Pesticides in the Environment

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Environmental quality is a major issue today. Since Rachel Carson wrote Silent Spring in 1962, pesticides have been considered by some as primary polluters of the environment. To enhance this feeling of "impending doom" because of the widespread use of pesticides, the increased use of gas chromatography since the late 1950s has detected pesticides in the environment that heretofore were unknown, All of a sudden the environment was polluted. The fact was the environment had been polluted for a long time and we were just finding out about it.

There is no doubt that pesticides kill: this is their reason for being -- to kill the target pest, whether it is an insect, a weed, a fungus, a rat and so on However, pesticides are also capable of killing non-target organisms directly and/or interacting with them in various ways through accumulation in the food chain. Primarily, this killing and interaction comes through the misuse of pesticides. However, most of us are aware of examples of environmental pollution with pesticides that came about through the recommended, supposedly safe, use of a particular pesticide.. Two of the more notorious examples of pesticides once thought to be safe, if used in the prescribed manner, are now known to cause serious damage to the environment. These are DDT and the mercurial fungicides. I am sure that there will be other examples as our technology improves and we understand environmental interactions more clearly

However, any meaningful discussion concerning pesticides in the nursery environment must deal with the here and now One thing we can say for certain is that modern pesticides are much safer than the pesticides of yesteryear, The inorganic pesticides of 25 years ago relied on such minerals as mercury, selenium, lead, copper, arsenic and cadmium, Besides being relatively toxic, these pesticides were permanent unless leached away, Even then they were still present, just diffused. On the other hand, modern, organic pesticides, in some cases more toxic than the inorganic ones, all oxidize to CO_2 and H_20 over a period of time,

The impact of any given pesticide on the environment depends on several factors: (1) its acute and chronic toxicity to non-target organisms that come in contact with it, (2) its rate of decomposition, (3) the nature and toxicity of its intermediate breakdown products, (4) the mobility of the pesticide and its intermediate breakdown products in the environment.

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With this in mind, then, let us look at the three major groupings of pesticides: fungicides, herbicides and insecticides Modern fungicides, except for those which contain heavy metals , are readily degraded by chemical and biological means. In addition, most of them have relatively low toxicity to mammals and other organisms and therefore create few hazards to the environment. Similarly, herbicides, with few exceptions, also have very low mammalian toxicities; one of the prime exceptions to this are the arsenical herbicides. Most herbicides, though, do their job by interfering with biological systems unique to plants such as photosynthesis and plant growth hormones. Also, herbicides are usually used in relatively small amounts so the cover crop won't be hurt but the weeds killed. One of the more commonly used herbicides, 2,4-D, is degraded rather rapidly by soil organisms; the same is true for 2,4,5-T. Two of the longest lived common herbicides , simazine and atrazine, may remain in the soil for more than one growing season but eventually hydrolize and disappear. However, their presence in the soil for more than one year may cause damage to susceptible plants planted the second year. A good example in Iowa is when a corn field treated with atrazine is planted the following year to soybeans Soybeans are susceptible to atrazine and may be killed if the chemical is present in sufficient amounts Fortunately, the mammalian toxicity of atrazine and simazine is very low , Generally speaking then, fungicides and herbicides are relatively nontoxic to mammals and otherwise create few hazards the environment, But what about insecticides?

Basically, there are four classes of insecticides: botanicals, carbamates, organic phosphates, and chlorinated hydrocarbons .

Botanicals are called "natural" organic chemicals because they are derived from plant materials. Botanicals are relatively low in mammalian toxicity, break down rapidly to nontoxic compounds and are therefore considered safe from an environmental standpoint. They do, however, provide rather poor insect control in many commercial type insect control operations

The other three classes of insecticides -- the organic phosphates, carbamates and chlorinated hydrocarbons — are synthetic organic chemicals that have caused the primary concern as far as environmental pollution is concerned. Many insecticides in these three classes are relatively toxic to mammals and other forms of animal life and one class -- the chlorinated hydrocarbons -- have fairly long half-lives; that is, they take a long time to break down. Most of my remaining remarks, then, will be directed at the toxicity and longevity of the carbamate, organic phosphate and chlorinated hydrocarbon insecticides.

Both carbamate and organic phosphate insecticides inhibit the enzyme cholinesterase. Cholinesterase is a chemical found in the blood and nervous tissue of all animals. It must be maintained at a proper level in order to sustain normal life. Because many carbamate and organic phosphate insecticides are absorbed readily through the skin they can cause serious harm not only if ingested and inhaled but also if they merely come in contact with the skin. For example, it takes as little as a few drops of a concentrated organic phosphate like TEPP, parathion or phorate taken either orally or through the skin to kill an average-sized adult. There are also some carbamates that fall into the same toxicity category as these toxic organic phosphates, but generally speaking the carbamates are somewhat less toxic than the organic phosphates, particularly dermally. In addition, there are some commonly used organic phosphates such as malathion that are relatively nontoxic and offer little hazard to either the user or non-target organisms. Fortunately, all of the carbamate and organic phosphate insecticides, whether of the extremely toxic or relatively nontoxic variety, are rather reactive and therefore are short lived in the environment. As an example, some may last only a few days in the environment. They do not accumulate in the environment and are unlikely to be found in food crops.

The chlorinated hydrocarbons, on the other hand, -- DDT being the most notorious example -- are known for their persistence, For example, some chlorinated hydrocarbons may be effective for as long as a year or more in the environment. Longevity of the insecticide is obviously an asset in many insect control jobs. However, longevity can also be a detriment to the environment, particularly if the insecticide accumulates or builds up in the food chain. Basically, there are three factors which account for chlorinated hydrocarbon persistence in the environment (1) they are practically insoluble in water, (2) they are soluble in fat, (3) they are generally unreactive.

Next, Let's look at some factors that affect chlorinated hydrocarbon persistence and pesticide persistence in general.

1 have discussed briefly the role the chemical itself plays in persistence. Carbamates and organic phosphates are inherently short-lived in the environment, and the chlorinated hydrocarbons are inherently long-lived in the environment. For example, if 5 lbs. of malathion, an organic phosphate, is applied per acre, eight days later only 3% of the original dose remains. On the other hand, if 5 lbs. of aldrin, a chlorinated hydrocarbon, is applied per acre, 40% of the original dose remains either as aldrin or dieldrin 5 months later. Formulation and method of application also influences persistence. The greatest breakdown of aldrin occurs when it is applied as a liquid emulsion on the soil

surface; the least amount of breakdown occurs when it is applied as granules incorporated into the soil. Soil type is yet another factor which affects persistence. Other things being equal, persistence is longer in soils that are high in organic matter or clay, In addition, soil type affects run-off and if your're dealing with a chlorinated hydrocarbon insecticide which adheres strongly to soil particles, the chemical is going to go where the soil goes.

One of the biggest factors affecting the persistence of carbamates and organic phosphates is the presence of moisture. These insecticides are hydrolyzed quite rapidly and, if the pH is either high or low , the breakdown reaction is speeded up even more. The chlorinated hydrocarbons, because they are fairly insoluble in water, are not influenced directly to any great extent by the presence of water, However, in the presence of water, chlorinated hydrocarbons may increase volatilization. Volatilization accounts for much of the chlorinated hydrocarbon translocation around the world; that is, the pesticide will volatilize or co-distil with water and then become trapped on atmospheric dust particles. And, of course, microorganisms have certain moisture requirements.

Very few pesticides can withstand the breaking down action of microorganism for any great length of time, And, indeed, these tiny forms of life are one of the major breakdown pathways for many pesticides. As an example, the persistence of aldrin and parathion in autoclaved (steam-heated) soil is much longer than in non-autoclaved soils because autoclaving kills the soil micro-organisms . Temperature also affects the persistence of pesticides by increasing volatilization and biochemical breakdown,

There are many biochemical reactions which affect pesticide persistence in the environment, but it is beyond the scope of this presentation to go into them here. For example, sunlight plays an important role in the breakdown of pesticides through photolysis, Also, all water-soluble pesticides are susceptible to leaching. Keep in mind, however, that the chlorinated hydrocarbons are insoluble in water and if they are transported by water must be attached to soil particles in the water,

In summary, let me say that organic pesticides are found in nearly all living matter that has been analyzed. Fortunately, most pesticides break down fairly rapidly in our environment. In many cases, though, we have no idea what the presence of these chemicals really means. Some of us like to speculate in rather emotional language what their presence means but the fact is that in many cases we simply don't know. Obviously, pesticides should only be used when it is absolutely necessary and at the lowest rate possible. I feel that for each individual pesticide you must decide whether or not it is detrimental to human health or upsets the environment in undesirable ways before it is degraded. As a rule of thumb you should always choose the least toxic, most specific pesticide that will achieve your control objective.

There is little doubt, I think, that the use of the heavy metal pesticides should be curtailed. Not only are these chemicals extremely persistent in the environment, but in most cases, less hazardous alternatives are available. The same comment might be made concerning the chlorinated hydrocarbon insecticides but perhaps with less emphasis. I feel their use should be avoided whenever possible; but, obviously, there are some control jobs where only chlorinated hydrocarbons will be effective.

In closing, let me say that if any of you are concerned about pesticide residues in your nursery environment, there are many analytical and testing laboratories available that can tell you precisely what your pesticide situation is if you send them a soil sample. I have a list of such laboratories for Iowa, but I am sure that the State Pesticide Coordinator in other states could provide the necessary information for his state.