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TEMPORARY PLANT IMMUNITY TO SUCKING INSECTS INDUCED BY CHEMICAL SPRAY MATERIALS

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The word immunity has been used in different ways and given various meanings by many workers. A recent article by Kenneth S. Chester (1) summarizes what is known in this field regarding plants, and he defines immunity in plants as "the capability of withstanding infection acquired by the host either through the introduction of protective chemical substances of biological origin (passive) or through the elaboration of such protective substances in the host as a result of stimulation by the parasite." He states further "it must be understood that the same principles as apply to the host-parasite relationship apply also to the relation between two symbionts or between a plant and introduced substances of a stimulative nature such as toxins or proteins which if not counteracted or inactivated would have a deleterious effect upon the plant."

Insecticides have been considered until very recently as materials which contained physical or chemical properties which produced toxic affects upon insects directly. They are usually classified under three divisions—stomach poisons, contact insecticides, and fumigants. A fourth group of chemicals which are frequently used are classified as repellants. It has been a common belief that in order to kill insects which obtain their food by sucking plant juices it is necessary to use insecticides which are known as "contact" materials and which have a direct insecticidal action upon the insect by the liberation of gases or their corrosive and penetrative effect upon the body of the insect. Such materials as nicotine sulphate and pyrethrum are known to produce toxic affects in this way. The plant has not been considered as a factor in insect control and has been given consideration only as it might be injured by chemical materials which were applied in attempting to control insects.

In 1928 experiments were undertaken to control the potato leafhopper (*Empoasca fabae* Harris) on bean and potato. When insecticides like pyrethrum were used in these tests, the entire population on the plant was killed within a few moments time following the application, but the eggs inserted in the plant tissues began to hatch in a few hours and continued to hatch for several days and were not affected by this previous spray. Field experiments soon indicated that certain materials when applied to these plants in the field gave no

(1) Quarterly review of Biol. 8: p. 192, June, 1933

immediate results as toxic agents and had no immediate effect upon the reduction of these populations, but in the course of three to five days after their application they reduced these populations remarkedly, causing motor paralysis of the insects and death. The effectiveness of these materials continued as the eggs in the plant tissues continued to hatch over a period of several days, and the young leafhoppers, upon hatching, began to feed. A series of experiments then carried out by special techniques showed conclusively that these materials had no effect upon the insects directly, since the sprayed insects placed on unsprayed plants did not die. But if they were applied to the plant, and the insects were then placed upon the treated plant, from a few hours to several days afterward, and were permitted to feed, these insects would die in the manner mentioned above. With the materials used only local areas of the plant were effected in this manner, and the plant system as a whole was not affected unless the plant foliage was covered with these materials. This apparently is in keeping with the factor of immunity in plants in general, since the cell is the seat of immunity and the system is usually not effected because of the absence of a circulatory system such as we find in animals.

This immunity effect or plant conditioning was first produced by Bordeaux mixtures and other copper compounds and was reported in 1929 (2) and 1930 (3).

At this time the writer referred to this condition as a residual toxicity effect because the plant, once conditioned, is able to produce toxicity for several days or weeks. More recently a similar type of induced immunity in plants has been produced by various sulphur materials. The apparent killing effect produced upon the insect is the same as in the case of copper compounds, although the effect upon the plant may be entirely different in case of these two materials.

The results obtained with sulphur were first reported (4) in 1933, when Dr. N. F. Howard, speaking before the Ohio Horticultural Society, cited the work which had been carried on during the preceding season (1932) by the author, under his direction. A more complete report (5) was made by Dr. Howard and the author in January, 1934. More recently it has been found that practically all types of sulphurs will produce this effect in varying degrees upon these plants, although the elemental sulphur materials and those forms in which the sulphur is not changed chemically by physical and chemical processes have given the best results. For instance, dusting sulphur, "Dry mix", dry wettable and under some conditions flotation

(2) Jour. Eco. Ent. 22: p. 345, April, 1929
(3) Jour. Eco. Ent. 23: p. 383, April, 1930
(4) 1933. Proceedings of the Ohio Vegetable Growers Association, March, 1933, p. 141
(5) Florida Grower 42, p. 8, 1934

sulphur, will give better results than liquid lime sulphur and colloidal sulphur when used to control the potato leafhopper on bean plants.

In some cases these sucking insects were introduced to sulphur sprayed plants as much as three weeks after their being treated, and the insect would develop paralysis and die in the course of from two to five days.

A recent article by List and Daniels (6) of Colorado, reports a similar control of the potato Psyllid upon potato and a similar residual effect upon the potato plant as that which has previously been produced by the writer with both Bordeaux mixture and sulphur materials on potato and bean.

The Psyllid is a sucking insect closely related to the potato leafhopper and apparently is affected in the same manner by inducing immunity in the plant by chemical treatments.

Although spray mixtures like Bordeaux are insoluble when placed upon the plant tissue, these materials in some way either cause the plant to produce abnormal quantities of a toxic material which may possibly be produced normally by the plant only in minute quantities, or the chemical effect upon the plant may be direct by causing the character of the sap to change remarkably and the general rate of metabolism to change by the presence of extremely small amounts of the insecticide which has been absorbed in some form by the plant. Experimental work has given evidence of both possibilities.

Materials of this type can scarcely be classified as contact insecticides in the same manner as those materials which kill the insect by direct effect upon the insect's body. It seems necessary, therefore, to classify insecticides which effect insects of this type in two distinct groups. First, those which we have previously designated as contact insecticides and whose toxicity value refers to the direct insecticidal action upon the insect through contact; and secondly those which might be said to have a residual toxicity value which is attributed to an indirect effect, since the toxicity is accomplished by a conditioning or partial conditioning of the plant (accessory to a certain possible inherent partial immunity) to produce a killing effect upon the insect.

Such a principle of toxic effect or insecticidal relationship—that of working through the plant and producing induced insecticidal immunity in the plant—has not received much positive support or serious consideration until this recent work of the past eight years has demonstrated conclusively these results.