



Practical Integrated Pest Management



■ A framework for Pest Management
in Nursery Crop Production

Canada

AAC
agricultural adaptation council

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■ Introduction

Integrated pest management and making it work for you

Integrated pest management (IPM) is a decision-making process that considers all available techniques in the effective, economical and ecologically sound management of pests. The main difference between conventional pest management and IPM is where you put your effort. Conventional pest management strives to control pests economically, with emphasis on cost-efficient treatments. While IPM is also concerned about the economics of pest management, it places a greater emphasis on understanding why pest outbreaks occur and finding sustainable solutions to those problems. Comparing both systems, IPM focuses effort in the preventative stages of pest management (namely preventing, monitoring and identifying, which will be covered in the first three chapters of this manual), whereas conventional pest management focuses its effort on treating (the fourth chapter of this manual), the reactive stage of pest management. With increasing pressure on agricultural producers (including ornamental and specialty crops) to become better environmental stewards, IPM is becoming the future of crop protection.

As crop growers in other industries have begun to change their approach to pest management, information and resources have become increasingly available and comprehensive. Government and academic institutions have responded to the need for more resources by providing publications and expert staff to help growers make the transition. IPM has not been established to the same extent in the ornamental sector as in other sectors. Clearly, despite the amount of information and expertise, there are still some factors that stand in the way of a wholesale acceptance and implementation of IPM programs in the ornamental industry.

One of these factors may be the lack of a clear outline for making the transition at your specific nursery. The majority of information available to you provides specific, IPM-based solutions to real and potential pest problems. This information is definitely useful when it is put in the decision-making framework of an existing IPM program. However, for a conventional pest management program trying to transition to IPM, the information is either overwhelming or irrelevant. At present, you must review and filter this information into something practical for your operations, which is a very intensive job. Since pest management decisions often need to be made at the same time as many other important production

decisions, the traditional approaches probably win out over new IPM approaches, either because it fits with your operational capacity or it is the default option. The problem is not a lack of information, it is being unable to apply it – there is no resource available now that can help you sort through the information and implement IPM methods over the conventional ones.

IPM solutions will work when you have an appropriate decision-making framework in place. This manual is designed to help you build that framework. Without that framework, IPM methods seem radically different from what you are used to. In a few cases they are, but overall, IPM is neither something that should be implemented overnight, nor should it be a complete revolution in pest management for you. Accordingly, this manual focuses on implementing an IPM program for your nursery in a gradual fashion. This approach will ease you into building and maintaining a framework for an IPM program that either fits with current operational procedures or changes them gradually over time as needed. Because of the large amount of information available to you already, specific procedures will be dealt with only superficially in this manual.

Manual features

This manual is designed to be accessible and functional. You will find features that will help you to implement IPM in a gradual and complete way. These features include:

- Checklists of Good, Better and Best IPM practices
- A scoring system used for self-assessment and tracking progress
- Short descriptions of each practice
- Thorough, concise and logical guidelines for practicing IPM in the nursery

Checklists of Good, Better and Best IPM practices

The checklists of practices itemize a number of common practices and good ideas currently used in the IPM programs of some Canadian nurseries. The purpose of these lists is to show you some of the IPM practices you may already do and to introduce you to practices that will fully complement your program. The lists are short, which further simplifies the implementation process. The practices are placed in the “Good”, “Better” and “Best” categories based on the level of sophistication they require. Good practices are easy to establish,

Good practices

Monitoring pest populations after treatments
Setting quality control and assurance standards

Better practices

Analyzing results of pest management efforts to identify problems
Measuring the economic impact of the IPM program

Best practices

Reviewing and comparing records and results
Sharing knowledge and expertise
Monitoring and revising standards

and many are common to nurseries already. Better practices build on the Good practices, and Best practices build on the Better practices. By establishing a hierarchy of practices, the checklist allows you to identify the strengths of your IPM program and begin planning on how to upgrade or maintain them. The checklist also allows you to identify the deficiencies in your current IPM program and start working to improve them.

The checklist is the key to building your nursery's IPM framework, and sets this manual apart from other sources of information available to you. It is a simple but effective approach to implementing IPM at your nursery, and will therefore be an important tool for you.

A scoring system used for self-assessment and tracking progress

It is likely that the IPM practices at your nursery are a mix of the Good, Better and Best categories. By scoring the practices, this manual gives you a tool to assess the overall level of your IPM program before and after you have used it.

Being able to track progress is an important element of any project, including implementing an IPM program in a nursery. By using a scoring system, you can track your progress and also compare it to the industry standard.

Avoiding favourable conditions for pest establishment	2
Improving stressful growing conditions	2
Applying knowledge from successes	2

Short descriptions of each practice

Each practice needs some explanation, and this generally requires just a few sentences. Instead of listing and focusing on detailed methods and different ways to implement these practices, the descriptions focus on why the practices are important to IPM. These descriptions will also illustrate how the things you already do, occasionally with slight alterations, can be used in your new IPM program.

Giving the necessary amount of information is a feature of this manual that will definitely add to its functionality. Instead of expanding on various techniques, many of which may not apply to specific nurseries, this manual allows the grower to first prioritize the practices that need attention and then determine what techniques suit him best.

Thorough, concise and logical guidelines for practicing IPM in the nursery

This manual is not designed to be read cover to cover. As a functional document, its emphasis is on providing you with the tools to implement IPM at your nursery. At the same time, the manual has to address each element of a complete IPM program in order to be relevant.

In order to be thorough, each component of a complete IPM program will have its own chapter. The chapters will all follow the same progression: Introduction, Checklist, Explanations and Conclusions. This predictable structure ensures that IPM will be thoroughly covered, and allows the grower to quickly refer to solutions.

This manual in perspective

IPM is the future of pest management in agricultural production, but making the transition from conventional pest management to IPM must be as simple as possible. The amount of detailed information about IPM elements and practices is needed, but has lacked context and organization to this point. This has impeded ornamental growers in adopting IPM methods. This manual has been designed to give context and organization to the information available to growers and to be their guide in developing and implementing IPM programs at their nurseries.

Chapter 1: Prevention

1. Introduction

Many pest problems can be avoided before they start. Preventing pest problems takes careful planning, but when successful, you benefit ecologically and economically. Since you are not reacting to a pest problem (i.e. trying to actively reduce a damaging pest population), you release fewer toxins into the environment and spend less time and money maintaining marginal stock that may have been affected by the pest. Although the methods of prevention can be simple, they often require more complex decision-making, more time and more labour. Despite the demands of practicing prevention, you, the grower, should not be discouraged by the prospect of hard work early on, nor should your IPM manager be afraid to suggest it. At the foundation of any IPM program is prevention, and there are many ways that prevention can be implemented at your nursery.

The preventative practices listed in the checklist below reflect many practices currently in place at nurseries across Canada. The “Good” practices are common to many, and form the basis of a good IPM program in general. “Better” preventative practices build on the Good preventative practices and develop a strong infrastructure onto which you will build the “Best” practices. The Best practices are designed to make good use of the Good and Better practices while continuing to challenge you to keep pest prevention in mind at every step of the growing process.

Preventing pest problems is something many nursery and pest managers do as a matter of course, but often do not realize it. Growing healthy plants that are well suited to the growing conditions or climate have fewer pest problems than stressed or non-hardy plants. These plants also sell better, which is why the preventative aspect of IPM may go unnoticed – producing high quality stock is not only essential to securing and sustaining sales, it is also a clear indicator of good preventative pest control. When looking over the Good, Better and Best preventative practices, try to think of things you do to maintain the health and quality of your plants already. These practices may not seem like IPM, but they will significantly reduce the effort you put into pest management down the line.

2. Checklist of preventative practices

Use this checklist to assess the practices at your nursery. For each practice, consider how prevention is done at your nursery and check all that apply. For the practices you checked, add up the numbers to the right to get a score for your nursery.

Good practices	Score
Monitoring fertility and pH	1
Monitoring plant health regularly	1
Applying knowledge gained from crop failures	1
Considering the economics of each pest management strategy	1

Better practices	Score
Choosing plants appropriate for the growing conditions	2
Avoiding favourable conditions for pest establishment	2
Improving stressful growing conditions	2
Applying knowledge from successes	2
Assessing pest risk	2

Best practices	Score
Basing replanting decisions on previous crop's success	3
Anticipating and avoiding stressful growing conditions	3
Improving on successes	3
Reducing pest risk	3

3. Practice descriptions

1. Good practices

Monitoring fertility and pH

Testing the fertility and pH of the soil or potting medium in field- and container-grown stock, respectively, is a key step in ensuring your plants are thriving and will continue to do so. A plant that is not given proper nutrition is weak and is therefore less resistant to pest attack. Medium or soil pH is also important in ensuring the nutrients needed for the plant are readily available. It is important to test your growing medium regularly (Figure 1.1), and to know what the tests are telling you. Knowing the nutrient and pH levels your plants need will help you make sense of the test results, and testing regularly will help you to make changes before the plant quality suffers. To name a couple resources, OMAFRA Publications 383 (*Nursery*

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& *Landscape Plant Production and IPM*) and 370 (*Production Recommendations for Greenhouse Floriculture*) provide nutrient and pH management guidelines for both field- and container-grown stock.

Monitoring plant health regularly

It is usually very obvious when a plant is not as healthy as it can be. It is important to monitor the health of a plant regularly to make note of changes — what are the symptoms, when they appeared, possible causes and follow-up actions (Figure 1.2). When a problem arises, it is essential to get an accurate diagnosis, and this is when consulting external sources of information is helpful. Keeping track of the plant quality and consulting external resources to find the cause are key steps towards finding effective solutions. After a few seasons, you should have a keen eye for common problems. Spotting common problems will make you more attentive to unusual symptoms that may indicate introduced pests or pathogens.



Figure 1.1 - This picture shows a pest manager testing electrical conductivity (EC) in container production. The EC of a medium is directly related to the concentration of ions it holds, so a higher EC reading means there are more ions in the medium. Since plants can only take up ions, a higher EC means there are more elements available to the plant.

Applying knowledge gained from crop failures

Throughout your growing experience, you have undoubtedly experienced crop failures. The key to making the most of these failures is to understand why the crop failed and then to document it. By documenting the failure and its cause, you

have something to reference when you are devising planting or pest management strategies for the next season so you do not repeat the mistake.



Figure 1.2 - Monitoring can be as simple as walking through your production areas and casually observing the progress of plant growth.

Considering the economics of each pest management strategy

The preventative practices in an IPM program represent the most significant shift from current practices. Ultimately, the practices you implement will save time and labour, so it is always important to consider the overall cost of a pest management practice before wholly committing to it. Refocusing your pest management efforts from treatment to prevention may result in obsolete machinery and techniques, but prevention has proven to be a sustainable long-term treatment strategy. For the nurseries that have implemented preventative practices, not only have treatment costs gone down, but the plant quality has been greatly improved, resulting in cost reductions and sustained sales.

2. Better practices

Choosing plants appropriate for the growing conditions

- PREREQUISITE: Monitoring plant health regularly

Although we know that better planting conditions lead to healthier plants, each nursery is different. By implementing good monitoring, you will learn more about the specific growing conditions at your nursery and be able to choose plants that suit those conditions best. Healthier plants are

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able to withstand minor pest pressures much better, consequently decreasing or removing the need for some pest management action.



Figure 1.3 - Although a couple weeds have found the cracks, the concrete floor in this greenhouse does an excellent job of preventing weed establishment. Seeds cannot find a suitable environment to grow in this greenhouse, which results in no weed pressure on the plants while growing and no weeds shipped with the plants.

Avoiding conditions that favour pest establishment

- PREREQUISITE: Monitoring plant health regularly

Some pests require specific conditions to survive (Figures 1.3 and 1.4). Consult external sources of information about these pests, and keep detailed monitoring records so that you can identify the conditions that these pests thrive in. Then you can use that information to avoid these conditions, ensuring pest populations will either be stressed or eradicated from the area and thus less likely to become problems in your nursery.

Improving stressful growing conditions

- PREREQUISITE: Monitoring plant health regularly AND Applying knowledge gained from crop failures

By paying attention to plant growth through monitoring and recording when and why crops fail, you will develop a good understanding of what stresses your plants and what you can do to help (Figure 1.5). Based on this previous experience and the ability to diagnose plant health issues you can isolate and improve stressful growing conditions.

Applying knowledge from successes

- PREREQUISITE: Applying knowledge from crop failures

Learning from your mistakes should result in successful growing practices. When you find solutions, it is important to understand why they work and document it. Just like a well-documented failure, a well-documented success should inform future plans for plant production. These successes form the basis for nursery-wide best practices.

Assessing pest risk

- PREREQUISITE: Considering the economics of each pest management strategy

Not all pests at your nursery carry the same threat to plant quality and marketability. Conducting a risk assessment for each potential pest — whether or not you have encountered it in your nursery — is a way to proactively deal with pest problems (Figure 1.6). Defining the inherent risk of past, current and potential (i.e., federally regulated and those associated with plant species new to your nursery) pests will help identify pests that require more preventative, monitoring and treatment efforts to achieve successful control.



Figure 1.4 - Laying down landscape fabric before you put plants in your hoop houses is a great preventative pest management strategy. Because weeds cannot grow through the fabric, you will not have them seeding and spreading into your stock, significantly reducing the amount of time and effort you spend keeping your plants clean.

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3. Best practices

Basing replanting decisions on previous crop's success

- PREREQUISITE: Choosing plants appropriately

Growing a crop that requires less management will save a lot of time and effort in the long run. Based on past successes, replanting a field with the plants your nursery grows well will result in a more successful and easier to manage pest management program. The continuing challenge will be to balance market demand with your nursery's strength.



Figure 1.5 - These are Rhododendrons of the same age. On the left of this picture are individuals that have been repotted into larger pots, and on the right are ones that have not been repotted. This grower identified that repotting significantly improved the growing conditions for his Rhododendrons, which is easy to see in this picture.

Anticipating and avoiding stressful growing conditions

- PREREQUISITE: Improving stressful growing conditions

Many factors affect the quality of plants during their production. Based on your experience (and information in your records), you should know what decisions have contributed to problems in the past, such as growing medium, water management, fertility management, container size, etc. Clearly, the best time to evaluate those past decisions is before you make decisions for the next growing season. By evaluating your past actions, you can anticipate and avoid problems in the future.

Improving on successes

- PREREQUISITE: Applying knowledge from successes

After a season or two, it is important to review the successful programs you have instituted at your nursery. When you have implemented a number of strategies that solve problems, it is worthwhile to see if they can be further improved. Regular reviews ensure that your IPM program's preventative strategies do not become obsolete and helps implement change by dealing with it in manageable chunks. Just like maintaining any piece of machinery, regular maintenance of these programs will ensure that they perform at optimal levels.

Reducing pest risk

- PREREQUISITE: Avoiding favourable conditions for pest establishment AND Assessing pest risk

As long as you grow plants, eliminating the risk of pest problems is impossible. Reducing your risk to pest outbreaks and establishment is the next best option (Figure 1.7). You have learned where your nursery is vulnerable to pest outbreaks or pest introductions by assessing your nursery's risk level and understand how to avoid favourable conditions for pest establishment. By applying these practices to your production methods, you are, at best, less susceptible to pest problems and, at worst, well prepared if pest problems come up.

Pest	1-10 Add	1-20 Add	1-10 Mult	1-4 Add	1-10 Add
Apple Grub	1	18			
Strawberry Root Weevil	1				
Apple Moth	1				
Spine Spider Mite	6	18	10		
White Pine Weevil	6				
Japanese Beetle	8	6	8	4	
Pine Striped Beetle	8				
Eastern Spruce Girdler	1	8	8	1	7
Spine Weevil	7	8	8		
Spine Bark	7				
Spine Bark	8	18	8	3	4
Spine Bark	8				
Pine Saw Weevil	9	10	8	1	2
Spine Bark	6	4	10		
Spine Bark	6	2	4	2	2
Spine Bark	6				
Spine Bark	7	8	8	4	4
Spine Bark	7				
Spine Bark	8	8	8	3	7

Figure 1.6 - A pest risk assessment measures the greatest potential significance of each pest at your nursery. The measurement is specific to your nursery and therefore helps you determine your priorities from year to year. A pest risk assessment is a great way to prepare for pests and maintain clean stock inside and outside your nursery.

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1. Conclusion

Using the sum of your points, you can judge how well your nursery measures up. A nursery with a Good preventative pest management component will score from 4 to 10 points, a Better score is from 10 to 16, and a Best score is 17 to 26.

Having assessed the preventative component of your IPM program, you should have an idea about what you're doing well and what you can improve. Look at the practices you have not yet mastered and develop plans that fit with your nursery to address the shortcomings. It is also worthwhile to look at the Good and Better practices you have mastered to develop plans towards mastering their consequent Better and Best practices, respectively. You should find that you have a number of good practices in place already, and all you need are a few adjustments here and there to bring your preventative pest management strategies to the next level. When you achieve Good, Better and Best preventative practices, you should find that "an ounce of prevention is worth a pound of cure."



Figure 1.7 - Restricting public access to your production areas is a simple way to practice risk reduction. Conducting tours in company vehicles and showing only certain production areas are compromises that make little difference to the customer, but may greatly increase your nursery's bio-security.

Chapter 2: Monitoring pests and plants

1. Introduction

A thorough but practical monitoring strategy lies at the heart of an effective IPM program. Regular monitoring is essential to limiting the negative consequences of pest populations. Without regular monitoring, you have no reliable way to gather the information needed for the other elements of your IPM program, namely identifying pests, establishing treatment thresholds, treating pest populations and evaluating your IPM program. Each of these components relies on you to collect information through monitoring.

This chapter will deal specifically with monitoring for pests. The monitoring practices listed in the checklist below incorporate a number of practices currently in place at nurseries across Canada. Establishing the “Good” practices will ensure that you have the best foundation on which to start building a great monitoring plan. “Better” monitoring practices develop in-house actions and resources that will be required for following the “Best” practices. The Best practices are designed to help you make the most of your resources to get the most important, detailed and reliable pest information possible.

Monitoring is something many conscientious growers do automatically – observing their crops regularly; hoping to see their plants growing well. By giving your monitoring efforts some structure and direction, you will take advantage of the time and effort you already put into monitoring by developing good habits and setting realistic milestones. In applying the good habits and reaching the milestones, your monitoring program will ensure that pest problems or pest introductions are identified quickly and the potential for economic and ecological damage is lowered significantly.

2. Checklist of monitoring practices

Good practices	Score
Keeping detailed records	1
Scouting regularly	1
Better practices	Score
Inspecting stock at time of shipping	2
Incorporating various monitoring techniques and sources of information	2
Providing additional manpower to monitoring when needed	2
Allocating more monitoring effort to higher-risk pests	2
Best practices	Score
Assigning staff specifically to monitoring	3
Inspecting stock at time of receiving	3
Coordinating monitoring activities with pest biology	3



Figure 2.1 - Make notes while in the field. Sometimes the small details are important, and these are often left out if observations are written down after a field inspection.

3. Practice descriptions

1. Good practices

Keeping detailed records

Monitoring is something all nursery or pest managers do, though the approaches to monitoring may differ. Much of the information a manager gathers from monitoring is very simple and is used in making everyday decisions. Recording and

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keeping track of this information is a fundamental element of good monitoring and good IPM (Figure 2.1). Regardless of the complexity of the information, your monitoring records serve as a reminder of what you did. Looking back on your records is an essential step to improving what you do because the records you keep will be useful in evaluating decisions and developing plans for subsequent growing seasons.



Figure 2.2 - Pests that can cause serious damage need more effort applied to controlling them. This is a method of sampling Strawberry Root Weevils in spruce - it is labour intensive but accurate, and monitoring this very destructive pest accurately is essential to achieving control.

Scouting regularly

Looking for pests and problems is an essential component of any pest management program, so practice scouting regularly. For example, scouting your entire nursery during the course of one or two weeks (depending on its size) is a good monitoring practice because it makes you interact with your plants. This interaction is essential to observing the natural development of your plants, which in turn will help you recognize when something abnormal (i.e., a pest outbreak) is taking place. The regularity of your scouting will give you a number of benchmarks for comparison, making evaluation easier and more meaningful.



Figure 2.3 - Looking at the root zones for root-feeding pests is a great way to sample a population before visible damage occurs.

2. Better practices

Inspecting stock at time of shipping

- PREREQUISITE: Keeping detailed records and Scouting regularly

Inspecting your stock before it leaves your nursery has a number of benefits. In terms of biosecurity, it is a crucial step in ensuring your pest problems do not become someone else's (Figure 2.3). Finding pests prior to shipping can also alert you to potential problems in the field, which may require immediate attention. It is also an essential part of quality control (covered in Chapter 6), ensuring that your customers receive the healthiest and cleanest stock you have.

Incorporating various monitoring techniques and sources of information

- PREREQUISITE: Keeping detailed records and Scouting regularly.

A comprehensive monitoring plan uses pest-specific techniques and information. Building on your regular scouting and record-keeping practices, it should not be difficult to change how you monitor (Figures 2.3 and 2.4). In addition to the information you gain by scouting and reviewing your records, a few other informational tools can help develop your monitoring plan. There is a wealth of information on the internet and in print about pests and how to sample them. You can also use internet sources to find weather information for your area and ways to calculate degree days. Another tool

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is biological or “phenological” indicators, which are plants whose different stages of development coincide with a pest’s development (more information can be found in *Coincide: The Orton System of Pest and Disease Management* by Don Orton). Using complementary information sources ensures that your monitoring program will be as effective as possible. It is important that you have adequately sampled a pest population, though – the additional techniques and information you incorporate should only help you scout better, not replace scouting altogether.



Figure 2.4 - Beating foliage to dislodge foliage-feeding pests is a great way to sample pests such as mites and aphids. Beating is quick and easy, so you can sample a lot of plants, which will also give you good information on population levels.

Providing additional manpower to monitoring when needed

- PREREQUISITE: Scouting regularly

Although monitoring is a significant component of any IPM program, its demands on time and effort are not constant throughout the growing season. Being able to meet these changing demands by adding flexibility to workers’ schedules will ensure that your monitoring effort pays off.

Allocating more monitoring time to higher-risk pests

- PREREQUISITE: Scouting regularly

The first step in making your monitoring program more effective is to devote more effort to controlling the pests that you have identified as high risk (see Assessing pest risk in Chapter 1). By monitoring these pests more closely, you will gain more information to use as you try to achieve better

control (Figure 2.2). Your nursery’s high-risk pests should include pests that are federally regulated, even if they do minimal damage to your nursery’s plants. A list of federally regulated pests can be found on the Canadian Food Inspection Agency website www.inspection.gc.ca – follow the “Pests” link found under the link to “Plants” on the sidebar.

3. Best practices

Assigning staff specifically to monitoring

- PREREQUISITE: Providing additional manpower to monitoring when needed

Having a dedicated pest monitor who oversees all monitoring efforts is a great way to ensure consistent quality. Dedicating someone who is knowledgeable and conscientious will also give you peace of mind in knowing that their diagnoses and recommendations are correct and based on facts (Figure 2.5). Because monitoring is crucial to making good pest management decisions, you should consider letting the pest monitor train other workers in monitoring and identification techniques. Having occasional, additional monitoring support will help the pest monitor do a good job of monitoring high-risk pests.



Figure 2.5 - Staff dedicated primarily to pest monitoring are great resources in an IPM program. Monitoring does not need to be their only function, but when the job needs to be done, they should be the ones to do it.

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Figure 2.6 - Using baited traps, like this pheromone trap, is a good way to monitor the population levels of certain pests. Monitoring according to pest biology is also much better than using a calendar alone to time treatments.

Inspecting stock at time of receiving

- PREREQUISITE: Inspecting stock at time of shipping and Allocating more monitoring effort to higher-risk pests

For the same reason that you inspect your plants before you ship them, inspecting plants that you receive at your nursery before they are distributed (within your nursery or to customers) adds a significant level of biosecurity to your nursery. You are ensuring that another nursery's problems do not become yours, since you can't control the other nursery's pest management program. In addition, if you find a pest that is not established at your nursery, you will have to react accordingly to this new threat. Because you inspect plants received at your nursery, though, it will probably be on a very small scale and you will have caught it before it can cause any damage.

Coordinating monitoring activities with pest biology

- PREREQUISITE: Incorporating various monitoring techniques and sources of information

Each pest is different, and needs special attention. By taking note of a pest's biology, you will know when it causes the most damage and begin monitoring populations before then (Figure 2.7). Ideally, you should be able to track the development of each pest throughout the growing season and use this

information in timing your pest-specific monitoring. A good way to organize your time is to develop a pest calendar (a template and example are given in the Resources section at the end of this chapter).

1. Conclusion

Using the sum of your points, you can judge how well your nursery measures up. A nursery with a "Good" preventative pest management component will score from 2 to 8 points, a "Better" score is from 10 to 15, and a "Best" score is 15 to 21.

The key to executing a good monitoring plan is building on the Good practices: Scouting regularly and Keeping records. There are many tools and techniques that can help make these practices easier and better, but until you master the good practices, they will not pay you back. Building on the fundamentals introduces the Better practices that reflect your acknowledgement and management of biosecurity risks. When you implementing the Best monitoring practices – by adding to and upgrading the Better practices – you position your nursery to succeed in obtaining the best possible information about your pest populations. Without good information, you cannot execute the other elements of an IPM program well – the best monitoring plan will give you the best information.

Chapter 3: Identifying pests and other organisms

1. Introduction

Identifying your pest problems accurately is essential to successfully managing them. The diversity of pests and treatment options requires that you know how to distinguish one pest from another. Practically speaking, the decision about treating a pest depends on whether or not the pest in question has been accurately identified. Inaccurate identifications can cost time and money without achieving any positive results. Part of making good identifications is also being able to distinguish pest species from beneficial or benign species. Despite what your experience may be, there are many more of these species than pest species.

The identification practices listed in this chapter will help you develop the ability to identify pest problems quickly and accurately. Applying the “Good” practices will instill good habits and knowledge concerning pest identification. Developing the Good practices will lead into the “Better” practices, which will increase the efficiency and accuracy of identification by your staff. The “Best” practices incorporate aspects of continual learning and proactive maintenance.

You can probably already identify certain species and distinguish between similar species – just look at your inventory. As diverse as the plants you sell are the pests that can inhabit them. Each species you grow likely has different growing requirements than a sister species; if this is true, then why wouldn't it be true for the pests? The great advantage of knowing what species you are dealing with, be it crop or pest, is that you also know what its specific biological strengths and weaknesses are. In IPM, identifying a pest accurately means that you can exploit its weaknesses efficiently.

2. Checklist of identifying practices

Good practices	Score
Understanding basic pest biology	1
Confirming pest infestation	1
Sharing knowledge of high-risk pests with field workers	1

Better practices	Score
Using additional indicators to identify pests	2
Developing referential material	2
Encouraging participation by all staff	2
Ensuring the accuracy of identifications	2

Best practices	Score
Identifying organisms accurately in-house	3
Distributing referential material to staff	3

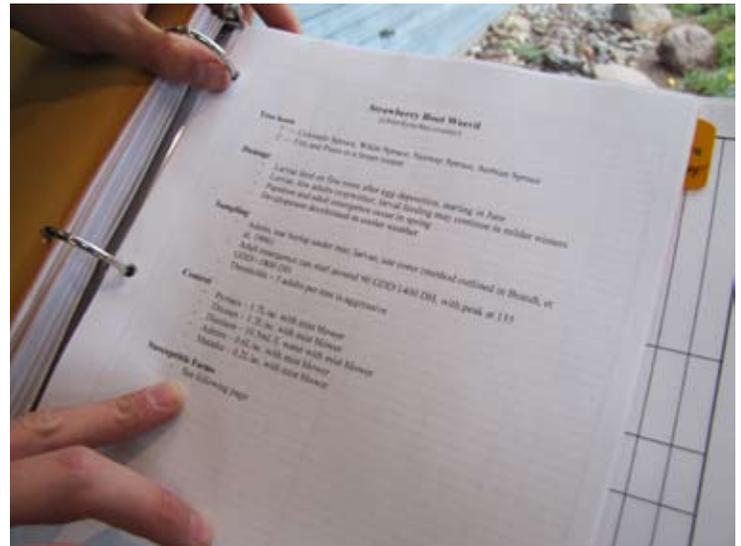


Figure 3.1 - Having a single place (like a page in a pest management manual as shown above) to write down the information about a pest's biology is a good practice. When you have a question, or want to add information, having that source easily accessible will make learning about pests much easier.

Chapter 3: Identifying

3. Practice descriptions

1. Good practices

Understanding basic pest biology

Treating pests effectively requires pest managers to know when pest organisms are most susceptible to control options, as well as the conditions under which they thrive. A basic understanding of pests will help you learn these important facts and incorporate them into your IPM program (Figure 3.1). For example, at the peak of growing season, your pest problems likely involve a mix of annual, biennial and perennial weeds as well as holometabolous (undergoes complete metamorphosis, or pupates) and hemimetabolous (having incomplete metamorphosis, so immature stages look similar to adults) insects. Understanding these distinctions is necessary to achieving good control because they indicate important biological differences that can affect the pests' response to your treatment efforts.

Confirming pest infestation

The best way to know you're treating a pest is to see it beforehand. It almost goes without saying, but a fundamental element of pest identification is seeing it. Without seeing the pest, you have little reliable information on which to base treatment decisions or with which to evaluate the success of those decisions. It is useful to have at least a hand lens for identification of small pests in the field, like spider mites (Figure 3.2). For even smaller mites – and fungal bodies if you're very ambitious – a dissecting microscope is better, but is cumbersome for field applications.

Sharing knowledge of high-risk pests with field workers

Due to their real or potential impact on plant health and quality at your nursery, high-risk pests deserve a lot of attention. By sharing identification information about these pests with field workers, you increase your chances of intercepting these pests earlier than if that job was left only to a pest manager.

2. Better practices

Using additional indicators to identify pests

- PREREQUISITE: Confirming pest infestation

In some cases, you can make an accurate pest identification without seeing the pest. Feeding damage is a very common indicator of pest presence and can often be a distinguishing



Figure 3.2 - Seeing a pest is both good and bad news -- good in that you have confirmed its presence, but bad in that you now have to make a decision about treating it. Having seen the pest, your decision will at least be informed and that is very important in practicing good IPM.



Figure 3.3 - Although this grower has not seen the pest, he knows that this tree has been attacked by a boring beetle. The damage he is pointing to is indicative of such insects, and the tree species and past history at his nursery has helped him accurately identify the pest.

characteristic (Figure 3.3). Pests can also be differentiated from one another by what they leave behind – the texture and volume of insect “frass” (the insects excrement) can vary greatly between orders and families. It is still important to see the pest itself, but by learning as many different signs of pest infestation as you can, you will be able to locate and identify pests easier.

Chapter 3: Identifying



Figure 3.4 - Developing a central source for informing and directing your IPM program is essential as your program grows. Any piece of information you think is worth recording should find a place in this document.

Developing referential material

- PREREQUISITE: Sharing knowledge of high-risk pests with field workers

The list of high-risk or general pest species at your nursery may be long, and can be hard to communicate all at once. Developing a notebook or manual that contains diagnostic and biological information on all your pests is a good way to keep track of pest history and stay up-to-date with current information (such as you would get from your monitoring program) (Figure 3.4). Keeping this material in one place will help make your pest management program efficient and tailored to your operation.

Encouraging participation by all staff

- PREREQUISITE: Sharing knowledge of high-risk pests with field workers

Many areas of pest management require some specialized technical training, and the job deserves a significant portion of one person's time. However, there is generally too much to do and too little time to do it in. A pest manager will benefit if all field staff is watchful and can identify some common pests as well as high-risk ones (Figure 3.5). Even if the pest manager is aware of the problems that field workers or other staff find, the redundancy ensures that pest problems will not go unnoticed for long.

Ensuring the accuracy of identifications

- PREREQUISITE: Understanding basic pest biology

While you develop basic identification skills in yourself and other staff members, it is important to ensure all diagnoses are accurate, especially early on. At this stage, it is best to proceed with caution and seek help if you're ever unsure. Getting a second opinion from an expert is the most efficient way to deal with organisms you can't positively identify yourself (Figure 3.6). There are also resources on the internet (including the Landscape Ontario pest database), which can at least be a step in the right direction. Remember, starting with good identifications not only ensures your treatment decisions will be good, it ensures you develop your in-house identification skills thoroughly and quickly.

3. Best practices

Identifying organisms accurately in-house

- PREREQUISITE: Developing referential material and Ensuring the accuracy of identifications

Being able to identify non-pest organisms will save you time and stress and also give you information about the health of your ecosystem. If you see a lot of beneficial organisms, your ecosystem is healthy and you may want to treat pest populations more precisely (that is, not with broad spectrum, very persistent pesticides). Getting to know beneficial



Figure 3.5 - Displaying information about pests you are currently monitoring will help ease the burden on whoever is responsible for monitoring. If your field workers can accurately identify pests in the field, your pest manager will be more productive. To get the information out, use cork boards, white boards, tail-gate meetings, or whatever works.

Chapter 3: Identifying



Figure 3.6 - These two leaves are infected by two different fungi. Although the leaves are from the same species and the fungi look very similar, a well-trained pest manager has learned how to identify them accurately.

organisms takes time, though, and is the fruit of curiosity and attention to detail. Being aware of all the organisms in your natural space will provide you with a better sense of the severity of your pest problems and how they are likely to develop.

Distributing referential material to staff

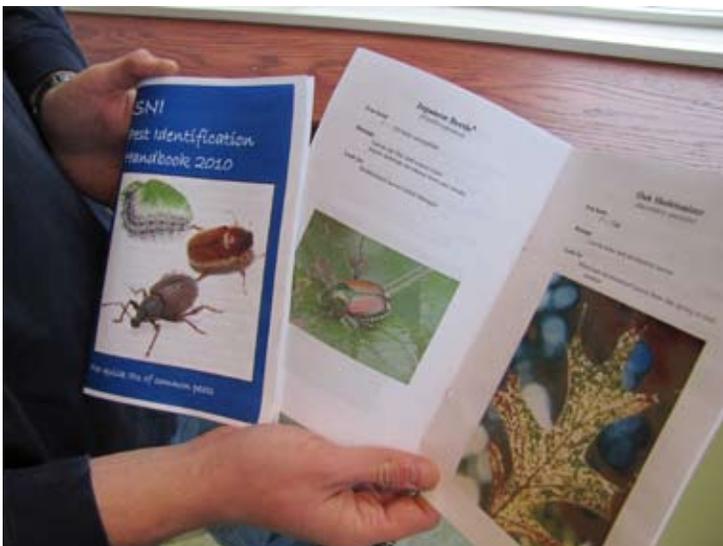


Figure 3.7 - A handbook that can be distributed to field workers is another way to ensure that field workers are giving the pest manager accurate information. Especially with language differences, having detailed colour photos will help clear up confusion.

- PREREQUISITE: Developing referential material

Having developed reference material to help you streamline pest management, it's an easy and very proactive step to simplify it and distribute something like a handbook to the rest of your field staff (Figure 3.7). Having this material will help them become better identifiers, support their involvement and increase the value of their information. You might take an opportunity to talk about pest identification in the field with your field workers at a pre-season meeting, like a tailgate meeting or orientation session, and distribute the handbooks then.

1. Conclusion

Using the sum of your points, you can judge how well your nursery measures up. A nursery with a “Good” preventative pest management component will score from 3 to 7 points, a “Better” score is from 9 to 16, and a “Best” score is from 14 to 22.

Accurate pest identifications are essential to effective pest management. Building this skill takes time and experience, but is worth the investment. It is important to base your decisions on good information, and to get the best information requires your pest managers and scouts to have some sophisticated knowledge. Building on that knowledge, you can implement practices to share and apply what your pest manager knows. These practices will then evolve into a perpetually efficient and accurate identification system at your nursery.

Chapter 4: Establishing thresholds for intervention

1. Introduction

Protecting your crop is one of your top priorities, and your treatment decisions need to be based on information. While monitoring provides the information, a threshold will allow you to use it in making a treatment decision. In IPM, a threshold is usually a predetermined pest population level at which it becomes necessary to act towards stopping or reversing pest damage. The aim of establishing thresholds is to make treatment decisions simple, effective and sustainable. Of course, developing a tool that does all of that takes deliberate mental and physical effort, and this is why it has a chapter dedicated to it.

This chapter will help you to develop and apply thresholds for treating your pests. The “Good” practices will establish the fundamentals of your thresholds – using good information and getting comfortable with not treating when you otherwise might have. The “Better” practices build on the foundation of the Good practices and give you tools to make your thresholds precise. The “Best” practices give you tools to apply precise thresholds to different situations.

There is always a degree of risk in making treatment decisions, especially whether or not to go ahead with a treatment. Traditionally, growers have erred on the side of caution and treated if there was any chance that a pest could cause serious damage. Although you likely employ some treatment thresholds in your current pest management program, the increasing regulatory, environmental and resource pressures facing pest management will soon require you to be more rigorous in establishing thresholds. Implementing the practices outlined in this chapter will ensure you are prepared for whatever changes may come, because you will have an efficient, well informed decision-making framework in place.

2. Checklist of monitoring practices

Good practices	Score
Understanding thresholds	1
Using information from monitoring to develop treatment thresholds	1

Better practices	Score
Developing more precise thresholds	2
Sampling thoroughly and consistently	2
Incorporating more specific information into threshold development	2

Best practices	Score
Maintaining precision of thresholds	3
Developing thresholds for different situations	3

Niveau d'infestation 1-10			Plante hôte	Localisation
3	Pyrus	675		
4	Lycium	672		
5	Rubus	672		
4	Ribes	379		
7	Hydrangea	379		

Figure 4.1 - Giving damage a rating level is a great way to track the progress of a pest. If the damage level continues to increase, you know that a treatment is probably warranted and should be done soon.

Chapter 4: Establishing thresholds

3. Practice descriptions

1. Good practices

Understanding thresholds

Treatment thresholds are decision support tools, developed in your nursery and based on information that you collected through monitoring (Figure 4.1). For example, you may set a treatment threshold for Pine False Webworm at 5 small colonies per tree on average. In establishing this threshold, you are saying that unacceptable levels of damage will occur if a population larger than your threshold is left untreated. This example shows that establishing thresholds and following their advice requires sampling information and the ability to accept that some pest damage may occur (Figure 4.2).



Figure 4.2 - No matter what type of pest management program you employ, damage is likely to occur. Thresholds let you know when to treat your stock. The plants in this picture are not going to improve after treatment, so it is too late to treat them.

Using information from monitoring to develop treatment thresholds

Because you know about monitoring, and hopefully have established some good monitoring practices, you likely have a feel for information gathering. This is an essential practice to establishing thresholds for your nursery because pest population data are the key pieces of information that a threshold uses. If you are starting out, you probably do not have much nursery-specific information to base a threshold on, so you will need to either consult external sources of information, or pick a population level arbitrarily. If you choose the latter, though, make sure your guess is as educated as possible.

2. Better practices

Developing more precise thresholds

- PREREQUISITE: Understanding thresholds and Using information from monitoring to develop treatment thresholds

A threshold must be precise to effectively support good pest management decisions. Just like the equipment you use to apply chemicals, a precise threshold makes a pest manager's job easier but requires an investment. Increasing the precision of your thresholds requires you to make an extra effort to have reliable information before and after treatment. If a treatment threshold allowed too much damage, you need to lower the threshold population so you reduce your losses next year. If the threshold allowed less damage than expected, perhaps you were too aggressive in your treatment, and may have wasted some time and effort in treating populations unnecessarily – you should increase the threshold population. In the end, precise thresholds result in efficient IPM programs that save time and help make money.

Sampling thoroughly and consistently

- PREREQUISITE: Using information from monitoring to develop treatment thresholds

Proper sampling is essential to developing better treatment thresholds. The goal of sampling is to get an accurate representation of the pest population without counting every individual. The challenge is therefore to find a balance between accuracy and effort. If your sample is too small then your estimates will be inaccurate; if your sample is too big then you will spend all your time sampling (Figure 4.3). Each pest will require different sampling intensities, so it is important to keep the goals of accuracy and efficiency in mind for each pest. It is also important to set a standard sampling unit so that you get comparable results from different areas. For example, if you have 10 fields, each at least 10 acres in area, on which you are growing Plant X, you can start by sampling Pest Y at a rate of one sample/2 acres. How you divide the fields into 2 acre sections is up to you, but you should cover the whole area of a field to get a sense of the pest's distribution. If you're doing it right, you should get a range of highs and lows within and between fields (or all highs if it is a bad infestation). If you get a lot of zeroes throughout your fields but you know Pest Y is causing problems, you should increase the intensity (e.g. one sample/acre).

Chapter 4: Thresholds



Figure 4.3 - This piece of equipment is used in counting spider mites. Fine brushes remove mites from foliage where they fall onto a plate. Individuals on the plate are counted. The brushes are thorough, so the counts are very accurate as long as the foliage is collected in such a way that reduces undersampling and sampling bias.

Incorporating more specific information into threshold development

- PREREQUISITE: Using information from monitoring to develop treatment thresholds

Through your experience with thresholds, you likely have identified sources of valuable information and other sources that do not quite give you what you want. Especially when it comes to sampling, having methods and protocols that are suited to specific pests will give you the most accurate information – we are lucky when they can be applied to multiple pests. At this point, identifying and incorporating sources of new or complementary information is crucial to developing your ability to establish thresholds. Consider alternate monitoring methods, monitoring different life stages and investigating phenological indicators (effective growing degree days or indicator plants). You should also keep records as specific as possible, within reason. For instance, some common pests are not spread out evenly in a production area, so your records should indicate that. And for pests that are uniformly distributed, they may be overrunning one field, but completely absent from another.

3. Best practices

Maintaining precision of thresholds

- PREREQUISITE: Sampling thoroughly and consistently and Developing more precise thresholds

As you use thresholds more, it is important to ensure they are working well. Reviewing the successes or failures of each treatment decision you have made should affect how you deal with your thresholds for the future. After a few seasons, your thresholds should be fairly precise, requiring moderate tweaks. At this point, maintenance is simply ensuring that your treatment decisions are striking the balance between treatment cost and product quality.

Developing thresholds for different situations

- PREREQUISITE: Incorporating more specific information into threshold development

When you have the ability to develop treatment thresholds from scratch, it is possible to develop them for different situations, too. The most obvious variables are the pests you are likely to treat, and each one should have its own treatment thresholds. Within the same plant species, you may be able to tolerate different levels of damage. For example, if you sell to garden centres and landscapers, you may decide to designate certain production areas for garden centres and apply (more aggressive) thresholds accordingly. The economics of treating a pest population should also be considered. In addition to damage thresholds, you can establish economic thresholds by determining the cost of treating and comparing that to the potential revenue of the field and the potential losses due to damage from pest populations. These are a couple additional applications, but once you appreciate the usefulness of thresholds, you will probably find more ways to apply them at your nursery.

Chapter 4: Thresholds

1. Conclusion

Using the sum of your points, you can judge how well your nursery measures up. A nursery with a “Good” preventative pest management component will score from 2 to 5 points, a “Better” score is from 7 to 12, and a “Best” score is 10 to 15.

Protecting your crop is essentially protecting your investment. Before you make decisions with your money, you research and find the most useful information that applies to your situation. In crop protection, treatment thresholds are the direct result of your monitoring and identifying effort and the tools you use to support your pest management decisions. With the best thresholds in place at your nursery, your IPM program will be effective and sustainable. Just like making the right decisions with your money, developing thresholds takes discipline and involves some risk, but you will nonetheless continue to reap the rewards long after you have established them.

Chapter 5: Treating in an Integrated Pest Management Program

Introduction

Let's start with a couple true or false statements. First, growers know what has worked in the past, and moving away from those methods is risky. Second, if a grower wants to develop and implement an IPM program, he can no longer use chemicals. The first statement is true. Your knowledge and experience is extremely valuable in choosing between pest management options, and moving off the beaten path might get you into trouble. The second statement is false. This is where the “I” in IPM comes in – by following an IPM program at your nursery, you integrate additional treatments into your range of pest management practices, including chemicals.

This chapter will help you integrate additional options into your current list of treatments. The “Good” practices will raise your awareness of the issues around effective treatment and where you might benefit from integrating no-risk or low-risk treatment options. The “Better” practices establish habits and approaches that will make your IPM program economically and ecologically responsible. The “Best” practices ensure that the treatments employed in your IPM program are always current and the people executing them are informed and well-trained.

The most significant concern with implementing IPM practices in a nursery is how effective alternate treatments will be. This concern arises not because growers want to use toxic substances, but because they want options that work and are cost effective, many of which happen to have toxic properties. This is a valid concern, and your IPM program should always use the most effective treatments. Under IPM, you are free to choose whatever treatment works the best after considering all of your treatment options. But, for reasons such as pesticide resistance, non-target effects or government legislation, you may not have a choice in adopting alternate treatments. Establishing an IPM program gives you the power to choose now, and will result in treatments that are effective and sustainable.

1. Checklist of monitoring practices

Good practices	Score
Rotating chemicals	1
Treating before economic damage occurs	1
Using well-trained personnel	1
Servicing equipment and monitoring its functionality regularly	1

Better practices	Score
Calibrating equipment regularly	2
Treating when necessary	2
Using alternate treatments	2
Certifying pest management personnel	2

Best practices	Score
Using chemical treatments as a last resort	3
Developing methods that treat reproductive stages	3
Conducting trials	3
Personnel receive regular training	3

2. Practice descriptions

1. Good practices

Rotating chemicals

Pesticide resistance occurs when a pesticide, or a few pesticides in the same chemical group, is overused and no longer effectively controls pest populations. Resistance is a real threat to achieving effective control of your pest populations, but rotating chemicals is a good practice to reduce the chance of resistance occurring. Each pesticide you apply to your crops is placed in a numbered group, based on how it acts on the target pest (its “site of action”). Rotating chemicals means using chemicals from different groups in subsequent treatments (Figure 5.1). For example, if you've sprayed a population once with a Group 3 insecticide and need to re-treat the population (either in the same or the next growing season), use a product that is not from Group 3. If you can't find a product that's labeled for your pest, you may not have any other chemical options. It's also not recommended to spray with the same chemical again, since you may either be dealing with a resistant population already, or you may help establish resistance within the population. A list of these groupings for herbicides, insecticides/acaricides and fungicides can be found on the Health Canada website www.hc-sc.gc.ca and searching for

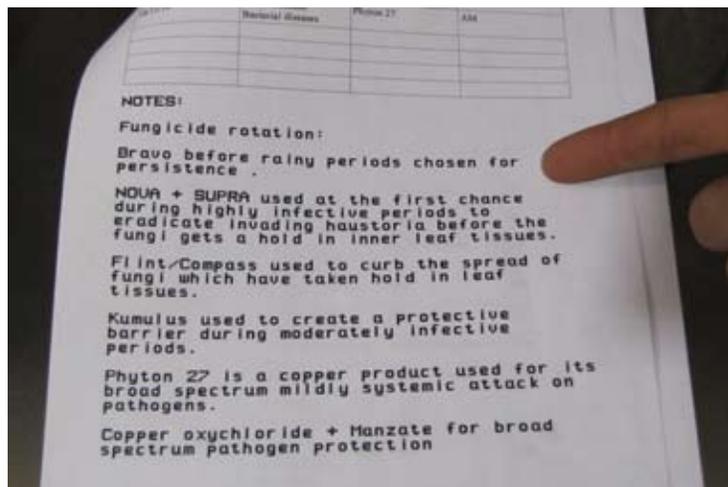


Figure 5.1 - One nursery has listed the fungicides it can use and under what circumstances. Knowing what you can spray will help you manage for pesticide resistance.

Regulatory Directive DIR99-06.

Treating before economic damage occurs

This is probably a common practice to every grower in Canada and may not need mentioning. However, to ensure you're making a good treatment decision, you should start monitoring three things: the crop's potential value, the minimum return value the crop needs to produce to cover input costs, and the cost of treatment. After calculating these values, you should be able to see whether your treatments have been done at the right time – namely before the losses (the value of damaged stock) are greater than the potential gains.



Figure 5.2 - Well-trained spraying personnel should know the importance of personal protective equipment.

Using well-trained personnel

Having capable people on-hand is essential to the long-term success of your pest management program (Figure 5.2). The results of using poorly-trained personnel can be worse than not having a pest management program in place at all. Do not forget – there are many precise calculations and complex decisions to be made, like rates and locations, that are easily taught and reviewed beforehand. Although experience is a great teacher – and all the best applicators you have now have probably made some mistakes and learned from them – it can also be a costly one. Training does not guarantee that mistakes will not happen, but it does ensure that the mistakes that are made are minor.



Figure 5.3 - Calibrating your sprayer is an easy thing to do, and can save you a lot of aggravation. Calibrating is a good way to determine how your equipment is functioning compared to how it is supposed to function, and to identify small problems that may turn into big ones if not addressed early.

Servicing equipment and monitoring its functionality regularly

Equipment that does not work properly is a common problem to many nurseries, and often the consequences are not major. It is important to know about current and potential issues before they become problems, though. Leaks and poor fittings in sprayers can lead to imprecise applications and can often be safety hazards. Equipment with small motors and even hand tools should also be serviced and maintained in good repair, not only for optimal performance but also for worker safety.

Chapter 5: Thresholds

2. Better practices

Calibrating equipment regularly

- PREREQUISITE: Servicing equipment and monitoring function regularly

In addition to performing regular service and maintenance on your equipment, you should check for wear on your sprayer nozzles. Old nozzles may seem to work as well as ever, but the gradual wear caused by regular usage is very hard to notice without looking directly for it. Nozzles that are performing poorly result in ineffective spraying, therefore wasting time and money. Calibrating your sprayer is a relatively quick and easy way to tell if the volume of spray actually discharged is what it is supposed to be (Figure 5.3), and replacing old nozzles is cheaper than dealing with a pest resurgence due to an ineffective spray.

Treating when necessary

- PREREQUISITE: Treating before economic damage occurs

Because you understand the value of your crop, you are able to avoid significant losses by treating threats to plant health before they cut too deeply into your profits. No matter what type of treatment you are planning, it is going to take time and money. The economic consideration is a very useful piece of information to use when deciding to treat. For example, if you have a small infestation affecting 5% of one field, the economics of treating can be used two ways. First, let's say the value to you of that 5% is \$5,000, making the whole field potentially



Figure 5.4 - This picture illustrates how one nursery is introducing predacious mites into its container production areas.



Figure 5.5 - Deer fence is a very effective method of physical control. This treatment is costly compared to repellents and other deer management options, but the effectiveness over the long and short terms cannot be matched.

worth \$100,000. If treating costs less than \$5,000, then you will not lose money by treating the infestation. However, if the infestation is unlikely to spread to where the economic damage makes the field a net loser, you may not need to treat at all.

Using alternate treatments

- PREREQUISITE: Rotating chemicals

The best way to avoid pesticide resistance is to not use pesticides at all. For large scale applications, cultural and physical control methods are hard to apply, but you may consider biorational and biological alternatives (Figure 5.4). The main difference between the two is that biological treatments are actually living organisms, like nematodes, bacteria, or predacious insects or mites that will kill the pest. Biologicals are also more specific, meaning they have less or no effect on non-target organisms. Biorational pesticides are not living organisms, though many are derived from natural sources. The biorational pesticides are not as specific, and in this sense are not that different from some newer chemical pesticides. They are generally less persistent in the environment, though, and are therefore less of a threat to non-target organisms.



Figure 5.6 - Plastic collars around caliper trees is an effective physical control method against the feeding of rodents. It is important to put the collar up high enough to ensure pests walking on top of snow are still unable to access the bark.

Using chemical treatments as a last resort

- PREREQUISITE: Using alternate treatments and Employing economic rationale

If you have fully integrated different treatments into your pest management program, the chemicals you spray are just one of many weapons in your arsenal. Being able to rely less on



Figure 5.7 - Burning material infected with contagious pathogens is a very effective cultural control method. It is important to prune and burn infected material at the correct times (based on the tree and fungal biology) in order to minimize the natural spread of fungal pathogens.

chemical pesticides takes time and effort, but the long term ecological and economical benefits will be significant. For instance, part of the reason non-target species are affected by chemical pesticides is that the chemicals persist longer in the environment than the alternatives – biological and biorational pesticides are very short-lived in the environment. And resistance to physical and cultural treatments (Figures 5.5 – 5.8) will never be an issue because these treatments exploit weaknesses in the pest that would take millions of years to overcome. Speak with your OMAFRA Nursery Crops Specialist about all the alternatives available to you, and also consult the OMAFRA Publications 383 and 370 for alternative treatments.



Figure 5.8 - Vacuuming leaf litter from containers is a good cultural control method to use in preventing foliar disorders. Leaving infected leaves to decompose in the soil builds up fungal populations in the soil, which can then spread to the new leaves of the plant, causing reinfection.

Developing treatments that target reproductive stages

- PREREQUISITE: Using alternate treatments

When you practice pest management, especially with non-chemical treatments, a big part of your success will depend on timing your treatments correctly. Correct timing has everything to do with maximizing the long-term result of your treatments, and there is no better way than targeting pests before they reproduce. Unlike humans, it is common for insects, mites and weeds to produce hundreds (if not thousands) of offspring each year. By targeting your efforts toward controlling adult populations, you should be able to successfully manage the immature (and often most damaging) stages of your pest species better.

Personnel receive regular training

- PREREQUISITE: Certifying pest management personnel

Pest management is a dynamic field. Implementing an IPM program is also a gradual change, and requires different perspectives and current information. Keeping your pest managers' information current with respect to changes in legislation and science will help maintain the quality of your IPM program.



Figure 5.9 - One nursery is experimenting with new fertilizers. It is important to sample a representative group of plants and enough of them in order to get good results.

Conducting trials

- PREREQUISITE: Using alternate treatments and Consulting monitoring and identifying information prior to treating

As you try out different treatments, you will certainly find yourself wondering how the new method compares to the old one. Conducting trials on new methods, fertilizers and chemicals is a good way to measure how effective they are against your current ones (Figure 5.9). Because such comparisons are essentially experiments, there are a few guidelines you should follow. First, focusing on only one or two questions will make your trial easy to manage and your conclusions clear and simple (for example, “How does chemical A compare to chemical B, which I’ve never used?” not “How does chemical A compare to chemicals B, and C, which I’ve never used AND planting at different times?”). Second, always include a control (i.e. the current practice) to compare your new idea with because without it you cannot draw any objective

conclusions. Finally, always keep the conditions the same for the control and the new idea as much as possible – use the same area, the same species, the same type of machinery, etc. The fewer differences between the control and the new idea will mean any differences between the two are likely due to whatever you are testing. With your ability to conduct trials, you will gain new information tailored to your operation that will help you develop the best IPM practices for your nursery.

1. Conclusion

Using the sum of your points, you can determine how integrated your pest management program is. A nursery with “Good” treatment options will score from 3 to 7 points, a “Better” score is from 8 to 15, and a “Best” score is 16 to 24.

Integrating a variety of treatments into your pest management program will ensure that it is effective for a long time. By establishing the basic principles of sound pest management – basing your decision on good information, training personnel and rotating your chemicals – you will be able to increase your IPM program’s function. Making a more functional program now will help reduce your nursery’s exposure to resistance, non-target effects and legislative restrictions later. Once you achieve a highly functional IPM program, you will be able to continue developing effective treatments for your nursery and maintain the advanced level of knowledge and expertise of your pest managers.

Chapter 6: Evaluating in an Integrated Pest Management Program

1. Introduction

Evaluating the success of your IPM program is easy – you treat, the pests are gone, the stock is sold, you make money. Although this simple timeline is probably fairly accurate, it overlooks some important details. Are the pests really gone? You sold the stock, but did the customer receive what they expected? All told, are you profitable, or could you have done better? These are not strictly IPM questions, but each one is related to how you practice pest management and, more importantly, how you measure its success and value.

The practices outlined in this chapter will help you establish, develop and maintain ways to evaluate the success of your IPM program, both ecologically and economically. The “Good” practices establish ways to get follow-up information and internally audit your performance. The “Better” practices build on the Good by having you interpret the information you gain from the Good practices. The “Best” practices help you maintain a good evaluation system by making you track the success of your program ecologically and economically, while also contributing to the improvement of the industry.

The key to learning from your mistakes and building on your successes is getting an unbiased evaluation. Although the content of this chapter will not be dealing specifically with any pest management decisions, it is necessary to build this element into your program so that you can critically evaluate it. Finding accurate and honest ways to evaluate your IPM program is an essential part of continuing to develop it, and developing your program helps to ensure the long-term economical and ecological stability of the industry.

2. Checklist of evaluating practices

Good practices	Score
Monitoring pest populations after treatments	1
Setting quality control and assurance standards	1

Better practices	Score
Analyzing results of pest management efforts to identify problems	2
Measuring the economic impact of the IPM program	2

Best practices	Score
Reviewing and comparing records and results	3
Sharing knowledge and expertise	3
Monitoring and revising standards	3

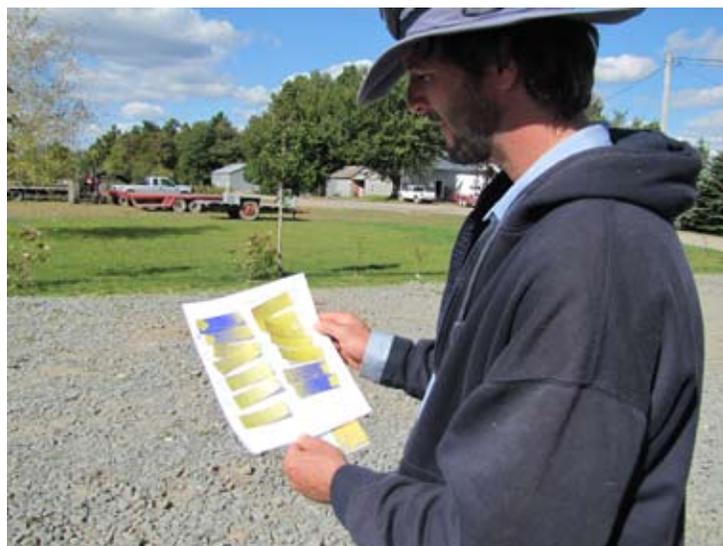


Figure 6.1 - Water sensitive paper is great for evaluating how your sprayer works in the field. By setting pieces of water sensitive paper in different places among the plants you spray, you can see where your spraying equipment is successful.

3. Practice descriptions

1. Good practices

Monitoring pest populations after treatments

This practice is fundamentally important to evaluating the success of your IPM program. Without follow-up information, you cannot accurately determine the level of control you are achieving. Monitoring does not have to be complex, and can be as simple as looking at a few plants to see if they are continuing to be damaged, or observing dead pest species on the ground after a spray. As you require more detailed information, you will want to do more thorough follow-up monitoring. Until then, getting into the practice is your main goal.

Setting quality control and assurance standards

Setting quality standards is a good way to work with your sales team in achieving profitability, and it can also help monitor consistency from season to season and monitor the impact of your IPM program. Growing and selling nursery stock are distinct and fairly specialized areas within the business, and often workers in these areas have different views on how to achieve the common goal of making the business profitable. In setting your own nursery's standards, you have to establish priorities that both the production and sales sides agree on. Establishing some quality standards is a good way to bridge the gap between these two areas of your business because you work towards common goals, not goals that are perceived as "production goals" or "sales goals".

2. Better practices

Analyzing results of pest management efforts to identify problems

- PREREQUISITE: Monitoring pest populations after treatments

Good information is collected the same way every time, relates directly to the question you have about your IPM program, and may even direct you to the problems (if there are any). To make good evaluations of your control efforts, especially if you think there may be a problem, you should compare results from similar circumstances (i.e., the same pest, chemical, equipment, etc.). The analysis comes from considering all the variables, and excluding those that are not consistently showing the questionable results. Ineffective treatments are not always due to ineffective chemicals – assessing your equipment (Figure 6.1) and your personnel regularly will also give you some

information to work with if treatments are not achieving the desired results.

Measuring the economic impact of the IPM program

- PREREQUISITE: Setting quality control and assurance standards

Any pest management program should have an effect on the financial health of a nursery. Track the costs of your pest management under an IPM program and compare them to previous costs. You can also track the success of your quality standards in your sales figures. As you know, the quality of the plants you grow depends a lot on how you manage pests and growing conditions. Measuring the economic impact in these ways gives you some tools to evaluate the long-term success of your IPM program.

3. Best practices

Reviewing and comparing records and results

- PREREQUISITE: Analyzing results of pest management efforts in identifying problems

You can evaluate the actual success of your IPM program, in terms of reducing pest populations and the damage caused by them, by reviewing the current season's results. This only gives you a snapshot, though; to get the best perspective possible, you should compare the results to other those from previous years. When comparing these results, it is important to keep in mind factors that may have played a part in the overall success or failure in certain years. Reviewing your progress year after year will keep you attentive to areas of weakness or strength, and give you a good idea about how your IPM program has worked over the long run.

Sharing knowledge and expertise

- PREREQUISITE: Analyzing results of pest management efforts in identifying problems

You have gained a lot of experience and knowledge by monitoring your IPM program and analyzing the results. For a number of reasons, it is worth sharing this experience and knowledge with your colleagues. Chief among these reasons is to maintain the overall health of the industry. You have put a lot of effort into maintaining the health of the plants you grow, but what about the people who supply material to you, or those you supply? If there are weak pest management links along

Chapter 6: Evaluation

the supply chain, your good work is liable to be undone either by introducing pest problems from other nurseries or having substandard conditions at the nurseries you supply reduce the quality of your product. Giving helpful hints along the way, in-depth presentations at growers meetings and anything in between all help the industry grow healthier plants in a sustainable way. You exemplify the standard in IPM, and may gain a market advantage because of that. You also can evaluate the success and impact of your own program when you hear about the progress at other nurseries.

Monitoring and revising standards

- PREREQUISITE: Measuring the economic impact of the IPM program

Your standards should set you apart from the competition, or at the very least help you stay competitive. When you first set your standards, keep track of how well they compare to what the market is demanding by asking yourself how much better is your product than another nursery's? As things like customer demand and nursery operations change, your standards should, too. Monitoring and revising your standards shows that you are conscious of factors inside and outside of your nursery that have an influence on the quality of the plants you grow. The standards you set after every review should reflect a compromise between operational considerations and market demand while still maintaining the highest quality possible.

1. Conclusion

Using the sum of your points, you can determine your ability to evaluate your nursery's IPM program. A nursery with "Good" evaluation tools will score from 1 to 3 points, a "Better" score is from 4 to 7, and a "Best" score is from 8 to 15.

Evaluating an IPM program requires tools that are as unique as the nursery that uses it. These tools should be as easy to use as possible to start. As you work with your internal evaluations, you will find ways to get more meaningful information from them, and develop the tools to become very elegant and informative pieces of your IPM program. At this stage, they add value to your program and ensure that you continue on a sustainable track in growing nursery stock. Ultimately, with the best evaluating system, you will be an industry leader, championing the ideals and practices of successful IPM and contributing positively to the long-term sustainability of the industry.

■ Conclusion

Implementing an IPM program at your nursery means that you recognize that the pest management landscape in Ontario is changing. You know that IPM can help you avoid and effectively manage the challenges that come with pesticide resistance, legislative restrictions and environmental risk. This manual is an important tool in helping you implement an IPM program in place at your nursery because it will help identify and prioritize your IPM needs. Using this tool, you can start taking the gradual steps towards developing and implementing a complete IPM program that should work as well, if not better, than your previous program. Using this guide, shifting to an IPM program should not require broad operational changes – IPM makes pest management a little different, but much better.

The long-term success of an IPM program depends on the effectiveness of its individual components. Good preventative strategies lead to good monitoring and identifying strategies. By monitoring and identifying problems, you can set good thresholds and treat problems more efficiently. And by evaluating your program, you will ensure that the productivity of each component is maintained to the best standards possible. If any one of these components is lagging, the whole system lags. Using this manual, you can objectively evaluate each component of your program using the scoring system. Based on the scores, you will see where your strengths and weaknesses lie, and then begin planning a strategy to improve the weaker parts. This manual, with its descriptions of Good, Better and Best practices, will also point you in the right direction towards achieving the goals you have set for your IPM program. Knowing where you want to end up is the first step to getting there, and this manual is intended to help clear the path to your IPM goals.

By implementing an IPM program at your nursery, you will become the best source of pest management information for your operation because you know your soils, plants and pests better than anyone. The process of implementing an IPM program at your nursery will take time – in fact, it is likely that the process will be continual with different things changing from year to year. This change is completely understandable when you proactively manage a program that is based on current information. Having a dynamic IPM program at your nursery ensures that pest management will be sustainable economically and ecologically. Making small changes year after year is also how you will stay ahead of pest problems and be able to react effectively when unexpected problems arise. Problems like pesticide resistance, decreased ecological diversity and introduced invasive species have taught us a number of hard lessons about managing pests the same way year after year. This manual applies the knowledge we have gained from those lessons. Using it to build your IPM program ensures that your pest management operations will contribute to the long-term viability of the industry by keeping your plants healthy and clean.

