic acid and precocious germination in soybean. *J. Exp. Bot.* 35 : 414-421.

Bhattacharjee, A. Gupta, K. and Purohit, S.S. 1986. Responses of plants towards dikegulac-sodium, a prospective growth retarding chemical. In *Hormonal Regulation of Plant Growth and Development.* Vol. III. S.S. Purohit(ed), Agro Botanical Publications, India.

Jana, S., Barua, B. and Dalal, T. 1988. Effect of dikegulac on senescence in *Canna indica* and *Coccinia cordifolia. Environ. & Ecol.* 6 : 597-599.

Johnson, B. J. 1972. Effect of artificial defoliation on sunflower yields and other characteristics. *Agron. J.* 64 : 688-689.

King, R.W. 1982. Abscisic acid in seed development. In *The Physiology and Biochemistry of Seed Development, Dormancy and Germination.* A.A. Khan (ed), Elsevier Biomedical, Amsterdam.

Lama, P.C. 1988. *Influence of phytohormones on some biochemical parameters during dark-induced senescence of Sechium edule in Darjeeling hills of eastern Himalayas.* North Bengal University.

Paolo Vernieri, P. Perata, R. Lorenzi and N. Ceccarelli, 1989. Abscisic acid levels during early seed development in *Sechium edule* Sw. *Plant Physiol.* 91 : 1351-1355.

Sabater, B. 1984. Hormonal regulation of senescence. In *Hormonal Regulation of Plant Growth and Development.* Vol. I. S.S. Purohit(ed), Agro Botanical Publications, India.

Vozari-Hampe, M.M. , C. Viegas, C. Saucedo, S. Rosseto, G.G. Manica and O.G. Hampe. 1992. A lectin from *Sechium edule* fruit exudate. *Phytochemistry*, 31 : 1477-1480.

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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 Young	 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.)	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).

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.