A SPRAY PROGRAM FOR VEGETABLE CROPS IN THE BEQA'A BASED ON A PEST SURVEY

by

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Spraying Vegetable Crops

Chaudhry

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ABSTRACT

The present investigation was undertaken to work out a spray program against the insects occuring on the vegetable crops in the Beqa'a valley. The number and timing of sprays were based on insect pest levels during the period of survey in the growing season of 1962 at the University farm. The effect of temperature on populations was considered, while the effect of relative humidity was not. The control measures taken by the incharges of vegetable plots were purposely neglected.

The present study was meant to protect the crops against the following six important insects, namely leafhoppers, aphids, thrips, Eurydema spp., the white cabbage butterfly and flea beetles, and two other pests of lesser importance. The qualitative data of disease occurance were also recorded.

Not all the vegetables grown on the farm were of commercial importance in Lebanon. Of particular interest were beans, cucurbits, chillies, eggplants, lettuce, onion, okra, potatoes, tomatoes and water melons. Besides vegetables, sugar beets were also included in the observations.

Leafhoppers were found infesting the host plants in summer while the air temperature was 20°C and above. At temperatures lower than 15°C, the aphids increased rapidly and this necessitated control.

The Eurydema spp. were found present on Brassica spp. throughout the season. Except for the month of August and the first three weeks of September, the white cabbage butterfly caterpillars were also present all the time the host plants were in the field. Thrips occured on onions, leeks, kohlrabi and sugar beets in the hot period in August. The flea beetles were very injurious in late July and August. Grasshoppers were observed throughout the survey period.

The chemicals for control measures were not specified.

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INTRODUCTION

Vegetables are important sources of minerals and vitamins for human diet. Areas under vegetables are increasing every year in Lebanon. Of the wide variety of vegetable crops, mainly cucurbits, potatoes, tomatoes, onions and melons are grown in the Beqa'a plain.

Among the other factors of lower yields, insect pests and diseases constitute the main trouble. Vegetable crops in the Beqa'a are attacked by a large number of insects. Since insect control is always costly when using pesticides, an efficient spray program is needed.

Often the spray schedules are based on the stage of development of insect or, are timed with the stage of development of the crop. Such schedules do not take into consideration the actual pest populations present in the field. They neglect the relative effect of various environmental factors on insects and food-plants, although the rate of damage with equal infestation has been found to differ noticeably with cultural, weather, soil, physiological and other variables (19).

Spray programs based on insect pest surveys, serve as both detection and warning systems. They not only warn when to spray, but also when not to spray.

Since 1953, survey entomologists have been employed on a State-Federal Cooperative basis in several states in U.S.A. Their duty consists of warning the farmers when and where the insect populations reach damaging density, so that timely treatments can be applied (4).

In the Middle East, including Lebanon, no quantitative data on pest survey based on field conditions, are available. Mostly the published work is concerned with the qualitative biological aspects of the insects. As any injurious organism may develop into a serious pest, when its ecological requirements are increasingly met, such a study is thought to be of direct benefit to the farmer. In view of the above facts, the present study was undertaken. Its two main objects are A, to attempt to determine a spray program for various vegetable crops in the Beqa'a, without recourse to the pest control specialist, and B, an economic evaluation of the cost of growing a crop in question.

REVIEW OF LITERATURE

A. Economic infestation levels.

Very rarely a spray program based on insect pest infestation level is reported. As it is not easy to estimate the number of insects a crop can tolerate without serious loss of yield, Strickland (41) reported that ranking by symptom expression or severity of infestation gives rapid assessment of losses.

King (19) realized the importance of quantitative insect population studies to determine the actual amount of damage done by the pest and the relative effect of environmental factors on insects and foodplant. Much later, Morris (28) reported that the extensive survey results are often combined into two or three classes, such as, "light", "medium" and "heavy", or even more simply "areas requiring treatment" and "areas not requiring treatment". But for practical purposes, such statements should be reduced to mathematical basis.

Earlier, Shotwell (36) classified the grasshopper, Melanoplus mexicanus Sauss., populations into "normal", "light", "moderate", "heavy" and "very heavy"; where "normal" denoted two live grasshoppers per square yard of irrigated fields, "light" three, "moderate" six, "heavy" twelve and "very heavy" twenty four. Treatment of crops is necessary in all cases except the "normal".

Strickland (40) classified cabbage aphid, Brevicoryne

brassicae L., as below:

"Clean"; where no colonies are visible on outer leaves or sprouts, and only a few scattered aphids not exceeding five or six in a random three-leaf sample.

"Slight"; where one or more colonies occur on the outer leaves or on the top, not more than ½ inch in diameter. Not more than about 200 aphids in a random three-leaf sample.

"Moderate"; where many colonies are present on leaves and/or top, often exceeding 2½ to 3 inches in diameter. Up to about 750 aphids in a random three-leaf sample. Treatment of crops below a peak density of 1.00 aphids per sample in August or September would be uneconomic.

Landis, Davis and Gibson (23) classified populations of Myzus persicae Sulz. occuring on potato as "light" when there were 0-50 wingless aphids per 50 compound leaves, "moderate" 51-500 and "heavy" 501-2000 plus.

Broadbent (13) quoted that Gorham recorded the nature of aphid, Myzus persicae Sulz., infestation on potato in Canada as "very light", "light", "medium" or "severe". But "very light" infestation in Canada is apparently anything up to ten aphids per leaf, which would be considered a "severe" infestation in Britain.

Mathes (25) reported that 10 per cent of the joints bored by Sugarcane borer, Diatraea saccharalis F., are considered to be "very light"; 10-20 per cent "light"; 20-30 per cent "moderate"; and over 30 per cent "severe". For control needs in spring and summer, surveys be made in February, and the infestation recorded as number of borers per acre as shown below:

	Cane trash	Young shoots of summer planted cane
"Non economic"	0-5	0-50
"Light"	5-25	50-100
"Moderate"	25-100	100-600
"Severe"	100-200	600-2000
"Very severe"	200 or more	2000 or more

Bowden (12) reported that 50 per cent infestation of maize by stem-borer reduced yield by 45-50 per cent, if there were about three larvae per stem, but by only 15-20 per cent with one larva per stem; while 20 per cent infestation with one larva per stem reduced yield by 5 per cent.

Beck (6) reported that the emergence of European corn borer moths should be used as a criterion of the probable time of the beginning of egg deposition. When the egg load reaches 50 masses per 100 plants of corn, approximately 35 inches in extended leaf height, the situation is serious enough to warrant control. For the second generation borers the treatment is recommended, when the egg load is 100 masses per 100 plants.

Reid and Bare (32) reported that control measures against cabbage caterpillars are worthwhile, when the caterpillar population reaches an average of about one caterpillar per plant (100 caterpillars per 100 plants).

Peay (29) reported that presence of one egg of tomato fruit worm, Heliothis armigera Hb., per 100 leaves at any time during the time

of fruit setting, will result in 2 to 5 per cent wormy fruits, and it justifies control measures.

Gyrisco (17) quoted observation of Floyd (1940) that a single alfalfa caterpillar, Colias philodice eurythema Boisd., consumed an average of 57 leaflets during its larval period. Smith and Allen (38) reported economic infestation of alfalfa caterpillars around 200 non-parasitised larvae per twenty sweeps, under standard field conditions.

Petty (30) recommended insecticidal treatment against spittle bug on first-year hay crops in spring, when an average of one-half or more nymphs per stem are anticipated.

Smith and Swift (39) recommended spray of alfalfa in early bloom stage against Lygus bug, when its count reaches one insect per sweep, but during the period of seed set when six insects are collected per sweep.

Smith (37) reported that ten Lygus bugs collected in 50 sweeps over the tops of a cottom row, is the minimum injurious number.

Granovsky (15) reported that five leafhoppers or ten advanced instar nymphs per one year old plant of alfalfa are sufficient to cause severe injury in from one to two weeks. Also, that one leafhopper or its nymph caused withering and collapsing of the leaves, petioles and the upper portion of succulent shoots of young seedlings in 24 to 48 hours.

Green (16) reported that an average of five beet leafhoppers per ten sweeps merits a chemical treatment, and that an average of two or three leafhoppers per ten sweeps over a large area can produce

damaging numbers.

B. Relation of temperature to the development of insect attacks.

Time of spray application is of more value for pests with 3-4 generations per year, than those with one annual generation (8).

The present study dealt with leafhoppers, aphids, thrips, Eurydema spp., white cabbage butterfly, flea beetles, leaf miner, and grasshoppers, all of which have more than one generation per year. The seasonal abundance of these insects as related to temperature and host plants was also considered.

1. Leafhoppers

Bodenheimer and Klein (9) found Empoasca (Chlorita) signata Haupt., causing considerable damage to egg plants in Palestine in 1928, tomatoes and peppers being also attacked. The insects were most injurious during the summer and autumn months. Talhouk (43) reported the presence of potato leafhopper, Chlorita signata (Empoasca fabae Harris), on potatoes, tomatoes and egg plants from late June until November in Lebanon. The same author (44) found the egg plant leafhopper, Empoasca lybica de Berg., on the above plants plus okra, cotton and alfalfa in Saudi Arabia. According to him a large number of generations succeed one another between 15°C to 38°C temperature. DeLong (14) found E. fabae Harris to pass its life cycle on a number of wild and cultivated host plants. The adults migrated to potatoes in the third week of June in Ohio. The generations overlapped considerably, and adults and nymphs were found present in the field even after a minimum temperature of 25°F

had occured. The average number of days from hatching to adult stage was more than 12 days for the first and the second generations, 14.4 for the third and 22 for the fourth. At a constant temperature of 78°F and relative humidity of 80 per cent, the period from egg to adult was 18 days.

Data on leafhoppers infesting cucurbits, salad-bowl, Swiss chard, summer savoy, sweet basil, anise, borage, dandelion, endive and kale are not available.

2. Aphids.

Although this insect is a serious pest of cabbage, collards, kohlrabi, Brussels sprouts, okra and salsify, data on its temperature relationship are not available. The cabbage aphid, Brevicoryne brassicae L., is reported by Talhouk (43) to occur on the Cruciferae during the late autumn or the early winter, and even in the winter when temperature does not fall below zero degrees centigrade. It has, probably, more than 10 generations per year on the coastal areas of Lebanon. The same author (44) reported the melon aphid, Aphis gossypii Glov., on cucurbits, okra, etc. to complete its life cycle in 10-12 days. Walton (48) reported that even sub-freezing temperatures do not reduce the populations of Rhopalosiphum pseudobrassicae Davis immediately.

Thompson and Kelly (45) pointed out that cabbage aphids are more injurious during the latter part of the crop season than the earlier.

3. Thrips.

Onion thrips, Thrips tabaci Lind., have not been considered as a

serious pest of vegetable crops in Lebanon. So, data for the same are lacking in and around Lebanon, except a note by Rivnay (33) that the food plants of the insect in Palestine included citrus, cabbages, and grapes. However, the insect was found here to attack onions, leeks, kale, kohlrabi, beets, cabbages and lightly cucurbits and tomatoes.

McLennan (26) reported over 50 per cent loss of onion crop in Canada; Vuillet (47) too, recorded 50 per cent loss in the yield of leeks in France and that the insect completed its life cycle in 17-47 days. Kinsey (20) recommended spraying at interval of three weeks - the time taken by the insect to complete its life cycle. Bonnemaison (10) in France reported that Thrips tabaci Lind. on tomato may have 5-6 generations per year. At 21°C, 21.4 days were required for development, while at 27°C only 17 days; and the adults survive 12-17 days. He further suggested 3 applications of insecticides at interval of 10 days.

4. Eurydema spp.

Eurydema ornatum L. (E. festivum E.) (E. ventralis Kol.) is a very serious pest of cabbages as reported by Talhouk (42), who noted that with the rise of temperature, the overwintering adults come out and mate (43). The insect completes its life cycle in 30-35 days. Servadei (35) reported that the eggs hatch in about 15 days at 15°C and 58 per cent humidity. Bonnemaison (11) in France found the insect to resume activity in late March or early April. Pairing took place 5-12 days later and oviposition started at the end of April or beginning of May. The number of days required for total development at 24 and 20°C

were averagely 38 and 58 for the first generation and 44 and 68 for the second generation respectively.

5. White Cabbage butterfly.

Pieris brassicae L. is another serious pest of cabbages in Lebanon (42), and has five generations per year (43). Klein (21) reported that seven generations in a year are possible in the coastal regions of Palestine. Further that the temperature dominated the rate of development of P. brassicae L., humidity being of little significance. The highest and the lowest temperature fatal zones were above 26°C and below 13°C respectively. At the former temperature 100% mortality of eggs occured, while at the latter or at a humidity below 60 per cent no eggs were laid. Kozhanchikov (22) in laboratory studies, found the thermal constant of P. brassicae, L., to be 700.5 day-degrees C. The egg stage required 98 day-degrees C, the larval and pupal stages together 389, the pupal 189, and the maturation of eggs in the females 24.5; the thresholds of these stages being 9, 7, 8 and 16°C respectively.

6. Flea beetles.

Data on temperature relationship of Phyllotreta atra F. (P. cruciferae Goeze) are lacking. Talhouk (42) recorded P. atra F. as a very serious pest of cruciferous crops in Lebanon, during their seedling stage. Scott (34) observed the beet foliage attacked by P. Cruciferae Goeze in Kurdistan, Iraq. Blunck and Meyer (7) reported that the flea beetles increase in hot and dry years. Pyatakova (31) (whose work resembles close to the observations made here) reported that there

were three generations of P. cruciferae Geoze, in a year in Kiev (Russia). The hibernating adults begin to come out in the middle of April and die early in June. They lay eggs in batches of 20-36, and the first generation adults appear in the middle of June. About the middle of July, beetles of the second generation appear, and those of the third generation are abundant by the end of August and the beginning of September.

7. Leaf miner. Agromyza sp.

The host plant, borage seems to be of minor importance as a crop, as it has not been found mentioned anywhere.

MATERIALS AND METHODS

The present study was conducted at the University Farm in the Beqa'a valley. The Farm is located 80 kms. north-east of Beirut and has a continental climate. The vegetable crops under observations were grown in spring and summer, and harvested as they matured. These crops could be grouped as:-

1. Museum crops - where only one or two rows five meters long, were planted. They included anise, beans, borage, Brussels sprouts, collards, dandelion, dil, endive, kale, kohlrabi, leeks, rutabaga, salad bowl, salsify, summer savoy, sweet basil and Swiss chard.

2. Students' plots - where one vegetable crop row was separated from its kind by ten other different vegetable rows. They included beets, cabbage, carrot, cucurbits, lettuce, onions, peas, potatoes, tomatoes and radish.

Lettuce, peas and radish were removed before any observations were recorded.

Sugar beets, a non vegetable crop were included in the observations. Later, radish grown in summer was also surveyed.

3. Experimental plots - where the vegetables were grown on sizeable plots, about a dunum or more in area. They included cabbage, chillies, egg plants, lettuce, okra, onions, sugar beets and water melons.

It is, therefore, seen that no crop was extensively cultivated.

All crops were grown under irrigation. The plots were operated independent of plant protection staff, and various insecticides were applied by the incharges, whenever in their view such applications were needed. The incharges were not specifically advised in the selection of insecticides, or in the method or time of application. On some vegetables insecticides were not applied.

Observations were started on 6th July 1962, when all the crops in the field were thinned to the desired stand, and were well established. The observations continued till the crops were removed from the field in winter. Regular weekly records of insect abundance and existing conditions of the crops were made. At a few times, the weekly observations were interrupted due to unavoidable circumstances, and the interval between observations was prolonged. Meteorological data were maintained at the Farm by the School, and were used by the writer in drawing his conclusions.

General survey methods were adapted for different insects in the field as shown below:

1. Leafhoppers.

Surveys were made in the morning hours when the insects were not very active. Five leaves randomly distributed in the field were selected. Such leaves were chosen as to show most representative population (18). The plants were carefully approached, and the upper surface of the selected leaf was observed for the presence of insects. It was then turned upside down, in such a way as to cause least shaking. The number of nymphs and adults were separately noted (1). In case of heavy infestation both adults

and nymphs were counted together, as exposition of the lower surface of the leaf to light caused the insects to move and intermingle. In all such cases the number of nymphs was more than the number of adults.

On tomatoes and potatoes the count was taken on five leaflets (3) each on a plant randomly distributed in the field.

On some vegetables the leaf did not constitute a unit. The populations were, therefore, only recorded as "high", "medium" or "low" as in borage, kale and summer savoy.

Meyers and Patch (27) mentioned that methods should be adapted to the particular circumstances of the investigation. Ahmad (2) pointed out that the number of insects per unit area of leaf surface on the plant would be a better guide to the importance of an infestation than the number of insects per unit area of field.

2. Aphids

Five arbitary classes of aphid infestation were adapted from Banks (5) with a little modification. They were:

(a) Zero (0); where no aphids could be seen.

(b) Very Light (V); where from one aphid to a small colony confined to the youngest leaves was found.

(c) Light (L); where there were several colonies of aphids present and not confined to the upper leaves.

(d) Medium (M); where aphids were present in large numbers, not in recognizable colonies, but diffused and infesting a large proportion of leaves.

(e) Heavy (H); where aphids were present in large numbers, very dense, infesting all the leaves and plants. Plants wholly covered with aphids.

3. Thrips.

Four classes of infestation were recorded based on Anon. (3) as follows:

(a) None: where no thrips were found.

(b) Light; where slightly brownish tinge color and very occasionally a thrips was seen.

(c) Medium; where considerable browning and some silvering was evident and thrips were seen readily.

(d) Heavy; where silvering was readily noticeable and thrips were numerous.

In aphids and thrips five plants were randomly examined, and the average infestation noted.

4. Eurydema spp.

Five host plants were randomly selected. The number of bugs feeding on them was recorded. The average number of bugs per plant was calculated. The eggs and nymphal stages were also noted.

5. White Cabbage butterfly.

Five host-plants randomly distributed in the field were selected as sample, and the number of larvae feeding on them recorded. The average number of caterpillars per plant was calculated (32). The adults were never netted, neither the pupal stages noted.

6. Flea beetles.

The population density was inferred from the damage done to the leaves and the number of beetles per leaf. Five host plants were examined every time.

7. Leaf miner.

Ten leaves of borage were randomly selected. The number of mined leaves and miners were noted and averages calculated.

8. Disease record.

No quantitative descriptions of the diseased plants were attempted, but the qualitative conditions of plants as regards the disease were noted.

The physical conditions of the crops in respect to the drying of the plant, leaf dropping as a function of irrigation and maturity were also noted regularly.

RESULTS AND DISCUSSIONS

The different insect populations on various vegetable crops and their fluctuations with the temperature* during the period of survey are graphically represented for the leafhoppers, aphids, thrips, Eurydema spp. and white cabbage butterfly, in Fig. 1 to Fig. 25.

No statistical transformation of the figures was attempted. Not only is it unrewardingly time-consuming, but a transformation of data can give rise to special problems (24). In the present study, the density range was considered to be sufficiently low for direct analysis. Upholt and Craig (46) too, concluded that a black scale population failed to confirm to any statistical distribution.

The crops were sprayed wherever indicated.

The word 'harvest' in this study means the removal of crop plants from the field.

A. Leafhoppers

1. Cucurbits. Fig. 1 shows the leafhopper population on cucurbits. It is observed that the number of insects per leaf remained high at temperatures 20°C and above, while below 20°C the population fell rapidly.

On splitting the population components, the nymphs were found highest in numbers in July and the end of August to mid September.

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* Unless otherwise stated, the term "temperature" is used in this study to refer to 'mean air temperature between two dates of observations'.

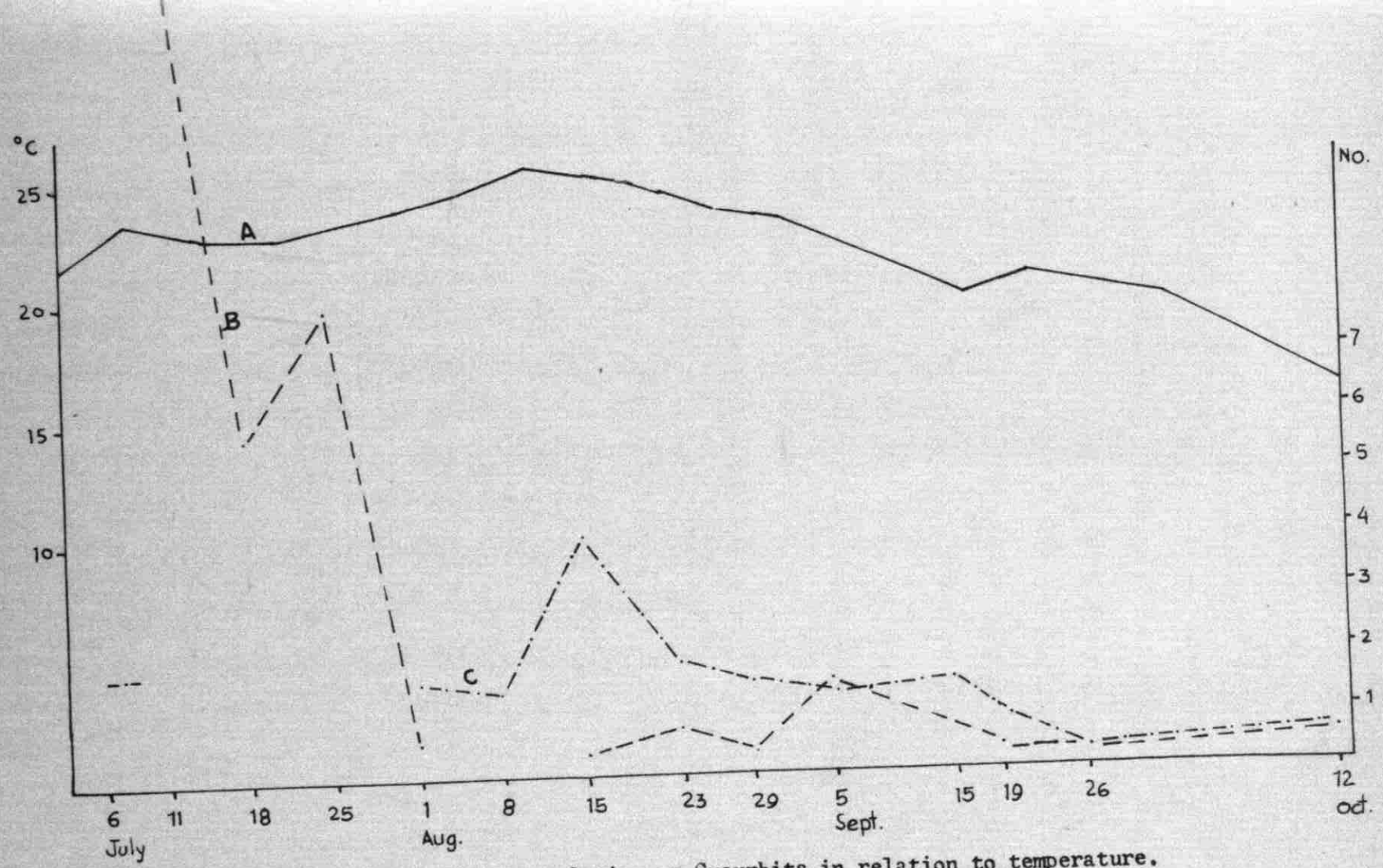


Fig.1.-- Leafhopper population on Cucurbits in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

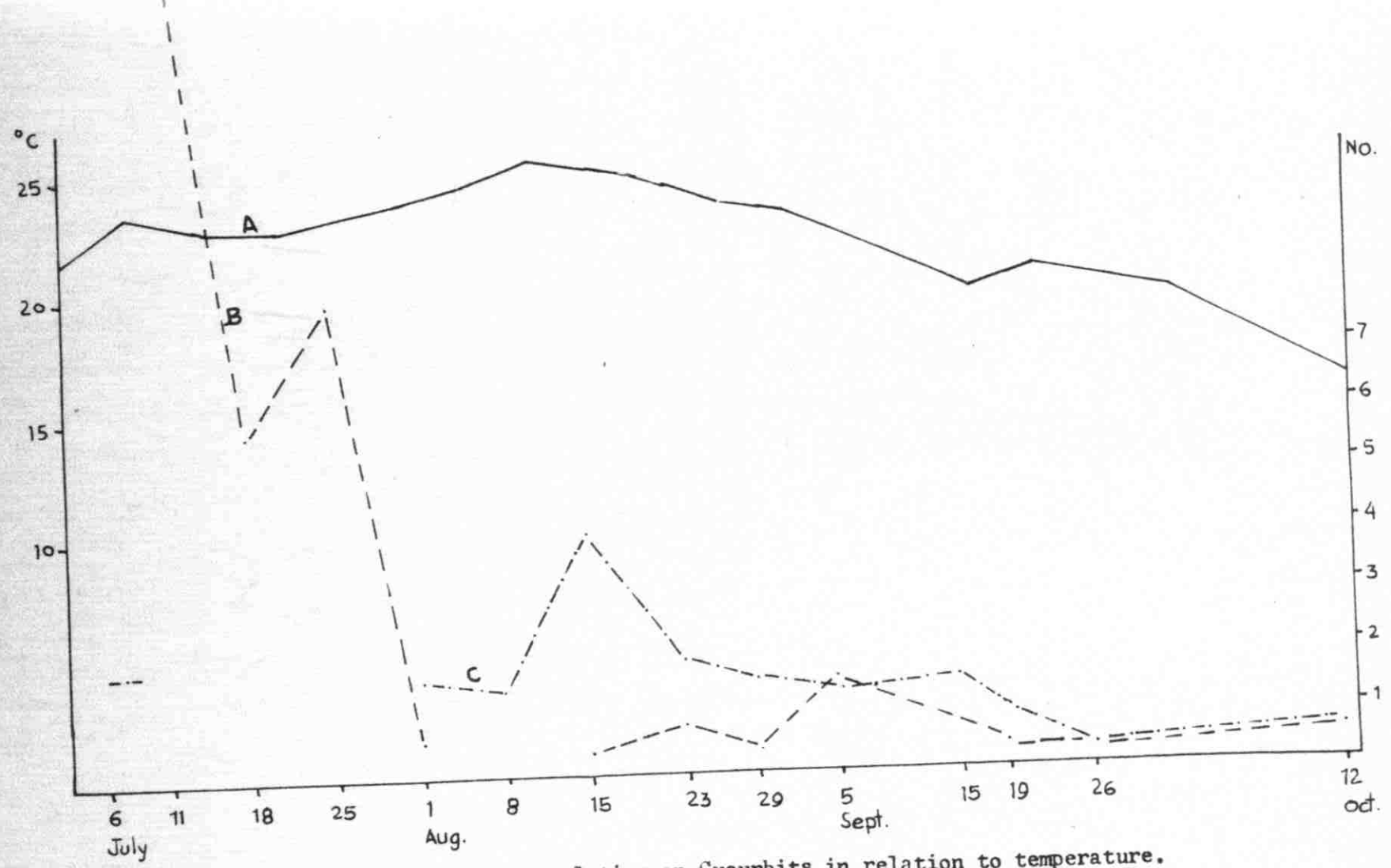


Fig.1.-- Leafhopper population on Cucurbits in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

The adults were more in numbers than the nymphs in the second and third weeks of August, after which they remained at constant level upto mid September. The low populations of both adults and nymphs present in the field were from late September to mid October.

The crop was sprayed against the leafhoppers on the third of August, but still the adult population remained high.

The crop was earlier attacked by the powdery mildew, Erysiphe cichoracearum D C., in early July. It covered both surfaces of old leaves by the end of August. Many leaves were dead by that time.

A general discussion on leafhoppers follows at the end of the sub-section.

It is difficult to determine the economic level of infestation. The level of 5 adults per 10 sweeps (16) is apparently quite low as compared to the visual observations. The survey revealed the desirability of spraying the crop when an average of 2 adults or 4 nymphs (1 adult = 2 nymphs) per leaf is observed. Spraying the cucurbits against leafhoppers is suggested in late June, and early August. The number of sprays is also regulated by other factors.

2. Dandelion. Fig. 2 shows the leafhopper population on dandelion from July 11 to November 16. The insects were observed more when the temperature was 20°C and above. The population fell considerably with decline in temperature.

The nymphs numbered high in hot periods from mid July to mid August and increased again in mid September. The adults remained at low level of infestation all the time except a slight increase in late August and early September.

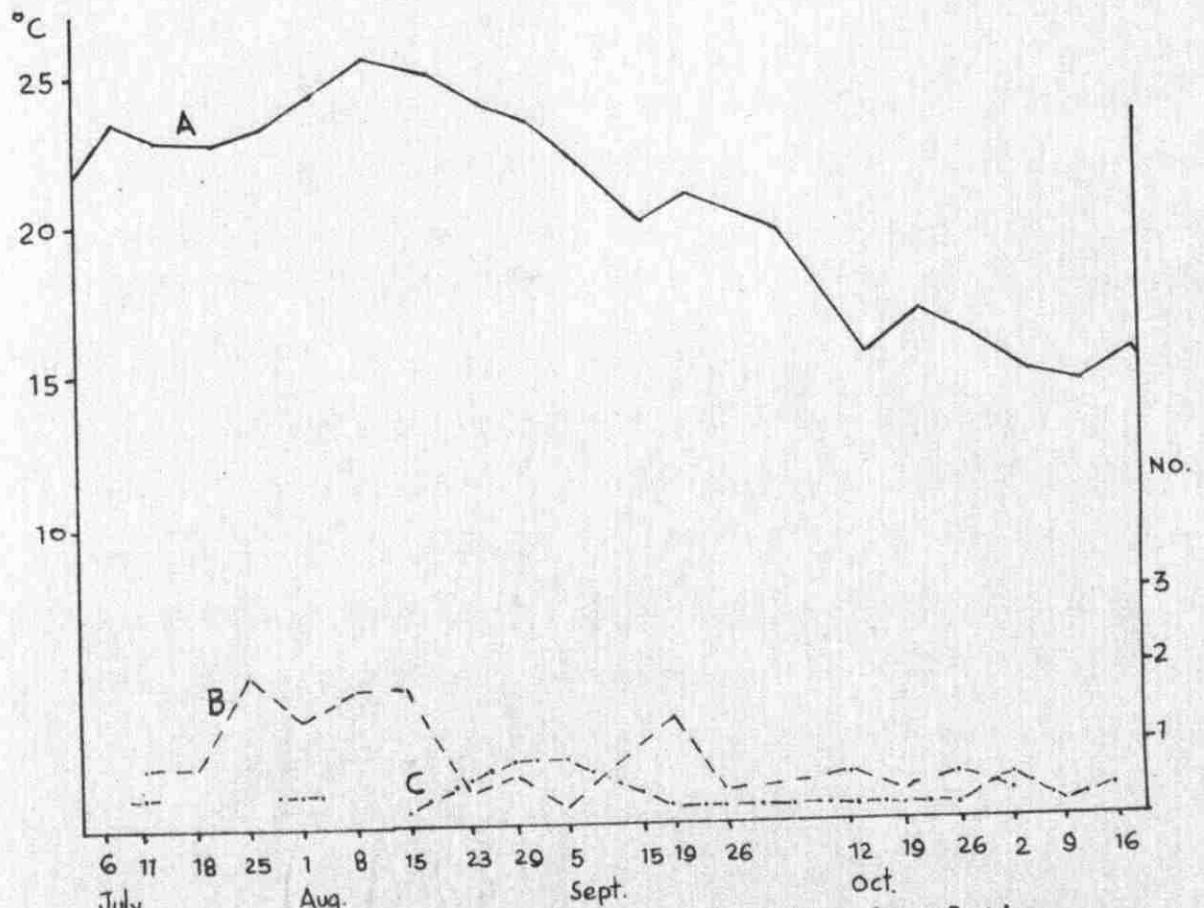


Fig.2.— Leafhopper population on Dandelion in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

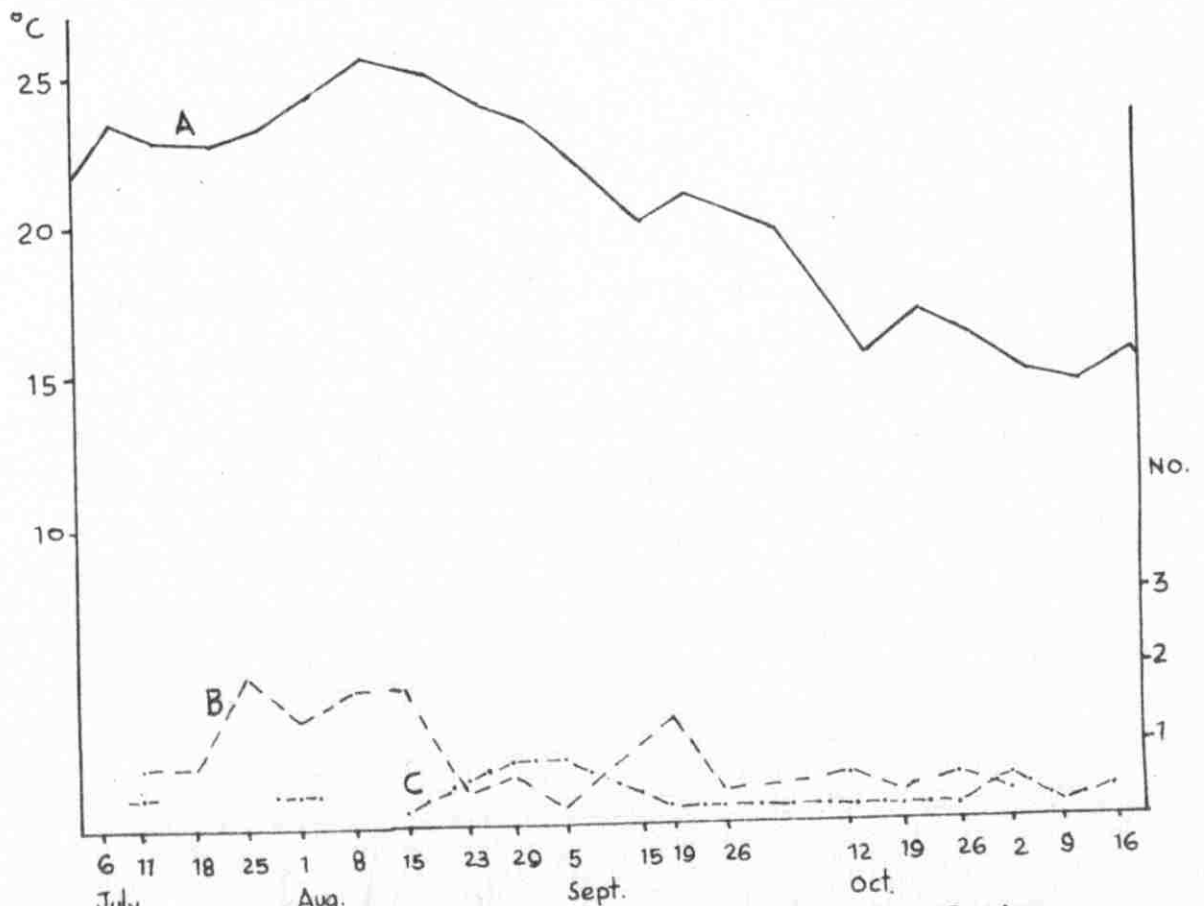


Fig.2.— Leafhopper population on Dandelion in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

The crop was attacked by powdery mildew in late August. It covered the whole crop by mid September and many leaves began to dry and die. By mid October about 50% of the leaves were observed dead. The insect population decreased as the powdery mildew advanced.

Spraying of the crop is recommended in mid July and mid August. One more spray at the end of the first week of September can also be applied, if found necessary. One adult or two nymphs per leaf is a good indication to apply the treatment.

3. Potatoes. Fig. 3 shows the leafhopper, E. fabae Harris infesting the potatoes from early July to mid September. The unit of observation was a leaflet. The insects were found at high level of infestation all the time the crop was in the field, since at no time the temperature went below 20°C.

The nymphs were always recorded higher than the adults. However, numerous adults were observed in the last week of July. They escaped observations on the leaflets.

Bronzing and dead leaves were observed in the field in early July. The same increased progressively, so that by mid September all the leaves were dead except the few young ones. The crop was sprayed on 10th and 28th of July. The leafhopper population was found sharply brought down by the first spraying, but not by the second.

It was found desirable to spray the crop when there is an average of one nymph or one-half adults per leaflet. The crop is recommended to be sprayed in late June and mid July and again in early August if found necessary.

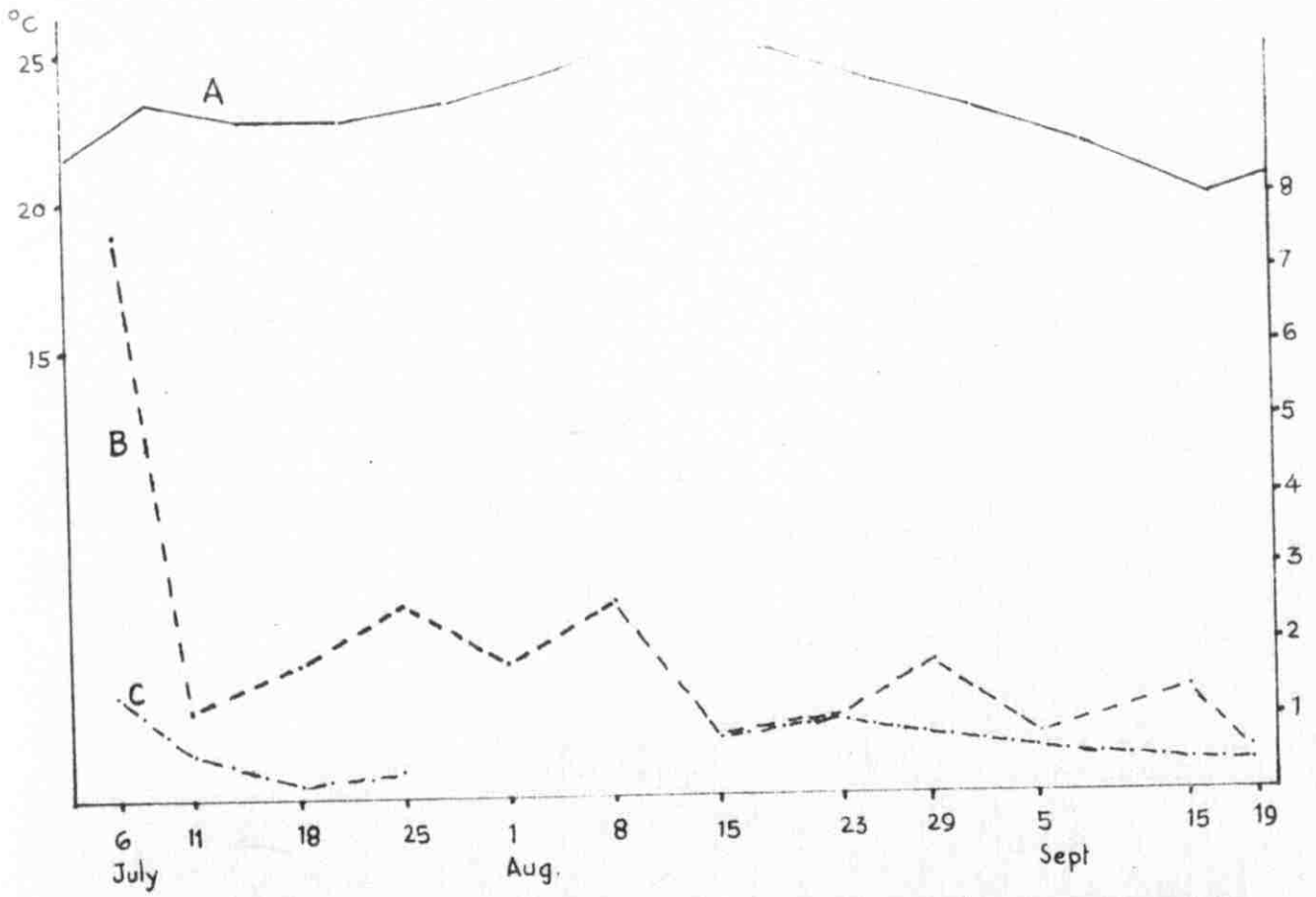


Fig. 3. — Leafhopper population on Potatoes in relation to temperature.
A.Temperature; B.Average No. of nymphs per leaflet;
C.Average No. of adults per leaflet.

4. Sweet basil. Fig. 4 shows the light infestation of sweet basil by leafhoppers. Although the insects were present all the time the crop was in the field, their number did not rise alarmingly. One spray in mid August is suggested.

5. Sugar beets (Student plots). Since this is not a vegetable crop, it was included in observations from mid July. Fig. 5 shows the leafhopper population on sugar beets. The insects were more in number at temperatures 20°C and above. With the fall of temperature in mid September, the population level also dropped readily and remained at the lower level till the crop was harvested in mid October.

The nymphs were at high level from mid July to the beginning of September. Their population remained low for the rest of the period. The adults were also seen to increase in the third and fourth weeks of August. Their number was more than the nymphs from early September till the harvest of the crop. The adult population level sharply fell down to that of nymphs, when the temperature fell to 16°C.

Powdery mildew was observed from mid July on. It increased progressively and covered both leaf surfaces by the end of the third week of September.

Looking into the figure, a heavy spraying program is suggested in mid July, first and the third weeks of August and early September, when an average infestation level of 2 adults or 4 nymphs per leaf reaches. However, the two early sprayings may keep the population below the economic level of infestation for the rest of the season.

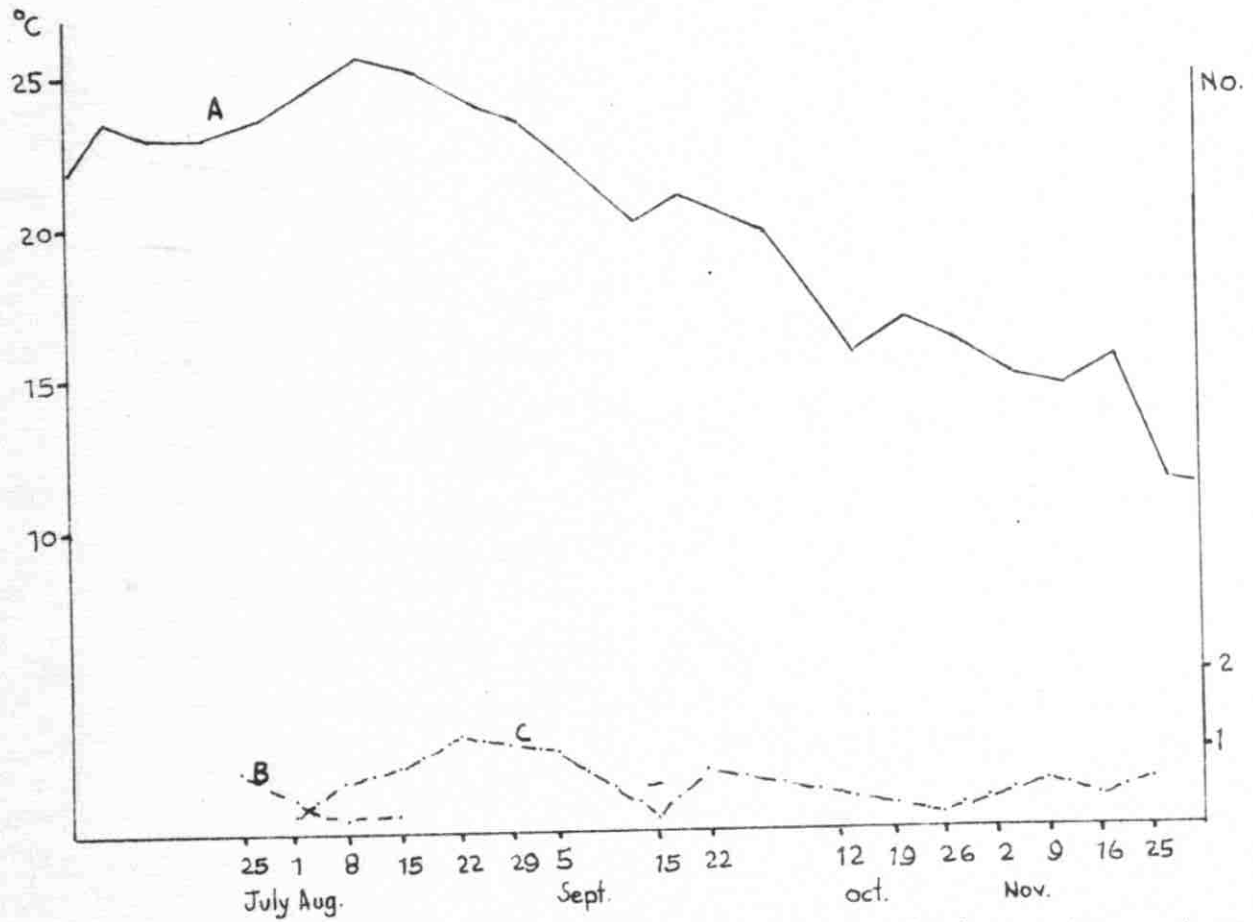


Fig. 4.-- Leafhopper population on Sweet basil in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

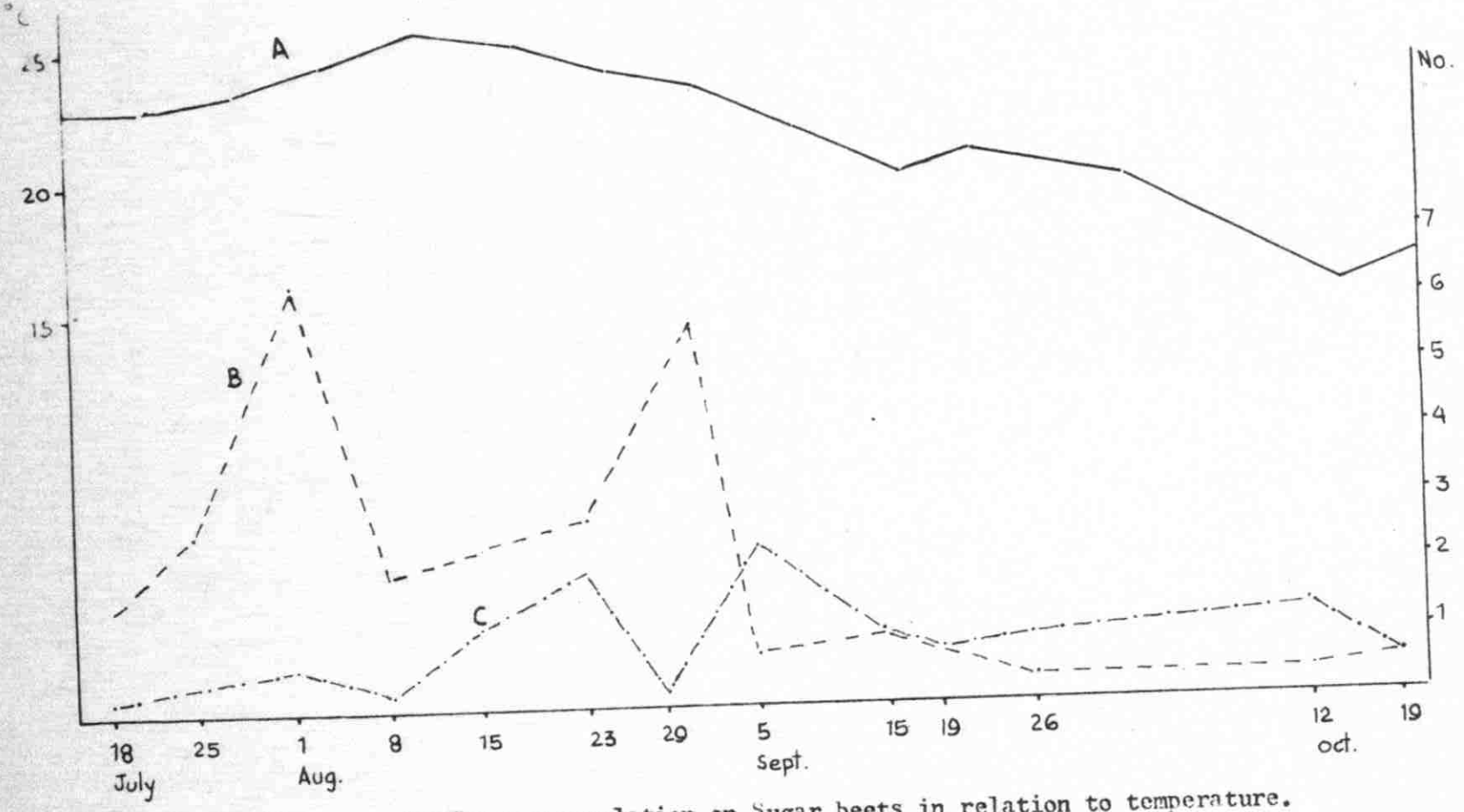


Fig.5. — Leafhopper population on Sugar beets in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

6. Swiss chard. Fig. 6 shows the leafhopper population on Swiss chard from July to November. The insects were found active throughout the season, even though the temperature went below 15°C. At low temperature, the nymphal population fell sharply, while that of adults increased steadily.

The nymphal population was very high in July and early August. During this period the adults were entirely absent. From mid August to late October, both populations remained at lower level. The adults increased in numbers in November.

Powdery mildew first appeared on old leaves in mid July, and the young leaves were attacked in mid August. The disease again appeared during the last week of September and covered all the plants by mid November. The lower leaves of Swiss chard were pale green in early July. Their number increased with leafhopper infestation.

The low infestation level from mid August to late October may be due to poor plant conditions. The high adult population in November may be due to A, absence of other host plats from the field at that time, and the insects migrated from other crops and/or B, Swiss chard was the only succulent crop in the field.

Spraying against the leafhoppers is suggested in late June, mid July and if necessary in mid August. An average of 2 adults or 4 nymphs per leaf is thought to be a suitable level to carry out spraying.

7. Beet Roots. The edible beets were harvested 15 days after the survey was started. The two weekly observations showed an average of 7 and 3 nymphs per leaf. The spraying is, therefore, recommended in

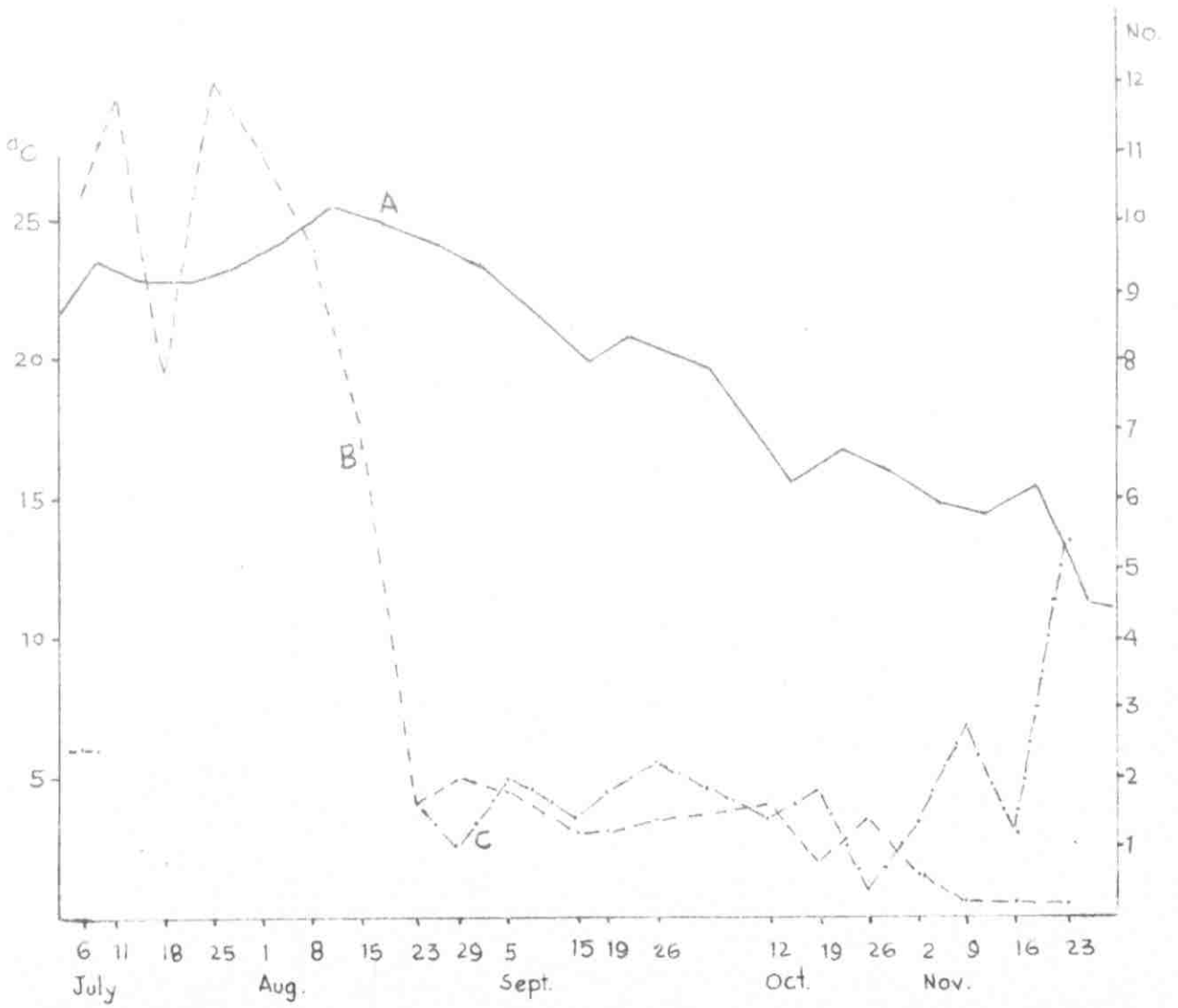


Fig. 6.-- Leafhopper population on Swiss chard in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

late June or even earlier before there is an average of 2 adults or 4 nymphs per leaf.

8. Anise, kale, summer savoy. Fig. 7 shows adult leafhopper populations, qualitatively recorded on these crops. The insects were found only at temperatures 20°C and above.

Anise was lightly attacked in mid July, kale from late July to mid August and again in early September, and summer savoy in late July to mid August and again in the last week of October.

One spraying for anise in early July before the leaves show purple color, is advised. One spraying for each of kale and summer savoy in early August is also suggested.

9. Borage, endive, salad bowl. Fig. 8 shows the adult leafhopper populations on these crops, as recorded qualitatively.

Borage was lightly infested from late July to mid August. This is one of the crops which dries early. Even though it was in the field upto mid October, no leafhoppers were seen from late August on. One spray in late July is recommended to control the insects.

Endive was observed under heavy adult attack from mid July to late August. With the gradual drop in temperature from 25.6°C, the population fell to low level up to late September. From then on although the crop was in the field for a month and a half, no insects were found on it. By mid August, the leaves of lower quarter were yellowish green and in the first week of September they were drying. Spraying is recommended in early July, and again, if found necessary in early August.

Salad bowl was heavily infested from early July to early August. It might have continued to harbour high populations, but

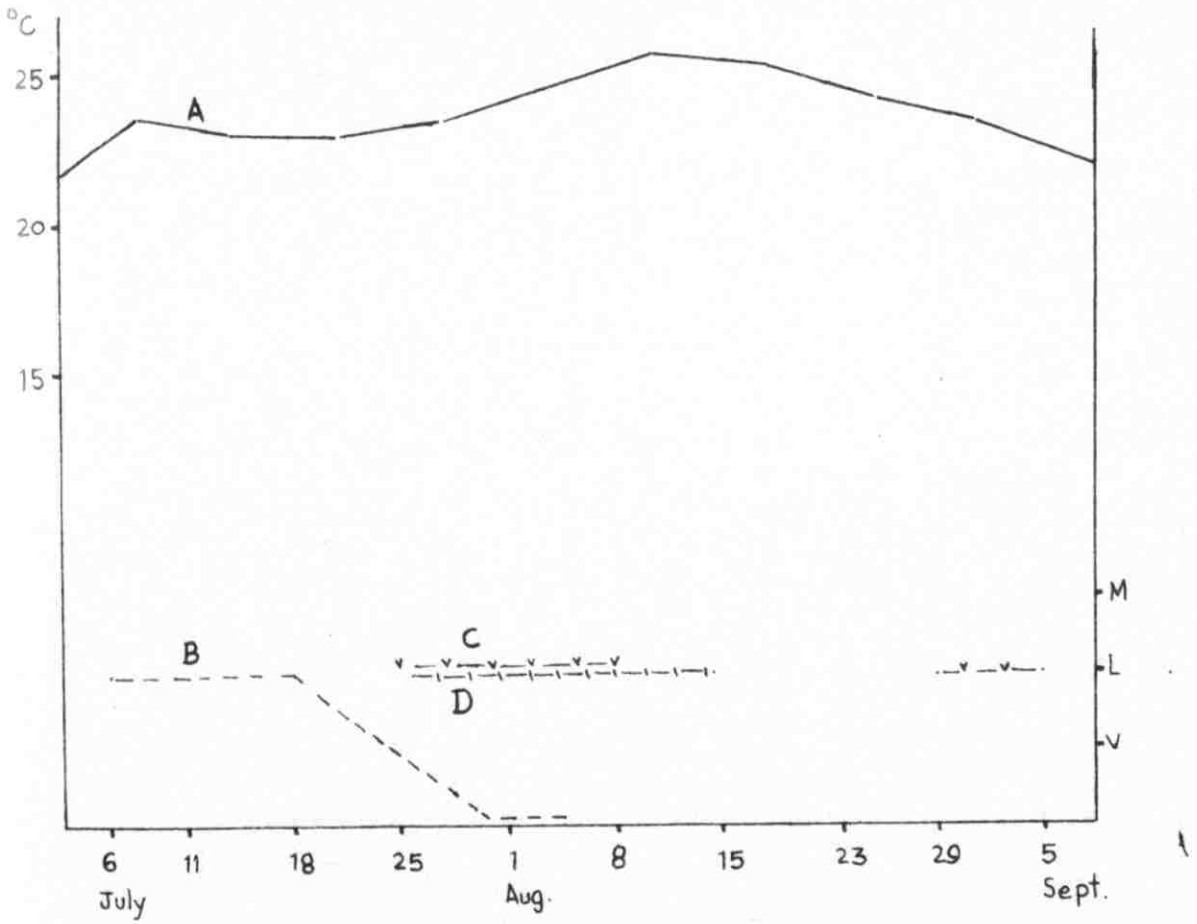


Fig. 7.-- Leafhopper intensity in relation to temperature. A.Temperature; B. on Anise; C. on Kale; D. on Summer savoy. V.Very light; L.Light; M.Medium.

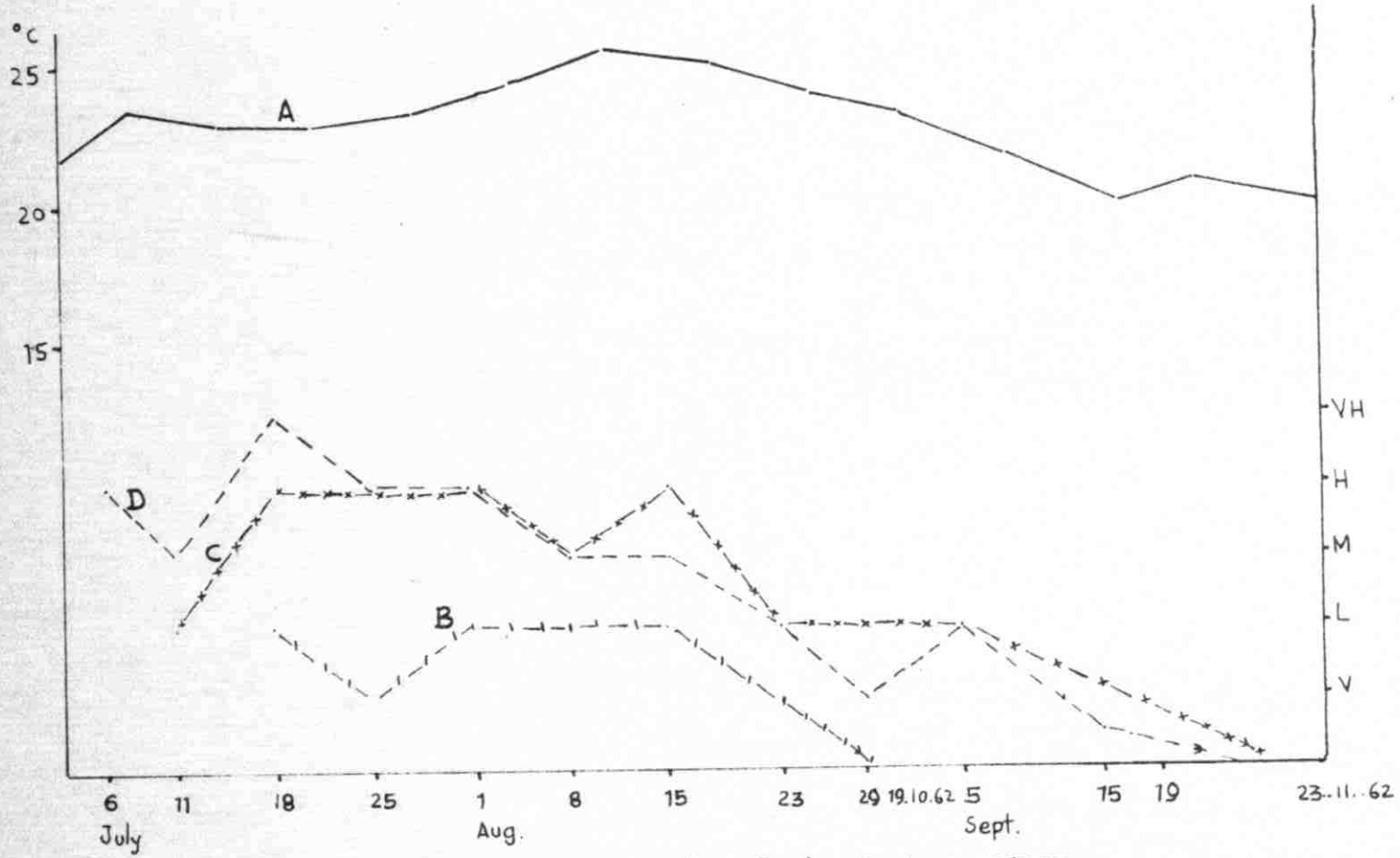


Fig. 8. — Leafhopper intensity in relation to temperature.
A.Temperature; B. on Borage; C. on Endive;
D. on Salad bowl. V.Very light; L.Light; M.Medium;
H.Heavy; VH.Very heavy.

for the early drying of the crop. The leaves started showing yellow color in the third week of July, and by mid August the lower half leaves were completely dead. The crop was without leaves by November 23. Two sprayings in late June and mid July are suggested.

10. Beans. Fig. 9 shows leafhopper infestation on beans from mid July to mid September. The population was high, as at no time the temperature was below 20°C. The nymphs were found at high level during the whole period of observations on beans. Their number dropped in early September due to heavy infestation of leaves by the red spiders at that time.

Spraying is suggested at an average infestation level of 2 nymphs per leaf, in early July and again, if found necessary in late July.

11. Chillies. Fig. 10 shows the leafhopper, E. fabae Harris populations on chillies. It was observed that with the fall in temperature below 20°C, the population level also decreased. However, the insects were present while the crop was in the field.

The nymphs were more abundant from late July to mid August. Later, the adults rose in numbers and remained all the time more numerous than the nymphs. Both adults and nymphs were observed in mid November, although a minimum temperature of 4°C had occured on the 9th and 10th of November.

Powdery mildew on leaves appeared in late September and covered both leaf surfaces by the first week of November.

Sprays against the leafhoppers on chillies are suggested in early and late August again, if found necessary, in late September, when an

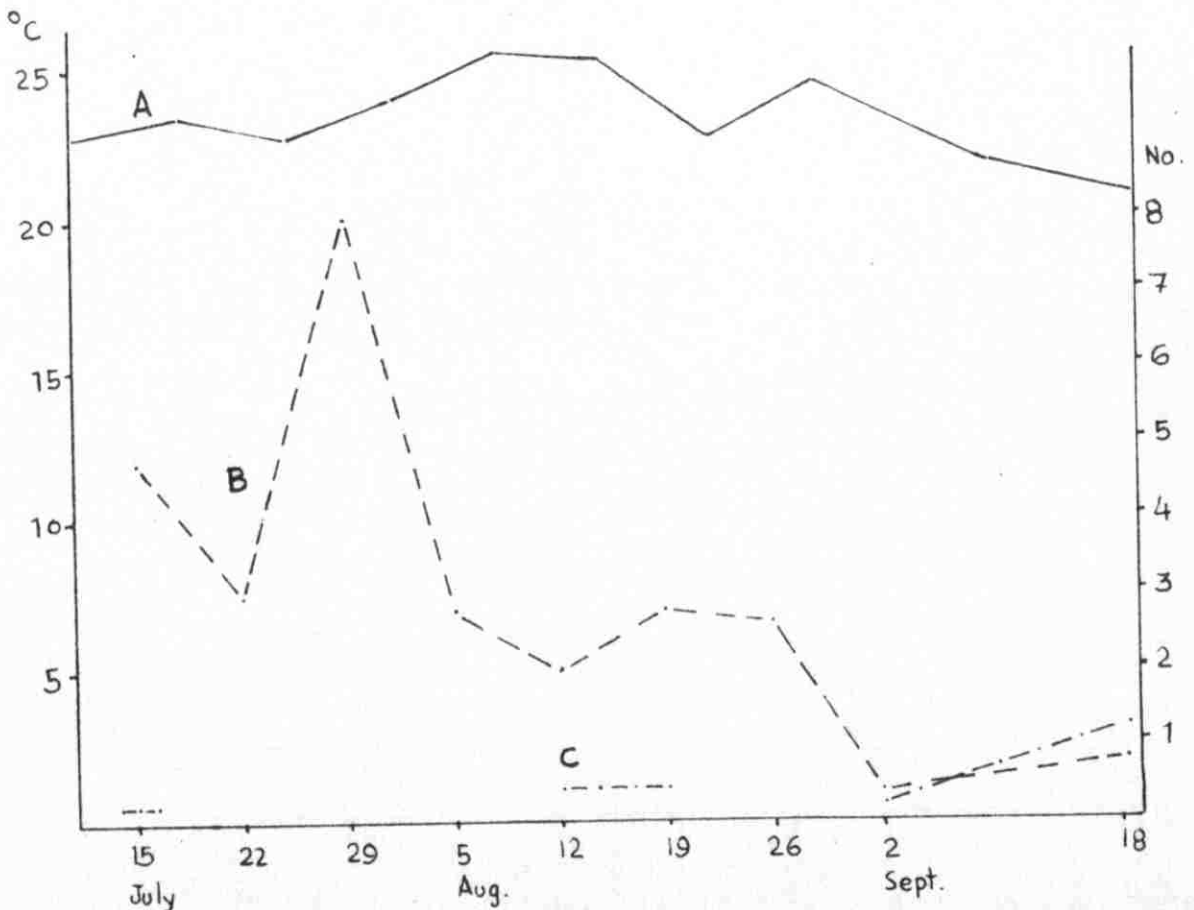
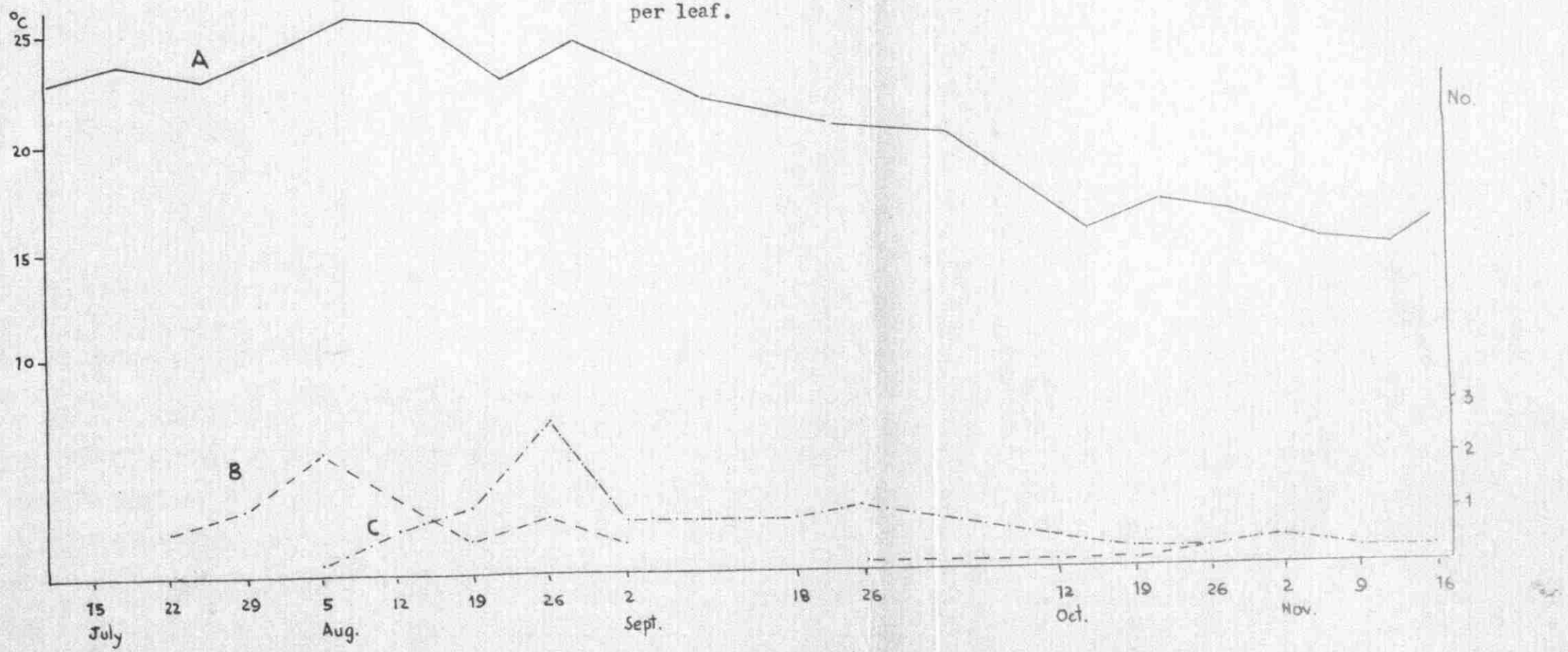


Fig. 9.— Leafhopper population on Beans in relation to temperature.
A.Temperature; B.Average No. of nymphs per leaf;
C.Average No. of adults per leaf.

Fig. 10.— Leafhopper population on Chillies in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.



average of 1 adult or 2 nymphs per leaf is observed.

12. Eggplant. Fig. 11 shows leafhopper population on eggplants from mid July to mid November. An apparent relationship between high insect population and temperature of 20°C and above is observed. With fall in temperature below 20°C in late September, the population was almost non-existent.

Nymphs were all the time more numerous than the adults during the high (20°C+) temperature period. The number of adults fluctuated during this period, but appeared more regularly in early November. The leaves began to become yellow in mid October and dropped in early November.

Two sprays, each in mid July and mid August, are recommended, when an average of 2 adults or 4 nymphs per leaf is observed.

13. Lettuce. Fig. 12 shows the progressive increase in leafhopper population on lettuce in the month of July. The crop was harvested after July 29. Since there were no fluctuations in the temperature, the insects were recorded to increase at a rapid rate. Nymphs were all the time more in numbers than the adults, except in the beginning. The adults were seen in mid July only.

The lower leaves were pale green and black spotted due to the leafhopper feeding. Light attacks of aphids and thrips were also observed.

Spraying the crop against the insects is suggested in early July, when an average of 3 adults or 6 nymphs per leaf is recorded.

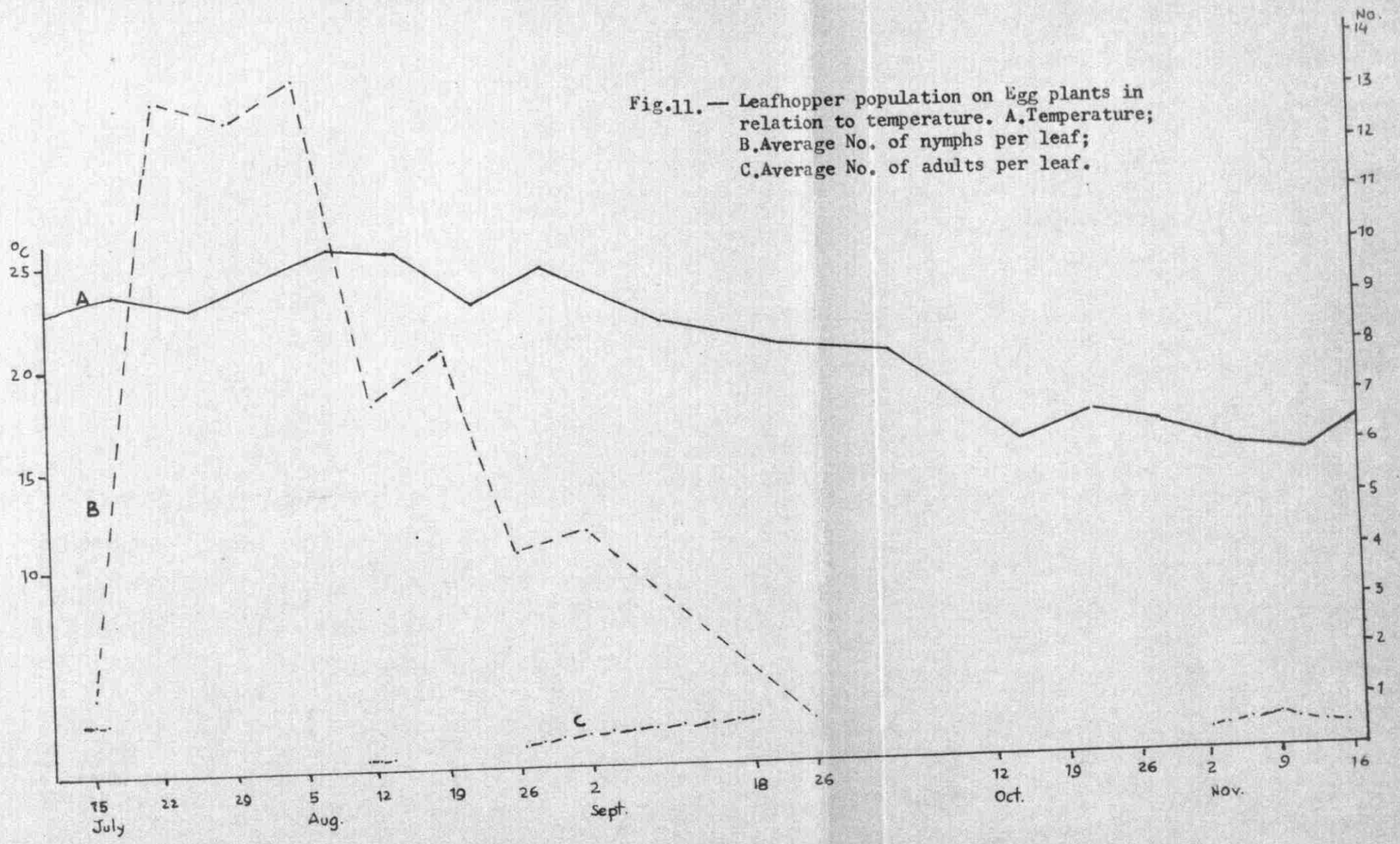


Fig.11.— Leafhopper population on Egg plants in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

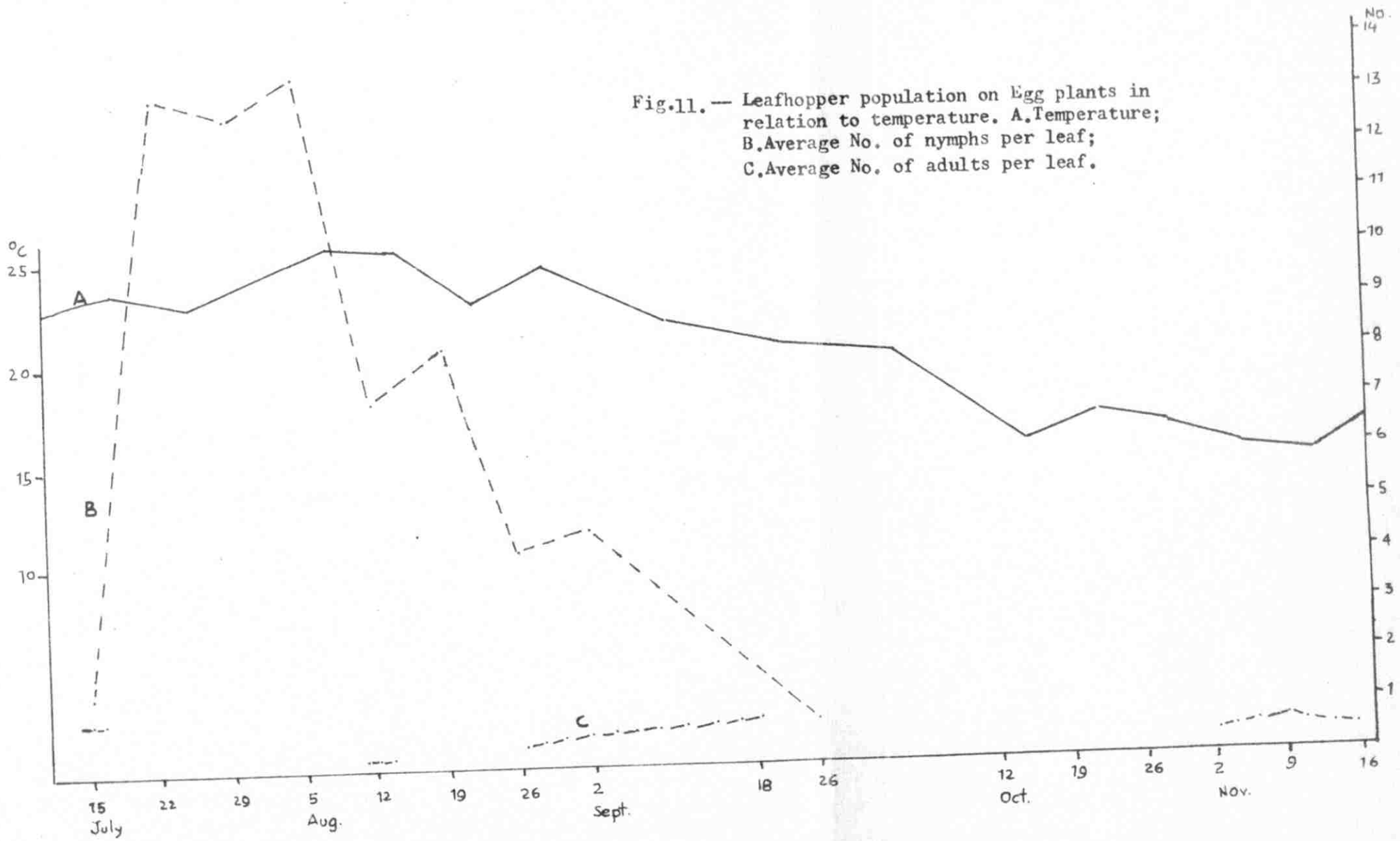


Fig.11. — Leafhopper population on Egg plants in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

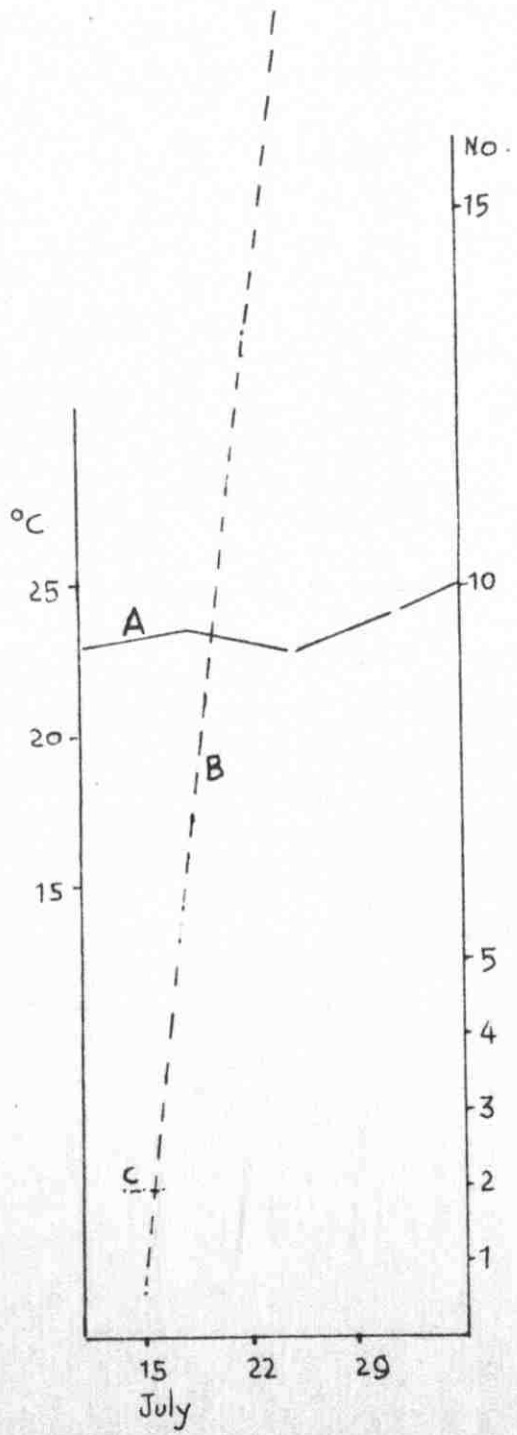


Fig. 12 — Leafhopper population on Lettuce in relation to temperature.
A.Temperature; B.Average No. of nymphs per leaf;
C.Average No. of adults per leaf.

14. Okra. Fig. 13 shows okra infestation by the leafhoppers. The insects were observed more when the temperature was 20°C and above. The population fell with decline in temperature below 20°C.

Throughout the period of survey the nymphs were found more than the adults, and were absent in the first fortnight of September. The low population of adults was continuously observed from mid August to mid October.

Powdery mildew on okra was first observed on 22nd of July, and by the third week of October, it covered both surfaces of the leaves. Many leaves began to drop at that time. The crop was also attacked by aphids and thrips; these will be dealt with later.

The crop was sprayed twice against insects and the diseases on 3rd of August and 25th of Septemb er. The leafhopper population was seen lowered on the 5th of August, but again increased in the following week. The second spray was against aphids only.

Spraying against the leafhoppers is suggested when an average population of 1 adult or 2 nymphs per leaf is observed. Sprays in late July and mid August are advised.

15. Sugar beets (Experimental plots). Fig. 5a shows the leafhopper population on sugar beets from late July to mid January 1963. The insects were found to exist all the time the crop was in the field, even though a minimum temperature of -0.2°C was recorded in December.

The nymphs were more than the adultsin number, during the period the temperature was 20°C and above. After mid September their number decreased. The adults increased from late August and were continuously

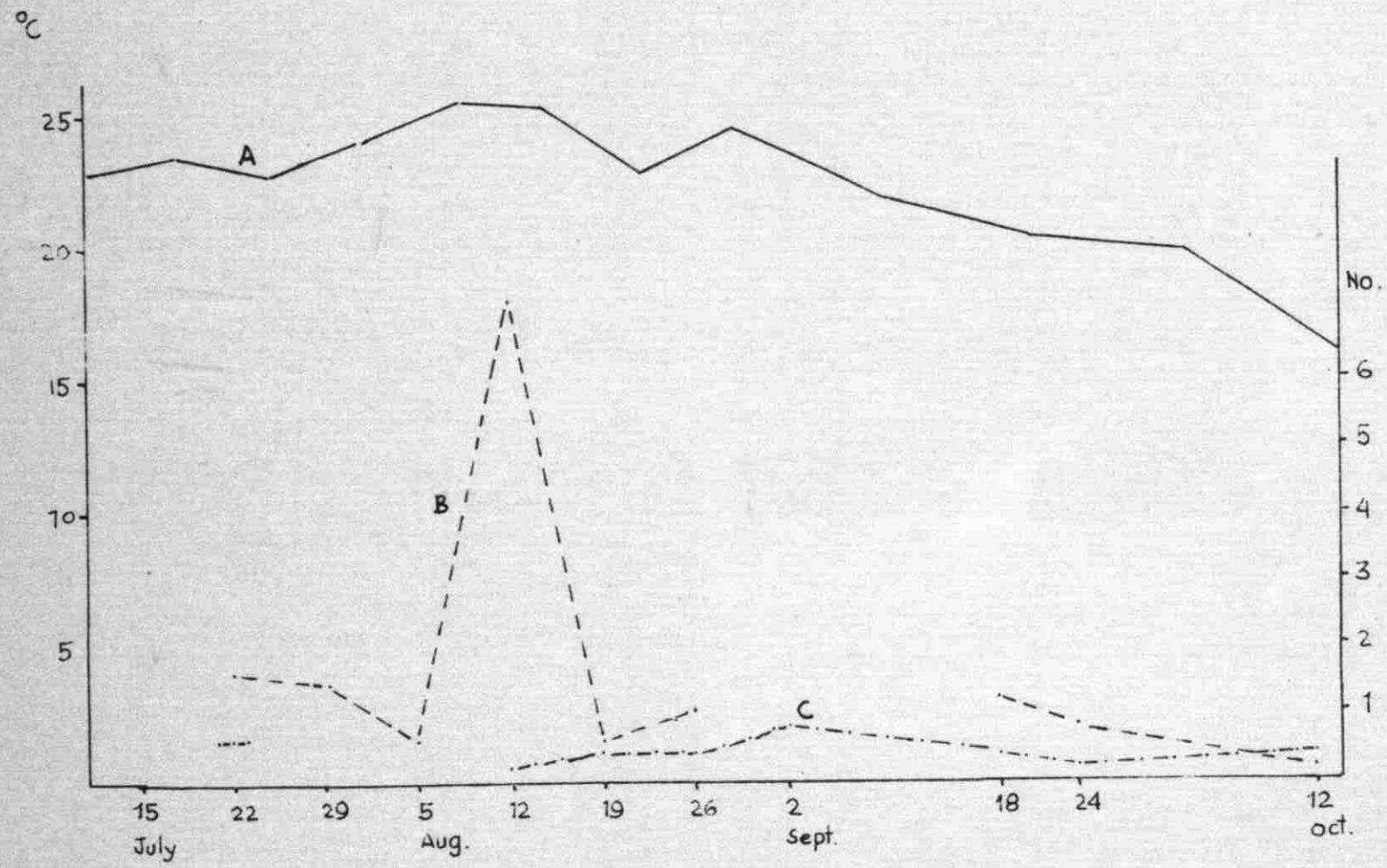


Fig.13.-- Leafhopper population on Okra in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Ave--rage No. of adults per leaf.

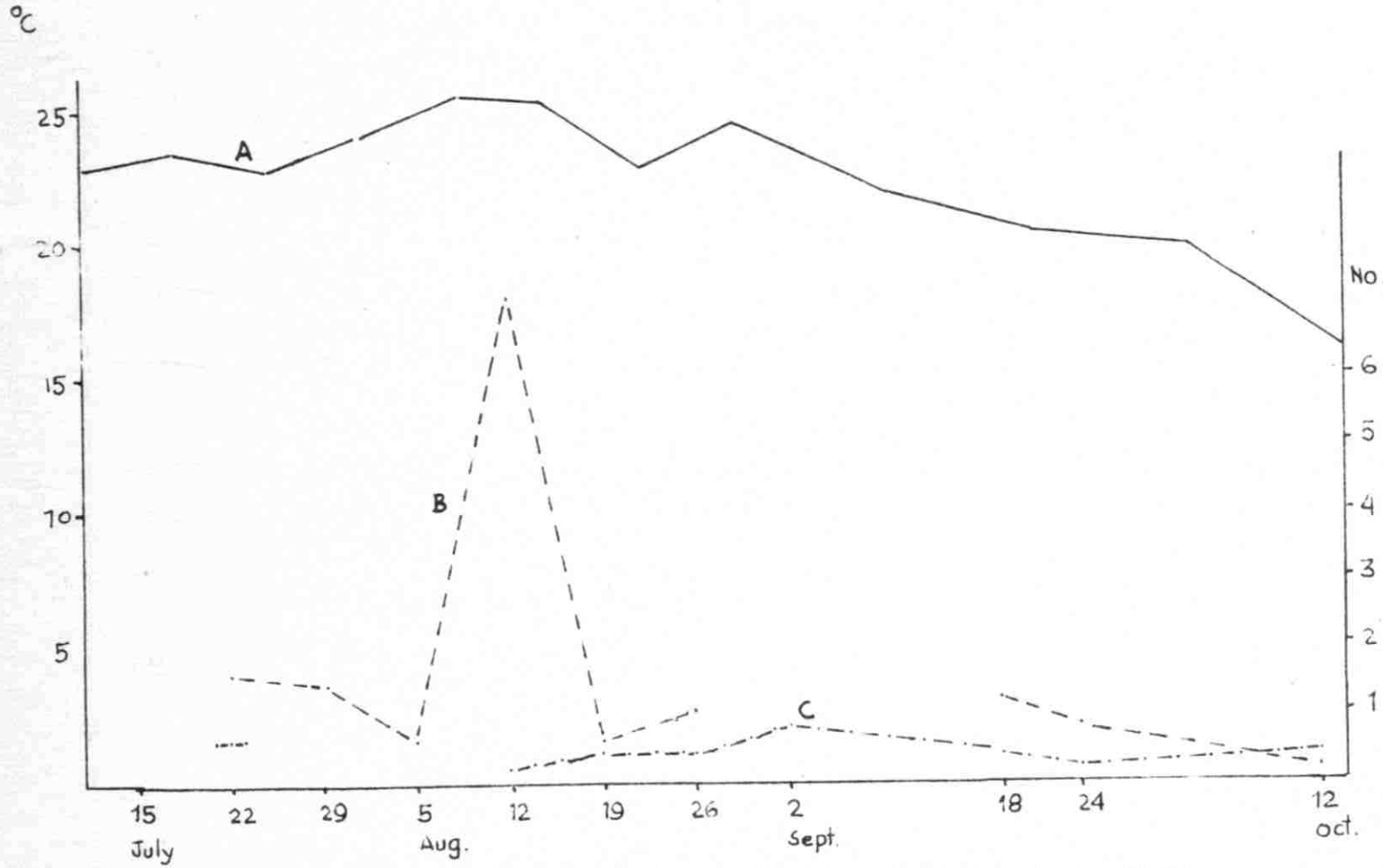


Fig.13.-- Leafhopper population on Okra in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Ave--rage No. of adults per leaf.

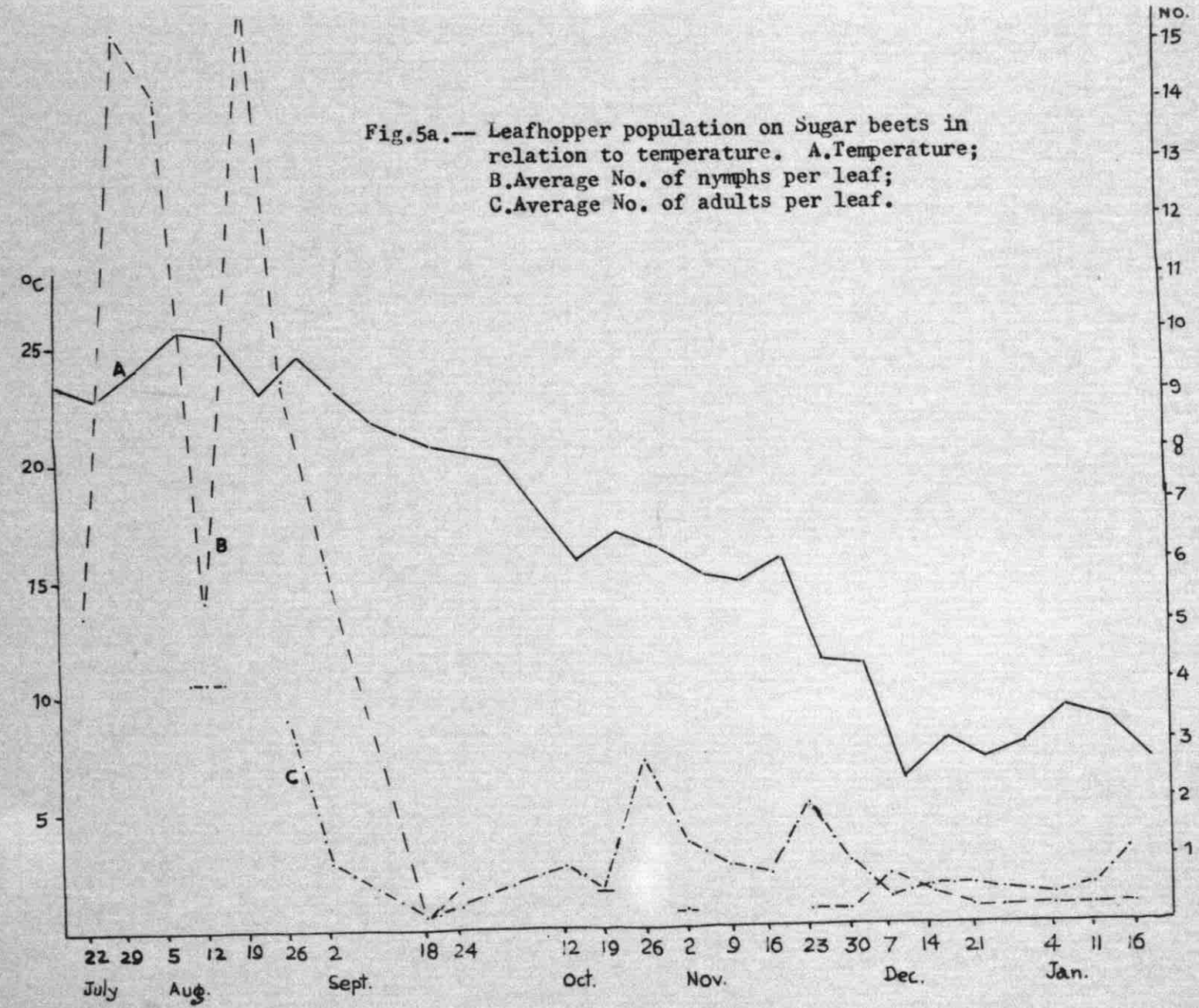


Fig.5a.— Leafhopper population on Sugar beets in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

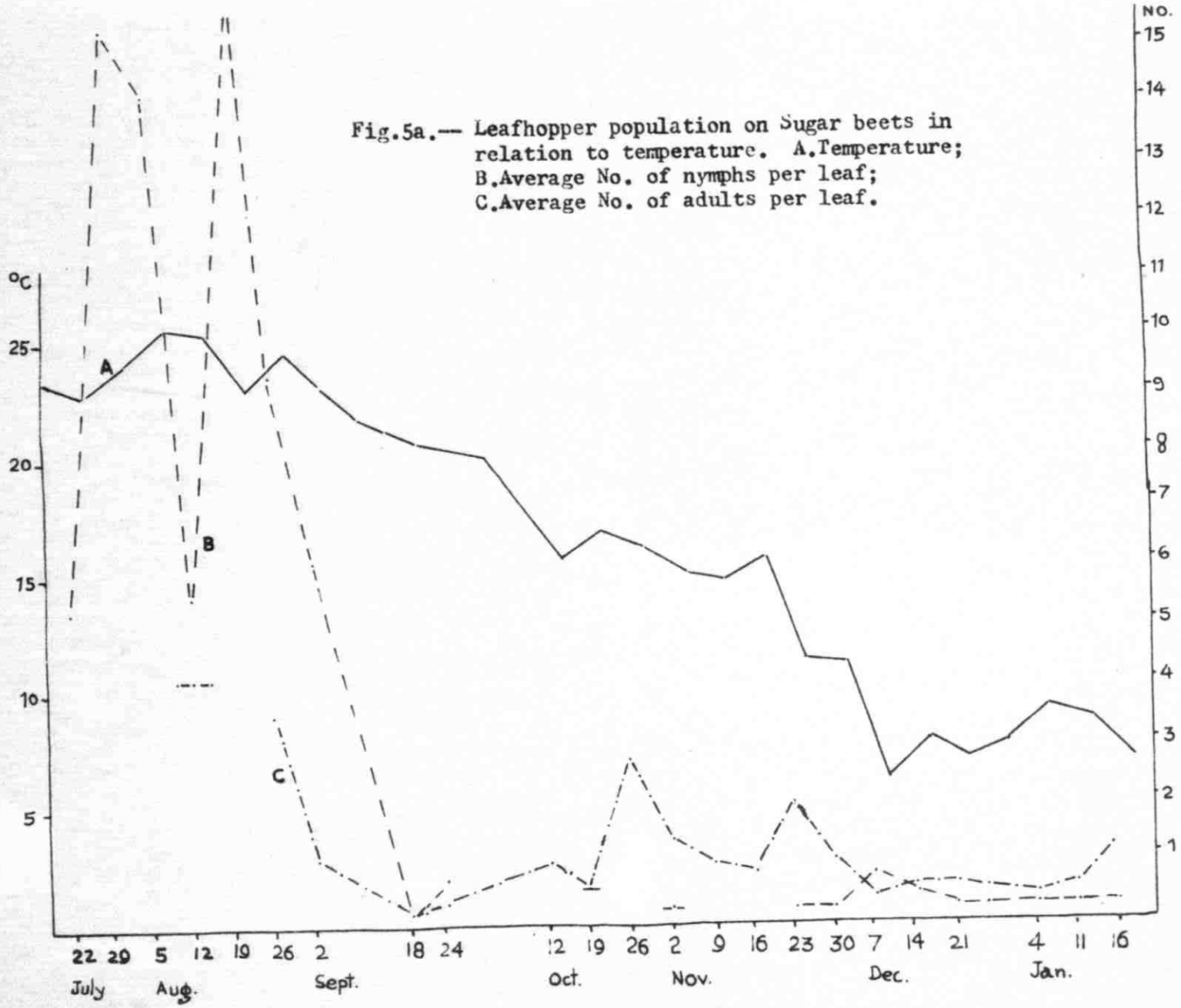


Fig.5a.— Leafhopper population on Sugar beets in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

present till the crop was harvested, also, they were constantly more abundant than the nymphs during this period.

The crop was sprayed on the 15th of September and the population level was temporarily lowered.

Spraying is recommended when an average of 4 nymphs per leaf is found in mid July and early August. One spray in late August, if found necessary, is also advised. These sprays are supposed sufficient to keep down the adult population in October and November.

16. Tomatoes. Fig. 14 shows the leafhopper, E. fabae Harris, infestation of tomatoes. The unit of observation was a single leaflet. The insects were found abundantly in the field, while the temperature was 20°C and above. Low populations were observed upto mid November, even though a minimum temperature of 4°C had occured on the 9th and 10th of November.

The nymphal population was seen higher than the adults upto the middle of September, when the adult population rose slightly high and remained so till the harvest of the crop. The slight fluctuations in the nymphal population, suggest the completion of at least three generations during the period of survey.

The yellowing and drooping of the leaves was apparent in early July, and the same were thick and bronze colored by early August.

The spraying of the crop against leafhoppers is recommended, when there is an average of one-half adults or one nymph per leaflet. It is suggested to spray in late June, early August and early September, so as to keep the population at low level for the rest of the period.

Fig.14.— Leafhopper population on Tomato in relation to temperature.
A.Temperature; B.Average No. of nymphs per leaflet;
C.Average No. of adults per leaflet.

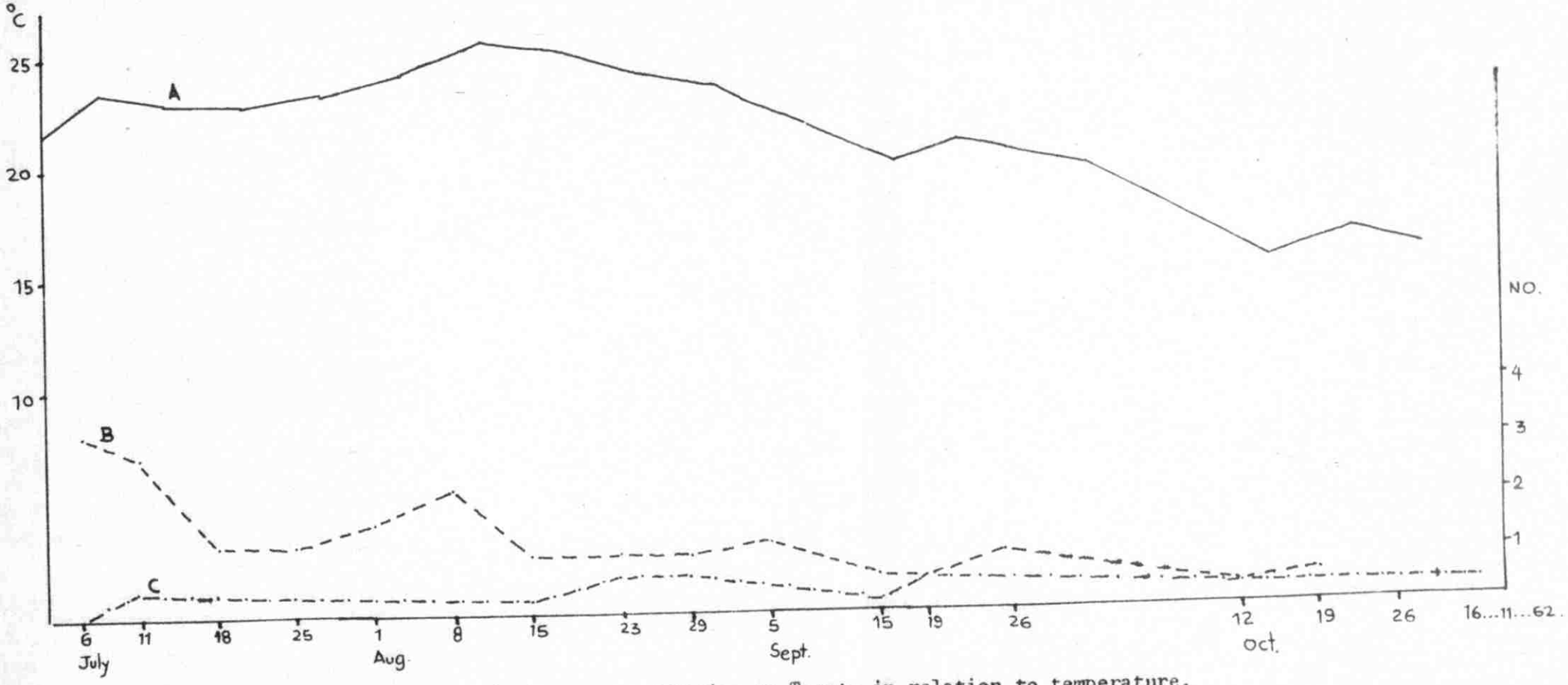


Fig.14.— Leafhopper population on Tomato in relation to temperature.
A.Temperature; B.Average No. of nymphs per leaflet;
C.Average No. of adults per leaflet.

17. Watermelon. Fig. 15 shows the leafhopper population on watermelons from the last quarter of July to late September. A decline in population was observed, when the temperature fell below 22.5°C.

The nymph population was at high level during the whole period of observation. The adult population was found present from mid to late August only.

The crop was in the field up to the first week of November, but no insects were observed from mid October on. The fall in population from early to mid September may be due to drying and bronzing of the leaves. Also the crop was mature and without irrigation for a long time.

Spraying is recommended in late July and mid August, when an average of 1 adult or 2 nymphs per leaf is observed.

Discussion:

The results of leafhopper survey on various vegetable crops from early July 1962 to mid January 1963, revealed that the insects can survive under wide ranges of temperature. The maximum and minimum air temperatures recorded during the period of survey were 37.4°C in August and -0.2°C in December respectively. The insects were found more active at air temperatures of 20°C and above. This temperature is close to that reported by DeLong (14).

The leafhoppers were also found to complete their life cycle in short periods between an average of 13.3-32.6°C in the months of July, August and September. These findings are also very close to those of Talhouk (43). At lower temperatures, the number of days required for

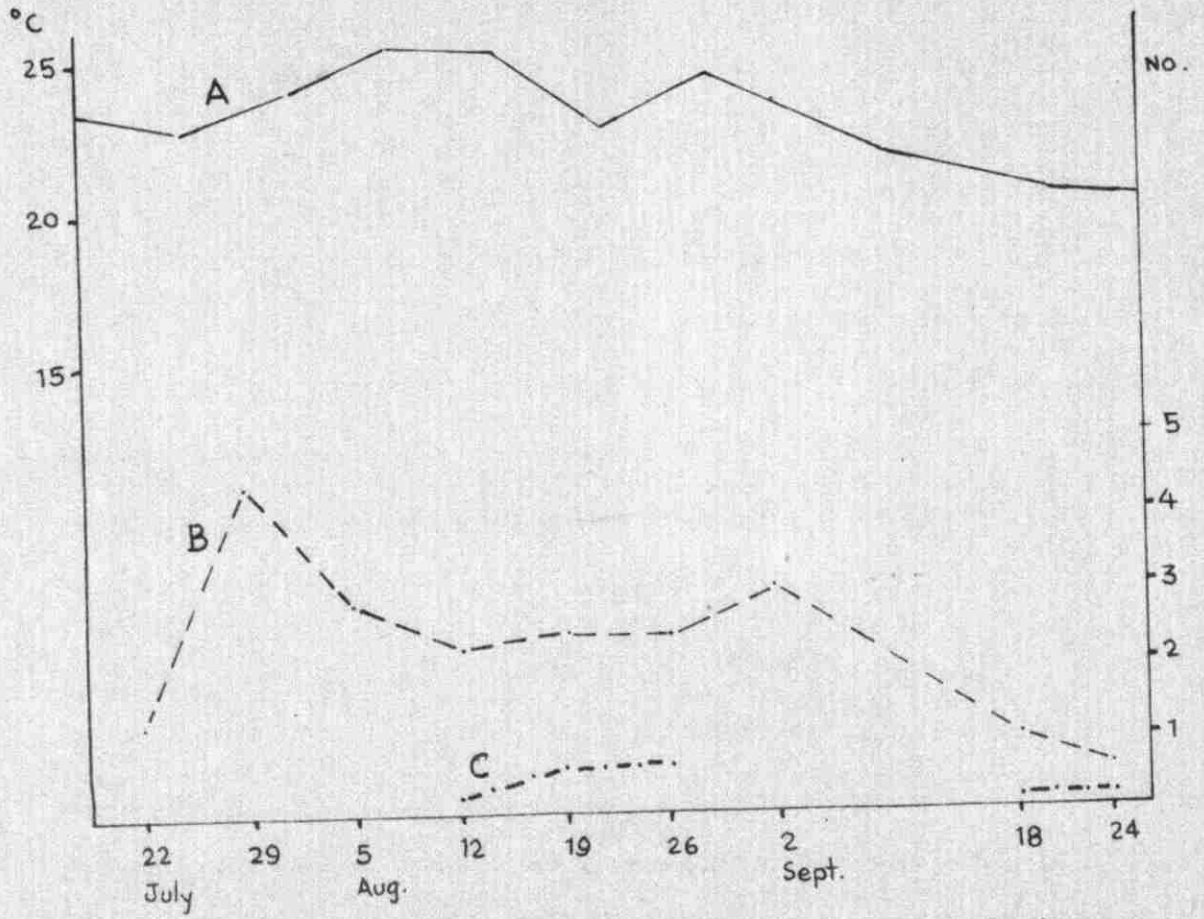


Fig.15.— Leafhopper population on Water melons in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

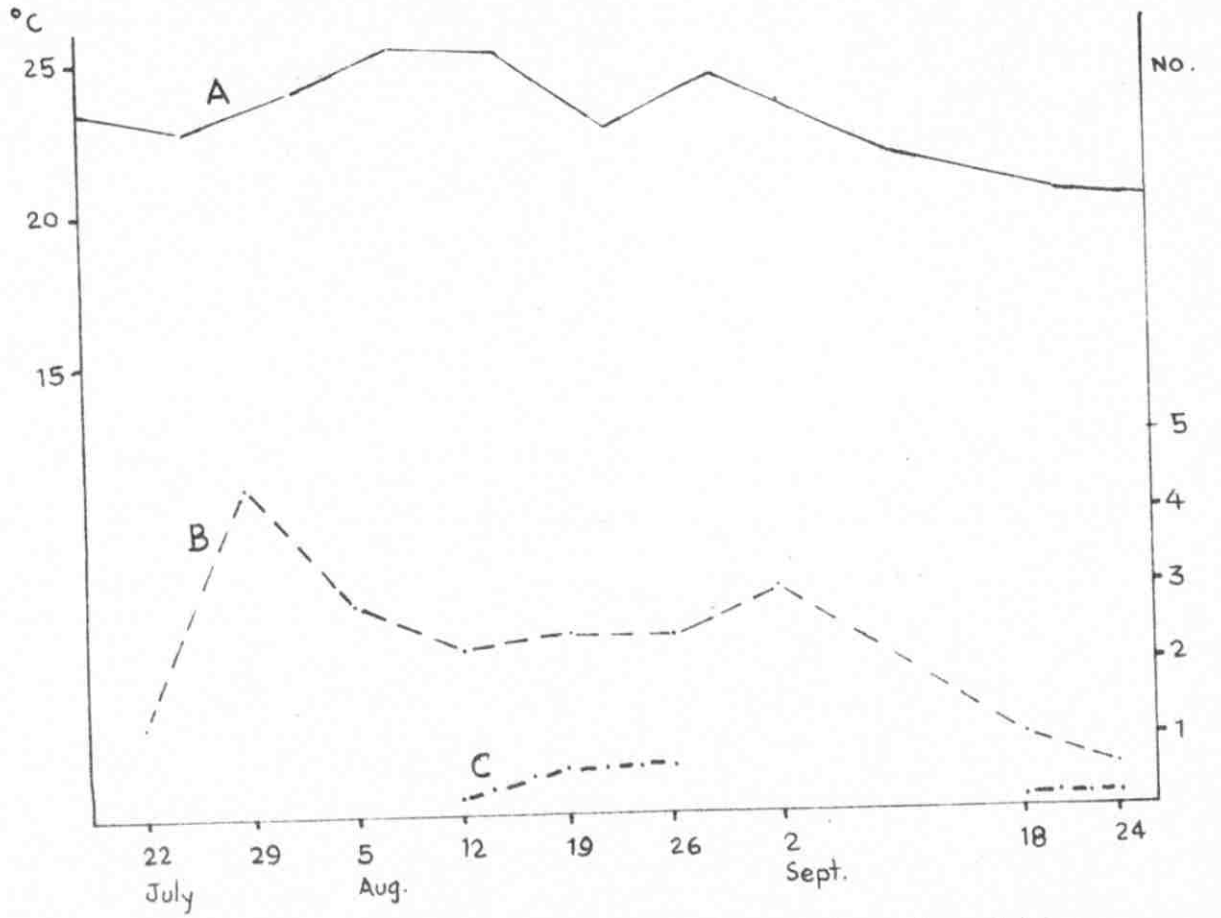


Fig.15.— Leafhopper population on Water melons in relation to temperature. A.Temperature; B.Average No. of nymphs per leaf; C.Average No. of adults per leaf.

complete development increased, while the number of individuals decreased.

The nymphs were found at high level of infestation, when the temperature was 20°C and above. Later, adults were found more in numbers than the nymphs in cool temperatures.

The leaf was determined as a better unit of measurement (2), as this was the actual part damaged. Sweeping was discarded as it is obvious that only the adults would be caught by this method (1).

The level of insect infestation which required spraying was determined on the basis of leaf area, the maximum number of insects found on a leaf, the field observations and the conditions of the crop as affected by the insects. The chemicals for control measures should be chosen according to the latest information on pesticides.

B. Aphids

18. Borage, kale, salad bowl and salsify. Fig. 16 shows the intensity of aphid infestations qualitatively recorded on the mentioned crops. It is observed that the aphids were present from early July to late November. However, "medium" intensity was seen at temperature 16°C and below.

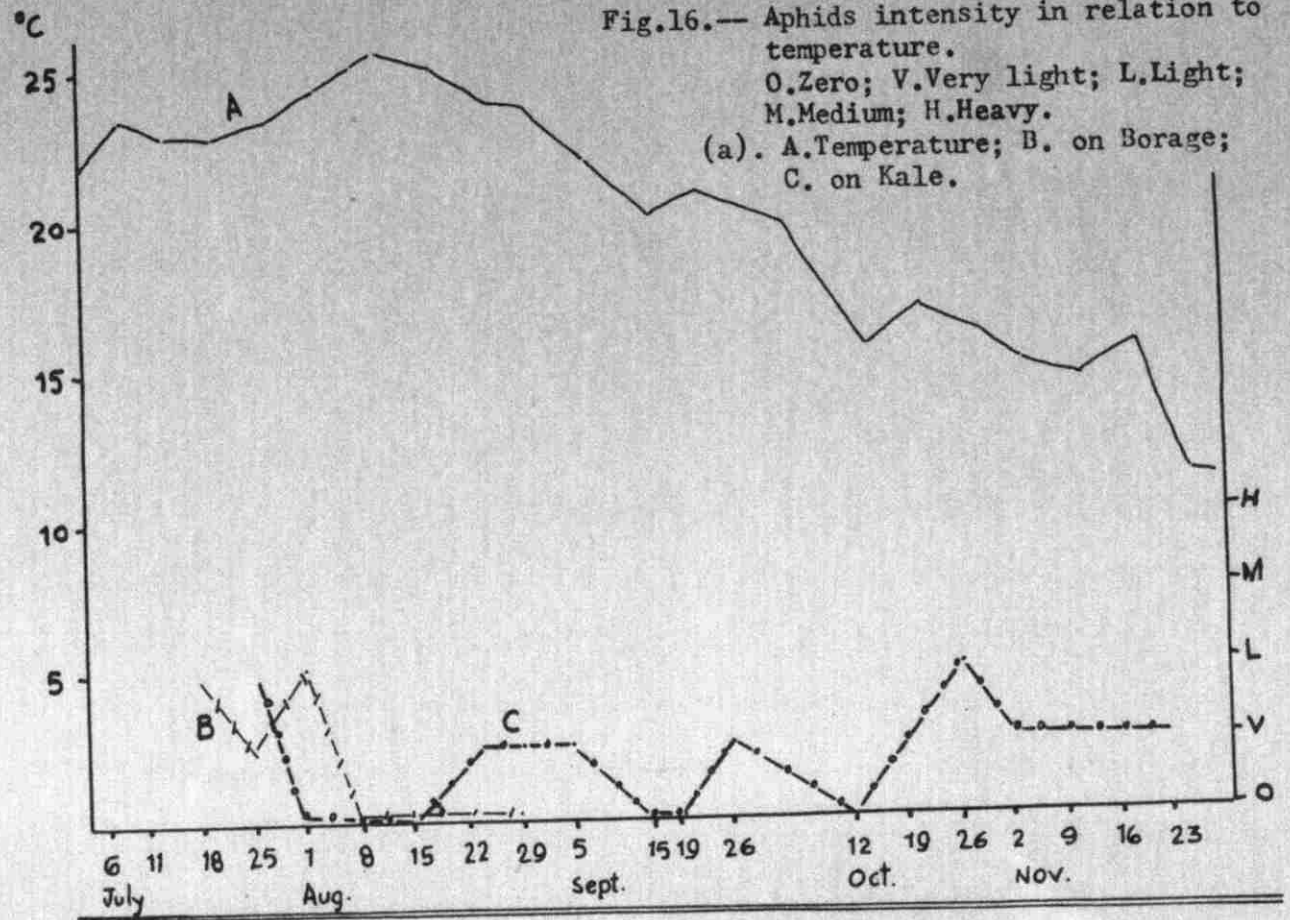
Borage was "lightly" infested in the second fortnight of July only. No spraying is advised against aphids on borage.

Kale also remained "lightly" attacked throughout the season, hence no spraying is suggested.

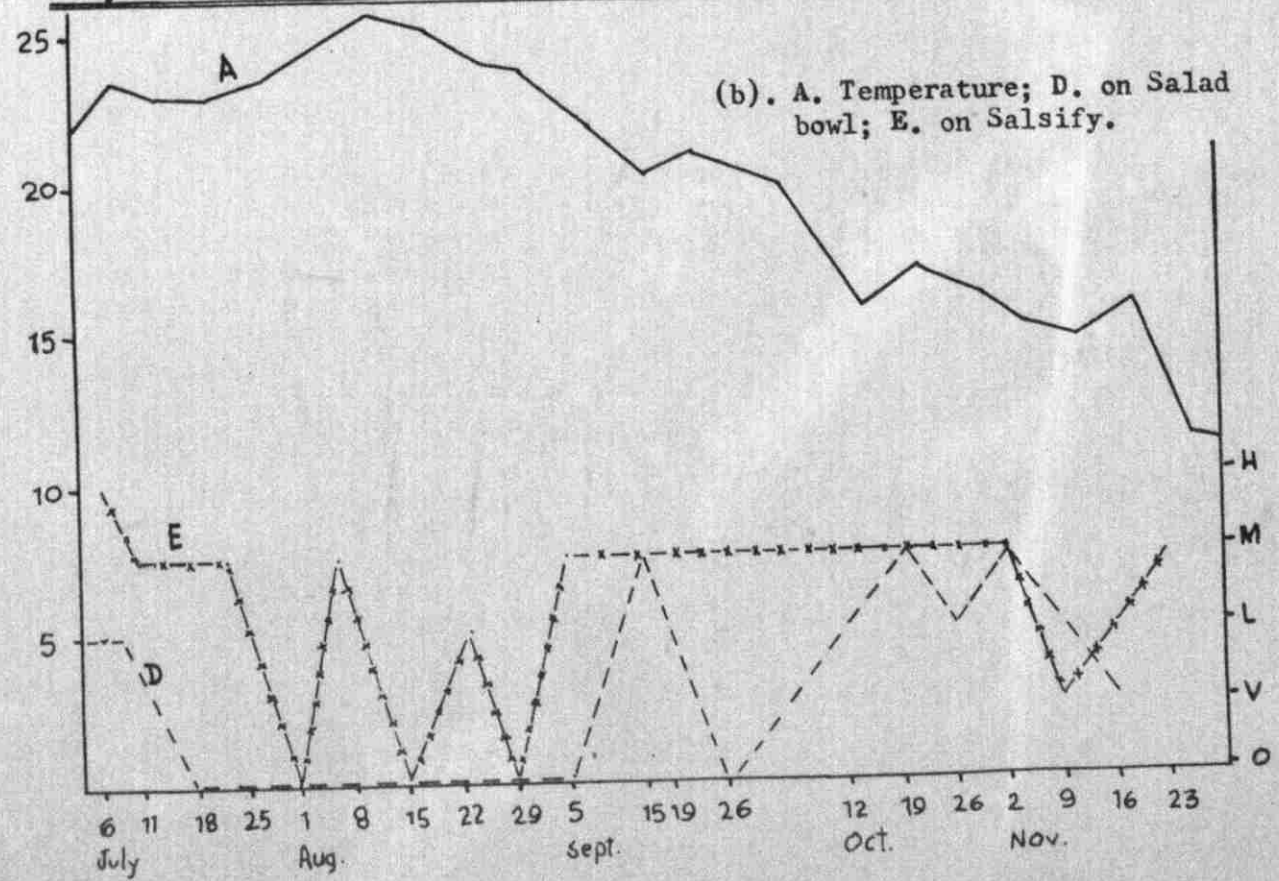
Salad bowl was observed with "medium" infestation from mid October to early November. One spraying in mid October is advised.

Salsify remained under "medium" attack throughout its period of growth, except in the last three weeks of August. The crop was

Fig.16.— Aphids intensity in relation to temperature.
O.Zero; V.Very light; L.Light; M.Medium; H.Heavy.
(a). A.Temperature; B. on Borage; C. on Kale.



(b). A. Temperature; D. on Salad bowl; E. on Salsify.



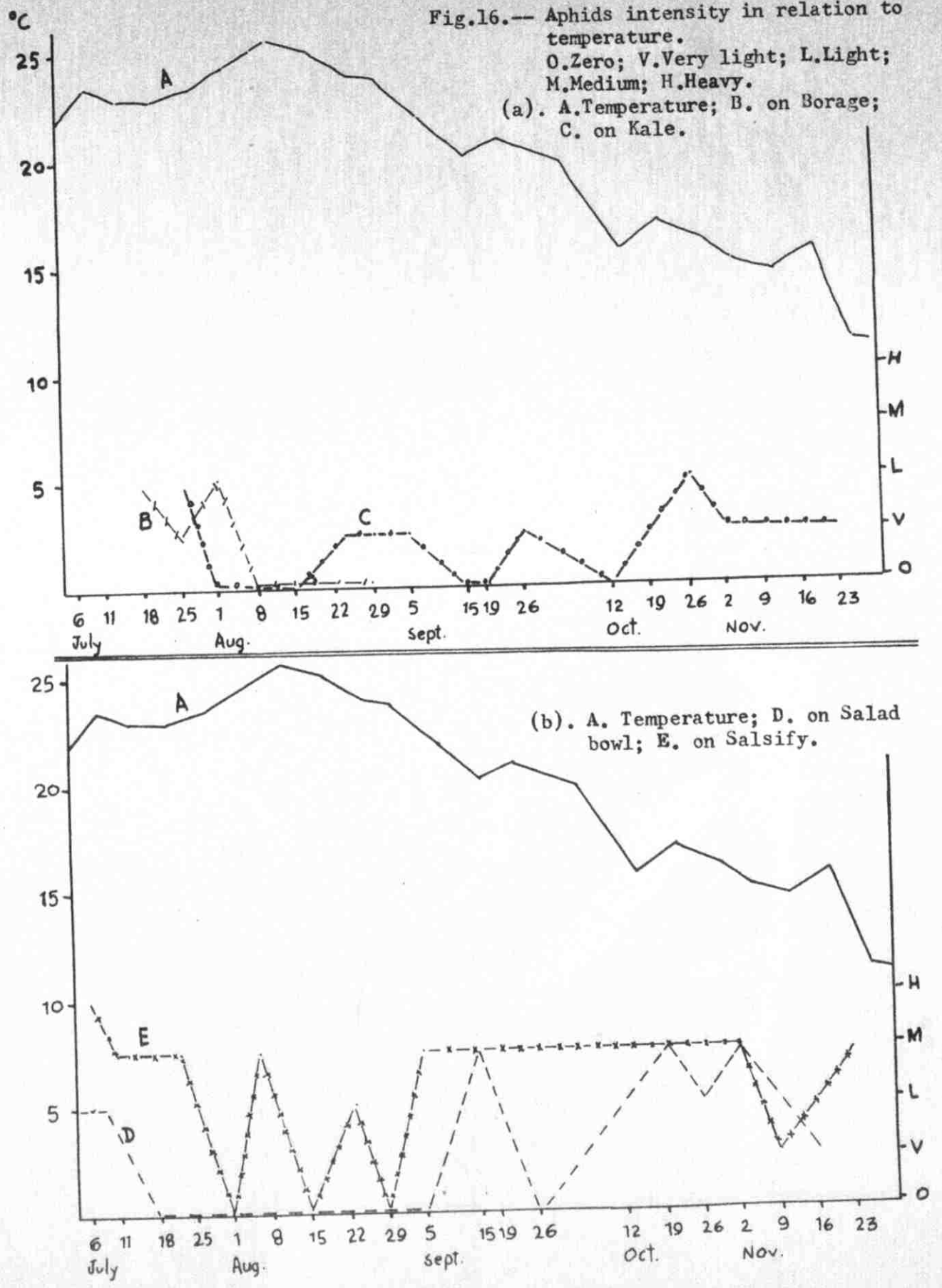


Fig.16.-- Aphids intensity in relation to temperature.
O.Zero; V.Very light; L.Light; M.Medium; H.Heavy.
(a). A.Temperature; B. on Borage; C. on Kale.

(b). A. Temperature; D. on Salad bowl; E. on Salsify.

also attacked by powdery mildew in the last week of July and covered by the same in late August. In mid October all the lower half leaves were dead and powdery mildew was again evident.

Spraying against aphids on salsify is recommended in the first weeks of July and August; in October, if the infestation is at "medium" level.

19. Brussels sprouts, cabbage, collards and kohlrabi, Fig. 17 shows the intensity of the aphid, Brevicoryne brassicae L., on the vegetable crops of the Brassica spp. The aphids were seen throughout the season the crops were in the field.

Brussels sprouts were seen "lightly" attacked in late July and mid September. As of mid October, the intensity increased from "light" to "medium" and to "high" in mid November. During the later period, the temperature was around 15°C or less.

Spraying at "medium" level is recommended in mid October and early November.

Cabbage in the Student plots was the preferred host of the aphid in July and mid September. Later the population was low, even under favourable temperature, because very few plants were left in the field and the crop condition was poor. Spraying in mid July and mid September is suggested at "medium" level of infestation.

Collards were "lightly" infested in the season. No treatment for them is advised.

Kohlrabi also remained "lightly" infested, hence no spray is recommended.

It may be noted that there were 10-15 plants of each vegetable, except cabbages.

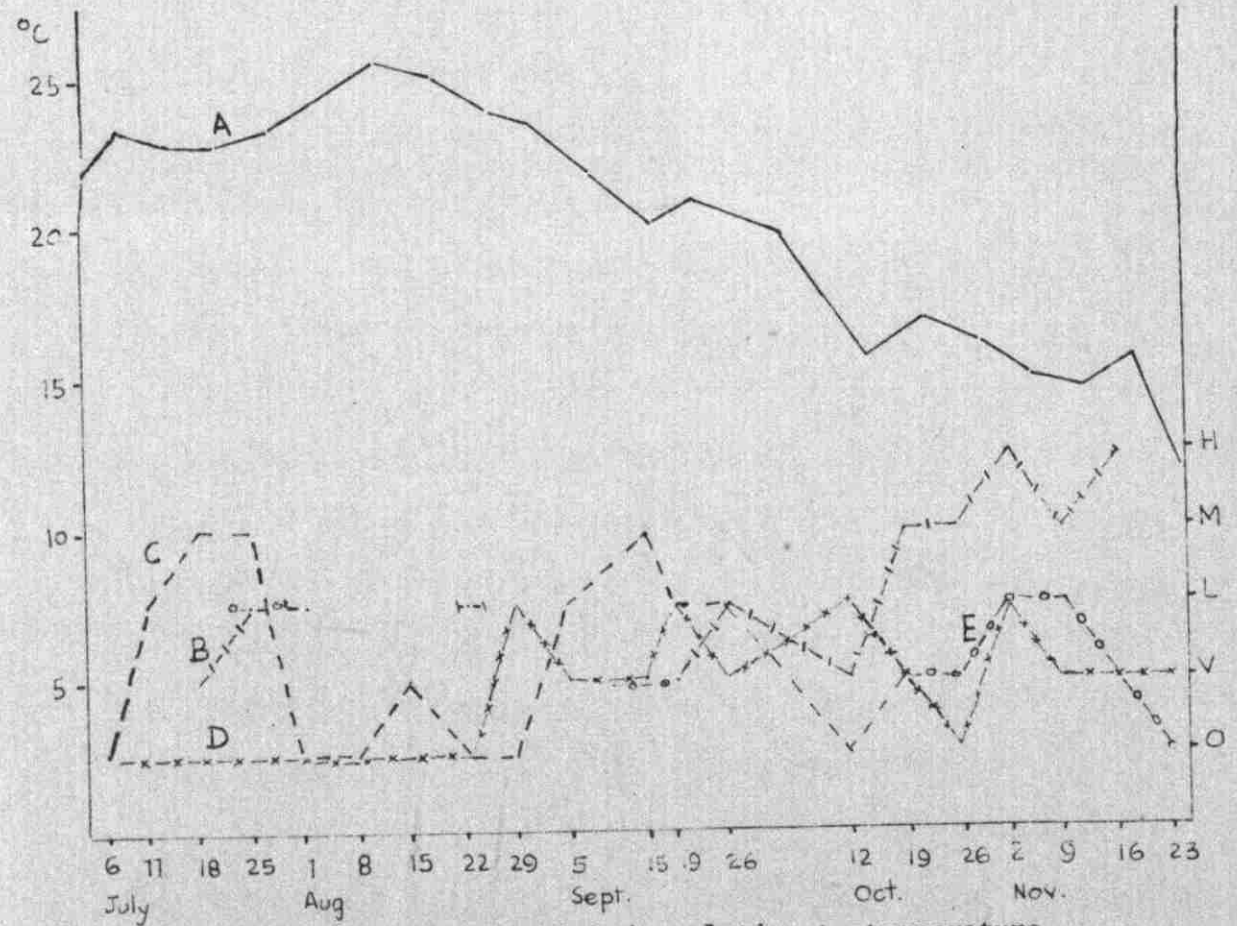


Fig.17.-- Aphids intensity in relation to temperature.
A.Temperature; B. on Brussels sprouts;
C. on Cabbage; D. on Collards; E. on
Kohlrabi. O.Zero; V.Very light; L.Light;
M.Medium; H.Heavy.

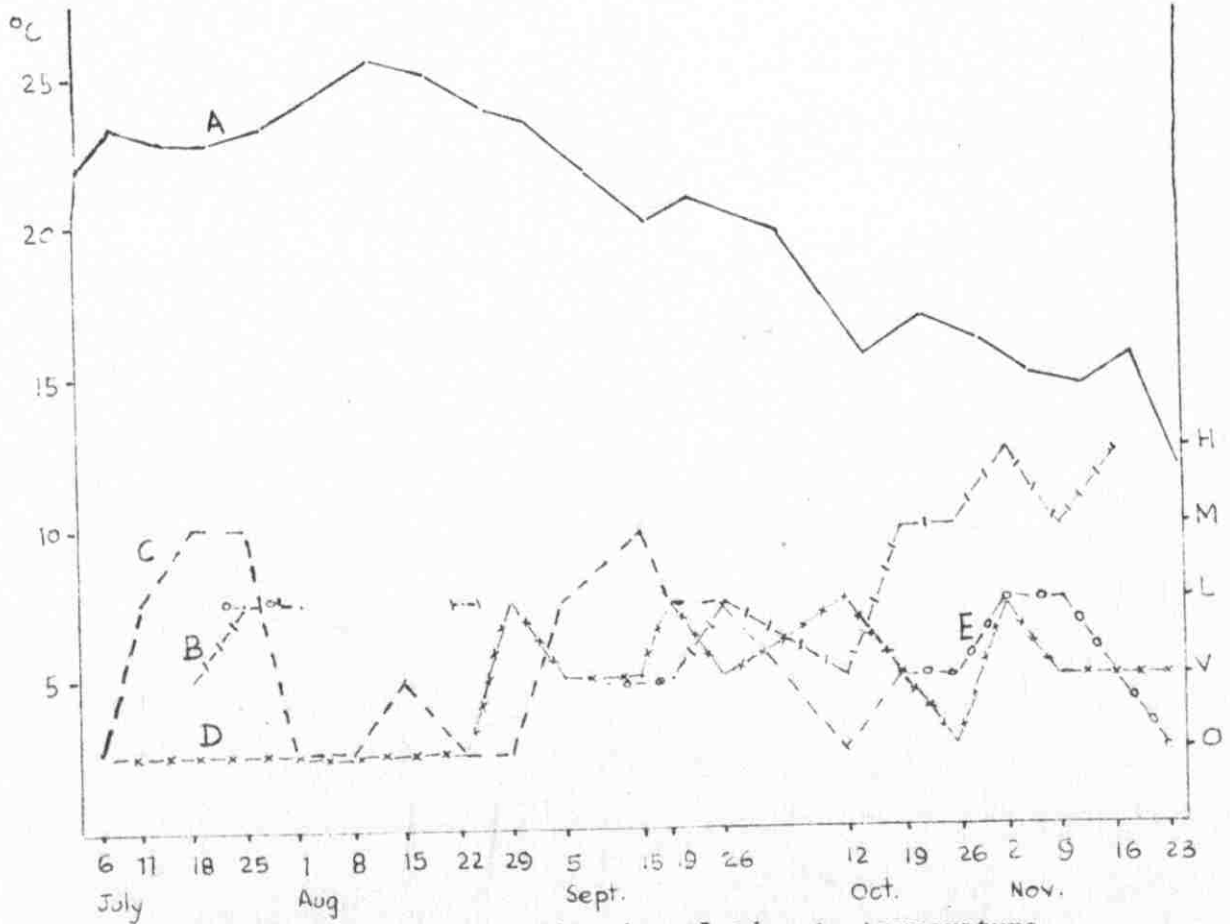


Fig.17.— Aphids intensity in relation to temperature.
A.Temperature; B. on Brussels sprouts;
C. on Cabbage; D. on Collards; E. on
Kohlrabi. O.Zero; V.Very light; L.Light;
M.Medium; H.Heavy.

20. Okra. Fig. 18 shows aphid infestation on the okra. The aphid, Aphis gossypii Glov., was "very light" in the early summer months, but increased in late August with decline of temperature from 24°C. It remained "medium" in September, then fell due to spraying on September 25. Later, heavy attack of powdery mildew in October and November kept the population at low level of infestation.

Spraying of the crop is suggested at "medium" level of infestation in early September, and later if required.

21. Cabbage (Experimental plots). Fig. 19 shows aphid infestation on cabbage sown in early August. It is seen that while the temperature was above 20°C, the intensity was "light". "Medium" and "high" intensities occured only when the temperature was 16°C or less. The insects were present in the field even though a minimum temperature of 0°C was recorded in November and December.

The crop was first sprayed on September 4 against the aphids and the observation on 18th of September showed a "light" infestation after a long interval. The crop was again sprayed on October 25, but the observation on 26th of October still showed "high" intensity, which might be due to a mistake in counting both the live and dead insects. However, in the week that followed it was again recorded as "high". The crop was sprayed for the third time on November 13 and the observation on 16th of November was recorded as "light", showing the effect of the insecticide. Later, in December, the population again increased to "medium" level. This shows that more spray applications are required.

Spraying is recommended at 15 days' interval from mid September to mid December at "medium" levels.

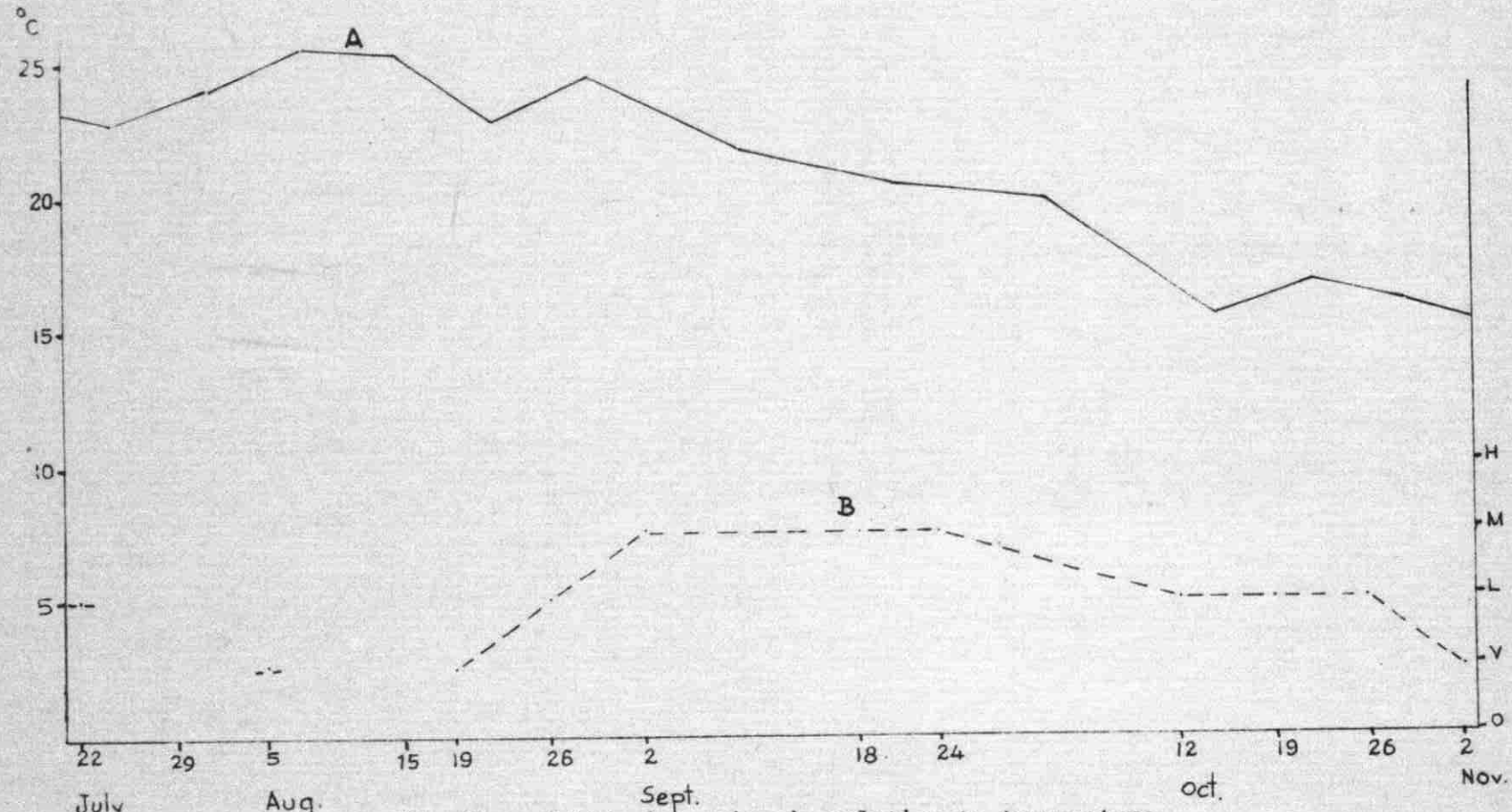


Fig.18.— Aphids intensity in relation to temperature.
A.Temperature; B. on Okra. O.Zero;
V.Very light; L.Light; M.Medium; H.Heavy.

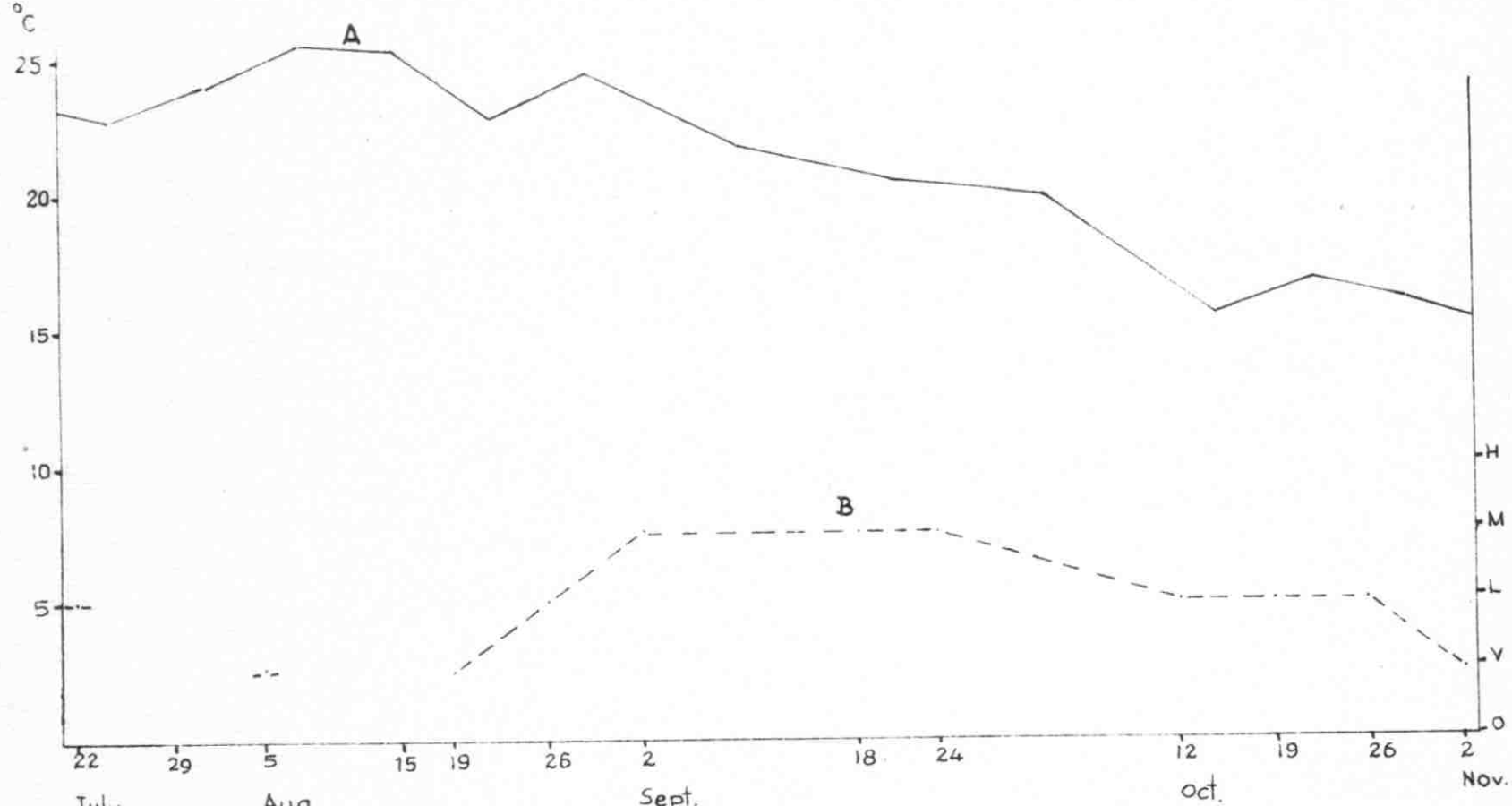


Fig.18.— Aphids intensity in relation to temperature.
A.Temperature; B. on Okra. O.Zero;
V.Very light; L.Light; M.Medium; H.Heavy.

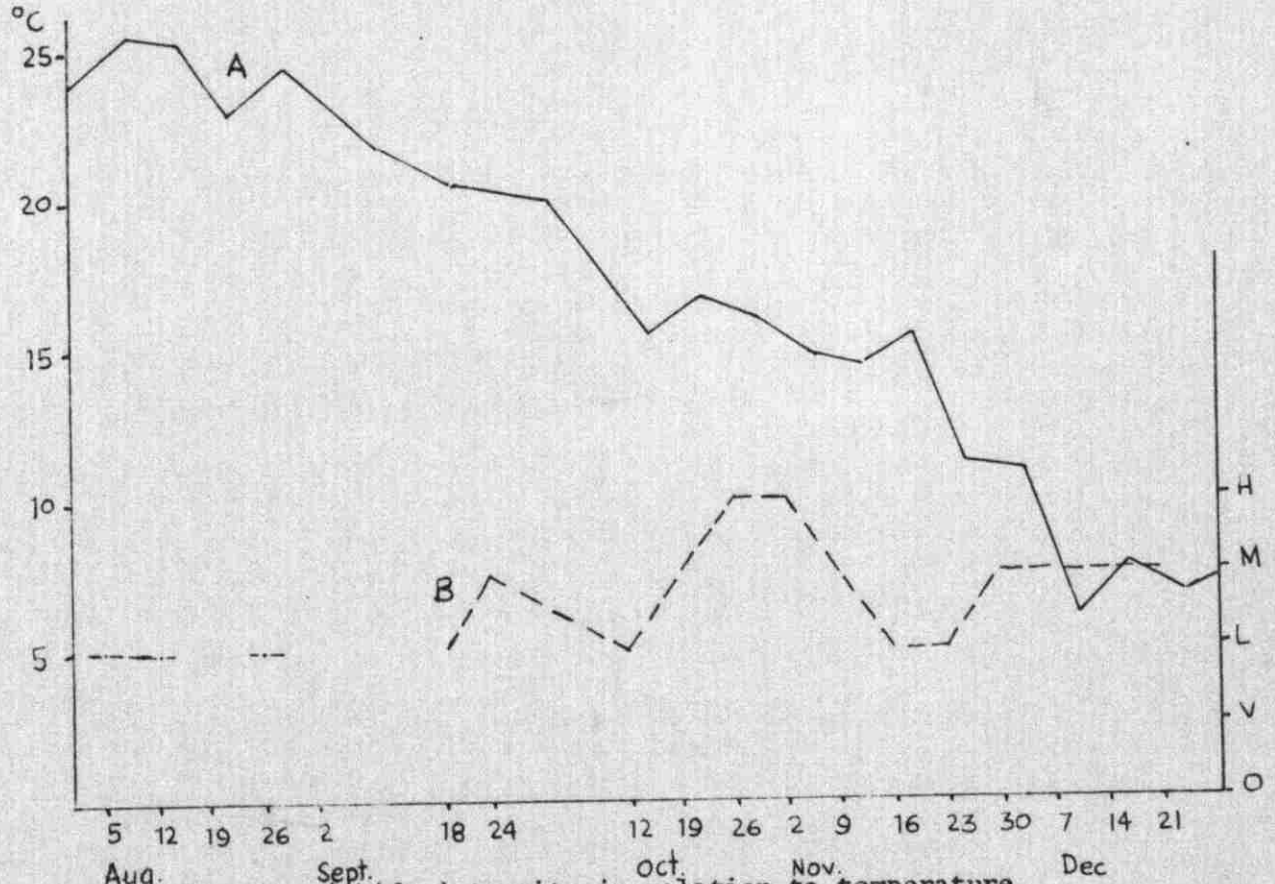


Fig.19.--Aphids intensity in relation to temperature.
A.Temperature; B. on Cabbage. O.Zero;
V.Very light; L.Light; M.Medium; H.Heavy.

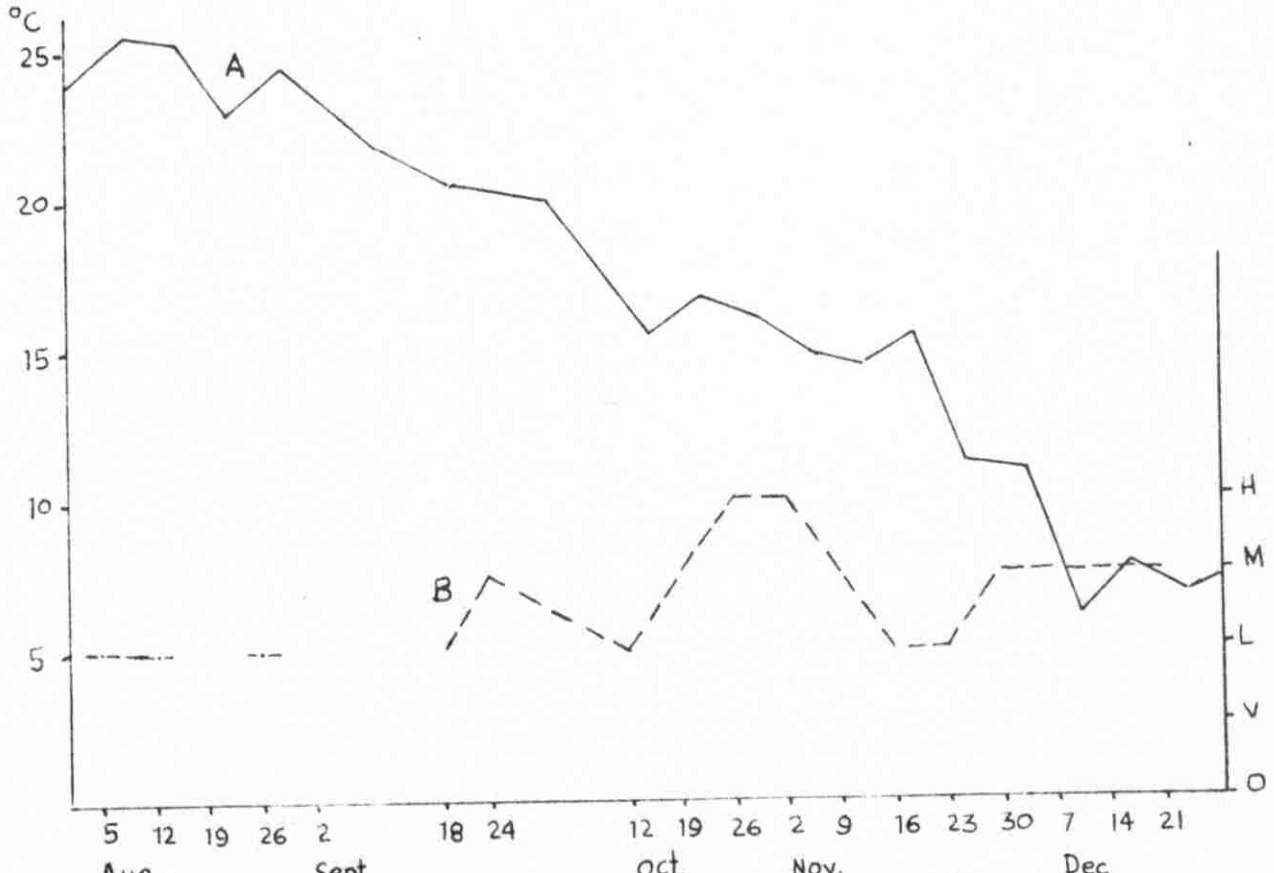


Fig.19.--Aphids intensity in relation to temperature.
A.Temperature; B. on Cabbage. O.Zero;
V.Very light; L.Light; M.Medium; H.Heavy.

Aphids were also observed on cucurbits, tomatoes, potatoes, eggplants and summer savoy. However, aphid intensity on these crops was too low to measure.

Discussion:

The aphid survey on vegetable crops revealed that in the summer months the insects infested the crops at "light" level, except cabbage and salsify. At air temperatures of 16°C and below, the aphids were found at higher densities and were not affected even by 0°C. Also they reproduced more and in quick succession at low temperatures.

Late infestation of cabbages is likely to do more damage (40, 45).

These results are in general in agreement with those of Walton (48) and Talhouk (43).

C. Thrips.

22. Brussels sprouts, cabbage, rutabaga and sugar beets. Fig. 20 shows thrips, T. tabaci Lind., on the said crops from early July to late October, as recorded qualitatively. The insects were found present throughout the season. Their intensity was particularly high at a temperature of 20°C and above.

Brussels sprouts showed "medium" infestation in mid July, which fell gradually by mid August. The infestation again reached "medium" level in the last week of August. Later the crop remained either lightly attacked or not at all.

Spraying in summer at "medium" level is suggested in early July and mid August.

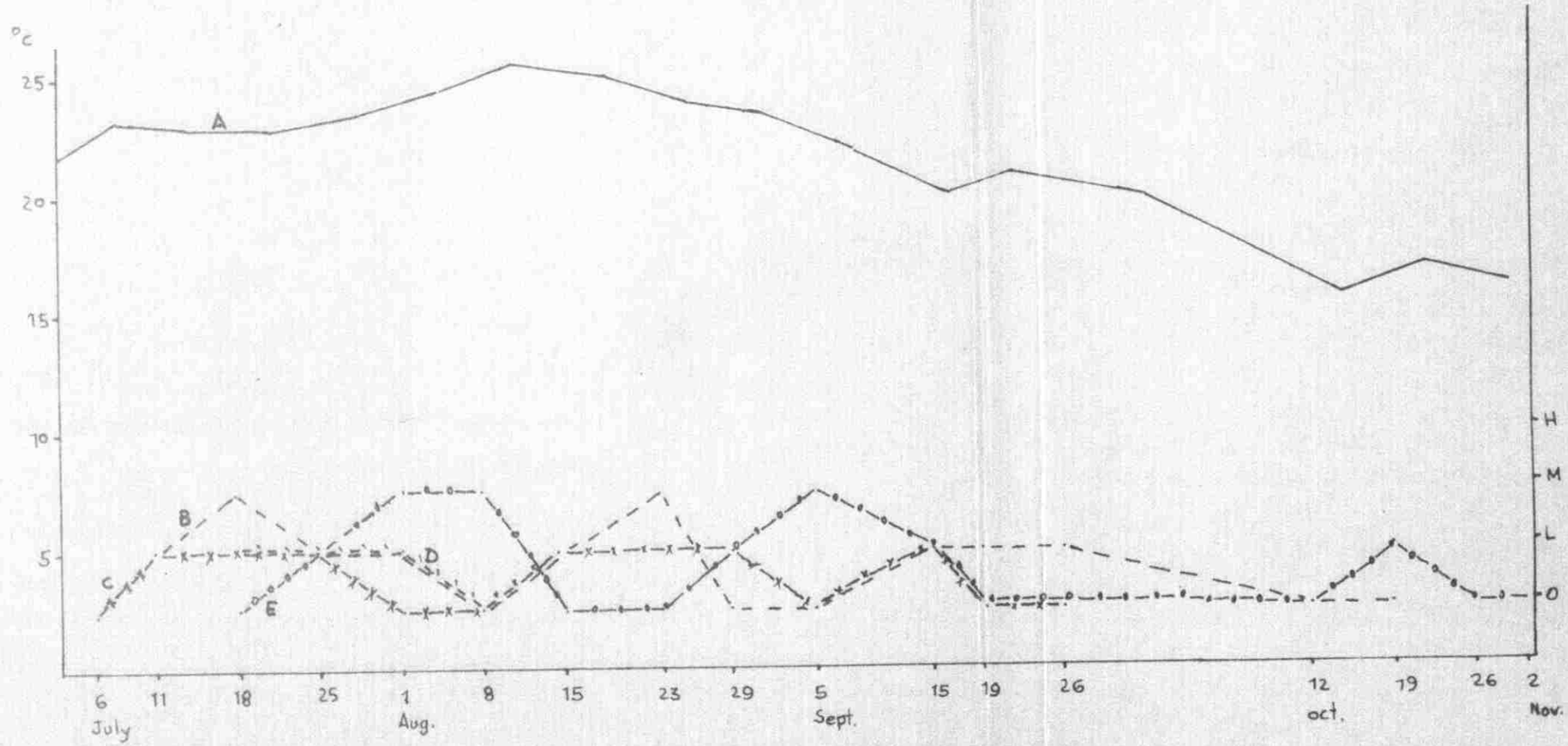


Fig.20.-- Thrips intensity in relation to temperature.
A.Temperature; B. on Brussels sprouts; C. on Cabbage; D. on Rutabaga; E. on Sugar beets. O.No thrips; L.Light; M.Medium; H.Heavy.

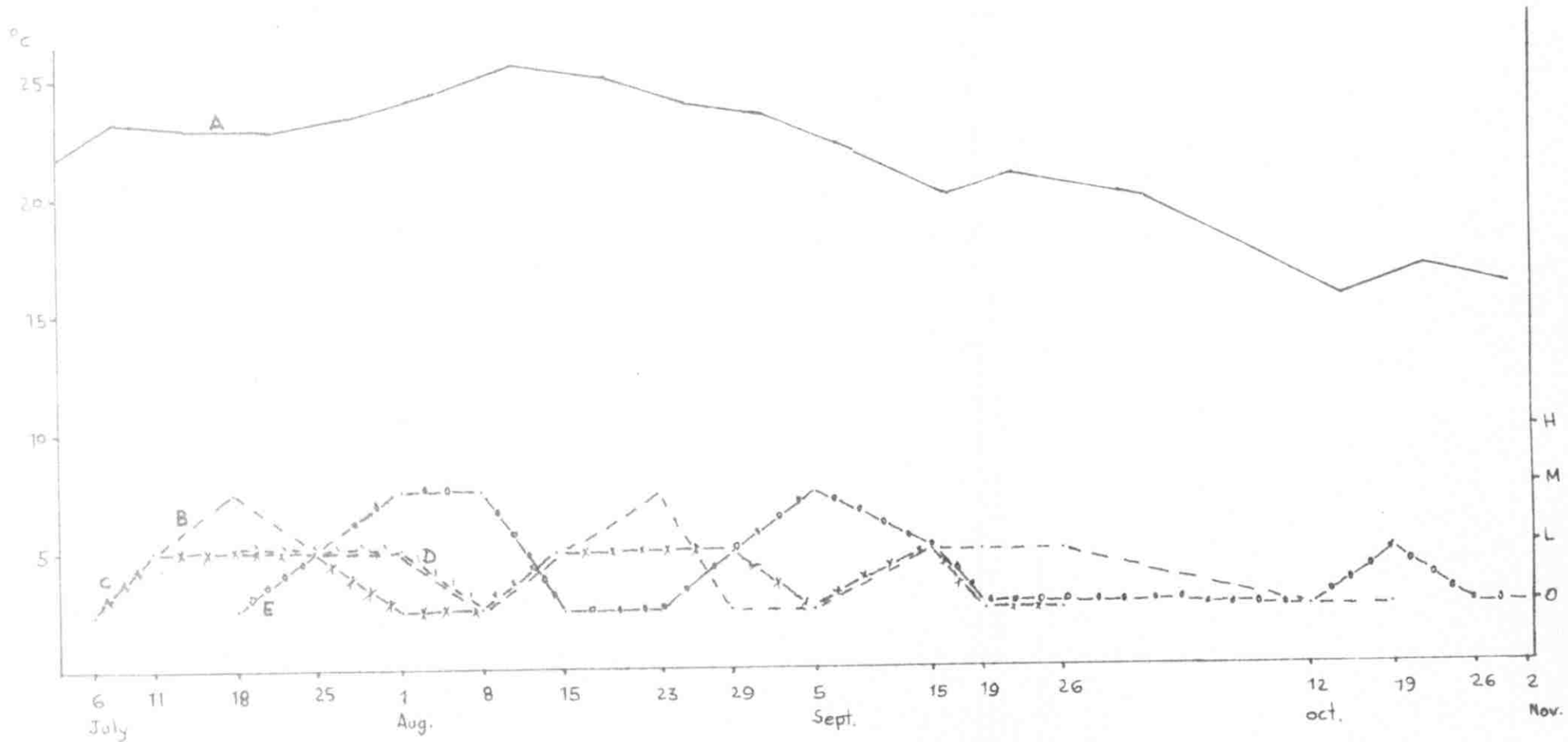


Fig.20.-- Thrips intensity in relation to temperature.
A.Temperature; B. on Brussels sprouts; C. on Cabbage; D. on Rutabaga; E. on Sugar beets. O.No thrips; L.Light; M.Medium; H.Heavy.

Cabbage remained "lightly" infested in mid July, mid August and mid September, suggesting that the insect has three generations in summer, Since "light" infestation does not damage the crop considerably, no spraying is suggested.

Rutabaga was also found "lightly" infested in the second fortnight of July. The crop was harvested in early August. No spraying against the thrips is advised.

Sugar beets were found "lightly" attacked in the last week of July; "medium" infestation developed in early August, early September and "light" in mid October. The findings suggest the occurence of two generations in a short period with temperature 22°C ; and a third delayed generation at a low temperature.

Since the amount of loss that thrips can do to the sugar beets is not known, the control sprays can only be suggested at "medium" levels of infestation in late July and early September.

23. Collards, kale and kohlrabi. Fig. 21 shows the thrips infestation intensity on the said crops. The insects were found on the three crops up to early November.

Collards were more heavily infested than the other two crops, Under the maximum mean temperature from mid July to the third week of August, the crop had "medium" to "heavy" infestation. From early September to mid October there was only "light" infestation. In November too there was "light" infestation. The insect, as it seems, is favoured by temperatures of 23°C.

Sprays in mid July and mid August at "medium" levels are suggested.

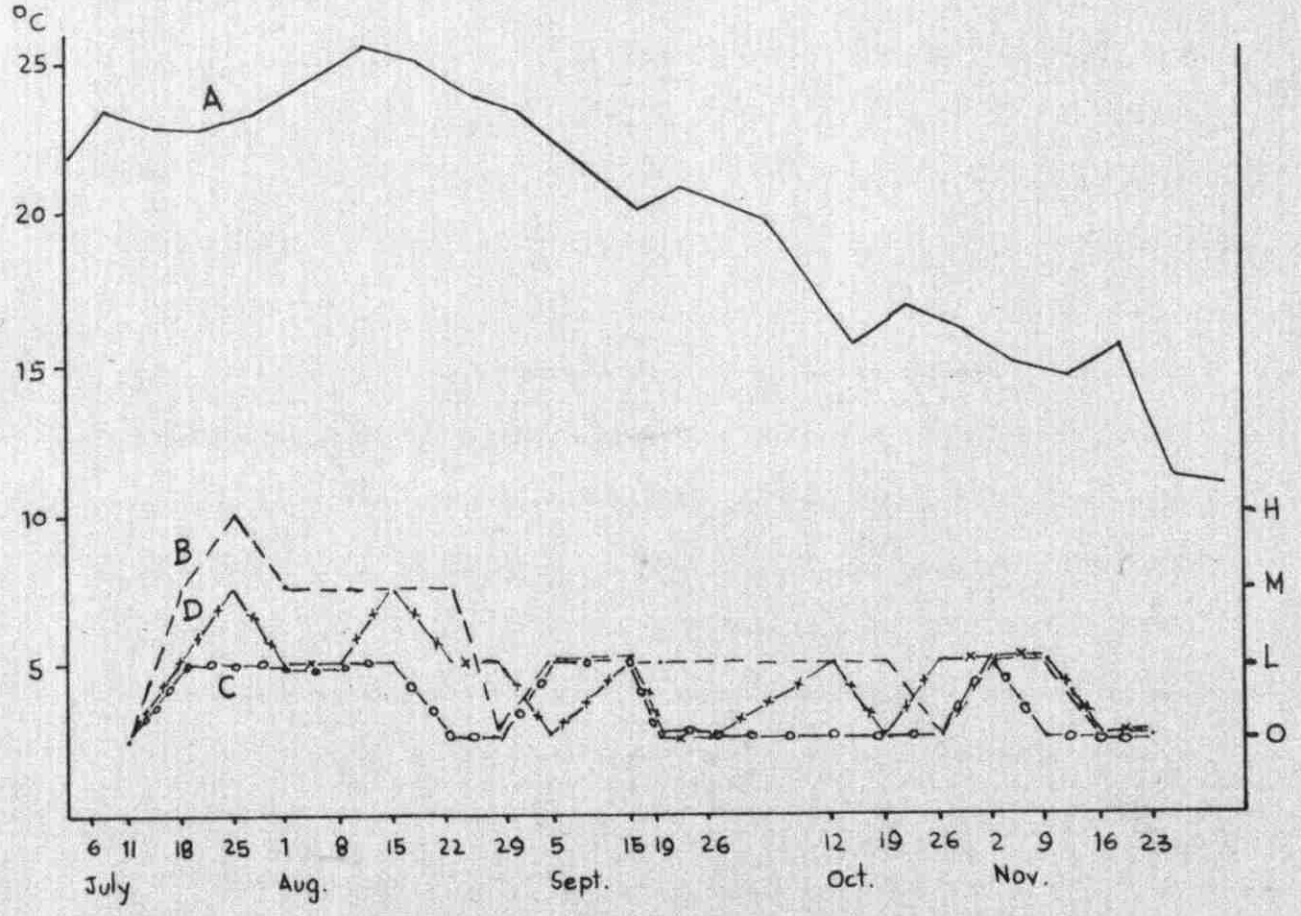


Fig.21.— Thrips intensity in relation to temperature.
A.Temperature; B. on Collards; C. on Kale;
D. on Kohlrabi. O.No thrips; L.Light;
M.Medium; Heavy.

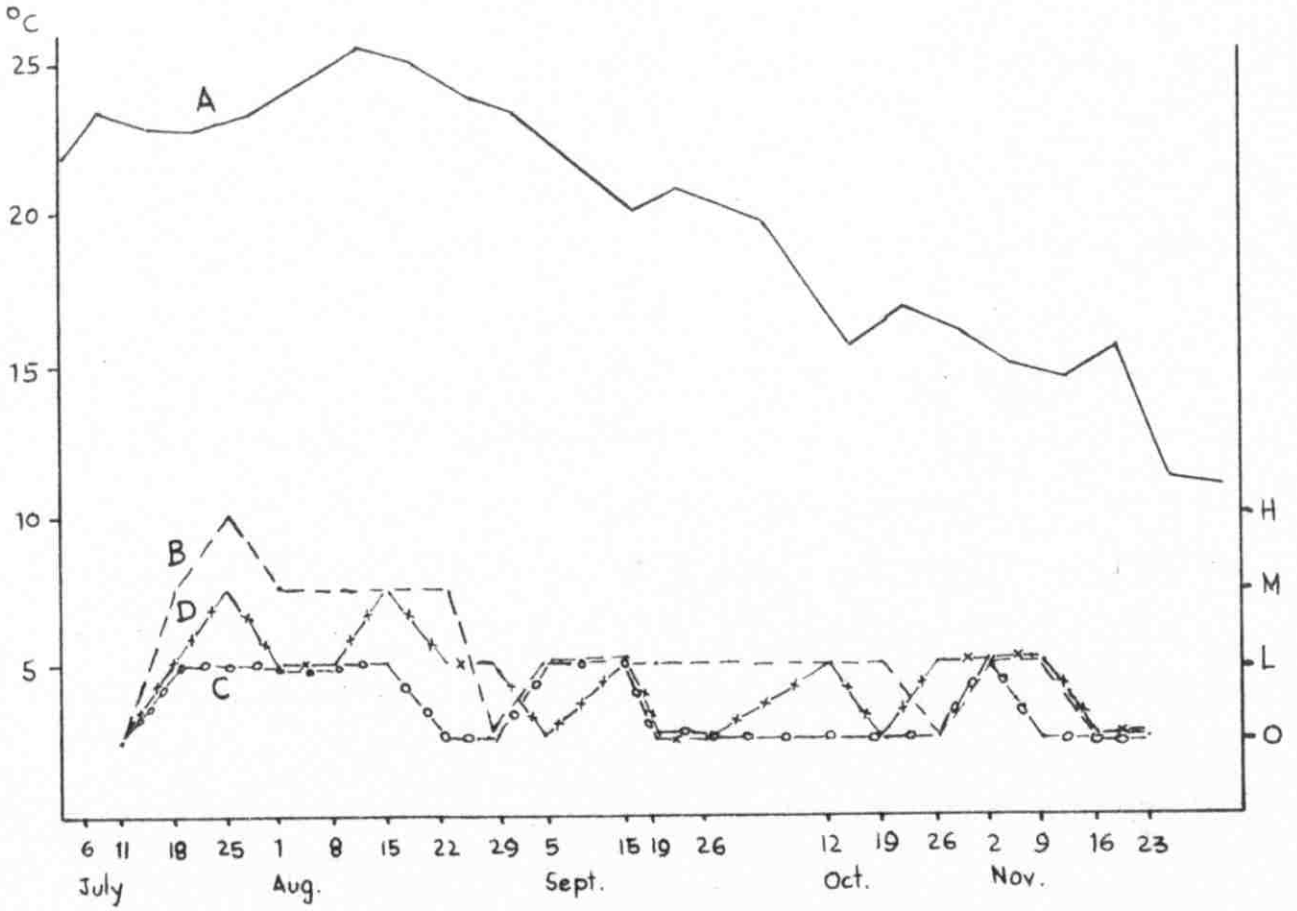


Fig.21.-- Thrips intensity in relation to temperature.
A.Temperature; B. on Collards; C. on Kale;
D. on Kohlrabi. O.No thrips; L.Light;
M.Medium; Heavy.

Kale was only "lightly" infested in the season, more so from mid July to mid August. No spraying for the crop is suggested.

Kohlrabi had "medium" attacks in late July and mid August, while the temperature was higher; it later continued to be "lightly" infested till early November.

A single spray at "medium" level in mid July is suggested.

24. Leeks and onions. Fig. 22 shows the infestation of leeks and onions by the thrips, T.tabaci Lind. The insects began to appear in the middle of July and were observed until mid October, when the crops were harvested.

Whereas the leeks remained "lightly" infested upto the first week of August, the onions were twice observed with "medium" infestation from mid July to the end of the first week of August. Leeks showed "medium" attack in mid August only. The thrips population afterwards became "light" and "zero". The onions continued to be the preferred host and the population reached "medium" level once more in the fourth week of August, before falling to "zero" level in early September. The infestation steadily increased from then on and reached "medium" level in mid October.

Onions in the Student plots were irrigated regularly, and leaves were also green. The observations suggest the development of three generations in temperature above 23°C and a fourth in the fall when the temperature was about 16°C.

Spraying at "medium" infestation level is suggested for leeks in mid August. Onions are suggested to be sprayed in mid July, early

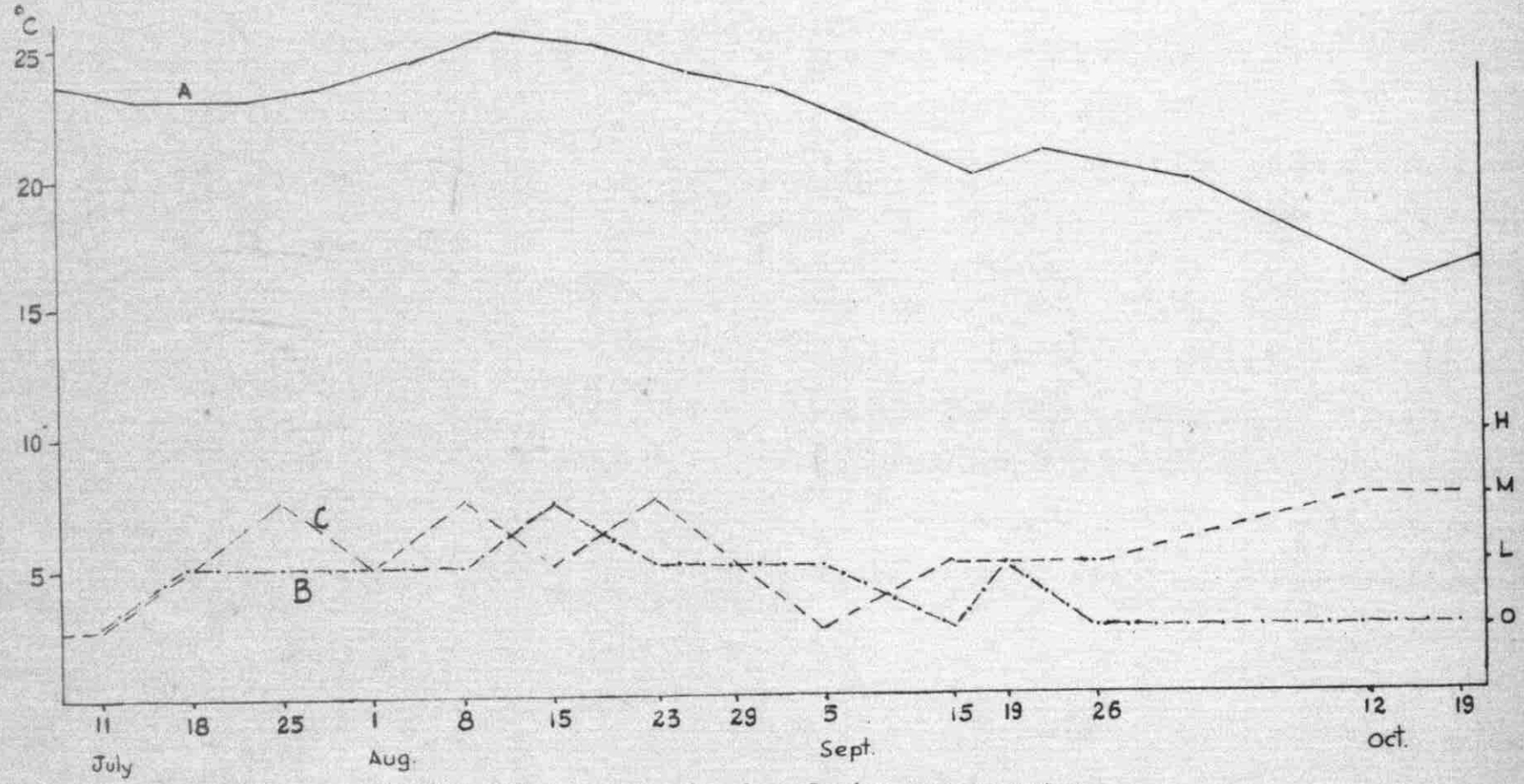


Fig.22.-- Thrips intensity in relation to temperature.
A.Temperature; B. on Leeks; C. on Onions.
O. No thrips; L.Light; M.Medium; H.Heavy.

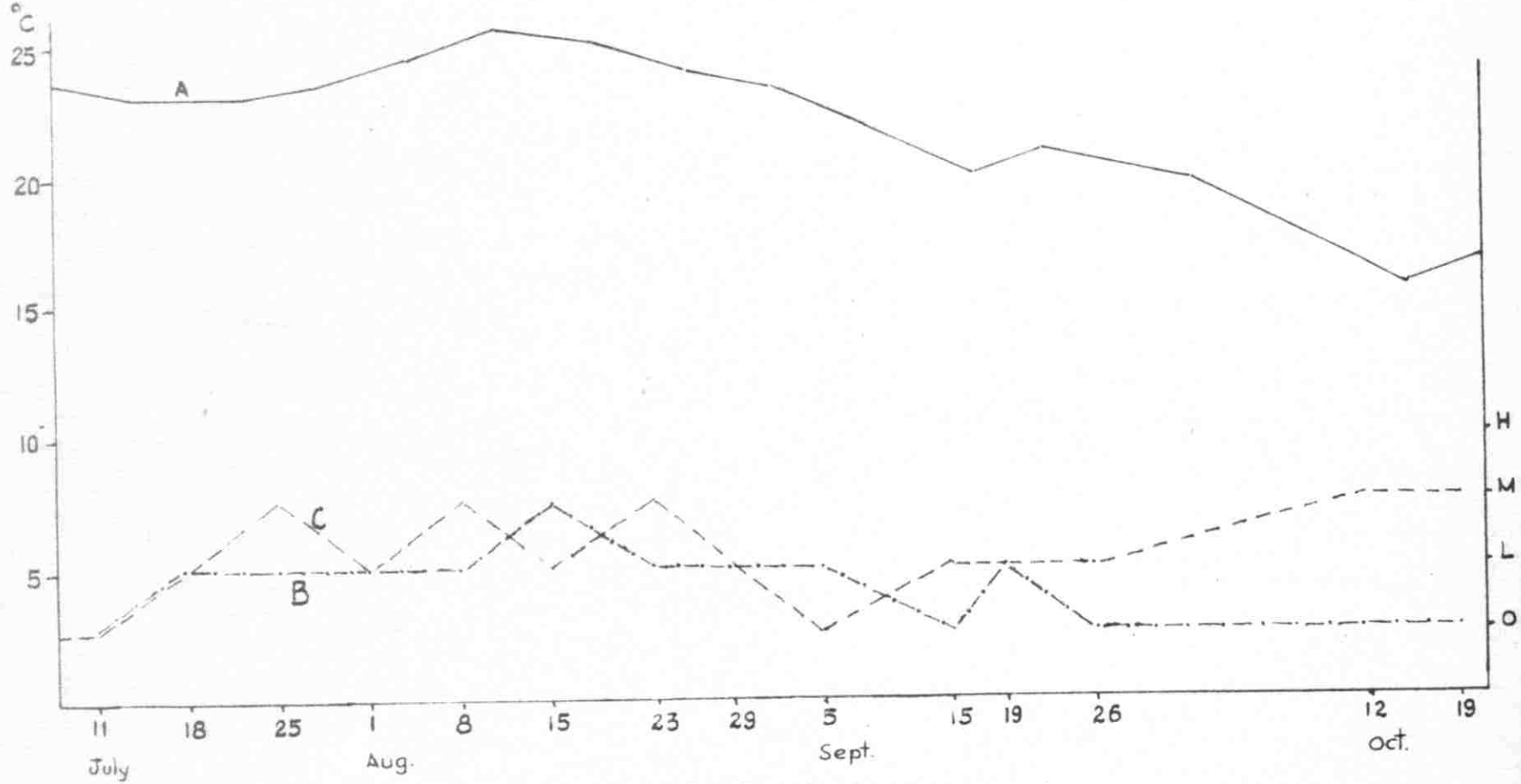


Fig.22.-- Thrips intensity in relation to temperature.
A.Temperature; B. on Leeks; C. on Onions.
O. No thrips; L.Light; M.Medium; H.Heavy.

August and, if necessary, mid October at "medium" levels.

25. Onions (Experimental plots) Fig. 23 shows thrips infesting the onions. The insects were observed from mid July to mid October. A good relationship between high temperature (23°C and above) and "medium" infestation was observed. From mid August the population declined to "light" level with fall in temperature. The decline in late August and onwards may also be due to the fact that the crop remained without water as of early August.

Spraying in late July and mid August is suggested.

Discussion:

Thrips survey on the various vegetable crops showed that the insects were particularly abundant and at higher infestation levels in summer when the temperature was 23°C and above. The insect completed its life cycle in a short time and probably three generations occured in July and August. Thrips were also found at lower temperatures (15°C) but their population levels were low. However, crops receiving irrigation regularly can be highly infested at low temperatures also, as found on onions in the irrigated Student plots.

These results are in close relation to the reports of Vuillet (47), Kinsey (20) and Bonnemaison (10).

D. Eurydema spp.

26. Fig. 24 shows Eurydema spp. adult population on Brussels sprouts cabbage and collards. It is observed that the insects were found under all the temperatures above 12.5°C.

Fig.23.— Thrips intensity in relation to temperature.
A.Temperature; B. on Onions.
O. No thrips; L.Light; M.Medium; H.Heavy.

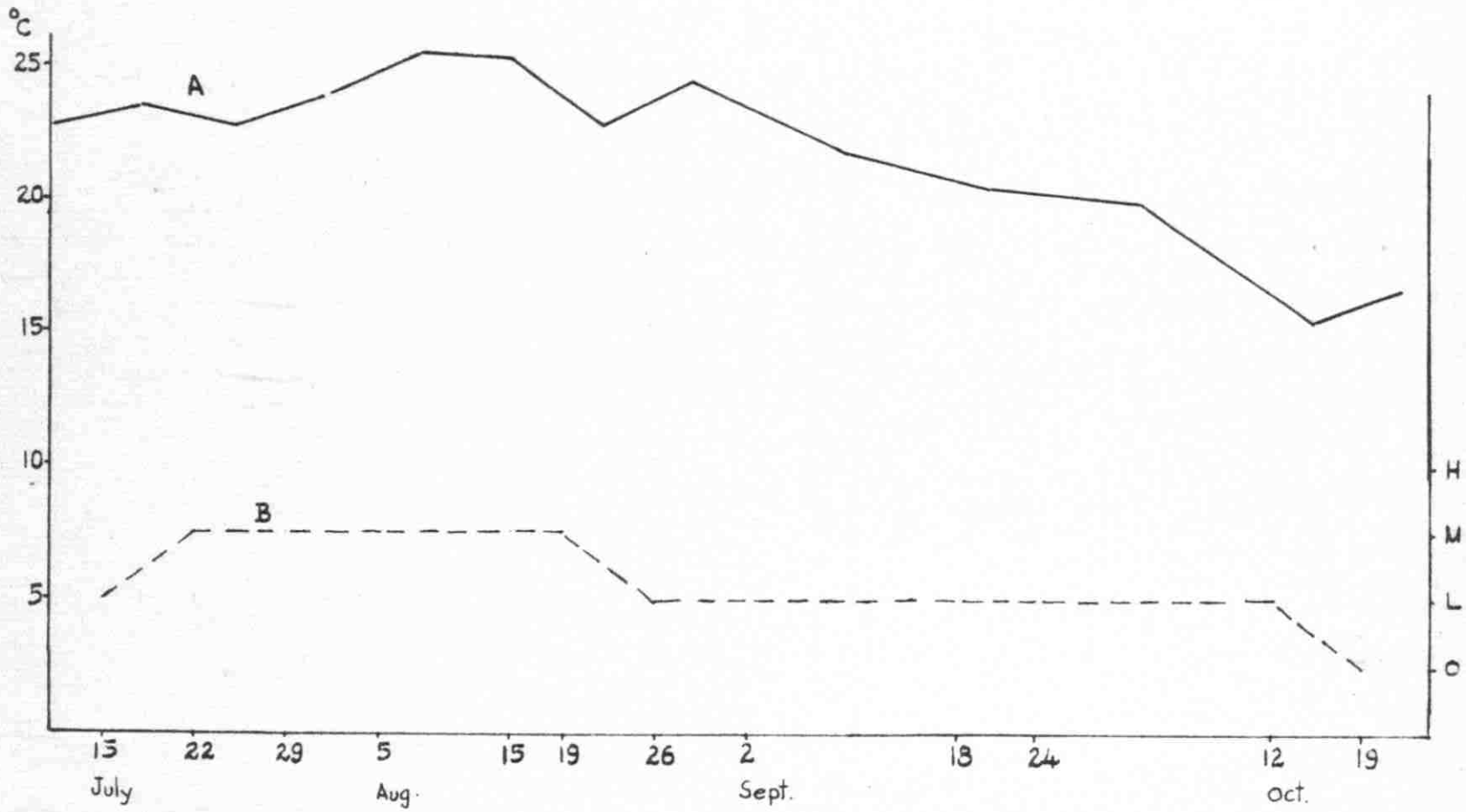


Fig.23,— Thrips intensity in relation to temperature.
A.Temperature; B. on Onions.
O. No thrips; L.Light; M.Medium; H.Heavy.

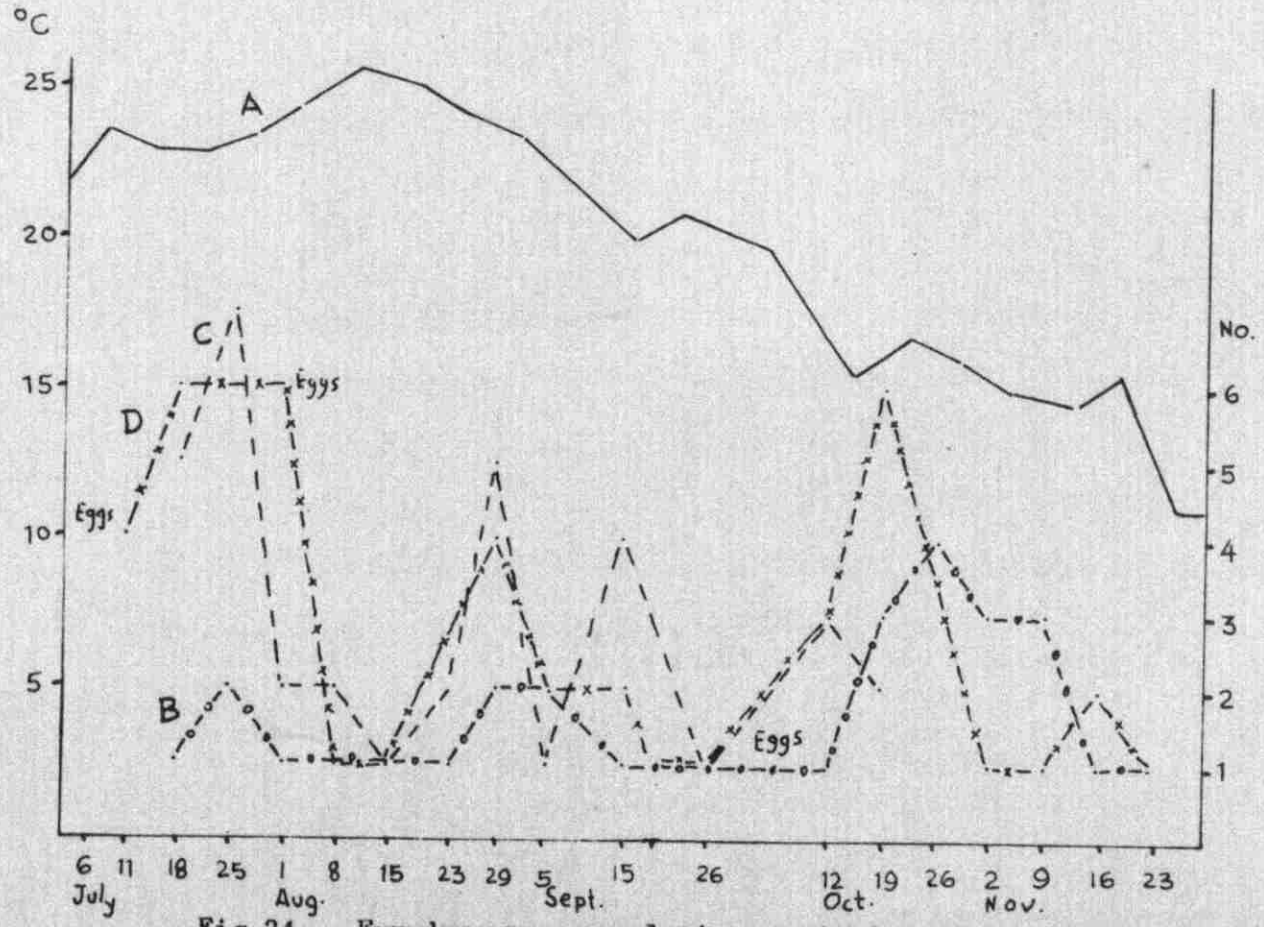


Fig.24.-- Eurydema spp. population on the Brassica spp. in relation to temperature.
A.Temperature; Average No. of bugs per plant of Brussel sprouts (B); Cabbage (C); and Collards (D).

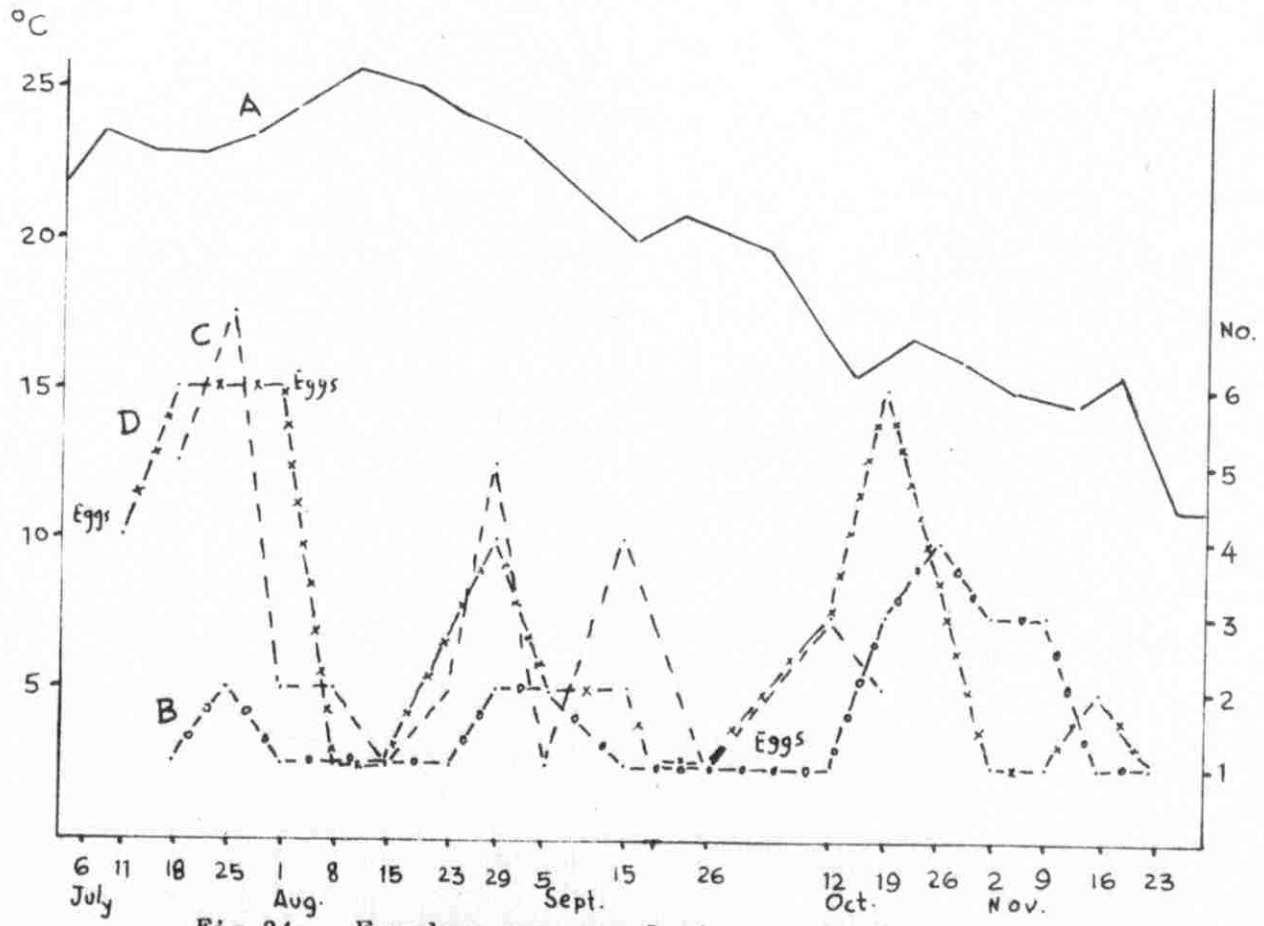


Fig.24.-- Eurydema spp. population on the Brassica spp. in relation to temperature.
A.Temperature; Average No. of bugs per plant of Brussel sprouts (B); Cabbage (C); and Collards (D).

Brussels sprouts were not favourable host plats in July, August and September. The eggs laid in late September (mean temperature 19.7°C) caused the bug numbers to increase in October and early November. A maximum average of 4 bugs per plant was observed in late October.

Spraying at the infestation level of one bug per plant is suggested in late July, early September and mid October.

Cabbage was all the time under heavy attack of Eurydema spp. from mid July. However, the adult population dropped to zero bugs in mid August. The second, third and fourth peaks in decreasing order were observed in late August, mid September and mid October respectively. The crop was harvested in mid October.

Spraying in early and late July, and if necessary in the third week of August, second week of September and the first fortnight of October is advised at an average infestation of one bug per plant.

Collards were also infested all the ti me the crop was in the field and the highest infestations were observed at the same periods as for the cabbage. In mid October, when the cabbage was harvested, the collards were more severely infested.

Spraying the crop is suggested as for the cabbage.

Discussion:

The Eurydema spp. survey on the Brassica spp. during early July to late November indicates the occurance of some four generations of the insect between the temperatures of 14.5 - 25.6°C. The time lapse between the first and second, second and third and third and fourth generations was 4, 3 and 4 weeks respectively. The shortest period occured in August between the mean temperatures of 23.3 - 25.0°C.

It is likely that this bug might have had 2 - 3 generations before the survey was undertaken, which brings the total to six generations or more per year.

These findings are in agreement with those of Servadei (35), Bonnemaison (11) and Talhouk (43).

Spraying was suggested on the same basis as for Lygus bug infestation on cotton and alfalfa (37, 39).

E. White Cabbage Butterfly.

27. Fig. 25 shows Pieris brassicae L., caterpillars infesting Brussels sprouts, cabbage and collards. The caterpillars were found in July, late September, October and November.

Brussels sprouts were infested from late September to mid November. The high levels of infestation occured in late September, mid October and early November. The crop was harvested in late November.

Spraying the crop in late September and if necessary mid October and mid November is suggested.

Cabbage was infested in July and again in late September and mid October. It was harvested in October, earlier than the other two crops.

Spraying the cabbage at an average of one caterpillar per plant is suggested in early July and late September.

Collards were infested in the second fortnight of July and again in mid October only. The crop was harvested in late November.

Spraying in mid July and early October is suggested at an infestation level of one caterpillar per plant.

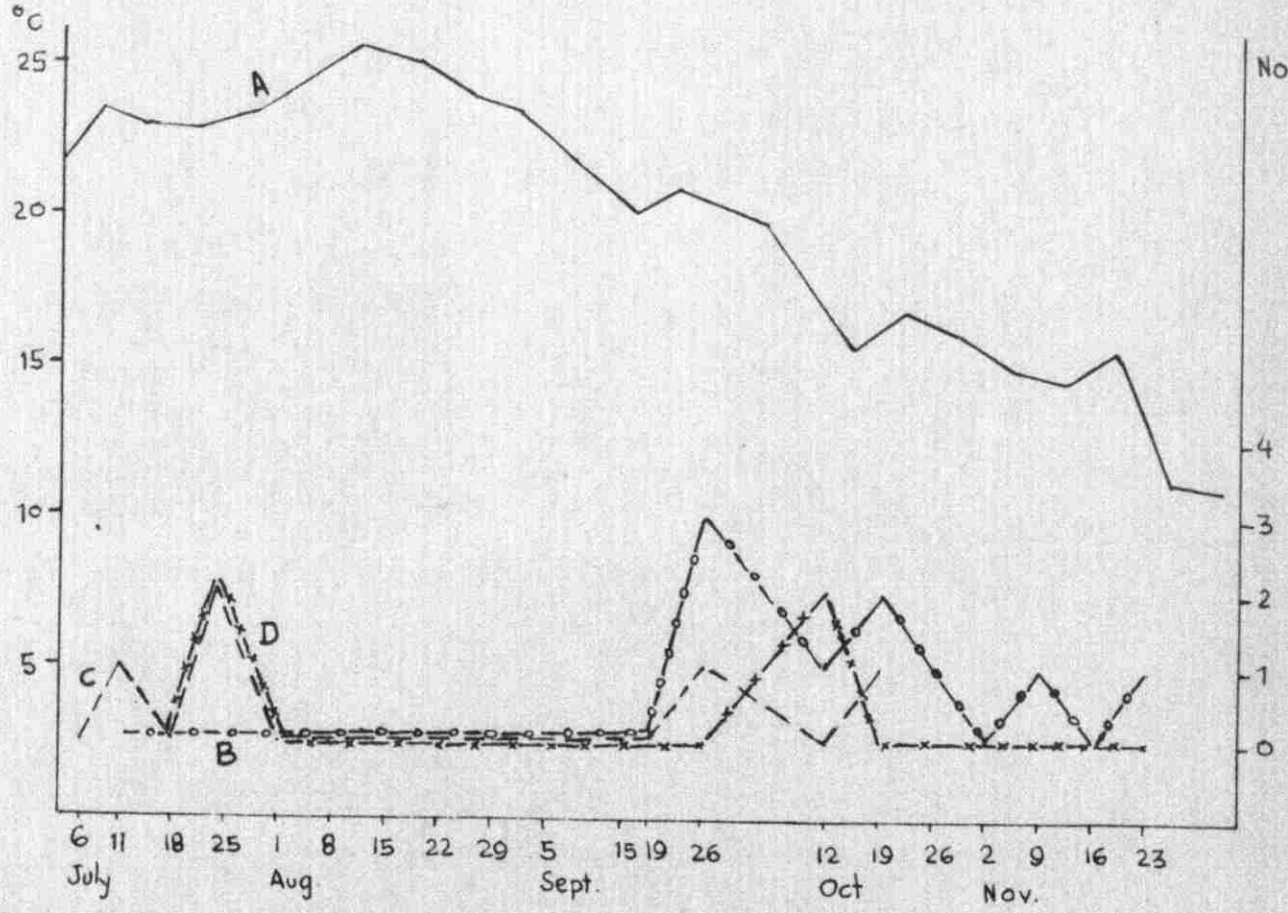


Fig.25.-- The White cabbage butterfly population on the Brassica spp. in relation to temperature. A.Temperature; Average No. of caterpillars per plant of Brussel sprouts (B); Cabbage (C); and Collards (D).

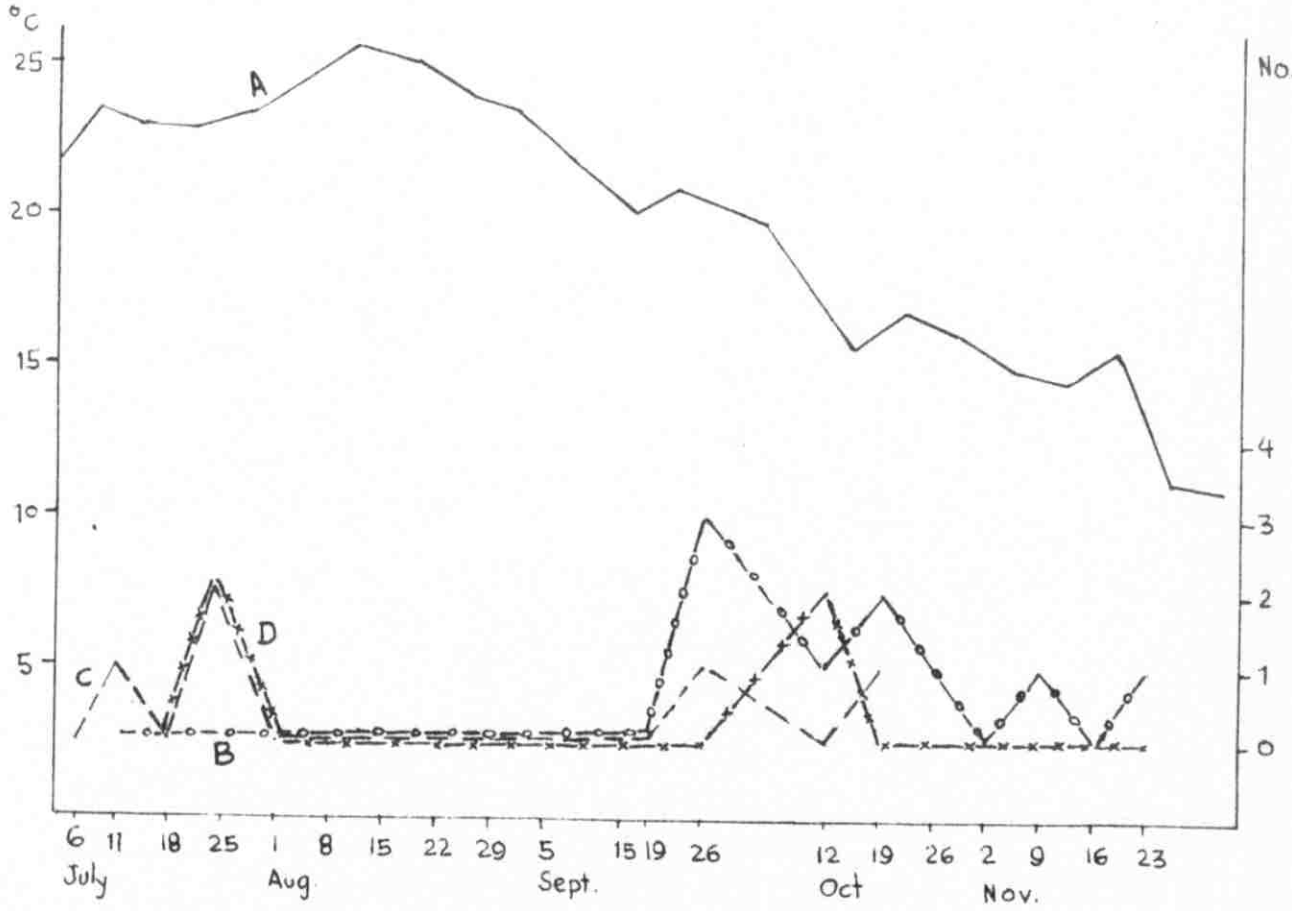


Fig.25.-- The White cabbage butterfly population on the Brassica spp. in relation to temperature. A.Temperature; Average No. of caterpillars per plant of Brussel sprouts (B); Cabbage (C); and Collards (D).

Discussion:

P. brassicae L. caterpillars were not found in the month of August (mean temperature 24.5°C) and the first three weeks of September (mean temperature of the month 23.0°C). This temperature is close to the lethal temperature of 26°C (21) where 100 per cent mortality of the eggs occurs. The caterpillars were observed in July (mean temperature 22.8°C) and again when the temperature was 20°C or below. The crops were harvested before a temperature of 13°C was recorded. The insect had probably 2 generations on cabbage and collards in July and October and three on Brussels sprouts from late September to late November.

These observations are in agreement with those of Klein (21) and Talhouk (43).

Spraying level is based on recommendations of Reid and Bare (32).

F. Flea beetles

28. 1962. While the survey progressed, radish were grown by students in early August. The crop was found "severely" attacked by the flea beetle, Phyllotreta atra F., on the 15th of August. More than half the leaves were damaged by August 23. An average of three insects was present on every observed plant measuring 2 - 2.5 inches in height. No undamaged leaf was found by the next week. "High" infestation continued up to September 15. No insects were found on September 19, The crop was harvested in the same week.

"Severe" attack of flea beetles was also observed on sugar beets in the third week of August. A "light" infestation occured by the end of October.

It may be noted that a previous radish crop, which was harvested before any observations were taken, was sprayed against the flea beetles on April 11.

1963. The observations made from mid July to mid August showed "severe" attack of flea beetles on Chinese cabbage, turnip, rutabaga and collards in mid July and on sugar beets, kohlrabi, and collards in the second and third weeks of August. Swiss chard and radish remained "moderately" attacked in this period. The newly grown radish crop was found "severely" attacked on August 15.

Spraying is suggested for the crops in early July and early August. Sugar beets and summer radish crop should be sprayed in mid August, before "severe" attack develops.

Discussion:

The heaviest infestation in 1962 occured in August and early September, coinciding with hot and dry periods (7). The preliminary observations reveal that the hibernating adults infest radish in April. The beetles of second generation were observed in mid July (1963). They reappeared again in abundance in August and early September. During the rest of the survey period the flea beetles were observed in late October only. Their density on sugar beets in October was very low. These findings agree pretty well with those of Pyatakova (31); and probably the insect follows the same pattern of a life cycle.

G. Leaf miner.

29. On the average 60% of the leaves of borage were found infested

by the Agromyzae in the last week of July. The miners were seen in all the infested leaves. By the end of the first week of August, all miners were found pupating, but no pupae was found in mid August. In the last week of August, the leaf miners were again seen. An average of 30 per cent of the examined leaves had miners.

The crop was found drying by the end of August and all plants were dry by mid September.

Spraying the crop in the last weeks of July and August is suggested.

H. Grasshoppers.

30. During the period of survey grasshoppers were always present in "light" populations (36) in all the crops and fields. The population was "heavy" from the last week of July to the end of the first week of August in watermelon and chillies plots. The sugar beets were more regularly infested throughout the survey period. Observations extended from the last week of July to mid December.

Spraying is suggested at "moderate" infestations on all crops where such densities are observed.

SUMMARY AND CONCLUSIONS

The present study was conducted at the University farm from July 1962 to mid January 1963, to determine the insect populations on various vegetable crops, as affected by temperature and to suggest control measures.

Leafhoppers were found on the host plants throughout the survey period. Their main food plants in descending order of infestation were potatoes, lettuce, tomatoes, Swiss chard, sugar beets, beans, cucurbits, watermelons, okra, eggplants and chillies. The ratio of nymphs to adults was higher when the average air temperature was 20°C or above; below this temperature, the ratio was in favour of adults which always occured regularly in the fields. The insects were found to survive a minimum air temperature of -0.2°C. Although spraying against the leafhoppers is suggested at higher levels of infestation in the months of July, August and September, lower levels should also be controlled, whenever the leafhopper is known to be a vector of an already occuring disease.

The aphids were found heavily infesting cabbages, Brussels sprouts, salsify, okra and kohlrabi in autumn and winter when the temperature was 15°C or below. Salsify was also found "heavily" infested in summer. The aphids were found to survive a minimum temperature of 0°C. A lower temperature than zero degrees centigrade was not recorded while the

aphids were present on the crops. Aphids were also observed in summer but at "light" infestations. Sprays are recommended against aphids in November and December at "medium" and "high" levels. "Light" infestations may also require sprays in case they are known to transmit an already existing disease.

Thrips on onions, Brassica spp., leeks and sugar beets were observed at "medium" levels when the temperature was about 23°C in August. Two sprayings in general are recommended in August.

Eurydema spp. were found on the Brassica spp., under all the temperatures while the crops were in the field. About four generations occured during the survey period. Two sprayings are suggested, one in July and one in August. If found necessary, a third spraying is also advised in September.

The white cabbage butterfly caterpillars were found on the same host plants as for Eurydema spp. The caterpillars were absent in August and the first three weeks of September, when the temperature for the said period was close to 26°C. Spraying the Brassica spp. against the caterpillars is suggested in July and again in October.

Flea beetles, as observed in 1962 and 1963 attacked radish, Chinese cabbage, turnip, sugar beets and Swiss chard in the descending order of the crops. The attack was "severe" in July and August. Sprays against the flea beetles are accordingly suggested in the months of infestation. They were found more abundantly during the hot and dry part of summer.

The borage leaf miner requires a single spraying in August.

The grasshoppers should be controlled whenever an infestation of "moderate" level is observed.

The names of insecticides for control measures are not suggested as they often change and new products always appear in the market. The pesticides should be selected on the basis of latest information on them.

The study was only for one crop year and the data obtained are indicative of probable infestation levels in the months of survey. The number of sprays suggested for the Beqa'a did not consider the effect of control measures taken by the incharges on the insect populations. The number of sprays are also regulated by the degree of cleanliness required, cost of applications, value of the crop and the effect of insect feeding in lowering the crop yield. The insect population pattern may change when these crops are grown on large areas. In this study the same plants had to be surveyed time and again due to the very limited area grown to the crops. An attempt was also made to correlate the laboratory findings on insects to actual field conditions.

It is proposed that data be obtained for many years about the population density fluctuation before an accurate estimation of their damage at different levels can be assessed, and a fixed spray program can be established.

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APPENDIX

List of vegetables surveyed

Common name	Scientific name
Anise	*Pimpinella anisum* L.
Beans	*Phaseolus vulgaris* L.
Beets	*Beta vulgaris* L.
Borage	*Borago officinalis* L.
Brussels sprouts	*Brassica oleracea* L. var. *gemmifera* Zanker
Cabbage	*Brassica oleracea* L. var *capitata* L.
Carrot	*Daucus carota* L.
Chillies	*Capsicum annum* L. var. *fasciculatum* L.
Collards	*Brassica oleracea* L. var. *acephalo* DC.
Cucurbits	*Cucurbita pepo* L. and *C. maxima* L.
Dandelion	*Taraxacum officinale* Weber
Dil	*Anethum graveolens* L.
Egg plant	*Solanum melongena* L. var. *esculentum* Nees.
Endive	*Cichorium endivia* L.
Kale	*Brassica ruvo* Baily
Kohlrabi	*Brassica oleracea* L. var. *caulo-rapa* DC.
Leeks	*Allium porrum* L.
Lettuce	*Lactuca sativa* L.
Okra	*Hibiscus esculentum* L.

Common name	Scientific name
Onion	*Allium cepa* L.
Peas	*Pisum sativum* L.
Potato	*Solanum tuberosum* L.
Radish	*Raphanus sativus* L.
Rutabaga	*Brassica napobrassica* Mill.
Salad bowl	?
Salsify	*Tragopogon porrifolious* L.
Sugar beet	*Beta vulgaris* L.
Summer savoy	*Satureja hortensis* L.
Sweet basil	*Ocimum basilicum* L.
Swiss chard	*Beta vulgaris* L. var. *cicla* L.
Tomato	*Lycopersicon esculentum* Mill.
Water melon	*Citrullus vulgaris* Schard.