LANDSCAPE INTEGRATED PEST MANAGEMENT

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Integrated pest management has been defined as the selection, integration, and implementation of pest control based on predicted economic, ecological, and sociological consequences (1). Today, perhaps more than ever, this approach is relevant to all landscape managers responsible for pest control. Never before have societal concerns regarding pesticide use so greatly affected the day to day operation of the landscape industries, particularly in the northeastern and southwestern parts of the United States. At the time of this writing more than a dozen states have enacted legislation requiring the posting of signs to areas treated with pesticides. Several states require written notification to neighbors or pesticide sensitive individuals adjacent to application sites. These changes in legislation occurred largely in response to societal concerns related to pesticide use. They clearly affect the economics of managing pests in landscape systems.

In addition to societal concerns, ecological considerations associated with pesticide use have become increasingly important in shaping management decisions and practices in landscapes. When pesticides are not managed wisely, unwanted ecological consequences can occur. For example, Tashiro (29) provided examples of six insect pests of lawns known or suspected to be resistant to one or more types of synthetic organic pesticides. In addition to the evolution of resistance in pest populations, pesticides may have other undesirable ecological effects. Although the exact role of predators in determining the dynamics of pest populations remains unknown for most systems, much research indicates that predators play an important role in reducing pest problems in landscapes (20,26). Cockfield and Potter (2) demonstrated that a single application of synthetic organic pesticides to control sod webworms significantly reduced webworm mortality caused by beneficial predators in turf plots. Outbreaks of secondary pests particularly scale insects and mites have been observed in other systems involving landscape plants (7,14,16). Other adverse ecological consequences associated with pesticide use in landscapes include the disruption of organisms such as earthworms that remove thatch (20). In addition, long term pesticide use in the same location can result in enhanced breakdown of pesticides by soil microbes (18). These and other adverse ecological effects reduce the utility of pesticides in landscapes.

Bottrell (1) outlined several principles fundamental to the development of an IPM program. First, the pest manager must accept the idea that potentially harmful species (pests) will continue to exist in the system. The usual goal of a pest management program should not be the eradication of all pests from the system. No landscape can be kept totally free of pests such as aphids, mites, caterpillars for extended periods of time. The cost of materials and labor to eliminate all pests is not justified. A more reasonable management objective is to maintain pest populations below a damaging level. Low levels of pests may provide food for beneficial organisms in the managed system. These beneficial organisms may help to control pests at a later time (1).

A second fundamental principal of IPM is that the entire landscape is the management unit and should be viewed as an ecosystem (1). Landscapes are complex ecosystems composed of interacting populations of plants, animals, and fungi. Abiotic factors such as temperature, rainfall, irrigation, soil structure and nutrients will affect associations between the living community of organisms found in landscapes. Managers have the ability to alter many of these associations to the benefit or detriment of pests. For example, Vargas (31) demonstrated that alterations in a physical factor (irrigation frequency) has a major impact on the abundance of beneficial fungi and bacteria in bluegrass turf. They suggested that frequent watering encouraged the buildup of beneficial microbes which in turn helped to suppress pathogenic fungi (31).

A third basic premise of IPM is that the use of natural control agents is maximized (1). A great diversity and number of beneficial organisms inhabit landscapes (20,26,30). When chemicals must be used to control tree or shrub pests, there are several ways to reduce potentially adverse effects on beneficial organisms. First, treat only plants or portions of plants requiring treatment. This practice of spot treatment has been shown to greatly reduce unnecessary pesticide use in a variety of ornamental plant systems (5,6,12,19,29). Second, apply materials at the time when they will be most efficacious against the target pest. For example, do not spray scale insects when most of the population is in the egg stage. Wait until the more vulnerable crawler stage is present. Most pests have specific times in their life cycle when they are relatively immune to control by pesticides. Pesticides should not be applied during these times. Third, select pesticides that are least disruptive to the complex of beneficial organisms found in the landscape ecosystem. Recently, there has been great interest in developing biorational pesticides for landscapes. Formulated biological control agents such as bacteria (Bacillus thuringiensis) and nematodes (Steinernema carpocapsae) and pesticides with short periods of residual activity such as soap and oil may be less disruptive to beneficial organisms found in landscapes then conventional synthetic organic pesticides. Much work remains to be done in this area.

A fourth principle of IPM is that any management procedure may produce unexpected and undesirable effects (1). For example, Potter et al. (20) described a scenario in which pesticides and fertilizers may directly or indirectly reduce earthworm populations in turf. They also demonstrated that earthworms were vital in breaking down the thatch layer. When thatch accumulates, the movement of fertilizers, pesticides, and water may be restricted. Turf may become more vulnerable to heat or drought stress or pest attack (20). In a similar way, McClure (15) has shown that fertilization greatly increases the injury caused by hemlock woolly adelgid by enhancing its performance on fertilized trees. This example demonstrates that a single management action can have an unexpected and unwanted effect on the ecosystem.

A fifth and final tenant of IPM is that the management approach should be interdisciplinary (1). This simply means that the most effective programs will be developed through the cooperation of people trained or experienced in several disciplines such as entomology, pathology, weed science, agronomy and economics and interested clientele groups including nurserymen, sod producers, golf course managers, lawn maintenance firms, landscape designers, and landscape managers.

The IPM approach has formed the foundation for pest management in many agricultural crop systems for more than two decades (17). This concept is especially relevant for landscape managers now that concerns of groundwater and environmental contamination, and pesticide use are in the focus of public attention. Moreover, the IPM approach is a sound alternative to control programs that encourage the development of resistance by pests and have unwanted and unnecessary effects on beneficial non-target organisms. Programs developed at the University of Maryland during the past decade have taken the IPM approach from the domain of the farmer and demonstrated its utility in several ornamental plant systems including home grounds, city-owned plants, parks, corporate landscapes, and commercial nurseries (3,4,5,6,10,12,22,29).

Several components must be implemented if an IPM program is to be effective. First, the pest manager must have a thorough knowledge of the key pests, key plants, and key locations in the managed system. These concepts are reviewed in greater detail in this volume in the chapter entitled "Key pests, Key Plants, and Key Locations" but will be reviewed briefly here. Key pests are those found in damaging levels year after year and usually involve a relatively small number of insects, diseases, weeds, and nematodes. Some of these pests will be the same over broad geographic regions but others will vary in turfgrasses in different locations. When the manager has obtained a sound knowledge of the identification, biology, and control of these pests his or her job is greatly simplified. Key plants are those most likely to incur damage and require treatment year after year (24). By knowing the cultivars and species most susceptible to pests, managers can reduce losses by growing resistant materials and by focusing their monitoring and management activities on pest prone plants. Trees and shrubs vary widely in their susceptibility to insect pests, diseases, and their response to environmental stresses. Key locations also occur in landscape ecosystems. These are locations that have a history of pest problems or are especially likely places for problems to develop. For example, in Maryland, lace bug problems usually appear first on azaleas planted in locations exposed to full sun (24). Areas like this should be identified, recorded, and monitored closely.

Monitoring is the regular inspection of plants to detect the presence of damaging insects, weeds, diseases, nematodes or other adverse environmental conditions (23). Monitoring provides the information to pinpoint the location of pests and apply controls in the most efficacious and timely way. It also provides information on the presence and activity of beneficial organisms that may eliminate the need for other controls. It also informs the manager regarding how effective previous controls have been. Monitoring is accomplished through the use of visual inspections, a variety of trapping devices, and may be facilitated by recording environmental data such as temperature, rainfall, and humidity. The use of degree day models for predicting pest activity has become quite widespread in recent years and represents a significant improvement for timing control actions compared to other methods (26).

If a problem is detected, the pest manager must go through a decision-making process that involves a minimum of the following considerations. First, is the problem severe enough now or does it have the potential later to cause true damage? This is one of the most difficult questions for a landscape manager to answer and the answer will be highly dependent on the specific pest and plant combination in question. Certainly, for a small dogwood tree, the presence of a few dogwood borer larvae represent a serious threat to the tree and control actions are warranted. For other pests such as many species of aphids relatively high levels must be present before intervention is considered. Recent research has indicated that defoliation must approach 5 – 10 % of the plant canopy before a majority of people will begin to notice the injury to the plant and consider remedial action (26). We now recommend this as a guideline for management of defoliators in landscapes.

A second question that must be considered: "Is control most efficacious at this time or would another time be better?". This question can only be answered when the pest manager has a sound understanding of the biology of the pests found in the management system. It is imperative to realize that pests have definite windows of vulnerability in their life cycles when they will be most susceptible to control by any given tactic. For example, a spray of oil or soap might be relatively ineffective for controlling a mature scale insect protected by its waxy cover. However, the same treatment directed at the crawler stage of the scale could produce highly acceptable levels of control. Knowledge of the best time in the life cycle of a pest to initiate a control action is fundamental to sound pest management.

Once the decision has been made to control a problem the pest manager combines one or more control tactics such as cultural controls, mechanical controls, biological controls, resistant plant materials, and chemical controls into an integrated management plan or strategy. The landscape manager must be aware that several environmental factors may contribute to pest problems and by eliminating or ameliorating these factors the risk of plant loss can be reduced. A classic example of this type of association is drought which can predispose plants to a variety of insect and disease pests. By providing supplemental water through irrigation or improving the structure and composition of the soil, drought stress can often be prevented or alleviated, thereby reducing the risk of pest attack. In other cases such as when natural enemies are present and active and known to have the ability to successfully keep pest populations below damaging levels, the pest manager may decide to do nothing at all. We often find this to be the case for aphid infestations on many types of landscape plants. Frequently, naturally occurring predators and parasites are able to reduce aphid populations before important plant injury occurs. Finally, when the pest manager decides to intervene with a chemical application, they should select the material least disruptive to the environment yet capable of effectively controlling the pest.

Now is an exceptionally exciting time in the development of alternative control tactics for managing pests in landscapes. Endophytic grasses resistant to many insect species provide an outstanding alternative to synthetic organic pesticides for managing insect pests found in turf (8,28). Renewed interest in biological control agents such as Bacillus thuringiensis and entomopathogenic nematodes will provide a better understanding of the efficacy and utility of these agents in landscapes (9,13,26,27).

The final component of IPM is an evaluation plan. Among other things, this plan allows the manager to determine the efficacy of control actions, the cost effectiveness of activities such as monitoring and control tactics and the overall value of the management program.

Integrated pest management programs conducted by the University of Maryland with homeowners, communities, arborists, commercial nurseries and Christmas tree growers have demonstrated the feasibility of this approach for some members of the green industry (26). Similar programs for homeowners have demonstrated the feasibility of the IPM approach in lawns (32). Benefits have included substantial reductions in losses due to pests on many crops, reductions in the overall costs of pest control, and dramatic reductions in the unnecessary use of chemical pesticides (6,12,19,26,29). These results were achieved without a reduction in the quality of the crop and with a high degree of grower satisfaction (6,11,25). The implementation and adoption of the IPM approach will not occur overnight. It will not be immediately feasible in all situations. However, due to ever growing societal concerns regarding the use of pesticides, a more comprehensive understanding of the ecology of landscape ecosystems, and the reality of economic constraints, IPM will provide a viable alternative to conventional pest management approaches for many landscape and managers.

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