RELATIVE SUSCEPTIBILITY OF CASHEW TYPES TO INFESTATION BY THE TEA MOSQUITO *Helopeltis antonii* SIGNORET (HEMIPTERA : MIRIDAE)

K. M. THOMAS

THESIS

Submitted in partial fulfilment of the
requirements for the degree of

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Kerala Agricultural University

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DECLARATION

I hereby declare that this thesis entitled "Relative susceptibility of cashew types to infestation by the tea mosquito *Helopeltis antonii* Signoret (Miridae: Hemiptera)" is a bonafide record of work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,
April 7, 1981.

(K.M. THOMAS)

CERTIFICATE

Certified that this thesis entitled "Relative susceptibility of cashew types to infestation by the tea mosquito *Helopeltis antonii* Signoret (Miridae : Hemiptera)" is a record of research work done independently by Sri.K.M. Thomas under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Vellanikkara,
April 7, 1981.

Dr. C.C. ABRAHAM,
Chairman,
Advisory Committee.
Associate Director of Research,
Kerala Agricultural University.

CERTIFICATE

We, the undersigned members of the Advisory Committee of Sri. K.M. Thomas, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology, agree that the thesis entitled "Relative susceptibility of cashew types to infestation by the tea mosquito _Helopeltis antonii_ Signoret (Miridae : Hemiptera)" may be submitted by Sri. K.M. Thomas in partial fulfilment of the requirements for the degree.

Dr. C.C. ABRAHAM,
Chairman,
Advisory Committee.

Dr. P.J. Joy
(Member)

Dr. A.I. Jose,
(Member)

Sri. P.V. Prabhakaran
(Member)

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Introduction

INTRODUCTION

Cashew(*Anacardium occidentale* Linn.) is one of the important dollar earning crops of India. The total annual production of raw cashewnuts in the country is over 1.79 lakh tonnes. Kerala has the maximum area under the crop and the production of raw nuts is about 72 per cent of the total Indian production. At present India has an installed capacity for handling about 4.5 lakh tonnes of raw cashewnuts, while the triennial average of indigenous production and imported raw nuts put together for the period 1975-77, has been of the order of about 2.3 lakh tonnes only. There is thus a gap of about 2.2 lakh tonnes between supply and demand of raw nuts. The majority of cashew processing factories are located in Kerala and these units provide employment for a total of about 1.5 lakh persons. Raw nuts are currently imported from East African countries, but consequent on establishment of processing units in these countries, imports are becoming increasingly difficult and the factories are forced to remain idle for most of the year.

To conserve the foreign exchange reserves of the country and for ensuring profitable functioning of the cashew processing industries, it is of utmost importance to bring about substantial increase in the yield of raw nuts. Among the short term strategies for increasing the yield of cashew, control of the tea mosquito bug Helopeltis antonii Signoret (Miridae : Hemiptera) is of major significance since this serious pest causes severe crop losses of the order of about 30 per cent due to shoot and panicle damage and due to driage of nuts.

The recommended control measures against H. antonii include three rounds of scheduled sprayings with Endosulfan/Carbaryl/Phosphamidon, first at the time of production of new vegetative shoots, second at the time of flowering and again at the time of fruit-set initiation. The chemical control measures are not found to be quite successful due to inadequate target coverage and failure to complete spraying operation within the recommended time-frame.

In view of the unsatisfactory levels of control obtained from insecticidal applications, it would be desirable to develop alternate methods of pest management against H. antonii. Cultivation of crop varieties resistant to pest infestation is the most effective and economical method of pest control.

If resistant types of cashew could be identified by proper screening techniques, it would be possible to ensure that the resistance is maintained through vegetative propagation of such types. Only very little work has so far been carried out on the relative susceptibility of cashew types to infestation by H. antonii and the mechanism of resistance involved (Sathiamma, 1979 and Ambika et al., 1979).

The present studies were, therefore, undertaken to screen out fourteen cashew accessions available in the germplasm bank of the Cashew Research Station, Madakathara, with reference to infestation by H. antonii and thereby to explore the possibility of pest control through the cultivation of types which are resistant or relatively less susceptible. Whether the relative susceptibility of the accessions is influenced by variations in some of the biochemical components, canopy architecture patterns and shade intensities within the canopies have also been investigated.

Review Of Literature

The adult longevity varies from 4 to 14 days for males and 4 to 24 for females. Pre-oviposition period was found to be 4 to 5 days while the oviposition and post-oviposition periods were 16 and 2 days respectively. The fecundity was found to vary from 10 to 60. The eggs are sub-oval and bear a pair of fine thread like processes. These are thrust deep inside the tender shoots and inflorescence axes and also in nuts. The incubation period ranged from 5 to 9 days. The nymphs pass through five instars to attain adulthood. The duration of the first nymphal instar is 3 to 3.5 days and the second instar lasts for 2.4 days. The third instar moults in about 2 to 4 days. The fourth instar lasts for 3 to 4 days. The last instar nymphs moult in 2 to 5 days. The total life-cycle occupied 22 to 35 days (Abraham, 1958; Sudhakar, 1975; Pillai et al, 1976 and Ambika and Abraham, 1979).

Nymphs and adults suck sap from the tender tissues of the plant by inserting the proboscis deep into the tissues up to the vascular region. The fifth instar nymphs cause relatively greater damage. On the shoots elongate streaks and brownish patches develop around the feeding punctures and these regions dry up eventually. A resinous substance exudes from the feeding punctures on the shoots and the exudate dries up and hardens on exposure to air. The shoot apices eventually dry up. On the inflorescence, feeding is usually restricted to the main axis. Secondary floral branches are also attacked. Irregular, elongate, shiny, rusty-brown lesions are caused due to feeding. On immature nuts and apples, scabby spots are produced due to feeding (Sathiamma, 1977; Ambika and Abraham, 1979).

The preferred temperature for fertilization and oviposition was found to be 25 ± 0.5°C, while 28 ± 0.5°C was found to be ideal for hatching of eggs (Ambika and Abraham, 1979).

The pest population build up in Kerala commences from October with the emergence of new vegetative flushes. The population reaches its peak during the blossom period in January. H. antonii populations are not recorded during the monsoon period (Pillai and Abraham, 1975). However, on young trees, the pest populations are observed throughout the year since the pattern of flushing in these trees is somewhat continuous (Sathiamma, 1977). Gopalan and Perumal (1973) reported that the occurrence of the pest on guava was not correlated with variations in the meteorological parameters.

Cashew was introduced in India in the Goan region and along the Malabar Coast during the 16th century (de Costa, 1578; van Linschoten, 1958). It is most likely that the original introductions were nuts belonging to a few trees and they had a limited genetic base from which all the cultivars in the country evolved. The variability observed among the cultivars at present with respect to plant characters may be due to segregation of inherent heterozygosity. The extent of variability in respect of plant canopy architecture, flowering period, proportions of male and bisexual flowers, apple characteristics etc. have been reported by various workers (Morada, 1941; Rao and Hassan, 1957; Cordoba, 1967; Northwood, 1967; Morton, 1970).

Studies on the varietal susceptibility to infestation by H. antonii are very limited and confined to cashew and guava.

In a preliminary study of the varietal reaction in guava to tea mosquito infestation, Perumal *et al*. (1970) detected considerable variations.

In Tamil Nadu state Gopalan and Perumal (1973) screened eleven guava varieties aged ten years and eight varieties of 28 years' growth for infestation by *H. antonii*. Total number of healthy and affected fruits on selected branches were recorded for assessing varietal susceptibility and the percentage of incidence was worked out. None of the varieties was immune to attack by the pest. However, there were variations in the incidence of the pest in different varieties indicating the preference of certain varieties by the pest. The variety 'Lucknow-46' suffered the maximum infestation of 81.9 per cent, while the variety 'Bangalore' showed the least incidence of 34.6 per cent. Most of the older trees were almost free from pest infestation and damage. Among the older trees, the minimum incidence was found to be 2.89 per cent in the variety 'Anakapelle' while the maximum damage was 6.01 per cent in the variety 'Red Fleshed'.

The intensity of infestation was estimated by counting the number of warts on 30 selected fruits in each variety. There was definite positive correlation between the percentage of incidence and the number of warts on the fruits. The percentage of incidence and the intensity of infestation were found to be greater in the susceptible variety 'Lucknow-46' being 81.9 and 78.7 per cent respectively and was least in the variety 'Bangalore' being 34.6 and 27.95 per cent respectively.

Balasubramanian and Kalyanasundaram (1974) evaluated nine guava varieties for their relative susceptibility to infestation by H. antonii. The varieties showed wide variation in the incidence of the pest. Varieties like 'Bangalore' and 'Red Fleshed' were severely affected, the percentage of incidence being 50.76 and 51.40 respectively. The varieties 'Safeda' and 'Seedless' were almost free from infestation and the percentage of incidence was 0.20 and 0.25 respectively. The varieties 'White Large', 'Round', 'Chittidar', 'Seedling' and 'Kohir' were grouped as moderately susceptible. No correlation could be detected between the age of the trees on the one hand

and the susceptibility to pest infestation on the other.

At the CPCRI Regional Station, Vittal, Sathiamma (1977a) studied the varietal reactions of 16 cashew types to tea mosquito infestation. The accession VTH-34 T.No.1 (Bapatla) and VTH 151 BLA 256-4 (Anakkayam) gave comparatively low percentage of pest attack with 2.2 per cent and 3.8 per cent shoot damage and 6.8 per cent and 5.5 per cent panicle attack respectively. The highest percentage of panicle attack (11.9) was recorded in theaccession VTH 1 Ansur 1 (Vengurla). The maximum shoot damage (8.5%) was found in VTH 36 T.No.56 (Bapatla).

Ambika et al. (1979) screened eleven accessions of five year old cashew seedling trees and hybrids for their susceptibility to H. antonii and found that none of them was absolutely resistant to infestation. The intensity of infestation on tender shoots and floral branches was recorded on a 0 - 4 scale based on the following criteria.

0 : no lesions/streaks

1 : up to 3 necrotic lesions/streaks - general vigour of the shoot/panicle unaffected

2 : 4 - 6 coalescing or non-coalescing lesions/streaks

3 : above 6 coalescing or non-coalescing lesions

4 : lesions/streaks confluent - complete driage of affected panicle/shoot.

With reference to shoot damage, the accession No.665 was found to be significantly less susceptible to infestation than the accessions HAF 1111, 650, K-10-2-1232 and K-10-2-1218, the damage scores being 1.00, 2.00, 2.00, 2.25 and 2.75 respectively. The accession No.K-10-2-1218 was highly susceptible to the pest as compared to the accessions 1097, BLA-139-1-1431, HAF 1098, Ansur-1352, 1112, 22 and 665. Regarding the extent of damage to the panicle, the damage score ranged from 1.25 in accession No.665 to 2.75 in the accessions K-10-2-1232 and K-10-2-1218. The damage caused to the panicles of the tree No.665 was significantly lesser than in the accession numbers K-10-2-1232, K-10-2-1218, BLA-139-1-1431, HAF-1098, HAF-1111, 1097, 650, 22, Ansur-1352 and 1112. The panicles of the types K-10-2-1232 and K-10-2-1218 were found to be highly susceptible to damage by *H. antonii*.

The variability in the damage ratings of the accessions was attributed to bio-physical or bio-chemical factors.

In a subsequent study involving seventy four cashew accessions, Sathiamma (1979) scored the intensity of damage inflicted by _H. antonii_. The pest incidence was found to very with the different accessions. Nymphs and adults of _H. antonii_ were found in all the types and the mean percentage of shoot infestation ranged from 1.8 to 43.3, while the panicle damage rating ranged from 5.5 to 54.3 per cent. The percentage of total damage was found to be relatively heavy in the accession numbers VTH 46(7/3 RASTUMBADA, Bapatla) with 31.8 per cent shoot attack, 34.5 per cent panicle damage and the average insect population of 56.5 nymphs and adult bugs per 100 shoots/panicles. The accessions such as VTH 54 (10/8 EPURUPALAM, Bapatla), VTH 78 (7/12 NEELIPUDI, Bapatla), VTH 64 (2/4 NATHAVARAM, Bapatla) and some other varieties were also found to be highly susceptible to infestation. The damage intensity was lower in the type VTH 151 (BLA 256-4, Anakkayam) with 3.8 per cent shoot damage and 5.5 per cent panicle damage. These types had an average of 6.0 adults/nymphs per 100 shoots/panicles. The other relatively less damaged accessions were VTH 153 (H-3-17, Anakkayam), VTH 152 (BLA 226-1, Anakkayam) and VTH 2 (VETURE 56, Vengurla). With reference to the pest population loads supported by the different accessions, the higher pest population loads were recorded in the accessions VTH 54 (10/8 EPURUPALAM Bapatla), VTH 42 (4/1 GOLLAGUDAM, Bapatla) and VTH 40 (2/9 DICHERLA, Bapatla) the range being 67.5 to 105.5 nymphs and adult bugs per 100 shoots/panicles per tree, while the accessions VTH 61 (10/15 KODUR, Bapatla), VTH 70 (5/12 DIVANCHERUVU, Bapatla) and VTH 153 (H-3-17, Anakkayam) supported only relatively low pest loads (1.5 to 3.2 nymphs and adult bugs per 100 shoots/panicles per tree).

Materials and Methods

MATERIALS AND METHODS

The field experiments for evaluating some cashew types for their relative susceptibility to infestation by *Helopeltis antonii* Signoret were carried out at the Cashew Research Station, Madakathara in the main campus of the Kerala Agricultural University, during the period from September, 1979 to March, 1980.

Fourteen accessions comprising of six year old seedling progenies and hybrids were tested for their relative field susceptibility to the pest.

Details of cashew types used for screening are indicated in the Table.

Rating of the accessions for natural field damage intensities

In order to ascertain whether non-preference and

Details of cashew accessions used for screening for relative susceptibility to infestation by *H. antonii*

Sl. No.	Type	Description
	Seedling Progenies	
1	T. 20 - 22	From a high yielding tree at the Cashew Research Station, Anakkayam.
2	Vengurla 37-3-1097	High yielding seedling type from Vengurla, Maharashtra State
3	Vengurla 37-3-1112	High yielding seedling type from Vengurla, Maharashtra State.
4	Vengurla 36-3-1469	High yielding seedling type from Vengurla, Maharashtra State
5	Vengurla 36-3-1548	High yielding seedling type from Vengurla, Maharashtra State
6	BLA-139-1-1391	A selection from among the Bapatla Germplasm collection
7	BLA-139-1-1431	A selection from among the Bapatla Germplasm collection
8	BLA-256-1-1430	A selection from among the Bapatla Germplasm collection
9	Tree-56 of BLA-1219	From the tree No.56 of the C.R.S., Bapatla.
10	Ansur-1-1352	A type from Vengurla
11	Ansur-1-1547	A type from Vengurla
	Hybrids	
12	H. 27-650	BLA 1-39-1 x E-2-1
13	H. 27-665	BLA 1-39-1 x E-2-1
14	H. 4-7-1111	Tree No. 30 x Tree No. 8 R2-18 of the Kottarakkara Station

preference traits are manifested under field conditions, the feeding injuries on the shoots and floral branches were recorded separately based on random samples.

The intensity of damage to shoots and floral branches was scored on a 0-5 scale on the basis of the number of necrotic lesions developing on the plant tissues as a result of feeding by the insects. The norms for recording damage ratings were as follows:

0 - No lesions/streaks

1 - Upto 3 necrotic lesions/streaks

2 - 4-6 lesions

3 - 7-9 lesions

4 - 10-12 lesions

5 - above 12 lesions which tend to be confluent.

One tree in each accession was scored for natural infestation. For this, the canopy of each tree was divided into four equal segments following the two long poles placed flat in ground along diametrical lines. Three fresh panicles and shoots were randomly selected from each segment and the intensity of infestation was recorded as already indicated.

Intensity of damage due to feeding activity of insects confined on shoots/floral branches

A large number of terminal shoots were selected and these were caged in the last week of July well ahead the commencement of vegetative flushing. For caging, perforated polythene bags (150 gauge) of size 30 x 20 cm were used. Just as the vegetative flushes were randomly selected in each of the four canopy segments, three caged floral branches were marked out at random in each canopy segment soon after flowering initiation.

For inoculation, five fifth instar nymphs (3 females and 2 males) were used in each randomly selected shoot/floral branch and these were confined for a period of 24 hours. The fifth instar nymphs are deep-brownish in colour with reddish-brown thorax, overlapping wingpads and two-segmented tarsi. The sexes are distinguishable on the basis of external genitalia and size variations, the females being slightly larger.

Nucleus cultures of <u>H. antonii</u> were reared out on fresh vegetative shoots in field cages by confining five pairs of freshly emerged adults in each cage. The F_1 progeny emerged in about 12 days and these attained the fifth instar stage in about 13 days. The nucleus cultures were examined on successive days and the insects were removed soon after the shoots revealed necrotic symptoms. These were transferred to fresh shoots and kept in cages for further development. The cultures were also sub-divided at appropriate intervals to avoid high population densities in field cages.

Cylindrical cages (Plate 1) of 30 cm length and 20 cm diameter were used for confinement of the test insects. The cages were made of wire frame work covered all over with polythene net-cloth having about four apertures per linear cm. The terminals of the wire frame work towards one side were provided with small hook like bends at the apices to facilitate the fixing of the frame work on shoots/floral branches.

The intensity of damage was scored after removing the floral branches and shoots, on a 0-5 scale as already explained.

Estimation of soluble sugars, nitrogen and tannin

In order to ascertain whether the susceptibility of cashew types to infestation by H. antonii was influenced by biochemical factors, the shoots and panicles were analysed for total nitrogen, soluble sugars and

Plate 1 Polythene net cage used for confining H. antonii on shoots and floral branches of cashew

tannins. For chemical assay, random samples of fresh shoots and floral branches were collected from the different accessions and dried in an electric oven at a temperature of 65°C for 24 hours. The dried samples were ground using a laboratory mill fitted with a 0.5 mm mesh sieve. The total nitrogen content was estimated as per the method indicated by Jackson (1958). For the estimation of tannins and soluble sugars (sucrose, glucose, fructose etc.), one g sample was boiled for 30 minutes with 80 ml of water and cooled. This was then transferred to a 100 ml standard flask and the volume was made up. The flask was shaken well and the contents filtered.

For the determination of tannins, the extract was diluted 250 times with water. The procedure suggested by the Association of Official Analytical Chemists (1970) was followed in estimating the tannin content.

For the estimation of soluble sugars polyphenolics were removed from the extract prepared, by the addition of basic lead acetate. The excess lead acetate was precipitated with five per cent aqueous potassium oxalate. The solution was then diluted 50 times and the soluble sugars were determined by the method suggested by Dubois *et al.* (1951).

Intensity of shade within the canopy

In order to ascertain whether the canopies of different types show remarkable variation on account of the pattern changes in the canopy configuration, the intensity of light in the central region of the canopy were recorded using a luxmeter ('APLAB' Type ML 4420) and the intensities under open conditions were also recorded side by side and light intensities inside the canopies were worked out from the two values as percentages. Monthly mean values were computed from weekly observations. The observations were taken at weekly intervals at 2 PM after fitting three filters in the lux meter. The light intensity below the canopy was recorded using two filters. The shade measurement was done during the period from October, 1979 to March, 1980.

Canopy architecture

The basic canopy architecture in cashew follows the Scarrone's model (Halle *et al.*, 1978). In order to ascertain whether tree to tree variations in the canopy configuration existed and also to study whether the type of canopy is related to susceptibility of the trees to infestation by H. antonii, the architectural patterns of the trees included in the experiment were studied. The parameters recorded to describe the architectural features were height, maximum canopy spread recorded along diametrical lines passing through the trunks as the centres and perimeter. The actual pattern of formation of branches was sketched.

Statistical analysis

For comparing the trees for natural field infestation levels and the damage ratings under confinement, the analysis of variance technique as described by Snedecor and Cochran (1967) was made use of. Data relating to natural field infestations on vegetative shoots and floral branches were analysed as a one-way classification model with the four quadrants in each tree representing the replications. Data relating to damage ratings under confinement of vegetative shoots and the floral branches were analysed as in a nested design. The influence of biochemical factors and shade intensities within the canopy on the susceptibility to infestation by H. antonii was ascertained by working simple correlation coefficients (Snedecor and Cochran 1967).

Results

RESULTS

Rating of the accessions for natural field damage intensities due to infestation by _Helopeltis antonii_ Sign.

Rating of different accessions with reference to damage to vegetative shoots

The intensity of damage inflicted to the vegetative shoots of the accessions was scored on a 0 - 5 scale as already explained under Materials and Methods and the mean score values are furnished in Table-1 and these are depicted in Fig.1. The raw data are furnished in Appendix-I and the Analysis of Variance table in Appendix-II.

The damage intensities ranged from 0.42 in the accession No.22 to 4.00 in the accession No.1111. The accessions22, 1112, 1430 and 1097 were found to be the least susceptible as compared to the remaining accessions, their intensity scores being 0.42 to 1.42. Accessions 650, 1391, 1548, 665, 1547 and 1111 were the most susceptible ones the damage intensity scores being 2.83 to 4.00.

Table 1. Mean score values indicating the intensity of natural field infestation of vegetative shoots by *H. antonii*

Sl. No.	Accession Number	Mean scores
1.	T. 20-22	0.42
2.	Vengurla 37-3-1112	1.00
3.	BLA-256-1-1430	1.33
4.	Vengurla 37-3-1097	1.42
5.	Vengurla 36-3-1469	1.58
6.	Ansur-1-1352	1.83
7.	Tree 56 of BLA-1219	2.50
8.	BLA-139-1-1431	2.58
9.	H.27-650	2.83
10.	BLA-139-1-1391	3.08
11.	Vengurla 36-3-1548	3.17
12.	H.27-665	3.25
13.	Ansur-1-1547	3.50
14.	H.4.7-1111	4.00
	F Test	Sig. (0.01)
	CD (p = 0.05)*	1.15

* p = 0.05 indicates the 5% level of probability

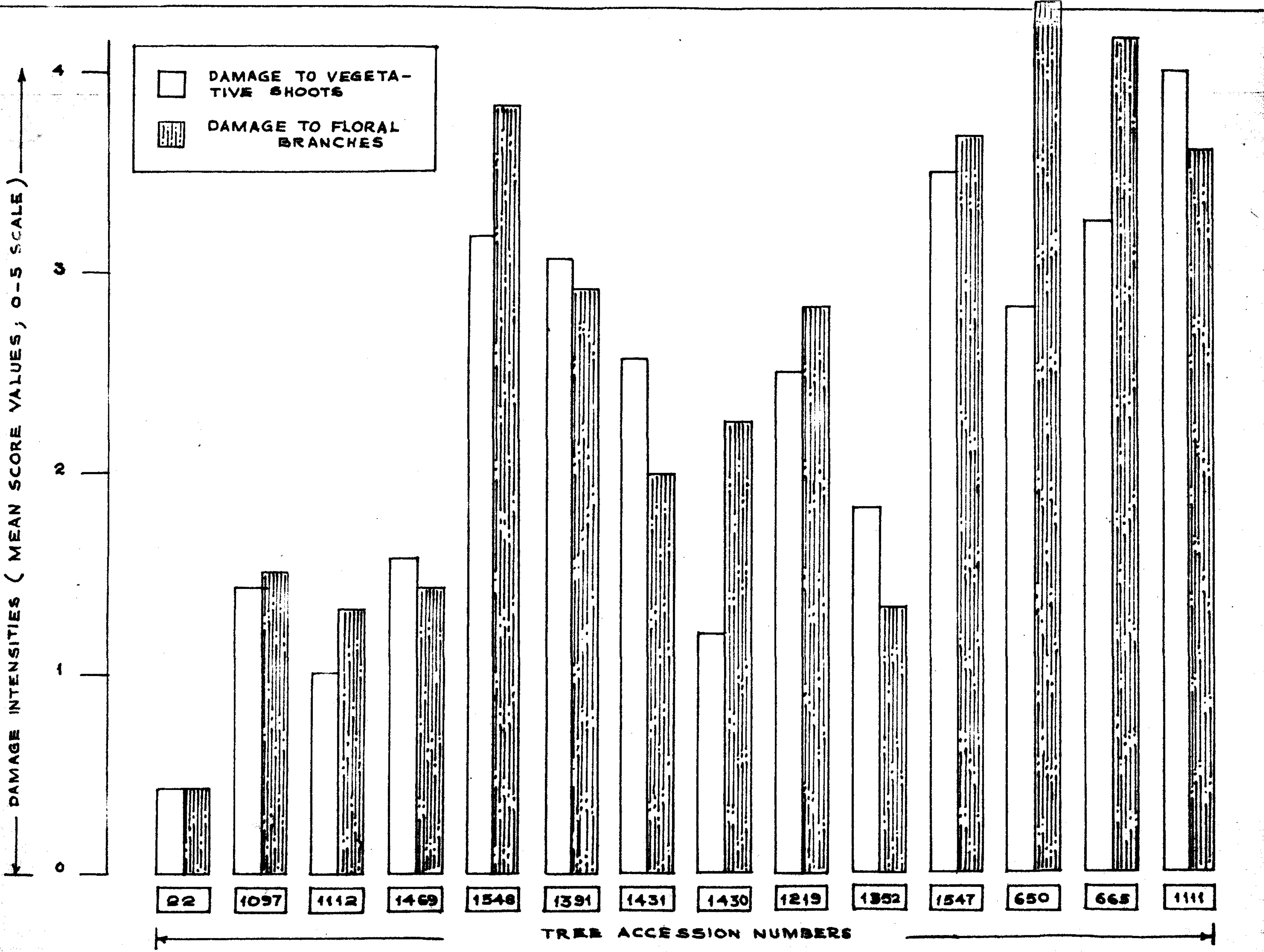

FIG: 1 DAMAGE INTENSITIES TO VEGETATIVE SHOOTS AND FLORAL BRANCHES OF CASHEW DUE TO INFESTATION BY H. ANTONII UNDER FIELD CONDITIONS

Rating of different accessions with reference to damage to floral branches

The intensities of field damage to the floral branches by H. antonii are indicated in Table 2 and diagrammatically represented in Fig.1. The raw data on this is furnished in Appendix-III and the Analysis of Variance table in Appendix IV. The tree No.22 showed the least damage (0.42), while the tree No.650 showed the maximum damage intensity of 4.50 and the differences among the accessions were found to be significant. The accessions 22, 1112, 1352, 1469 and 1097 showed intensity ratings ranging from 0.42 to 1.50 and these were significantly less susceptible as compared to the rest of the accessions. The accessions 1111, 1547, 1548, 665 and 650 were the most susceptible ones, with damage ratings of 3.59 to 4.50. These were significantly more susceptible than the rest of the accessions.

Intensity of damage to the accessions due to feeding activity of H. antonii under confinement

Intensity of damage to the vegetative shoots

The mean score values indicating damage intensities to fresh vegetative shoots as a result of feeding

Table 2. Mean score values indicating the intensity of natural field infestation of floral branches by *H. antonii*

Sl. No.	Accession number	Mean scores
1.	T. 20-22	0.42
2.	Vengurla 37-3-1112	1.33
3.	Ansur-1-1352	1.33
4.	Vengurla 36-3-1469	1.42
5.	Vengurla-37-3-1097	1.50
6.	BLA-139-1-1431	2.00
7.	BLA-256-1-1430	2.25
8.	Tree 56 of BLA-1219	2.83
9.	BLA-139-1-1391	2.92
10.	H.4.7-1111	3.59
11.	Ansur-1-1547	3.67
12.	Vengurla 36-3-1548	3.83
13.	H. 27-665	4.17
14.	H.27-650	4.50
	F Test	Sig.(0.01)
	CD (p = 0.05)*	1.39

* p = 0.05 indicates the 5% level of probability

activity of fifth instar nymphs (3 female and 2 males) are given in Table 3 and illustrated in Fig.2. The raw data and the Analysis of Variance table are appended (Appendices V and VI).

The differences among the accessions with respect to the mean damage intensities were not found to be significant. The shoot damage intensities in the accessions ranged from 3.75 in the tree 665 to 4.92 in the tree No.1547.

Rating of damage to floral branches

Data on infestation ratings of the accessions consequent on confinement of fifth instar nymphs on floral branches are indicated in Table 4 and are diagramatically represented in Fig. 2. The details of score values in the accessions and the Analysis of Variance table are given in Appendices VII and VIII respectively. The differences among the accessions with respect to the damage inflicted to the floral branches were found to be significant. The tree 1219 showed the least damage of 3.83 while the tree nos. 1469 and 1431 registered the same rating of 4.08. The tree numbers 1430 and 1097 showed the same damage rating score of 4.92.

Table 3. Mean score values indicating the degree of infestation of vegetative shoots by *H. antonii* under confinement.

Sl. No.	Accession number	Mean scores
1.	H.27-665	3.75
2.	Tree 56 of BLA-1219	3.92
3.	BLA-139-1-1391	3.99
4.	BLA-139-1-1431	3.99
5.	Ansur-1-1352	4.00
6.	H.47-1111	4.08
7.	Vengurla 37-3-1097	4.09
8.	H. 27-650	4.17
9.	Vengurla-37-3-1112	4.17
10.	Vengurla-36-3-1469	4.25
11.	Vengurla-36-3-1548	4.25
12.	T.20-22	4.42
13.	BLA-256-1-1430	4.50
14.	Ansur-1-1547	4.92
	F Test	NS*

* Non-significant

Table 4. Mean score values indicating the degree of infestation of floral branches by *H. antonii* under confinement

Sl. No.	Accession numbers	Mean scores
1.	Tree 56 of BLA-1219	3.83
2.	Vengurla-36-3-1469	4.08
3.	BLA-139-1-1431	4.08
4.	H.27-665	4.25
5.	Ansur-1-1547	4.34
6.	BLA-139-1-1391	4.34
7.	Vengurla-37-3-1112	4.58
8.	H.4.7-1111	4.58
9.	Ansur-1-1352	4.67
10.	T.20-22	4.67
11.	Vengurla-36-3-1548	4.72
12.	H.27-650	4.75
13.	BLA 256-1-1430	4.92
14.	Vengurla 37-3-1097	4.92
	F Test	Sig.(0.05)
	CD (p = 0.05)*	0.61

*p = 0.05 indicates the 5% level of probability

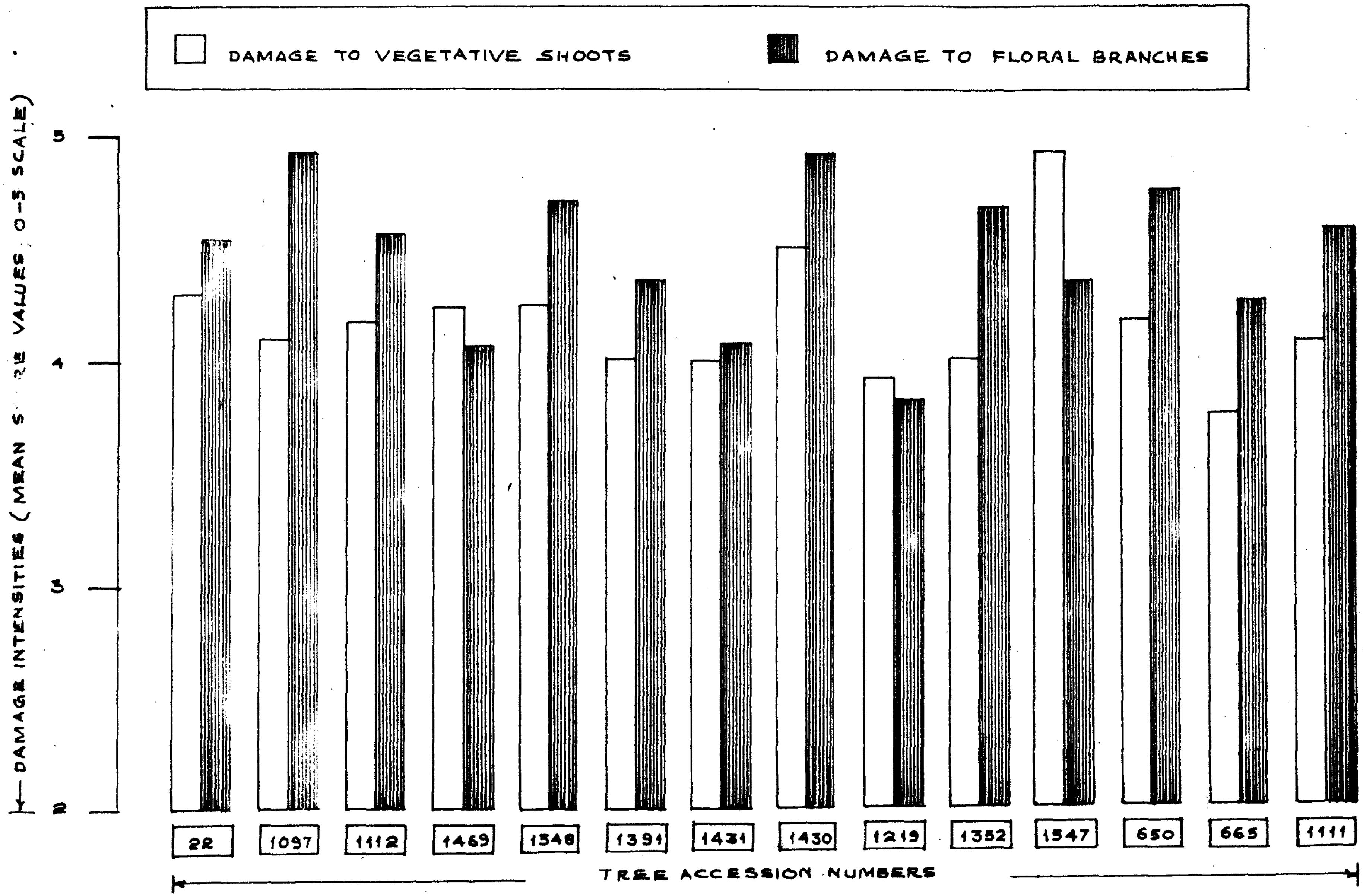

FIG: 2 DAMAGE INTENSITIES TO VEGETATIVE SHOOTS AND FLORAL BRANCHES OF CASHEW DUE TO INFESTATION BY H. ANTONII (5 FIFTH INSTAR NYMPHS) UNDER CONFINEMENT ON VEGETATIVE SHOOTS/ FLORAL BRANCHES

Influence of biochemical factors on susceptibility of the trees to infestation by *H. antonii*

The shoots and floral branches were analysed for the total nitrogen (Jackson 1958), soluble sugars (Dubois *et al*., 1951) and tannins (Association of Official Analytical Chemists, 1970) in order to ascertain whether these influence the intensity of damage of the accessions to infestation by *H. antonii*.

The percentages of nitrogen in shoots and floral branches are given in Table 5 and illustrated in Fig. 3. The percentage nitrogen content in the shoots ranged from 0.42 in the tree no. 650 to 2.94 in the tree no. 1112. The percentage nitrogen content of floral branches ranged from 0.42 in the accession 1547 to 2.10 in accessions 1430 and 1219.

The contents of soluble sugars in vegetative shoots and floral branches are given in Table 6 and illustrated in Fig. 4. The range in sugar content in the shoots was quite wide being 1.82 per cent in tree No.1219 to 26.01 in tree no.1469. In the trees, 1111, 1097 and 665 the contents ranged from 7.74 to 8.73. In the panicles also the range in soluble sugar content was wider being from 2.01 per cent in tree 1352 to

Table 5. Nitrogen content in shoots and floral branches of different cashew accessions

Sl. No.	Accession Number	Nitrogen content (%)	
		Shoot	Floral branches
1.	T. 20-22	1.96	1.75
2.	Vengurla 37-3-1097	0.70	0.77
3.	Vengurla 37-3-1112	2.94	0.70
4.	Vengurla 36-3-1469	1.12	1.68
5.	Vengurla 36-3-1548	2.24	1.82
6.	BLA-139-1-1391	1.96	1.12
7.	BLA-139-1-1431	2.38	1.54
8.	BLA-256-1-1430	1.68	2.10
9.	Tree 56 of BLA-1219	0.98	2.10
10.	Ansur-1-1352	1.40	2.03
11.	Ansur-1-1547	1.33	0.42
12.	H.27-650	0.42	1.82
13.	H.27-665	2.38	0.84
14.	H.4.7-1111	1.61	1.33

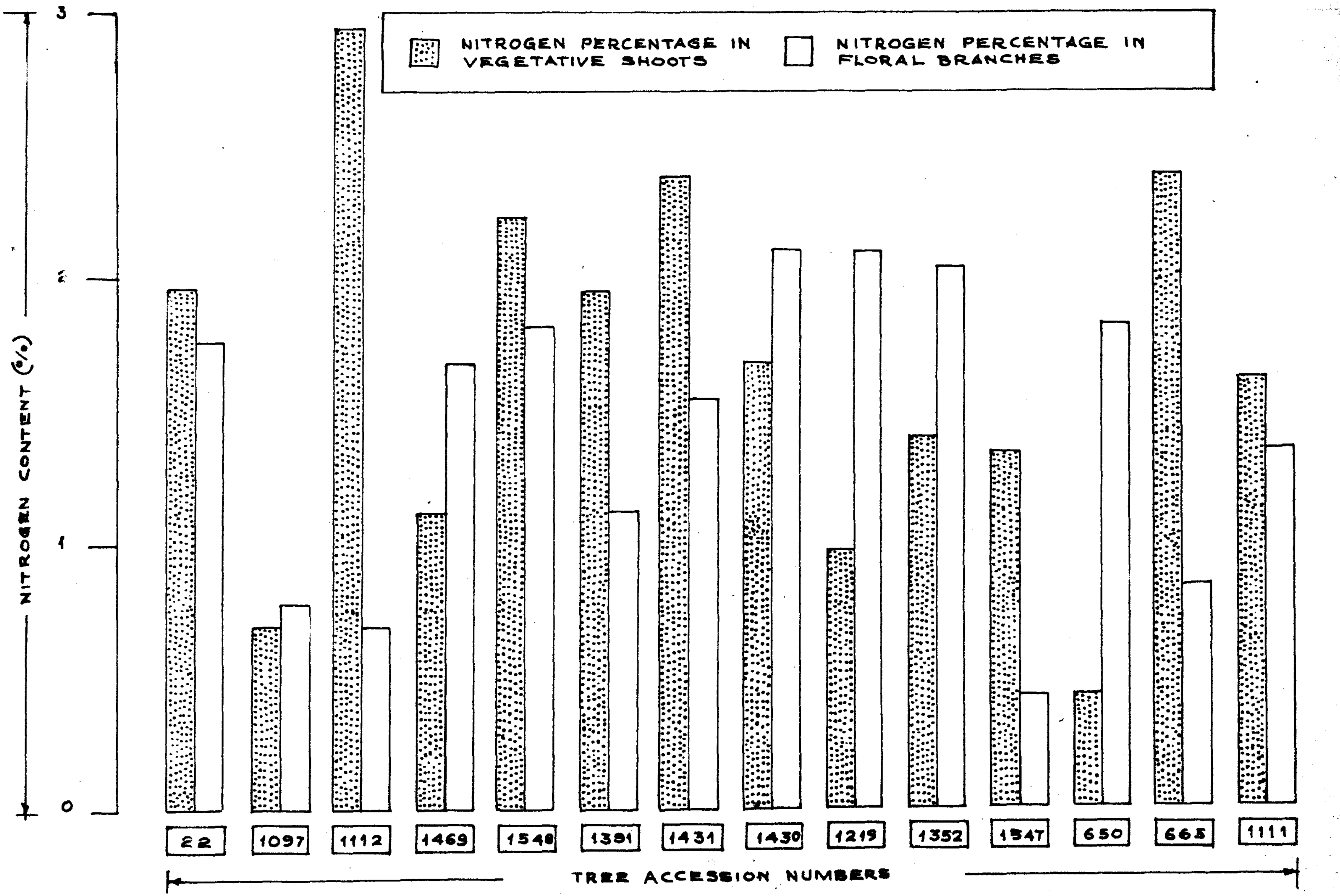

FIG. 3 NITROGEN CONTENT IN VEGETATIVE SHOOTS AND FLORAL BRANCHES OF DIFFERENT CASHEW ACCESSIONS

Table 6. Sugar content in shoots and floral branches of different cashew accessions

Sl. No.	Accession Number	Sugar content (%)	
		Shoots	Floral branches
1.	T. 20-22	15.79	18.86
2.	Vengurla 37-3-1097	8.33	25.40
3.	Vengurla 37-3-1112	6.27	7.05
4.	Vengurla 36-3-1469	26.01	19.39
5.	Vengurla 36-3-1548	6.63	5.81
6.	BLA-139-1-1391	3.06	5.36
7.	BLA-139-1-1431	11.34	14.16
8.	BLA-256-1-1430	5.81	5.59
9.	Tree 56 of BLA-1219	1.82	3.30
10.	Ansur-1-1352	4.30	2.01
11.	Ansur-1-1547	5.25	8.40
12.	H. 27-650	14.75	13.96
13.	H. 27-665	8.73	10.86
14.	H. 4.7-1111	7.74	13.22

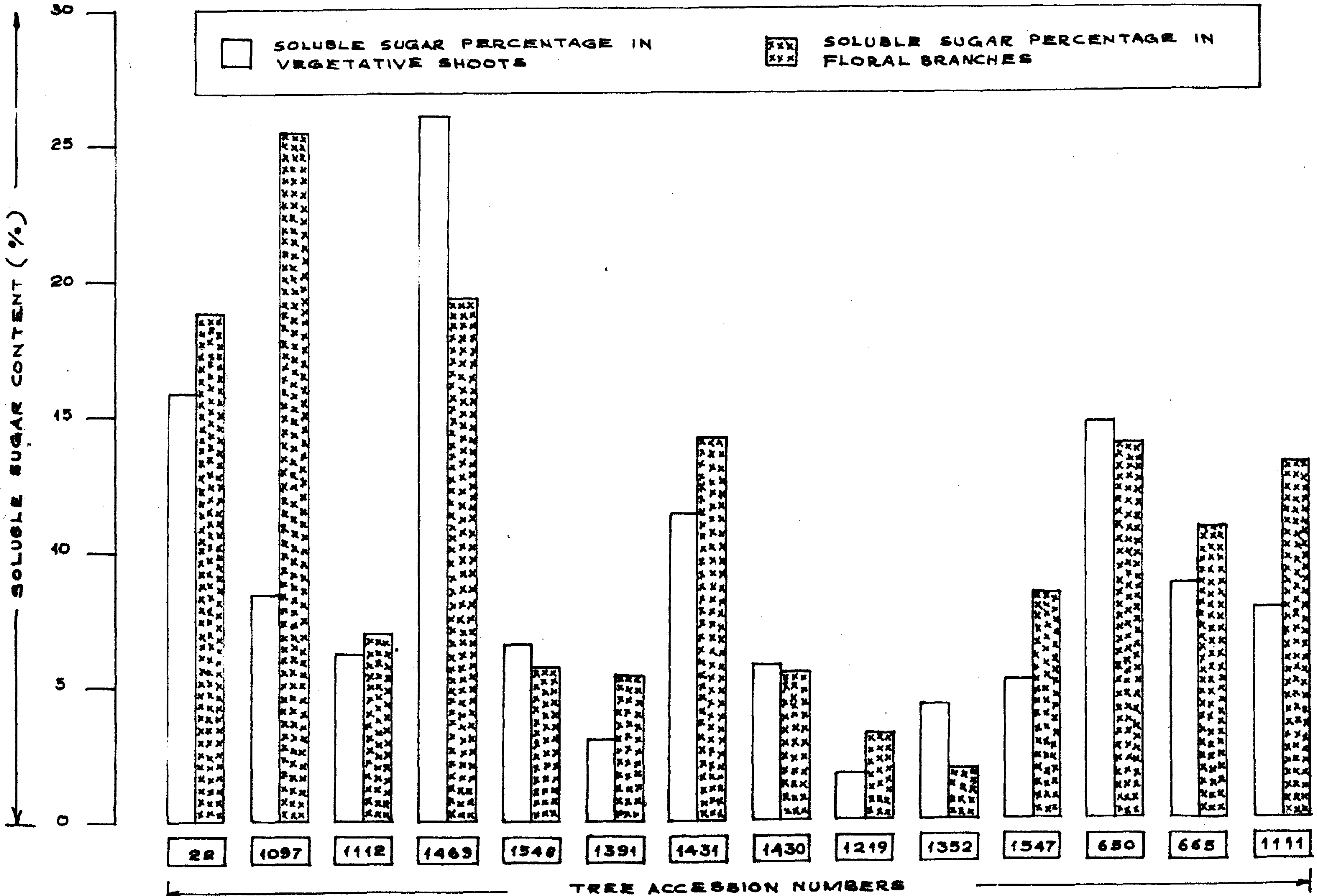

FIG: 4 SOLUBLE SUGARS (%) IN SHOOTS AND FLORAL BRANCHES OF CASHEW ACCESSIONS

25.40 per cent in tree no. 1097.

The ratios of soluble sugars to nitrogen were worked out to ascertain whether the relative proportions of these had any influence on susceptibility to infestation by H. antonii. These ratios in shoots and panicles are furnished in Table 7. The sugar-nitrogen ratio in shoots ranged from 1.56 in tree no. 1391 to 35.12 in tree no.650. In the floral branches also sugar-nitrogen ratio was found to be quite wider the range being from 0.99 in tree No.1352 to 32.59 in tree No.1097.

The data on the tannin content of vegetative shoots and panicles are furnished in Table 8 and diagramatically represented in Fig. 5. In the shoots the tannin content showed a range from 5.58 per cent in tree No.1430 to 14.44 in the tree 1352. In the floral branches the range in tannin content was found to be relatively narrow being from 11.59 per cent in tree No.1430 to 17.84 per cent in tree no.1548.

Correlation coefficients involving the biochemical constituents and susceptibility to pest infestation

Simple correlation coefficients were worked out to ascertain the nature of relationship between the

Table 7. Sugar-nitrogen ratio in shoots and floral branches of different cashew accessions

Sl. No.	Accession Number	Sugar-nitrogen ratio	
		Shoots	Floral branches
1.	T. 20-22	8.06	10.78
2.	Vengurla 37-3-1097	11.90	32.99
3.	Vengurla 37-3-1112	2.13	10.07
4.	Vengurla 36-3-1469	23.22	11.54
5.	Vengurla 36-3-1548	2.96	3.19
6.	BLA-139-1-1391	1.56	4.79
7.	BLA-139-1-1431	4.76	9.19
8.	BLA-256-1-1430	3.46	2.66
9.	Tree 56 of BLA-1219	1.86	1.57
10.	Ansur-1 - 1352	3.07	0.99
11.	Ansur-1 - 1547	3.95	20.00
12.	H.27 - 650	35.12	7.67
13.	H.27 - 665	3.67	12.93
14.	H.4.7 - 1111	4.81	9.94

Table 8. Tannin content in shoots and floral branches of different cashew accessions

Sl. No.	Accession Number	Tannin content (%)	
		Shoots	Floral branches
1.	T. 20-22	8.79	12.89
2.	Vengurla 37-3-1097	6.49	16.02
3.	Vengurla 37-3-1112	5.76	15.17
4.	Vengurla 36-3-1469	10.13	12.38
5.	Vengurla 36-3-1548	8.19	17.84
6.	BLA-139-1-1391	13.05	16.75
7.	BLA-139-1-1431	11.35	15.29
8.	BLA-256-1-1430	5.58	11.59
9.	Tree 56 of BLA-1219	11.23	12.74
10.	Ansur-1-1352	14.44	16.75
11.	Ansur-1-1547	8.80	16.14
12.	H. 27-650	6.95	15.11
13.	H. 27-665	14.02	15.41
14.	H. 4.7-1111	11.86	13.74

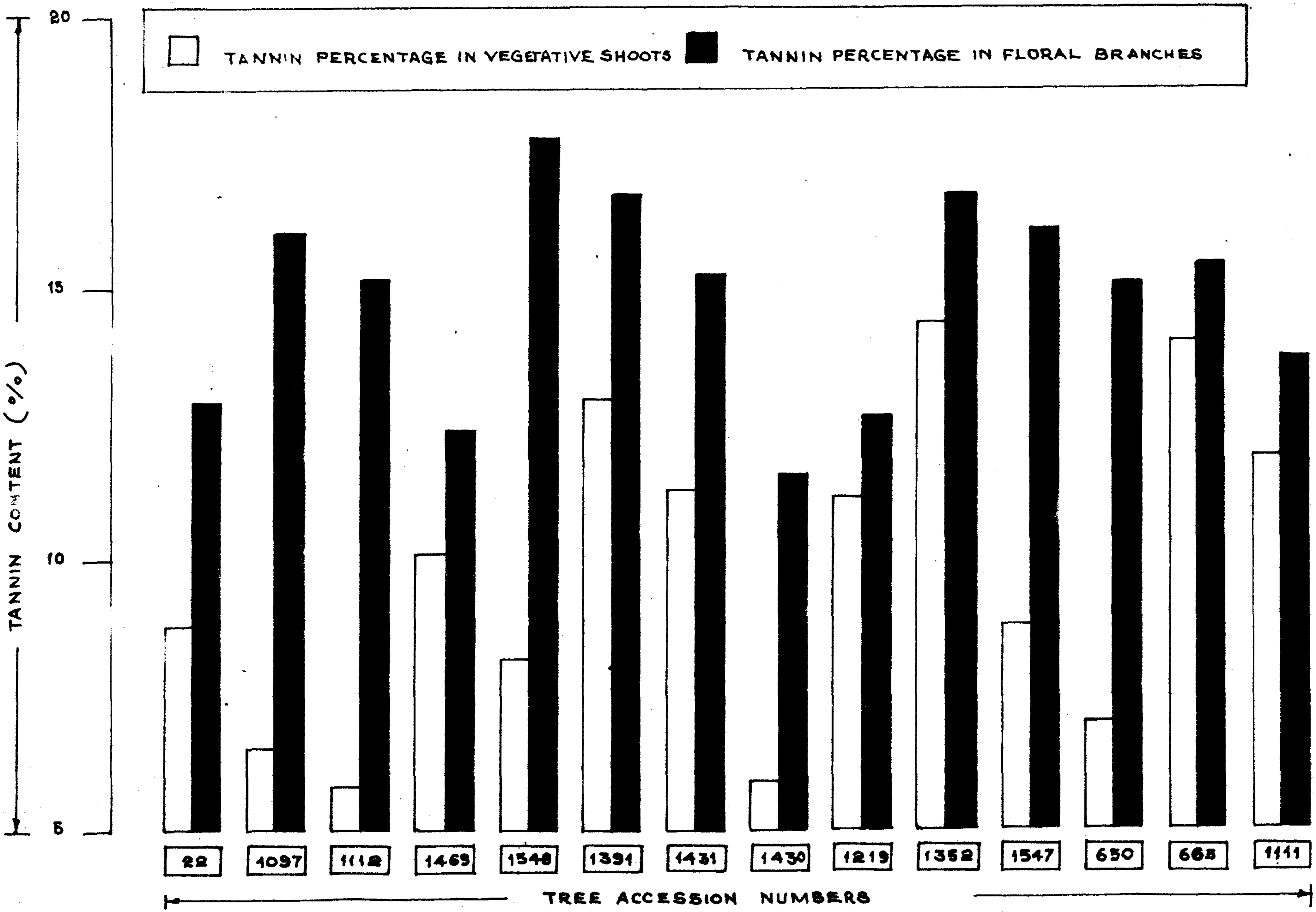

FIG: 5 TANNIN CONTENT IN VEGETATIVE SHOOTS AND FLORAL BRANCHES OF DIFFERENT CASHEW ACCESSIONS biochemical constituents on the one hand and the extent of susceptibility on the other. The correlation coefficients are furnished in Table 9.

All the correlation coefficients except the one between tannin content in shoots and the degree of infestation of shoots due to confinement of the insects were not found to be significant. Negative correlation was detected between tannin content of the shoots and damage intensity scores registered from shoots under confinement with H. antonii.

Intensity of shade within the canopy of the cashew accessions and its influence on susceptibility to infestation by H. antonii

The shade intensities within the canopies of the accessions included in the study were recorded with a luxmeter and the monthly mean values for the period from October 1979 to March 1980 are furnished in Table 10. The shade intensities within the canopies of the accessions showed a narrow range of 87.22% in tree No.1430 to 98.59% in the tree No.1219.

The simple correlation coefficients involving the natural field infestation ratings and the intensities

Table 9. Simple correlation coefficients involving the biochemical constituents and the intensities of damage due to *H. antonii* infestation

Sl. No.	Character associations	Simple correlation coefficients (r)
	Damage to shoots - natural infestation	
1.	Percentage of soluble sugars in shoots and degree of natural infestation on shoots	- 0.307
2.	Percentage of nitrogen in shoots and degree of natural infestation on shoots	0.055
3.	Sugar-nitrogen ratio in shoots and degree of natural infestation on shoots	- 0.087
4.	Percentage of tannin in shoots and degree of natural infestation on shoots	0.422
	Damage to shoots under confinement	
5.	Percentage of soluble sugars in shoots and degree of infestation on shoots due to confinement of insects	0.106
6.	Percentage of nitrogen in shoots and degree of infestation on shoots due to confinement of insects	- 0.131
7.	Sugar - nitrogen ratio in shoots and degree of infestation on shoots due to confinement of insects	0.006
8.	Percentage of tannin in shoots and degree of infestation on shoots due to confinement of insects	- 0.546*

Table 9 (contd...)

	<u>Damage to floral branches - natural infestation</u>	
9.	Percentage of soluble sugars in floral branches and degree of natural infestation on floral branches	- 0.279
10.	Percentage of nitrogen in floral branches and degree of natural infestation on floral branches	- 0.132
11.	Sugar-nitrogen ratio in floral branches and degree of natural infestation on floral branches	- 0.113
12.	Percentage of tannin in floral branches and degree of natural infestation on floral branches	0.336
	<u>Damage to floral branches under confinement</u>	
13.	Percentage of soluble sugars in floral branches and degree of infestation on floral branches due to confinement of insects	0.152
14.	Percentage of nitrogen in floral branches and degree of infestation on floral branches due to confinement of insects	0.194
15.	Sugar-nitrogen ratio in floral branches and degree of infestation on floral branches due to confinement of insects	0.182
16.	Percentage of tannin in floral branches and degree of infestation on floral branches due to confinement of insects	0.299

* Significant at 0.05 level

Table 10. Intensity of shade inside the canopies of different cashew accessions

Sl. No.	Accession Number	Shade intensity (%)
1.	T. 20-22	97.70
2.	Vengurla 37-3-1097	97.56
3.	Vengurla 37-3-1112	97.87
4.	Vengurla 36-3-1469	97.28
5.	Vengurla 36-3-1548	97.95
6.	BLA-139-1-1391	98.05
7.	BLA-139-1-1431	97.34
8.	BLA-256-1-1430	87.22
9.	Tree 56 of BLA-1219	98.59
10.	Ansur-1 - 1352	97.52
11.	Ansur-1 - 1547	95.61
12.	H. 27 - 650	97.74
13.	H. 27 - 665	97.79
14.	H. 4.7 - 1111	98.06

of damage under confinement on the one hand and the susceptibility to pest infestation on the other have been separately worked out. The correlation coefficients between percentage of shade and natural field infestation ratings of shoots and that between percentage of shade and damage intensity under confinement were found to be 0.245 and 0.477 respectively. In the case of floral branches, the correlation coefficients between percentage of shade and natural field infestation ratings and that between percentage of shade and damage intensity under confinement were 0.072 and - 0.364 respectively. These were insignificant.

Influence of the canopy architecture patterns on relative susceptibility of the trees to pest infestation

The canopy architecture pattern of the trees included in the present studies have been sketched and these are depicted in Figures 6 to 19. The parameters describing the canopy architecture are furnished in Table 11. The characteristic features of the canopy architecture patterns of the selected cashew accessions are as follows:

Table 11. Canopy architecture parameters in different cashew accessions

Sl. No.	Accession Number		Parameters (meters) Height	Maximum canopy spread	Peri-meter
1.	T. 20-22		7.50	7.75	25.50
2.	Vengurla 37-3-1097		6.64	7.82	21.75
3.	Vengurla 37-3-1112		7.79	9.18	23.89
4.	Vengurla 36-3-1469		4.85	6.41	19.20
5.	Vengurla 36-3-1548		5.61	8.67	24.64
6.	BLA-139-1-1391		6.89	11.29	30.91
7.	BLA-139-1-1431		5.90	11.63	33.26
8.	BLA-256-1-1430		6.27	6.34	18.72
9.	Tree 56 of BLA-1219		9.25	9.62	30.85
10.	Ansur-1	1352	7.39	9.69	27.40
11.	Ansur-1	1547	6.75	8.68	29.10
12.	H. 27	650	6.48	10.66	33.80
13.	H. 27	665	5.70	9.65	27.18
14.	H. 4.7-1111		6.81	9.98	30.80

1. Accession number T. 20-22

The tree is profusely branching (Fig. 6). The apical control is not manifested and the main stem height is, therefore, relatively shorter. A number of primary branches each with limited apical control are formed. The tree is presenting an elliptic canopy. Positive geotropic tendency is not evident.

2. Accession number Vengurla 37-3-1097

The tree shows a good number of branches (Fig.7) and the canopy is somewhat denser. Two main branches each showing apical control are developed in the initial growth period. The secondary branches produced from these two primary branches subtend relatively wider angles with the primaries.

3. Accession number Vengurla 37-3-1112

The tree shows extensive branching, there being relatively lesser number of branches (Fig. 8). A moderate apical control is detected in this tree. The older branches initially showed positive geotropism but later on the tendency is reversed. The canopy silhouette is somewhat globular.

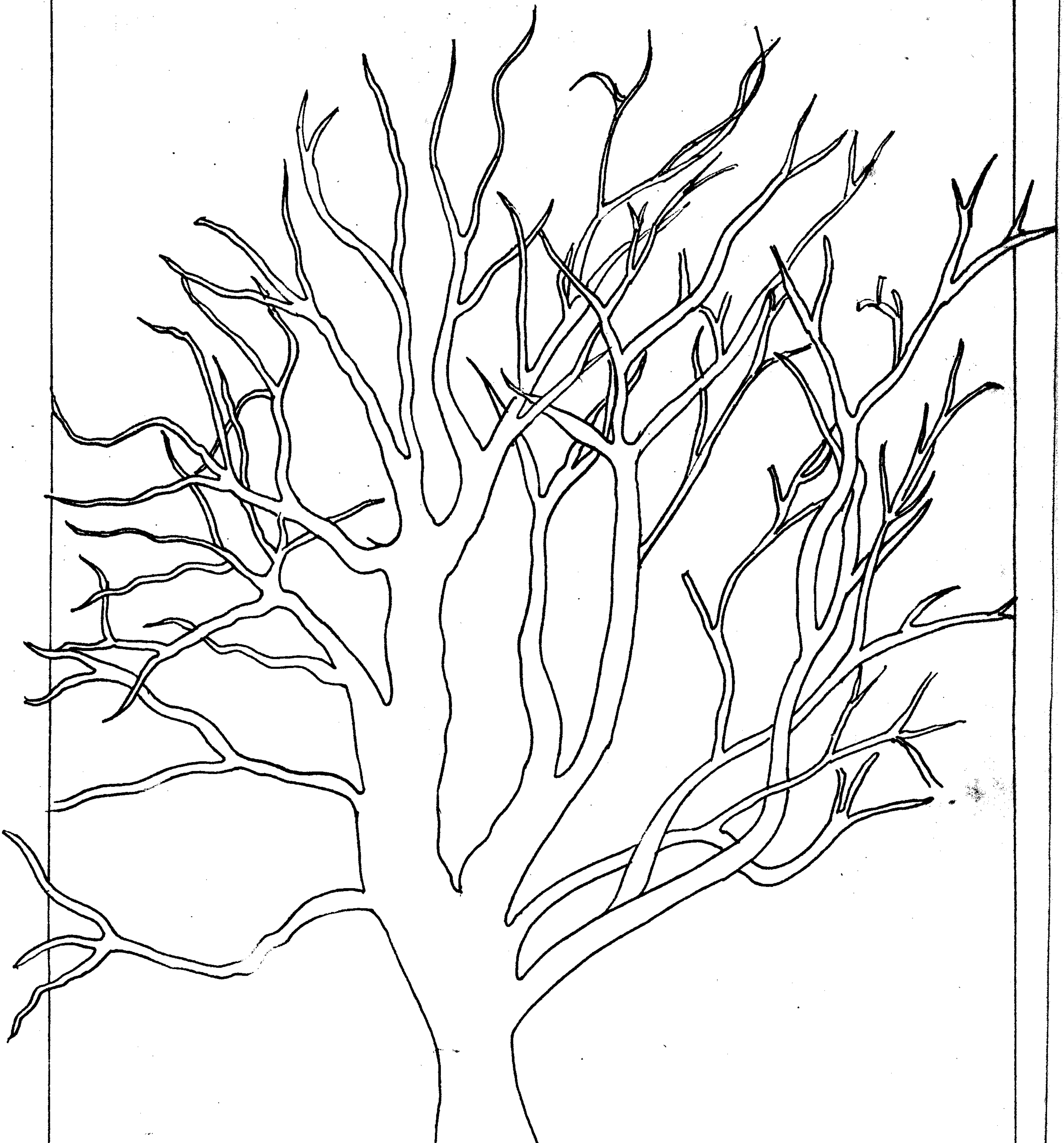

FIG.6. CANOPY ARCHITECTURE PATTERN OF

TREE NO.T 20-22

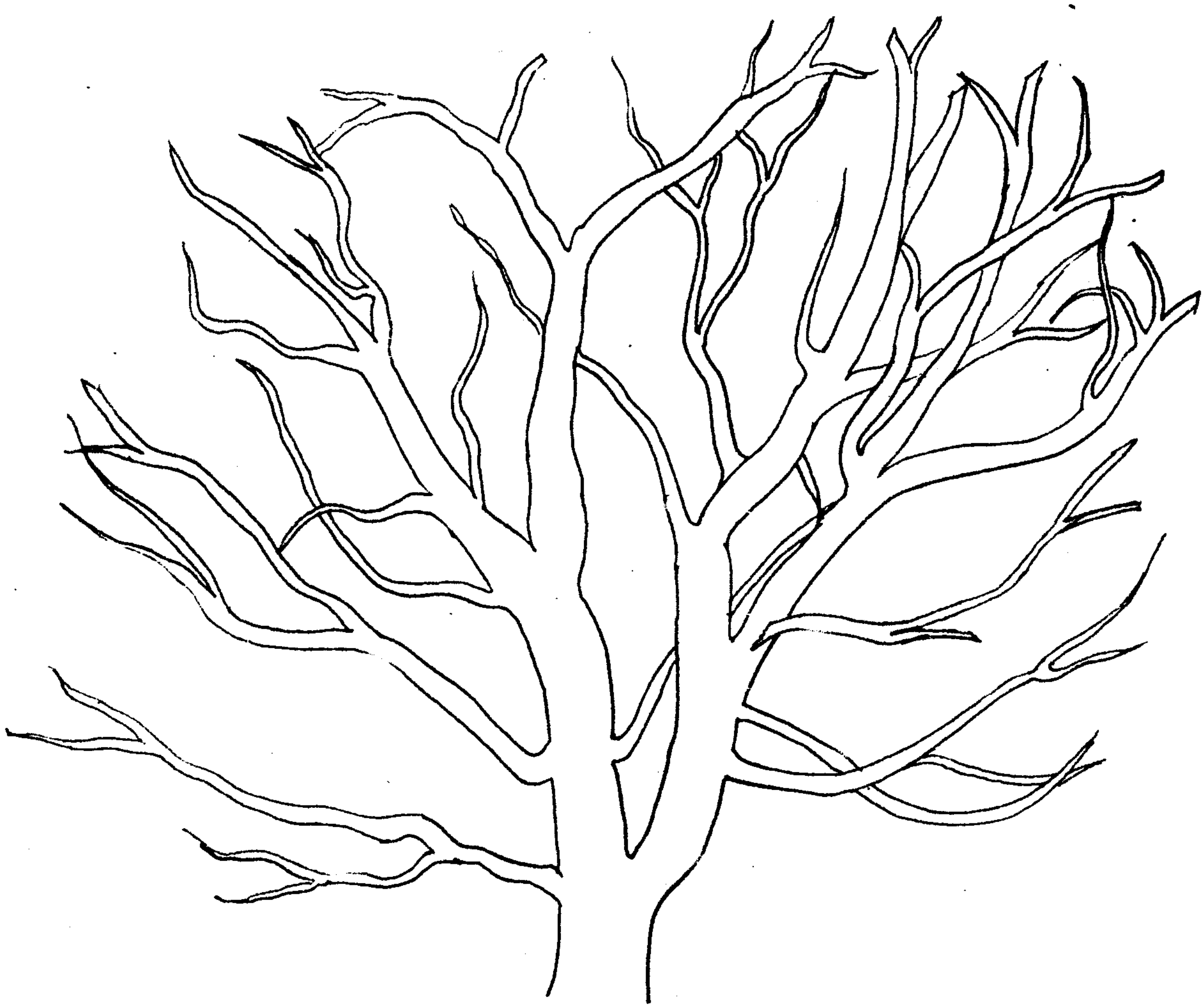

FIG. 7. CANOPY ARCHITECTURE PATTERN OF TREE NO.

VENGURLA 37-3-1097

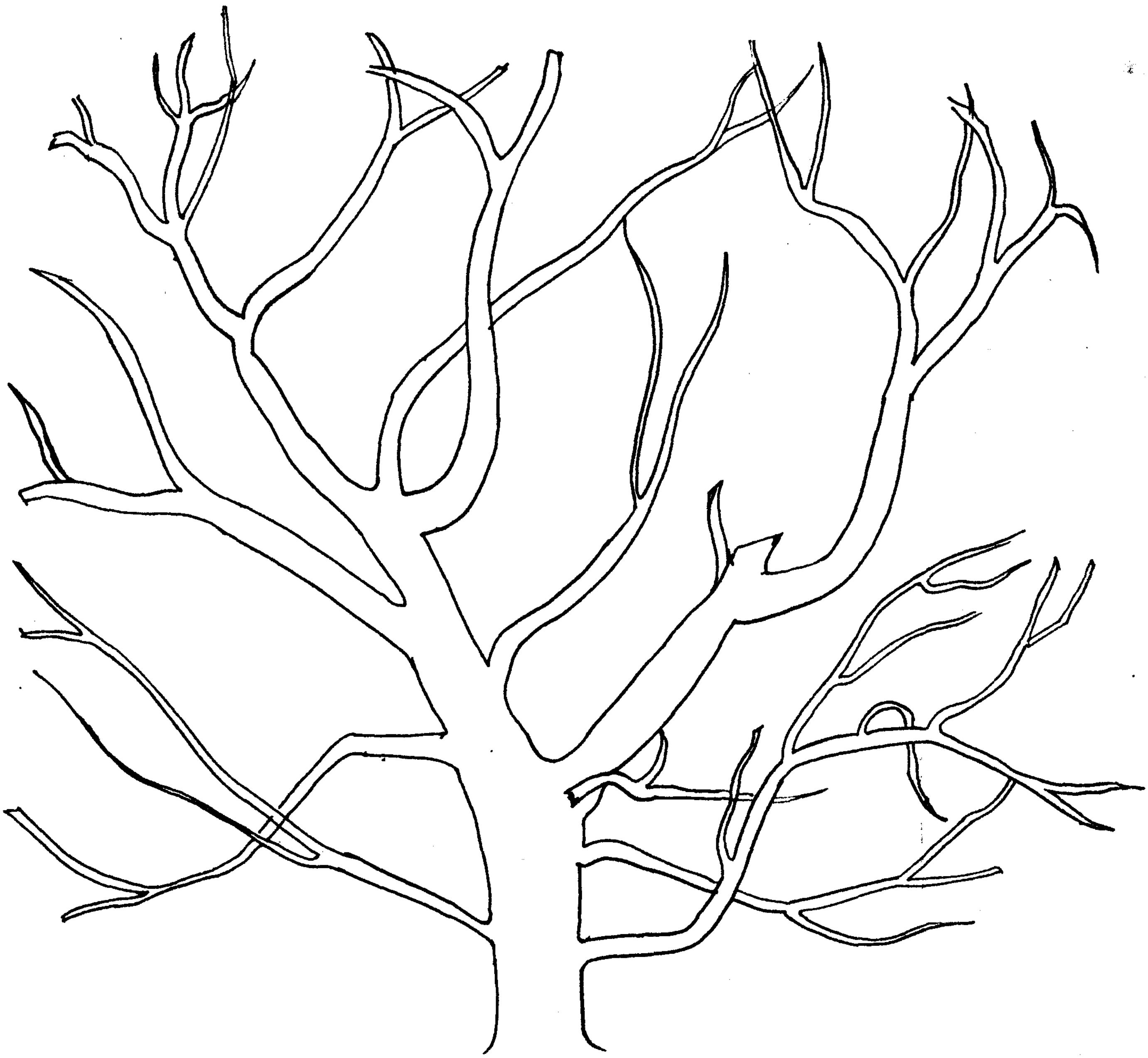

FIG. 8. CANOPY ARCHITECTURE PATTERN OF TREE

NO. VENGURLA 37-3-1112

4. Accession number Vengurla 36-3-1469

The canopy architecture pattern is presented in Fig.9. The tree is somewhat short-statured, and shows very strong apical control with an elongate main stem. Branching is sparse in this tree and perhaps due to some physical factors, the canopy as a whole shows orientation towards one side of the main stem.

5. Accession number Vengurla 36-3-1548

The branching pattern of this accession is depicted in Fig.10. The tree shows intensive branching and bushy appearance. Apical control is stronger for initial growth stages, while subsequently this tendency is reversed. The lower branches show very strong positive geotropic tendency but eventually with the cessation of strong apical control, the branches show more acute angle of inclinations. The overall canopy shape is hemispherical.

6. Accession number BLA-139-1-1391

A very weak apical control is noticed (Fig.11), the main stem being relatively very short. The basal

FIG.9. CANOPY ARCHITECTURE PATTERN OF TREE

NO. VENGURLA 06-3-1469

FIG.10. CANOPY ARCHITECTURE PATTERN OF TREE

NO. VENGURLA 36-3-1548

FIG. 11. CANOPY ARCHITECTURE PATTERN OF TREE NO.

BLA-139-1-1891

branches are relatively stouter and the angles of inclination of the secondary branches are somewhat acute. There is very little tendency of positive geotropism in the branches. The branching is extensive and the canopy is wide spreading the perimeter being 30.91 m.

7. Accession number BLA-139-1-1431

The branching pattern is diagrammatically given in Fig.12. A moderate apical control is noticed. The lateral branches are produced in acropetal succession, the upper branches being relatively shorter. The older branches show strong geotropic tendency. The canopy is of a spreading nature due to extensive branching and the canopy silhouette is conical.

8. Accession number BLA-256-1-1430

This sparsely branched tree (Fig.13) shows strong apical control and the main stem is somewhat erect. The lower branches show a tendency of positive geotropism initially but eventually this tendency is reversed. The angles of inclination of the secondary branches are relatively very wider. The canopy as a whole is thinner, the silhouette being somewhat of an

FIG.12. CANOPY ARCHITECTURE PATTERN OF TREE NO.

BLA-139-1-1431

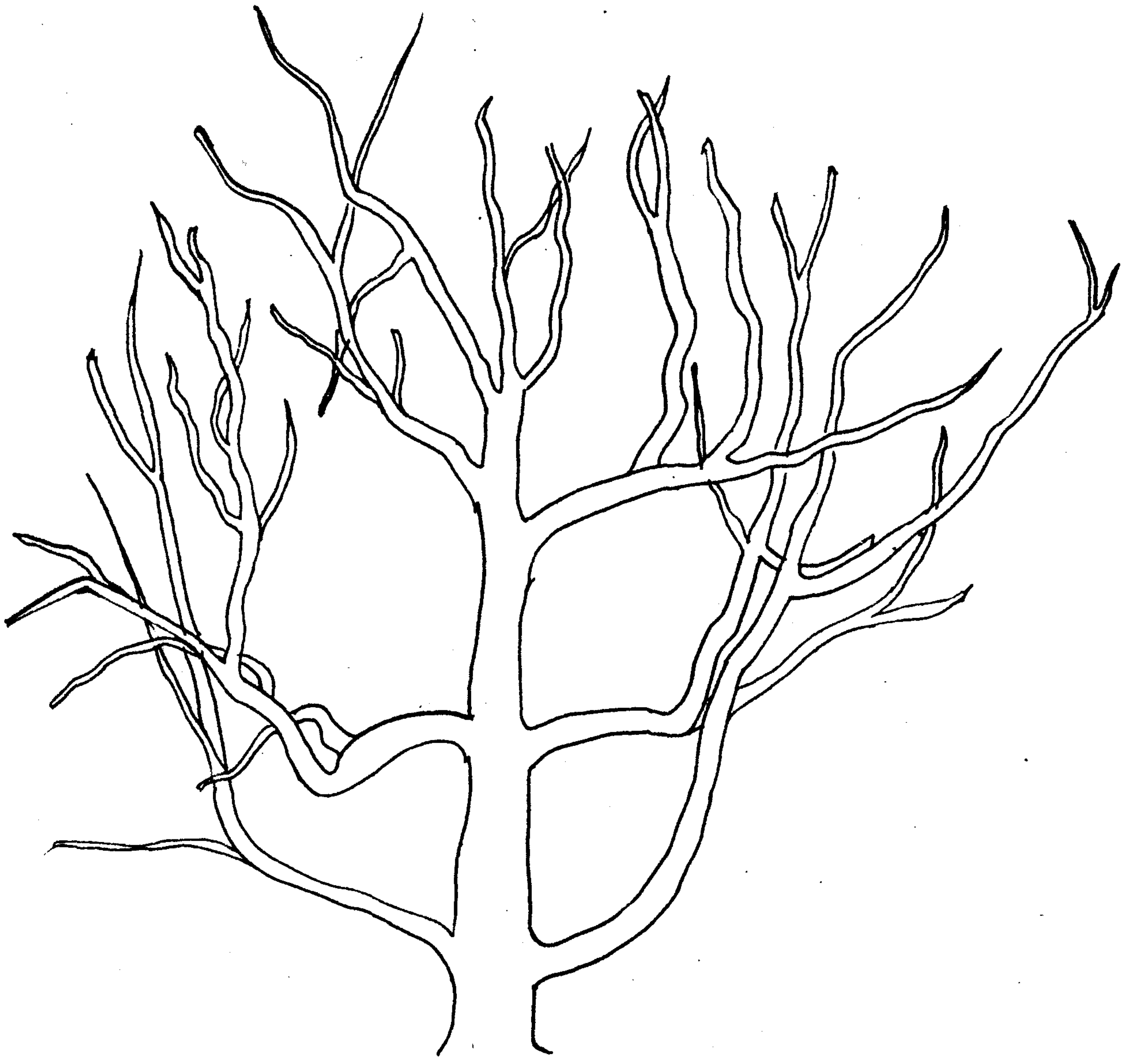

FIG.13. CANOPY ARCHITECTURE PATTERN OF TREE NO.

BLA-256-1-1430

oblong shape.

9. Tree 56 of BLA-1219

The tree is very profusely branching (Fig.14). Apical control is practically absent. Two primary branches found near the base of the trunk exhibit moderate apical control. The branching is quite intensive and the canopy presents a bushy appearance.

10. Accession number Ansur-1-1352

The canopy architecture is illustrated in Fig. 15. In general apical control seems to be almost absent. However, the two branches of equal size which are produced at the initial stage of growth show strong apical control. The secondary branches initially showed negative geotropic tendency with acute angle formations with the primaries.

11. Accession number Ansur-1-1547

Strong apical control is detected (Fig. 16) in this tree. Lateral branches are formed in regular acropetal succession. All the branches show moderate geotropic tendency with wider angles of inclination.

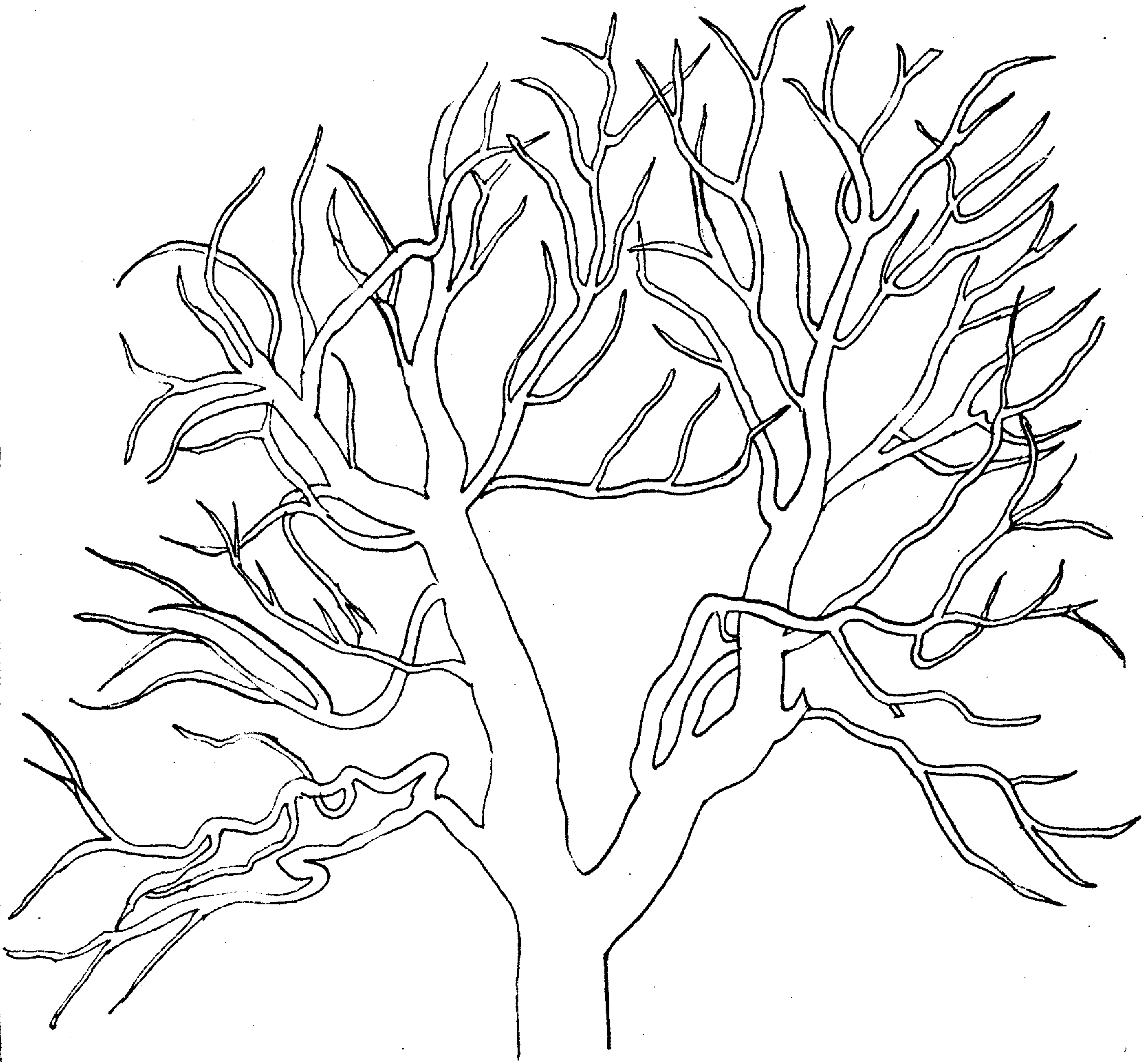

FIG. 14. CANOPY ARCHITECTURE PATTERN OF

TREE NO. 56 OF BLA-1219

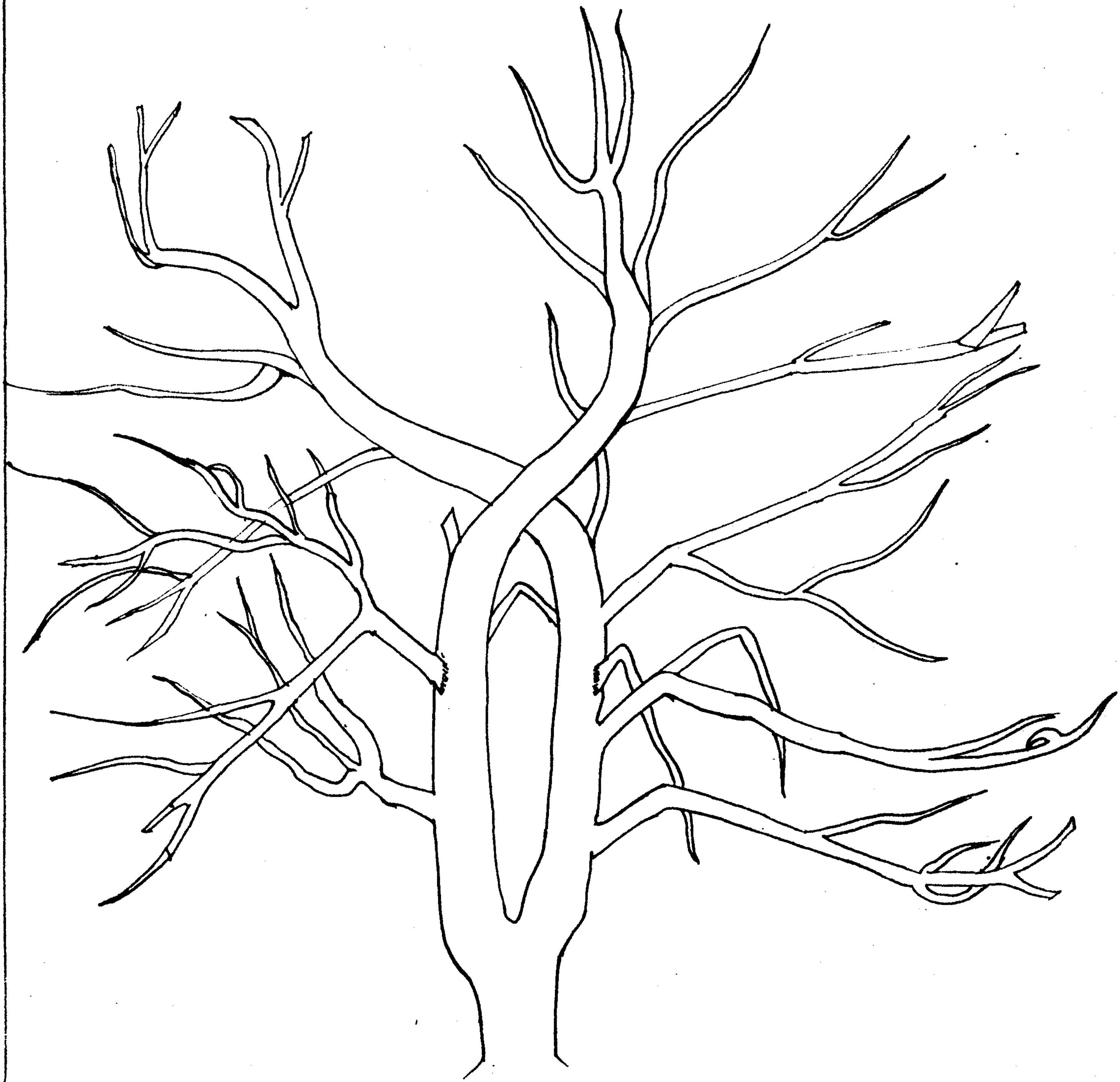

FIG. 15. CANOPY ARCHITECTURE PATTERN OF TREE NO.

ANSUR-1-1352

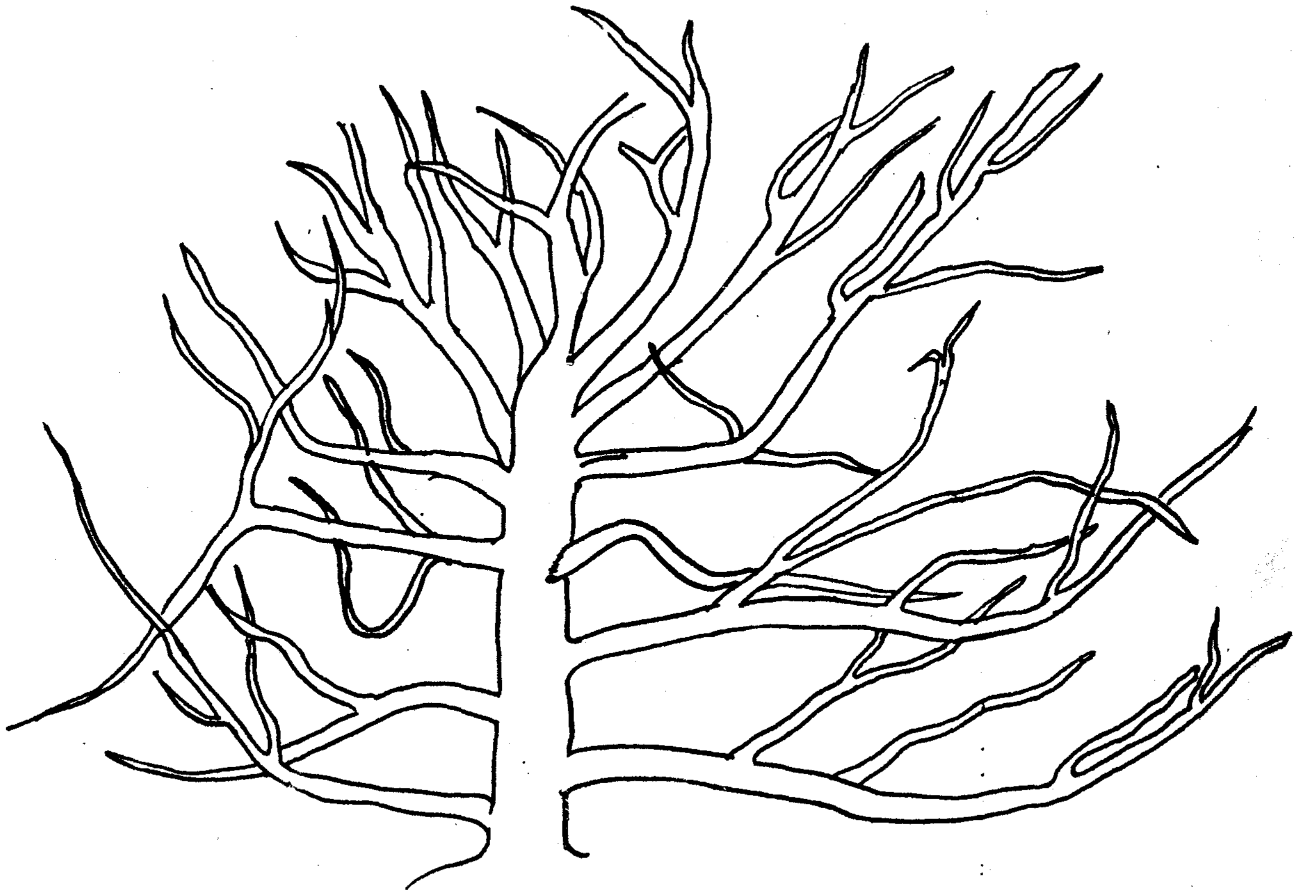

FIG. 16. CANOPY ARCHITECTURE PATTERN OF

TREE NO. ANSUR-1-1547

12. Accession number H.27-650

Moderate apical control is seen in this tree (Fig.17). The lower branches show very strong positive geotropic tendency. The branches are in regular acropetal succession. The canopy is very bushy with hemispherical canopy outline.

13. Accession number H. 27-665

Apical control is moderate. The branches show strong geotropic tendency and are in regular acropetal succession, (Fig. 18). The canopy is extensively branched with a spreading nature. The canopy ultimately presents a hemispherical shape.

14. Accession number H.4.7-1111

There is somewhat stronger apical control (Fig.19) during the initial growth stages. Geotropic tendency is practically absent and the branches subtend acute angles of inclination. The tree bears a good number of branches.

FIG. 17. CANOPY ARCHITECTURE PATTERN OF TREE

NO. 27-650

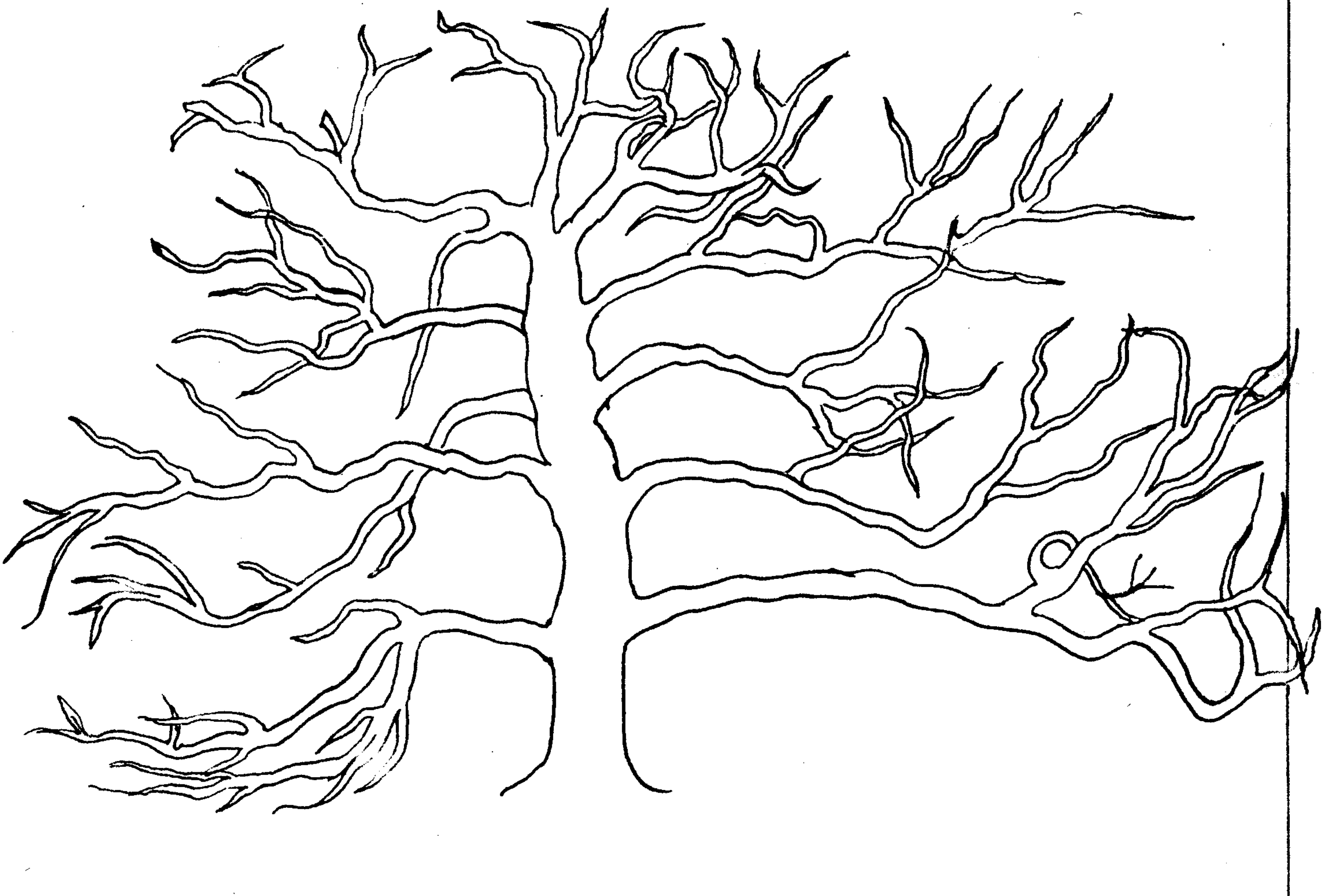

FIG.18. CANOPY ARCHITECTURE PATTERN OF TREE

NO.H.27-665

FIG. 19. CANOPY ARCHITECTURE PATTERN OF

TREE NO. H-4-7-1111

Discussion

DISCUSSION

The relative susceptibility of fourteen types of cashew, *Anacardium occidentale* L. to infestation by the tea mosquito bug *Helopeltis antonii* Signoret was ascertained by recording the field damage intensities and the extent of damage inflicted by the insect under confinement on shoots and panicles. The damage intensities were recorded on a 0-5 scale based on the nature and extent of lesions developing on the plant tissues as a result of the feeding activity of the insect.

Susceptibility of the accessions with reference to damage intensities on vegetative shoots

The accessions 22, 1112, 1430 and 1097 were found to be the least susceptible as compared to rest of the types, while the trees 1391, 1548, 665, 1547 and 1111 were found to be the most susceptible ones in respect of natural damage on vegetative shoots (Table 1, Fig.1). Under confinement, the vegetative shoots did not reveal any significant variability in the intensity of damage inflicted (Table 2). The damage ratings under confinement is expected to reveal the relative susceptibility in a more precise manner as compared to the damage intensities recorded on the basis of field damage. Therefore, the present findings indicate that the fourteen cashew accessions tested for their relative susceptibility are not significantly different with reference to the intensity of damage inflicted to the vegetative shoots.

The differences in the intensity ratings under open and confined conditions are perhaps explicable on the basis of the changes in the microclimatic conditions and in the associated natural enemy populations under open and caged conditions. Under field conditions preference/non-preference for oviposition and/or for feeding might be expected to be manifested, but under confinement the insects are constrained to feed and unless the variety is remarkably resistant, feeding/oviposition injuries could be normally expected. The absence of consistent susceptibility trends under field conditions and confinement indicate that none of the varieties included in the studies is absolutely resistant to H. antonii infestation.

While studying the varietal reactions of 16 cashew types to infestation by H. antonii, Sathiamma (1977a) reported that the accessions VTH 34 and VTH 151 – BLA-256-4 showed comparatively low percentage of shoot damage.

Ambika *et al*. (1979) also reported significant variability among eleven cashew accessions with reference to shoot damage intensity. The accession No.K-10-2-1218 was found to be highly susceptible to the pest as compared to the accessions 1097, BLA-139-1-1431, HA-F, 1098, Ansur-1352, 1112, 22 and 665. None of the types evaluated by Sathiamma (1977a) was included in the present studies and, therefore, the present results are not comparable with the former. However, both in the present studies and in the studies carried out by Ambika *et al*. (1979), eight accessions, namely, 1111, 1097, 1112, 665, 650, 22, 1431 and 1352 were tested. Among these accessions, the type 665 was earlier found to be the least damaged. But in the present studies, this accession was rated as relatively more susceptible one (Table 1 and 2). The differences in the susceptibility trends of the tree 665 might perhaps be due to the differences in the weather parameters during the periods of testing as a result of which the expression of susceptibility was modified. It is also probable that the early finding that the tree no.665 was less damaged may be due to pseudo-resistance conferred by nutritional factors. The divergent results could also be due to the variation in the number of test insects used for confinement and variation in the durations of exposure under caged conditions. In studies conducted by Ambika *et al*., 10 fifth instar nymphs were exposed for seven days while in the present experiments five fifth instar nymphs were exposed for 24 hours only. The fifth instar nymphs are very actively feeding stages and feeding lesions develop around the feeding sites within 10 - 15 minutes of feeding and the tissue necrosis is manifested within 2 - 3 days (Sathiamma, 1977). Therefore, confinement of the fifth instar nymphs for a period of 24 hours, would certainly be expected to reveal the extent of susceptibility.

Susceptibility of the accessions with reference to damage on floral branches

The relative susceptibility of the fourteen cashew accessions with reference to the intensity of damage inflicted to the floral branches by *H. antonii* was evaluated by recording the field infestation levels and by registering the damage caused to the floral branches by five fifth instar nymphs confined on floral branches for 24 hours (Tables 3 and 4, Fig.2). Significant variability was detected both under open field and under confinement conditions. Under open field conditions, the tree No.650 revealed the maximum damage intensity, while the trees

22, 1112, 1352, 1469 and 1097 showed least susceptibility. However, the above trend was not revealed under confined conditions. The trees, 1219, 1469 and 1431 were found to show relatively less floral damage intensity as compared to the rest of the accessions. Damage inflicted to the floral branches is relatively more important in view of potential yield losses. Viewed in this context, the trees 1219, 1469 and 1431 appear to be more promising.

Influence of biochemical factors on susceptibility of the trees to infestation by H. antonii

The shoots and floral branches were analysed for the total nitrogen, soluble sugars and tannins (Tables 5, 6 and 8). The Correlation coefficients (Table 9) were worked out to ascertain whether the extent of infestation by the pest is correlated with the biochemical factors. The only significant correlation detected was between the tannin content of the shoots on the one hand and the pest infestation ratings of the shoots due to confinement of insects on the other, the trend being of a negative nature. The broad spectrum of defensive mechanisms provided by tannins against larvae of the winter moth Operophtera brumata (L.) infesting oak trees due to repellency and antibiosis have been already reported

(Feeny, 1970). The antibiosis may be due to the formation of complexes involving tannins and protiens and the resultant inhibition of vital enzymes (Goldstein and Swain, 1965). That the polyphenolic compounds have inhibitory influence on growth and development of Dacus cucurbitae Coq. infesting musk melon (Chelliah, 1971), of Amrasca devastans (Distant) infesting cotton (Singh, 1970) and of Heliothis armigera (Hubn.) infesting lablab (Sivasubramanian, 1978) is already established.

It will be seen from Table 9 that the negative relationship between tannin content and shoot damage intensities is not maintained in the case of the relationship between the former and the intensity of damage to floral branches. This might perhaps be due to the presence of certain substances in the floral branches that are antogonistic to tannins.

There was no correlation between nitrogen content of the shoots and infloresences on the one hand and the intensity of damage to the shoots and floral branches, on the other. But in many crop varieties, higher nitrogen content has been reported to predispose the crop to higher levels of pest infestation. The higher susceptibility in rice varieties to infestation by Nephotettix bipunctatus F. and Nilaparvata lugens S.

as a result of increased nitrogen content is reported by Ananthanarayanan and Abraham (1956). Viswanath and Nair (1969) got positive correlation between higher doses of nitrogen and infestation by *Aphis gossypii* Glover on 'bhindi'. Hanifa (1971) reported that rice varieties susceptible to *Cnaphalocrocis medinalis* Guenee contained relatively more nitrogen. 'Bhindi' varieties susceptible to infestation by *Amrasca devastans* (Dist.) contained higher levels of nitrogen (Uthamasamy *et al.*, 1971). Balasubramaniam (1975) found that cotton varieties susceptible to infestation by *Amrasca biguttula biguttula* Ishida, contained more total nitrogen than the susceptible ones. It is probable that the above general trend is not manifested in tree crops as already reported by Salama and Saleh (1972) in the case of mango infested by the scale insects *Mycetaspis personatus* (Comstock).

There was no significant relationship between the content of soluble sugars and the pest infestation in vegetative shoots or floral branches. This is in conformity with the results obtained by Turner (1951) in corn varieties subjected to infestation by the European corn borer *Pyrausta nubilalis* Hübn. Kasting *et al.* (1958) also could not detect any relationship between the sugar content in spring wheat varieties and susceptibility to infestation by the saw flies. In the case of the brown plant hopper, *Nilaparvata lugens* Stal. also no relationship could be established between the sugar content and level of resistance in the rice crop. (International Rice Research Institute, 1969).

However, there are numerous reports on the association of resistance to pests in crop varieties and higher content of sugars. Beck (1956) reported that high carbohydrate content was implicated in the resistance of corn varieties to infestation by the European corn borer *Pyrausta nubilalis* (Hübn). Maltais and Auclair (1957) found that the pea varieties susceptible to infestation by the pea aphid *Acyrthosiphon pisum* had lesser content of sugars than in the resistant varieties. Thorsteinson (1958) concluded that sugars at higher concentrations were definitely toxic to many insect species though at lower concentrations these may act as phagostimulants. High concentrations of sugars were reported to increase resistance in potato varieties to infestation by the leaf hopper *Empoasca fabae* (Harr.) (Hibbs *et al*., 1964) and in castor varieties to damage by the jassid *Empoasca flavescens* (F.) (Jayaraj, 1967) and also in cotton varieties to infestation by the jassid *Amrasca devastans* (Dist.) (Krishnananda, 1973). On the contrary Knapp _et al_. (1966) recorded that greater concentration of sugars in the silks of maize cobs were responsible for their susceptibility to the European corn borer. Singh _et al_. (1972) also reported a similar trend in the susceptible strains of cotton infested by _Amrasca devastans_ (Dist.) which contained higher levels of reducing sugars.

The variations in the influence of soluble sugars on the extent of susceptibility to crop pests is quite expected due to subtle variations in the nutritional requirements of the insect species belonging to different taxa.

The relative proportions of soluble sugars and nitrogen in vegetative shoots and floral branches in the different accessions were found unrelated to the damage intensities to which the shoots and floral branches were subjected as a result of feeding activity of _H. antonii_. That the carbohydrate-nitrogen ratio in resistant varieties of rice was wider as compared to ratios in the susceptible varieties was reported by Hanifa (1971) and Jayaraj (1967). However, in the present studies the proportion of sugars to nitrogen was found to have no influence on infestation by _H. antonii_.

Influence of the intensity of shade on the relative susceptibility of cashew accessions to infestation by *H. antonii*

The variations in the intensity of shade within the canopies of the trees were not found to be significant, the range being from 87.22 per cent in tree number 1430 to 98.56 per cent in tree number 1219.

Roepke (1916) reported that *Helopeltis* infestation in cocoa was the maximum under least shaded conditions. Mervyn (1950) also obtained similar results regarding intensity of damage to cocoa plants due to *Helopeltis* infestation.

On the contrary, De Jong (1931 and 1935) reported that in heavily shaded tea bushes there were heavier populations of *Helopeltis*. Similarly, Puttarudriah (1952) found that *H. antonii* were more active in shady portions on guava.

Field population counts of the different stages of *H. antonii* were not taken in the present experiment and, therefore, the effect of shade on the population levels cannot be indicated. Since the damage ratings of the shoots and panicles were recorded under field conditions and since correlations could not be established between shade intensities and intensity of damage on vegetative shoots or floral branches, it is evident that shade is not an important factor regulating damage intensity levels.

Influence of canopy architecture on relative susceptibility to infestation by H. antonii

A study of the canopy architecture patterns of the fourteen accessions revealed that in the types 1469, 1430 and 1547, strong apical control was manifested, the trunks being relatively longer. On the contrary, the accessions 22, 1391, 1219 and 1352 revealed very little apical control and the main trunk was, therefore, relatively shorter. In the rest of the accessions, apical control was quite moderate or was expressed in the initial growth stages only. Positive geotropism was exhibited by lower branches of the types 1431 and 650 while in the accessions 22, 1391 and 1111 such tendency was altogether lacking. In some of the accessions (1112, 1548, 1391, 1431 and 650) branching was very extensive and the canopy somewhat of open and spreading type. However, in the accessions 22, 1097 and 1219, the branching was somewhat intensive and the canopy was relatively closed and denser.

The canopy architecture pattern in cashew is basically of the decurrent type in which the lateral branches grow as fast as or faster than the terminal shoots to form a spreading crown (Zimmermann and Brown, 1974). The decurrent pattern conforms to the Scarrone's model (Halle *et al*., 1978) to which most of the members of the Anacardiaceae belong. Dasarathi (1958) reported the occurrence of two basic types of branching in cashew, namely, intensive involving the production of more number of branches and presentation of a bushy appearance and extensive involving the production of fewer number of branches and giving a spreading appearance.

In the present studies it is found that the architecture pattern of the different accessions could be classified into the two different categories as already reported by Dasarathi (1958) and not strictly following the Scarrone's model. A rating of the accessions with reference to the two branching habits is as follows:

Intensive branching and bushy appearance (Accessions)	Extensive branching and thinner appearance (Accessions)
22	1112
1548	1469
1219	1391
1547	1431
650	1430
1111	1352
	665
	1097

Apparently, the intensities of shade within denser and thinner canopies are likely to show substantial variation. The shade intensities within the denser canopies of the accessions 22, 1548, 1219, 1547, 650 and 1111 varied between 95.61 and 98.59 per cent, while the range in relatively thinner canopies of the accessions 1112, 1097, 1469, 1391, 1431, 1430, 1352 and 665 was between 87.22 and 98.05 per cent (Table 10). It will be seen that there are not much variations in the shade intensities depending on the nature of canopies of the trees. It has been already established that natural field infestation ratings and the damage intensities under confinement conditions are both unrelated to the shade intensities within the canopies of the accessions included in the present studies. It will be seen that highly susceptible (1111, 650) and least susceptible (22, 1219) types are found among trees with bushy canopies (Tables 1, 2 and 4). Among the spreading canopies also, the susceptibility ratings are not consistent and highly susceptible (665, 1097) and least susceptible trees (1112, 1469) are found among accessions belonging to this type (Tables 1, 2 and 4). An analysis of the canopy architecture corroborates the above finding since the shade intensities did not show much variations on the basis of the differences in apical control and the nature of branching. Puttarudriah (1952) reported that H. antonii populations preferred shady situations in the guava tree. Based on this the insects are expected to withdraw to shady regions inside the canopies as the light intensity and ambient temperature level increase. It would thus appear that a tree type with denser canopy might support large populations of the insects, thereby increasing the pest load on such trees. The present studies, however, reveal that the relative susceptibility of the tree types is unpredictable merely on the basis of the shade intensities and canopy configuration patterns. The unpredictability is perhaps due to the fact that irrespective of the shade intensities in the canopy core areas, the insects might move on a shade intensity gradient on shoots and settle wherever optimum conditions are available.

Therefore, the finding that the susceptibility ratings of the trees are not correlated with shade intensities does not altogether rule out the involvement of shade intensity as a factor regulating the expression of relative susceptibility.

Summary

SUMMARY

Studies on the relative susceptibility of fourteen accessions of cashew (Anacardium occidentale L.) to infestation by the tea mosquito bug Helopeltis antonii Signoret were carried out at the Cashew Research Station, Madakathara during September 1979 - March 1980. The extent of infestation was recorded both as the field damage intensities and the damage caused by the insect when confined on shoots and floral branches adopting a 0 - 5 scale.

The nature of influence of certain biochemical factors (total nitrogen, soluble sugars and tannins), canopy architecture patterns and shade intensities within the canopy on the relative susceptibility to pest infestation was also ascertained.

The accessions 22, 1112, 1430 and 1097 were found to be the least susceptible with reference to the intensity of natural field infestation of the vegetative shoots. Regarding the intensity of field infestation of the floral branches, the accessions 22, 1112, 1352, 1469 and 1097 were significantly less susceptible than the other types.

With regard to the intensity of damage to the vegetative shoots consequent on confinement, none of the accessions was found to be promising.

The accession numbers 1219, 1469 and 1431 were found to be least susceptible to *H. antonii* infestation under confinement on floral branches. Since the damage to the floral branches,particularly under confinement is relatively more important in view of potential yield losses, these trees can identified to be relatively more promising.

The influence of the biochemical constitution of shoots and floral branches (total nitrogen, soluble sugars and tannins) on pest infestation was ascertained by working out simple correlation coefficients. The only significant association detected was between the tannin content of vegetative shoots on the one hand and pest infestation ratings under confinement on the other.

The shade intensity within the canopy ranged from 87.22 to 98.56 per cent. Correlation studies indicated that shade intensities did not influence the relative susceptibility of cashew types to infestation by *H. antonii*.

The canopy architecture patterns in the accessions were basically of two different types, namely, extensively branching (spreading) and intensively branching (bushy). Relatively more susceptible and less susceptible accessions were found in both the types thereby indicating that the canopy configuration did not influence the extent of relative susceptibility of the types.

The inconsistencies in the relative susceptibility of the different accessions with reference to shoot and panicle damage intensities have been discussed.

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*Originals not seen

APPENDIX I

Score values showing natural field infestation to vegetative shoots of cashew by _H. antonii_ (raw data)

Sl. No.	Accession Number	Segment I			Segment II			Segment III			Segment IV		
		S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
1.	T. 20-22	0	0	0	0	0	0	1	1	0	3	0	0
2.	Vengurla 37-3-1097	2	0	1	2	0	1	4	2	1	1	0	3
3.	Vengurla 37-3-1112	2	1	1	1	0	1	0	1	1	0	2	2
4.	Vengurla 36-3-1469	1	0	0	2	3	1	5	2	1	3	0	1
5.	Vengurla 36-3-1548	4	2	5	5	4	2	[illegible]	2	3	3	1	3
6.	BLA-139-1-1391	5	2	3	1	1	2	5	4	3	1	5	5
7.	BLA-139-1-1431	2	2	2	2	2	5	2	5	2	3	3	1
8.	BLA-256-1-1430	1	0	2	3	1	1	4	0	0	2	0	2
9.	Tree 56 of BLA-1219	4	3	4	2	3	3	3	4	1	0	2	1
10.	Ansur-1-1352	1	2	2	3	1	3	4	2	1	2	0	1
11.	Ansur-1-1547	5	4	3	3	4	3	3	1	5	2	5	4
12.	H.27 - 650	4	5	4	3	4	0	1	3	4	4	0	2
13.	H.27 - 665	5	1	3	5	4	4	5	5	3	2	2	0
14.	H. 4.7 -1111	4	5	3	3	4	4	5	4	4	4	4	4

S_1, S_2 and S_3 represent the randomly selected shoots in each segment for recording natural infestation of _H. antonii_

APPENDIX II

Analysis of Variance table for natural field infestation to vegetative shoots of cashew by *H. antonii*

Source	SS	df	MS	F
Total	88.57	55		
Between trees	58.71	13	4.52	7.06**
Within trees (Error)	26.86	42	0.64	

** Significant at one per cent level of significance

APPENDIX III

Score values showing natural field infestation to floral branches of cashew by *H. antonii* (raw data)

Sl. No.	Accession Number	Segment I			Segment II			Segment III			Segment IV		
		P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
1.	T. 20-22	0	0	0	0	0	0	0	1	0	2	2	0
2.	Vengurla 37-3-1097	1	2	4	0	2	3	0	0	0	0	1	5
3.	Vengurla 37-3-1112	2	2	0	0	0	0	2	1	3	2	3	1
4.	Vengurla 36-3-1469	0	1	5	2	2	5	2	0	0	0	0	0
5.	Vengurla 36-3-1548	4	1	5	5	5	2	2	5	5	5	5	2
6.	BLA-139-1-1391	1	2	3	5	5	2	4	2	2	2	4	3
7.	BLA-139-1-1431	1	3	0	4	1	4	4	0	2	2	3	0
8.	BLA-256-1-1430	3	1	4	0	5	2	1	3	2	5	1	0
9.	Tree 56 of BLA 1219	5	3	3	4	5	4	0	0	0	4	4	2
10.	Ansur-1-1352	2	0	1	4	0	0	3	0	0	1	2	3
11.	Ansur-1-1547	5	2	5	5	5	1	1	3	5	5	2	5
12.	H. 27- 650	5	5	5	5	5	5	5	5	5	5	3	1
13.	H. 27- 665	5	5	5	5	5	4	5	5	5	2	1	3
14.	H. 4.7- 1111	4	3	5	4	0	4	5	1	5	5	3	4

P_1, P_2 and P_3 represent the randomly selected floral branches in each segment for recording natural infestation of *H. antonii*

APPENDIX IV

Analysis of Variance table for natural field infestation to floral branches of cashew by _H. antonii_

Source	SS	df	MS	F
Total	123.44	55		
Between trees	83.60	13	6.43	6.77**
Within trees (Error)	39.84	42	0.95	

**Significant at one per cent level of significance

APPENDIX V

Score values showing the degree of infestation to vegetative shoots of cashew by *H. antonii* under confinement (raw data)

Sl. No.	Accession Number	Segment I S_1	Segment I S_2	Segment I S_3	Segment II S_1	Segment II S_2	Segment II S_3	Segment III S_1	Segment III S_2	Segment III S_3	Segment IV S_1	Segment IV S_2	Segment IV S_3
1.	T. 20 - 22	4	4	3	5	5	4	4	5	5	5	5	4
2.	Vengurla 37-3-1097	3	4	5	5	5	4	4	4	3	4	3	5
3.	Vengurla 37-3-1112	5	5	5	2	5	4	4	4	4	4	5	3
4.	Vengurla 36-3-1469	5	5	4	4	3	4	3	3	5	5	5	5
5.	Vengurla 36-3-1548	3	3	4	4	4	5	5	5	4	5	4	5
6.	BLA-139-1-1391	5	5	2	5	5	5	5	4	5	3	2	3
7.	BLA-139-1-1431	2	5	3	5	5	5	2	4	4	3	5	5
8.	BLA-256-1-1430	5	5	5	5	3	2	5	4	5	5	5	5
9.	Tree 56 of BLA-1219	3	3	3	5	3	5	5	3	4	4	5	4
10.	Ansur-1-1352	5	5	5	3	4	5	5	3	5	2	3	3
11.	Ansur-1-1547	5	5	5	5	5	5	5	5	5	5	5	4
12.	H.27-650	5	5	5	2	5	3	3	5	4	3	5	5
13.	H.27-665	3	4	3	5	4	5	2	3	4	3	4	5
14.	H.4.7-1111	5	5	5	4	4	5	5	4	3	4	3	2

S_1, S_2 and S_3 represent the randomly selected shoots in each segment for confinement of *H. antonii*

APPENDIX VI

Analysis of Variance table for the degree of infestation to the vegetative shoots of cashew by _H. ankonii_ under confinement.

Source	SS	df	MS	F
Total	151.28	167		
Between trees	12.7	13	0.98	0.64
Between segments within trees	63.91	42	1.52	2.27
Between shoots within segments within trees (Error)	74.67	112	0.67	

APPENDIX VII

Score values showing the degree of infestation to floral branches of cashew by *H. antonii* under confinement (raw data)

Sl. No.	Accession Number	Segment I P_1	Segment I P_2	Segment I P_3	Segment II P_1	Segment II P_2	Segment II P_3	Segment III P_1	Segment III P_2	Segment III P_3	Segment IV P_1	Segment IV P_2	Segment IV P_3
1.	T. 20 - 22	4	5	5	5	4	5	4	5	5	5	5	4
2.	Vengurla 37-3-1097	5	5	5	5	5	5	5	5	5	4	5	5
3.	Vengurla 37-3-1112	3	5	5	5	5	5	4	5	4	5	4	5
4.	Vengurla 36-3-1469	5	3	5	4	4	3	5	5	2	4	4	5
5.	Vengurla 36-3-1548	5	5	4	4	5	5	5	5	4	5	5	5
6.	BLA-139-1-1391	5	3	3	4	3	5	5	5	5	5	5	4
7.	BLA-139-1-1431	3	4	3	5	5	3	5	5	5	4	4	3
8.	BLA-256-1-1430	5	4	5	5	5	5	5	5	5	5	5	5
9.	Tree 56 of BLA-1219	3	4	4	3	5	5	5	3	5	3	1	5
10.	Ansur-1-1352	5	5	4	5	4	5	5	5	4	4	5	5
11.	Ansur-1-1547	5	4	3	5	5	4	5	4	5	4	5	3
12.	H.27-650	5	5	4	5	5	5	5	5	3	5	5	5
13.	H.27-665	4	2	4	4	5	5	4	3	5	5	5	5
14.	H. 4.7-1111	5	5	4	5	5	5	5	4	4	5	5	3

P_1, P_2 and P_3 represent the randomly selected floral branches in each segment for confinement of *H. antonii*.

APPENDIX VIII

Analysis of Variance table for the degree of infestation to the floral branches of cashew by *H. antonii* under confinement

Source	SS	df	MS	F
Total	103.95	167		
Between trees	17.37	13	1.34	2.48*
Between segments within trees	22.58	42	0.54	0.95
Between floral branches within segments within trees (Error)	64	112	0.47	

*Significant at five per cent level of significance

RELATIVE SUSCEPTIBILITY OF CASHEW TYPES TO INFESTATION BY THE TEA MOSQUITO *Helopeltis antonii* SIGNORET (HEMIPTERA : MIRIDAE)

K. M. THOMAS

ABSTRACT OF A THESIS

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Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF HORTICULTURE
VELLANIKKARA 680 654
KERALA : INDIA

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ABSTRACT

The relative susceptibility of fourteen cashew accessions (*Anacardium occidentale* L.) to infestation by the tea mosquito bug *Helopeltis antonii* Signoret (Miridae : Hemiptera) was evaluated in field experiments conducted at the Cashew Research Station, Madakkathara during September 1979 - March 1980.

The field damage intensities and the extent of damage inflicted by the insect consequent on confinement on shoots and panicles were recorded on a 0 - 5 scale and it was found that the accessions 22, 1112, 1430 and 1097 were least susceptible with regard to the intensity of natural field infestation of the vegetative shoots. Regarding the intensity of field infestation on floral branches, the accessions, 22, 1112, 1352, 1469 and 1097 were significantly less suceptible than the other types.

With reference to the intensity of damage to vegetative shoots under confinement none of the accessions was found to be promising. The accession numbers 1219, 1469 and 1431 were found to be least susceptible to *H. antonii* infestation under confinement on floral branches. Since the damage to the floral branches, particularly under confinement, is relatively more important factor

responsible for yield reduction these trees can be identified to be relatively more promising.

The influence of certain biochemical factors (total nitrogen, soluble sugars and tannins) on pest infestation in shoots and floral branches was ascertained by working out simple correlation coefficients. The only significant association detected was between the tannin content in the vegetative shoots on the one hand and the pest infestation intensities under confinement, on the other.

The shade intensities within the canopies had no influence on the extent of susceptibility to the pest.

The tree architecture patterns were found to be of two basic types, namely, extensively branching (spreading) and intensively branching (bushy). Variations in the canopy configuration did not influence the suscepti-bility trends.

The inconsistencies in the relative susceptibility of different accessions with reference to shoot and panicle damage intensities have been discussed.