SYSTEMIC IN AGRICULTURE

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I. Definition of a Systemic Pesticide:

1. Has ability to be absorbed by the plant.
2. Has ability to be translocated by the plant.
3. Has to be stored temporarily by the plant, in biologically active amounts.

II. Why are we interested in systemics?

1. Length of residual control is enhanced - not subject to washing, mechanical abrasion, etc.
2. Selectivity, as in case of killing target pest insects but not exposing beneficial insects.
3. Safety to humans, wildlife, and domestic animals - no surface contamination.
4. Easier to treat dense foliar mats with a systemic than it is with a traditional contact pesticide.
5. Economy in application: can apply the systemic with fertilizer, etc.
6. Lack of dependence on water supply (in case of granules or ULV's), etc.
7. Lack of dependence on suitable weather for spraying (again as related to granules,) etc.
8. Lack of visible residues of inert ingredients, etc.

III. History:

A. First systemics were known many years ago - were inorganic compounds such as the selenium and fluorine compounds. They are highly active agents but are apt to be phytotoxic and also very toxic to mammals utilizing the plants for food.

IV. Present Use: A large (and growing) number of systemic pesticides are now registered for use in agriculture.

A. Several types of compounds are represented. These include:

1. Insecticides
2. Fungicides
3. Antibiotics
4. Herbicides
5. Growth Regulators
6. Defoliants

To take each of these groups up in a bit more detail (no attempt is made to include all compounds available):

1. Insecticides

   a. Organic phosphate compounds. This includes by far the largest number of currently used compounds. As examples: SYSTOX, DI-SYSTON, Thimet META-SYSTOX-R, Cygon, Bidrin, OMPA (schraden) and Azodrin.

2. Fungicides. This is a much newer field of endeavor, and is just now coming into concerted research and development. Examples we are beginning to hear much about are: Plantvax and Vitavax of Uniroyal. The "benzamidozole" type of compounds such as Merck's TBZ (Thiobendazole), DuPont's 1991 and Chemagro's BAY 33172. These compounds offer exciting new vistas of coping with some of agriculture's most vexing problems.

3. Antibiotics. Such as streptomycin, offer good activity against such pathogens as bacterial diseases. It is sometimes really difficult to separate these from the classical definition of fungicides. Other antibiotics, however, show promise as insecticidal agents. Extremely small concentrations, often only a few parts per million, are effective.

4. Herbicides. We have become accustomed to use of systemic herbicides such as 2, 4-D and Tordon, which are absorbed by the plant and move throughout the plant including the root system, before killing the plant.

5. Growth Regulators. This is a broad field and includes such diverse uses as chemical thinning agents, "stopdrop" compounds and growth retardants. Compounds that fit into this category are such things as NAA, the gibberellins, and the Uniroyal compound Alar ("B-9").

6. Defoliants. At present used mostly in the cotton industry, but beginning to have a place in other types of agriculture, such as in deciduous fruits. An example is DEF, which is an organic phosphate material.

B. Mode of Action

1. Absorption - the pesticide must first get into the plant. It must be liposoluble enough to prenetrate the waxy cuticle of the plant, then water soluble or hydrophilic enough to be transported in the plant sap. Spray adjuvants often enhance this penetration, and in fact appear to be mandatory in some cases to get systemic activity, as is true for certain of the systemic fungicides now being researched. The roots of plants are the most absorptive part of the plant for many systemics.

2. Translocation - with most plant species this is primarily in an upward direction in the xylem vascular system. Very little translocation downward occurs through the phloem seive tubes. Exceptions of this are some of the systemic herbicides which do travel down into the root systems.

3. Metabolism - in living systems most biochemical activities are dynamic, and such is the case with most but not all systemics. They can be broken into 3 main categories:

   a. Stable - remain as the original compound in the plant for long periods; examples are sodium selenite and fluoracetate. These are long persisting, very toxic compounds, and consequently do not fit in our modern concept of useful, safe pesticides.

   b. Endolytic - the parent compound is the active agent but is gradually biodegraded into non-toxic metabolites. As example is Schradan.

   c. Endometatoxic - the parent compound is chemically changed within the plant to biologically active metabolites. Sometimes these metabolites may be even more effective, active, pesticides than the parent compounds. DI-SYSTON is an example. Often a series of these chemical changes take place. This is, of course, the reason why a pesticide residue method must not only be perfected to detect the parent material, but also all of its biologically active metabolites.

4. Detoxification - the process of metabolism eventually progresses until the active compounds are degraded into various inactive components. Ideally, this occurs just prior to harvest, so that a maximum period of protection

occurs, but ceases just in time to not be a residue problem. Hydrolysis, oxidation, and desalkylation are perhaps the three most active chemical processes involved.

C. Application Methods: These are varied, but the main types currently used are:

1. Spray - overall dilute or undiluted (ULV), to the foliage of plants.

2. Broadcast, either as a solid or liquid, to the soil surface with, or without, soil incorporation.

3. Banding, or sidedressing, in relatively narrow concentrated areas, adjacent to the root systems.

V. Predictions for Future Use of Systemics - Optimistic for Chemical Industry. New cropping techniques will result in:

1. Increased plant populations by means of reducing or eliminating rows; this only leads to a need for increasing the amount of active ingredients used per acre to achieve an equivalent dosage per plant unit. For example, today many recommendations are for "X" number of ounces of active ingredient per 100 feet of row. It is only a matter of simple arithmetic to see that if we reduce row spacing from 36" to 18" as an example, we increase the row-feet per acre from 14,520 to 29,040.

2. An increased need for herbicides, because the decreased row space will not allow for any mechanical tillage and cultivation after planting.

3. A need for chemicals to effect plant growth control, to shape the plant to make maximum use of the available light, to get the fruit or harvestable portions of the plant readily accessable for mechanical harvesting.

4. A need for chemicals to cause uniform maturity of fruit or harvestable produce.

5. A need for defoliants, in many cases, to get the foliage, no longer needed, out of the way, to facilitate mechanical harvest of the desirable plant parts.

6. An increased need for selectivity to fit into the "integrated control" concept of pest management, in which all available "tools" are used to control the pest, including biological control as well as chemical means.

7. A need for new formulations and application equipment. As an example, certain experiments have shown the feasibility of stem treatment only with a very small amounts of chemical per plant. As little as 0.75 mg. active per plant has given effective and long lasting control of a variety of insects on cotton. This tiny amount of material must be placed with precision equipment, and these experiments have shown that a suitable, somewhat viscous, carrier will enhance the uptake. A minimum of about 50 mg. total formulation/plant is necessary for best results This type of preceision placement has certain obvious advantages, such as lessening, evenfurther, the chance of contact action against beneficial insects or other organisms. Other promising new formulations under research are:
   a. "Time-capsule" - or slow release granulars in which differentially soluble granular particles release the pesticide over a long period of time, thus greatly extending the period of protection.
   b. ULV's
   c. Fertilizer and/or herbicide mixtures with insecticides to enable "on-time-over" applications to cut down on cost of application.
   d. Combinations of fungicides with insecticides, nematocides, growth regulators, nutrients, etc., to enable the farmer to achieve the (at present) utopian ideal of one treatment to control all pests and growth characteristics of his crop.

8. Finally, the development of single chemicals to control a wide variety of pests. We have some systemic chemicals at present that have multiple activities. The "benzamidazole" systemic fungicides previously mentioned also possess miticidal and nematocidal activity, as examples.

To Sum Up: I feel that we in the business of developing systemic chemicals are in a unique position to fill many of these anticipated needs of the changing cultural practices in vegetable production. I am confident we are on the threshold of developing multiple use systemics that will achieve as-yet-undreamed-of proficiency in aiding the farmer to produce ever more efficient food production.