


Role of Sugars in the Uptake and Translocation of Systemic Insecticides in Plants

By Agha A. Husain, Safia Hashmat and Abid Askari

With 2 Figures

Abstract

In line with the importance of foliar-feeding in agriculture a selective preference for this method over other technique of insecticidal administration is recommended. On the basis of some experimental evidence utilizing aphids it has been suggested that locally available cheap forms of carbohydrates should be incorporated as promoters of the effectiveness of systemic insecticides through increased uptake and dissemination within the plant.
Introduction

A new horizon of useful possibilities appeared when it was realised that plant can be supplied its nutrients through the foliar medium and independent of soil fertilizers, as the leaves possess wonderful capabilities of absorption through their surfaces. It can be claimed that “foliar-feeding” in plants is fast becoming adapted as an important agricultural technique (5).

Along with the foliar-spraying of insecticides, chemical nutrients both organic and inorganic could be supplied in one go thus saving double efforts as well as the complexity of techniques.

Reports already exist (2,7), concerning preferential uptake of sugars by leaves and their subsequent influence on the dissemination rates of the carbohydrates through the phloem strands.

This work has been undertaken with a view to ascertain if cheap forms of carbohydrates could be utilised (within the plants) for increasing the effective ranges of the conventional insecticides generally employed in these regions. It should also be pointed out in this connection that the author being a transport-physiologist of plants is more concerned with those aspects in the technology of systemic-insecticides that have a direct bearing on the subject of translocation.

Materials and Methods

Thirty days old Pisum sativum plants grown indoors in earthen-ware flower-pots containing purified sand receiving diffused sunlight and nourished at regular periods with Haogland’s nutrient solution (at Room Temperature appr. 20° C) were transplanted to especially designed 3” wide plastic flower pots approximately 3 hours prior to their treatment. After the treatment the plants were left for 18 hours under Neon Tubes with a total light intensity equalling 400 ft. candles approx, care was taken to avoid any injury to the roots during the transplantation.

Small 5 ml capacity glass containers, to serve as reservoirs, were inserted in the pots adjacent to the plants without affecting the later, while the optical portions of each plant replicate inclusive of trifoliate leaves were slightly bent and gently introduced inside the reservoirs so that these occupied nearly 3/4th depth of the reservoir capacity.

The depth of plant portions introduced, was kept in position by extending a cello-tape strip in a bow-bridge fashion across the plant with both ends stuck to the opposite walls of the plastic pots.

A 10% solution of ordinary gurr \(^1\) was prepared on w/v basis, dissolving 10 gms in 100 mls distilled water to which about 0.004 gms of Sodium Borate and 15 mls of 1 M Sucrose Solution were added.

Two separate strengths (1 % and 2 %) of the insecticides Diazinon and Malathion were prepared respectively, in distilled water and a mixture of the detergents (LISSAPOL and TEEPOL) was added in strengths 0.1% v/v. The glass reservoirs adjacent to each replicate were then filled up, and the respective strength of the insecticidal solution evenly distributed among the total number of plants, three replicates being available for each strength of the solution. One half of the total number of plant replicates were added with sugar solution (10% gurr solu. + 15 mls of 1 M sucrose) in quantities equalling 0.3 mls approx, followed by gentle stirring.

---

\(^1\) Local name for a crude form of cane sugar condensate.

\(^2\) Originally about 65% emulsified commercial samples of the insecticides were obtained through courtesy of Officers at the P.P.D. Later a pure sample of Insecticides became available (through Dr. A. A. BAIG, Head of Inorganic of the Chemical Division) and were employed forthwith in strengths already stated.
The aphid population employed comprised mostly of *Acyrthosiphum pisum*.

The average number of aphids per plant being between thirty and forty. Aphids were transferred to the plants by means of a camel hair brush around the source, in a radial centripetal fashion. Covering approximately the major surface area of the plant as a whole, care being taken to deposit more aphids on the petiolo than on the lamina, however to facilitate the habitation of aphids on the plant, brush smears of 2% sucrose solution were sparingly made all along the petiolo lengths and the mid-ribs of the foliage.

Majority of these aphids were observed to have started their feeding within 30 minutes of their deposition on the plants.

**Observation Results and Interpretation**

The observations were recorded after giving an 8 hours translocation period, when the submerged portions were gently swerved off and the ratios of the dead aphids to those alive were recorded for each of the replicates. This ratio has been projected in Fig. No. 1 through histograms indicating different strengths of insecticides with and without the sugar additive factor against the percentage mortalities of the aphid population per replicate. A total of 24 plants were employed, divided into eight different sets of 3 replicates each.

The histograms apparently reflect a bias to the "Saccharide-factor" i.e. the additive sugar solution.

**Effectiveness Analysis**

Intensity of effect to achieve significantly higher mortality percentage was found when sugar was added to different concentration of the insecticide. The insecticide composition M (2% + S) was found to be of greater effectiveness which yielded an average of 44.2% mortality of the aphids.

It can be seen that this addition of sugar to insecticide solution creates increased effectiveness in killing of insects to the extent of 39.59% with variability ranging from 32.4% minimum to 44.2% maximum.

The results are significant to the extent of 97.5%–2.5%. However these inferences drawn from the data relative to effectiveness of various compositions of the samples have been based on simple statistical calculation and not on any sophisticated statistical technique that would require mass data.

Perhaps it seems plausible, to assume, that sugars play some essential role in increasing the uptake rates and distributory processes at the leaf...
Role of Sugar of Systemic Insecticides in Plants

There seems a marked preference for Malathion compared with the Diazinon in the minus sugar replicates as well, which incidentally is quite an independent observation from our limited experimental objective and no attempt will, therefore, be made here to explain the same.

The plot in Fig. No.: 2 represents the mean values of four different sets of observations carried out at different times on 4 swerved petioles of 30 day old seedlings of *Vicia faba* about 8 cm in length and with intact leaves at the apical end. Just below the leaves, with the help of a sharp razor edge the epidermal cells were gently scraped exposing apex, half a centimeter wide area on the side of the petiole.

Four aphid were deposited along the length of the petiole at a distance of 2 cm from each other, and were kept confined on the spot with some skill (A miniature paper cone and a camel hair brush were employed to keep the aphid confined to the selected spot on the petiole where a trace of sugar was also smeared till it gave up wandering and resumed feeding). The 1st one being 2 cm away from the source i. e. the scraped end of the petiole, which was kept in contact with sweetened Malathion solution (5 % Malathion sol + 3 % sucrose) contained in suitable reservoirs. The nearest accurate time of reaction on the part of each feeding aphid confined to its geographical position were recorded and a curve indicating the respective reaction time of the aphids against the distances from the insecticidal source was plotted.

The curve thus obtained might be considered somewhat comparable with the typical exponential curves generally

<table>
<thead>
<tr>
<th>Plant</th>
<th>Sample No.1</th>
<th>Sample No.2</th>
<th>Sample No.3</th>
<th>Sample No.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Sample Size</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Plant Sample No.1</td>
<td>D (1%) + S</td>
<td>11.1</td>
<td>14.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Plant Sample No.2</td>
<td>D (1%) + S</td>
<td>13.4</td>
<td>15.2</td>
<td>15.2</td>
</tr>
<tr>
<td>Plant Sample No.3</td>
<td>D (2%) + S</td>
<td>11.1</td>
<td>14.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Plant Sample No.4</td>
<td>M (2%) + S</td>
<td>12.4</td>
<td>15.2</td>
<td>13.4</td>
</tr>
</tbody>
</table>

The reaction time in this case was arbitrarily synchronized with the display of agitation or the withdrawal of the proboscis on the part of the aphid.
arrived at whenever massflow through phloem is being interpreted graphically. Such exponential fall-off pattern presupposes a simple model for the mass-flow inside the phloem tissues first proposed by Horwitz (3) and discussed in greater detail by Spanner and Prebble (4).

The relationship is $\text{KS/AV}$.

(Where “$A$” is the cross sectional area of the conducting elements, “$S$” the perimeter and “$V$” the velocity while “$K$” is a co-efficient with dimensions of the velocity. It is assumed that as the flow starts in the phloem column, there is a constant lateral leakage presumably at fixed intervals and this imposes the typical exponential pattern of the flow down the axis.)

A sort of “Phloem chanelled” transport from the area of direct contact with the insecticide is perhaps suggestive, as has been discussed in the following lines.

### Summarized Discussion

Perhaps the work suffers somewhat from limitations like the absence of sophisticated tracing techniques etc., almost indispensable in translocation studies these days, paucity of laboratory facilities led the way for adoption of simpler methods and relative standards and accordingly the extent of aphid mortality has been chosen as an approximate measure for the degree of distribution of the insecticidal solution within the plant body. Further it has been assumed that any dilution of the insecticide due to the presence of sugar complexes would be to some extent balanced by an increased feeding of sweetened insecticide on the part of the aphids.

Whereas the significance of results of the main experiment (Fig. 1) lie in demonstration of the magnitude of influence of sugars over the extent of uptake and distribution of insecticide within the plant, the later set of observations (Fig. 2) perhaps reflect a partial selectivity on the part of the “Sweetened” insecticide solution to maintain a greater bulk-flow in the phloem column of the swerved petioles as compared with the xylem strands (Presuming of course that the aphid probociss remains confined to the phloem tissue.) However there certainly is not enough evidence here to assert this.

Such observations perhaps illuminate to some measure the positive influence of an extragenous, foliar-supply of the sugar mixture on the uptake and dissemination of systematic insecticides within the plants. The result being a net increase in the effective range of the insecticide concerned. The
presence of Boron is considered as purely complimentary and in capacity of a catalysing agent promoting the transfer of the saccharide molecules (which in turn get associated with those of the insecticide) through the xylar regions. What is being implied here is that Boron perhaps helps, complementing the flow of the insecticide-sugar-complexes that are already moving along the phloem column (in accord with the typical Horwitzian, phloem mass-flow patterns) by channelling the excess via “lateral leakage” from the phloem regions into the adjoining xylar vessels thus ensuring a speedier xylar-transport simultaneous to the translocation stream passing in the phloem.

It is regretted that an investigation into the extent of influence of the “Boron Factor” was not possible, however, it is hoped to pursue this object in some future work. The specificities of the foliar uptake capacity, for different plants vary enormously and no generalised set of rules for sugar solution concentrations or insecticide strength could be recommended at this stage. It can however be stated with certainty that the actual quantities of sugars required in their role as catalysts would be very small indeed and hence economical.

A vast amount of comparative work has to be done in this line if useful application of the principles involved has to be made.

Since transport physiologists have already found that certain saccharides, and especially sucrose (6:7) are among the most mobile of plant sugars, the activities of different sugar solutions therefore, would naturally be in relation with their saccharide contents, as compared with the strength of the insecticidal solutions to be incorporated.

While molasses are the cheapest of the locally available forms of natural carbohydrates, it can be suggested that these or a mixture of molasses and sugars should be tried out in various concentrations of solutions over a wide range of useful plants.

As a starting step an analysis of different samples of gurr and molasses can be made for their diaccharide contents. This coupled with some data on the physio-chemical foliar uptake pre-requisites for important plants in relation with climatic and other physical conditions of their environment could ultimately provide a coordinated scheme for a more economical utilization of the systemic insecticides in this country.

Acknowledgements

It is a pleasure to record the inspiration and help extended by Dr. A. Kamal (Director PCSIR. Labs., Karachi) from time to time during this work. Many thanks are also due to Mr. Malik Akhtar of the P.P.D. for his help in more than one direction.

References


Vergleichende Untersuchungen an der Kronenfauna der Eichen in Latenz- und Gradationsgebieten des Eichenwicklers
(Tortrix viridana L.)

3. Die Bedeutung der Parasiten für den lokalen Fluktuationstyp des Eichenwicklers

Von Fritz Schwerdtfeger

Abstract

Studies on the top-fauna of oaks in outbreak- and non-outbreak-areas of Tortrix viridana L. 3. Importance of parasites for the local fluctuation type of the oak Tortricid. Based on investigations of Moeller-Lotz 1968 and Betz-Schwerdtfeger 1971 carried out in a latency area of Tortrix viridana (where the species always remains on a low population level) and in comparison with it in a gradation area (where temporary outbreaks occur), the following model concerning the importance of parasites for the local fluctuation type of the Oak Tortricid could be developed:

In the latency area, the population density of the Oak Tortricid is regularly held on a low level by bad temporal coincidence between the hatching of the caterpillars and the swelling of the oak buds as well as by relatively strong activity of parasites together with other mortality factors. In the gradation area, owing to local climatic conditions the coincidence between caterpillar hatching and bud swelling becomes better from time to time; then the mortality of the freshly hatched larvae decreases and the density of the Tortricid population increases. More hosts are offered to the parasites, and they increase too. The plurivoltine species attack in greater numbers the lepidoptera needed as alternate hosts in the late summer, they nearly extinguish them thus bereaving themselves of the possibility to survive. The efficiency of parasites is reduced thereby hastening the move upward of the Tortricid abundance.

A. Einleitung

Die Untersuchungen gingen von folgender Überlegung aus: Der Eichenwickler weist an oft nicht sonderlich weit voneinander entfernten Orten unterschiedliche Fluktuationstypen (Schwerdtfeger 1968, S. 307) auf; am