Sustainable Pest Management for Hobby Farmers*

Introduction

What do we mean when we use the term sustainable pest management? This is a sub-topic under the larger term sustainable agriculture. And what does that term mean? Sustainable agriculture is a reasonably self-evident, descriptive name but it is not defined in regulatory wording as is organic or organic food in most developed countries. Sustainable agriculture comes directly from the objective of sustainability with the understanding that this should be over a very long time-frame but that there are different routes under which sustainability can be attained. The conservation of resources and avoidance of pollution are core themes in sustainable agriculture. Clearly, sustainable pest management will utilize knowledge and procedures that fit within these core themes of sustainable agriculture.

Land Preparation

Site selection and land preparation for sustainable hobby farming have direct connections to later pest management challenges. It has been found that vigorous plants growing under optimal conditions are better able to resist infection by some diseases or produce a reasonable crop while showing a moderate level of infestation. The situation below ground, and in particular with regard to excess moisture, is likely the most critical point. Other specifics like pH are also directly related to control procedures for diseases such as clubroot of the cole crops and potato scab. So the hobby farmer or gardener must make every effort to ensure that the soil is almost "perfect" for the crop(s) to be grown.

As detailed in *Introduction to Sustainable Vegetable Production* and *Introduction to Sustainable Fruit Production*, the soil must have adequate depth for the crop. This can range from as little as 30 cm (or raised beds) for many row crops to a full meter for tree fruits and grapes. Drainage must be excellent throughout the required rooting depth, not only to avoid water-logged soils but also to reduce drought stress. Heavy, wet soils prevent deep roots but deep roots are required for drought resistance. The pH and nutrient levels in the soil must be appropriate for the crops to be grown and both must be adjusted prior to the first crop. Soil testing is available from the provincial department of agriculture, for a small fee, and specific directions on sampling the soil and soil sample boxes can be picked up at the regional agricultural offices. It is critical that soil testing be conducted as much as two years before the crop(s) will be

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planted. Agricultural lime is used to increase the pH of an acid soil. The nutrient and organic matter status of the soil can be boosted with old manure, good compost, and green manure crops. Any appropriate green manure crop will raise the organic matter content but only the legumes will provide nitrogen. A practical, down-to-earth discussion of on-farm composting is available here:

http://www.uvm.edu/vtvegandberry/factsheets/compost.html

A well-drained soil with lots of organic matter and a pH in the 6.0-7.0 range will be very biologically active with a huge population of beneficial microorganisms such as fungi, nematodes, mites and insects. Generally, pests like fungal diseases and insect larvae that attack plant roots will be kept well under control by these beneficials. A healthy soil exhibits biodiversity with virtually all species staying within balance. This is the essence of land preparation and maintenance for sustainable pest management.

Crop Rotation

Crop rotation for sustainable pest management is not a magic bullet but more like the use of knowledge to reduce pest challenges. To avoid the buildup of pests over time, a crop is never allowed to follow itself or a related crop (usually in the same plant family) nor, in specific cases, to follow an unrelated crop that suffers from the same pest. Crop rotation is likely most relevant for plant diseases that live in the soil and for insect pests that seldom or never fly (e.g. Colorado potato beetle, various weevils). So how is crop rotation applied in practice?

In the vegetable crops, almost all plant diseases (at the species level) and many insect pests are confined to one crop family and are able to attack most or all crops within the family. The actual degree of susceptibility might vary species by species but not enough to make “rotation” within the family a good idea. Sample crop rotations can be found in books on organic vegetable production. The major vegetable crop families are:

1. Tomatoes, peppers, eggplant, potatoes
2. Cucumbers, squash, pumpkins, melons
3. Cabbage, broccoli, cauliflower, Brussels sprouts, turnip, radish
4. Onions, leeks, garlic
5. Spinach, beets, Swiss chard
6. Peas, beans
7. Carrots, parsnips, parsley

A crop rotation could be designed using this list. There are other horticultural aspects that should be considered that are outside of this discussion.

In the fruit crops, the situation may be more complex. As detailed in *Introduction to Sustainable Fruit Production*, it is never wise to replant one of these perennial crops on the same site, or even nearby if that can be avoided. There are diseases, weeds and insect pests that will build up over the years to the point that it could be a very bad investment decision to replant. The concern about a nearby site relates to specific flightless pests such as strawberry clipper weevil and strawberry root weevil that increase year by year and overwinter in or near (walking distance) the older plantings. A planting at the same location will be infested much sooner, and worse, than at a new site. Of course, wild strawberries grow at many locations so as with most pest management concepts we are reducing the challenges, not eliminating them.

Another example of complexity in fruit crops concerns the serious disease verticillium wilt**.** This disease attacks both strawberries and brambles as well as melons and the entire solanaceous family (potatoes, tomatoes, peppers, eggplant, nightshade). Therefore, a new planting of strawberries or brambles should not follow any of these species. In this case, more detailed knowledge is required than the common sense plant family concept used in vegetables.

There are also replant diseases of tree fruits and it would always be best to find a new location. The actual replant problem in fruit trees is complex and can include non-biological factors (e.g. historic pesticide residues). Depending on the degree of the replant problem, there are solutions such as 'fresh' topsoil in the planting hole. The severity of any replant problem can be tested by planting tree seedlings in buckets, using replant soil and fresh topsoil. The test requires an entire growing season.

Pest Resistant Varieties

The science of plant breeding has made a tremendous contribution to sustainable pest management. Over 100 years ago the first scientific results of the benefits of plant breeding were produced. (Plant breeding with no understanding of genetics has gone on for several millennia!) About 1910 W.A. Orton crossed the watermelon variety Eden with the citron melon (Stock Citron) to obtain resistance to *Fusarium* wilt.

"*The F2 generation segregates produced resistant watermelon types, and subsequent selection and crossing to watermelon led to the introduction of the wilt resistant watermelon Conqueror. This is probably the first use of the back-cross method in breeding for disease resistance."* (Nelson, 1973).

The progress and sheer number of accomplishments are easily overlooked as the variety selection in each crop evolves year after year. As effective resistance to important diseases is seldom dropped, even commercial producers forget the diseases that they no

longer deal with and focus only on those that still require management. This is logical but it is important that we understand the progress made over the past 100 years.

As pointed out in *Introduction to Sustainable Vegetable Production*, there are numerous varieties available with disease resistance in seed catalogues. Disease resistant or tolerant varieties are available for summer cabbage, lettuce, eggplant, cucumbers (pickling, European, regular), green peas, sweet pepper, potatoes, radish, zucchini, winter squash, and tomatoes (field and greenhouse), among others. The Internet can be used to research disease resistant or disease tolerant varieties of vegetables and fruit.

As noted in *Introduction to Sustainable Vegetable Production*, the word 'resistance' means that a given disease will not occur on that variety while 'tolerance' means that a disease may occur at low levels, under worst conditions, but will have no impact on crop yield. The difference is really just for clarity because in either case the disease will have no effect.

Turning to the fruit crops, the plant breeders at the Kentville Research and Development Centre have made great progress in apples and strawberries in particular. As noted in *Introduction to Sustainable Fruit Production*, the researchers selected and released the apple varieties Nova Easygro, Novamac (at right) and Novaspy which require no treatment for apple scab. Novamac was intended as a replacement for McIntosh (highly popular, but one of the most susceptible varieties) while Novaspy was a replacement for Northern Spy (the best variety for pies). The above apple varieties, and others from the United States such as Liberty, have made the sustainable production of apples much more feasible making them a logical choice*.

The strawberry breeding program has produced strawberry varieties such as Annapolis, Cornwallis, Cabot and Mira that have red stele resistance. Mira also has a high level of resistance to most foliar diseases, Blomidon is moderately resistant to gray mold (*Botrytis*) and Cornwallis is moderately resistant to powdery mildew and verticillium wilt. Mira was released as a 'named variety' in 1996. Again, under a sustainable production system, a strawberry variety such as Mira is a logical choice*.

*It should be noted that plant varieties are developed to reflect new and emerging disease and pest pressures, which are changing constantly. Varieties and diseases listed here may not be the most relevant or best choice for a given area.

It should be clear from the above that considerable disease resistance is available in vegetable and fruit varieties. Anyone who plans to farm under either sustainable or organic principles is encouraged to research and use these varieties.

Weed Control without Herbicides

Weed control under sustainable pest management begins with the selection of the site to be farmed. The optimal site is one that is currently under row crops where weeds have been maintained at minimal levels. If the chosen site is new and currently under sod, a minimum of two years will be needed to prepare the site, including elimination of the worst weeds such as couchgrass. This is covered in detail in *Introduction to Sustainable Vegetable Production.*

Going forward, weed control must be planned, timely and effective. Control procedures must be directed towards never allowing the weeds to increase and get ahead of the grower. Flowering and seed production cannot be allowed, nor the spread of underground root systems. The procedures used are relatively simple. Weed seedlings are shallow rooted and delicate. Quick work with a hoe or a small, hand-held tiller can lift these out of the soil and leave them on the surface for desiccation. The space between the planting rows can be tilled with a self-propelled rototiller as needed. Hand weeding of any 'escapees' that are approaching flowering is worth the time. Spring tillage reduces weeds that were established the previous fall.

Other good cultural practices like rotation and cover crops have a direct connection with sustainable weed management. Even where herbicides are not being used, certain weed species tend to be found in certain crops. This relates to the exact time of year that each crop is planted and harvested, crop-specific field-scale tillage and cover cropping, crop canopy density, and so forth. Therefore, crop rotation prevents the steady increase of specific weeds compared to no rotation. Appropriate cover crops such as buckwheat or rye are well-known to compete with weeds for light, water and nutrients and to have a critical value in preventing weed buildup on bare soil. (This is in addition, of course, to other benefits such as soil organic matter and erosion control).

In strawberries and tree fruits, cultural procedures and weed management are more specific to those crops; see the *Introduction to Sustainable Fruit Production*. Weed management in perennial fruit crops is critical in the early years or plantings may never reach their potential.

In general, it is unlikely that herbicides will be used in sustainable pest management. However, there may be a case for an eradicant like glyphosate where sod is badly infested with couchgrass. It would be better to start clean than to struggle for years with frustration. The fossil fuel used in tillage is an issue for sustainable agriculture also. Black plastic may also have a place in sustainable weed management in limited situations. It does provide another way to eradicate sod, for example, on small areas.

Sustainable Control of Plant Diseases

Some of the most important considerations for sustainable plant disease management have already been discussed above under **Land Preparation**, **Crop Rotation** and **Pest Resistant Varieties**. The specific points in those sections provide the core understanding through which many (or most) plant diseases will be avoided as significant issues. The points discussed are pro-active; additional re-active control procedures will seldom be needed. Again, this is the essence of sustainable pest management.

The importance of sanitation is covered in both the *Introduction to Sustainable Vegetable Production* and *Introduction to Sustainable Fruit Production*. Crop residues are an organic resource but they are also an obvious route for plant diseases to carry over from one year to the next. Many plant diseases increase steadily on the crop over the course of the growing season. Also, in some cases resistant overwintering bodies are formed late in the season. In vegetables there is leaf and stem crop residue in all but the salad greens and root system residue in all but the root crops. In berries and tree fruits there are leaf, cane and pruning residues. In vegetables all crop residue should be composted. In the fruits renovated strawberry leaves, bramble canes and tree prunings should be composted or chipped and composted. All of this material is composted off-site and then the finished compost applied where needed. This procedure introduces a critical break in the natural annual survival of the disease organisms.

The sanitation concept also applies to diseased fruit and unpicked fruit when dealing with fruit diseases like gray mould (*Botrytis*). The seasonal buildup in a crop like strawberries or raspberries can be very difficult.

Most plant diseases are fungi. There are limited fungicides approved for Certified Organic production, which at least sets the direction for sustainable agriculture. There are copper products (e.g. copper sulphate), sulphur products, and others. The Atlantic Canadian Organic Regional Network (ACORN) website has a downloadable *Directory of Organic Inputs*.

In reality, it is quite likely that a sustainable hobby farmer, or home gardener, will not use any fungicides at all. If all procedures are followed as above, the need for fungicides will be limited.

Sustainable Control of Insect Pests

As discussed in the *Introduction to Sustainable Vegetable Production* and *Introduction to Sustainable Fruit Production*, for successful, sustainable insect pest management, it may be necessary to have more species-specific knowledge than with the diseases. Insects are certainly a diverse group and each species has its own biology and behaviour. An understanding of both will be needed in order to understand how to proceed, that is, when

and where is the weak point and what can be done to exploit it? On the other hand, the point is made that only one or two dozen species are important in each crop group.

Specific advice on a number of key insect pests is given in the *Introduction to Sustainable Vegetable Production* and *Introduction to Sustainable Fruit Production* and serves to illustrate why species-specific knowledge is important. For example, the Colorado potato beetle, strawberry clipper weevil and strawberry root weevil all move into their host crops by walking. This leads to physical barriers and advice on where to locate new plantings. Also, the specific knowledge that Colorado potato beetles have a very strong tendency to be visible on the tops of the plants allows one to understand how effective hand picking can be. An understanding of the apple maggot life cycle shows why picking up early drop apples (and destroying them) can have a real impact on population numbers the next year.

Scouting and keen observation are needed for success. The sustainable hobby farmer should walk slowly through the crops on almost a daily basis, possibly in the evenings. The focus is on anything that is different, numbers of pests, numbers of beneficial insects, degree of crop damage, and so forth. In reality, weeds, diseases and insects will all be checked. The economic threshold concept will be discussed shortly; just because a pest is present does not mean that anything needs to be done. The purpose of scouting is to find problems at a time when something useful can be done, if needed. When there is an egg mass on every second plant, it's too late to start hand picking Colorado potato beetle adults. When earwigs have eaten the growing points on one-half of the bean seedlings, it's almost too late to use diatomaceous earth.

There is at least one aspect of sustainable insect pest management where two important objectives are in direct conflict. It is well known that the hundreds and thousands of beneficial insect predators and parasites require wilder, unmanaged areas in which to survive from year to year (overwinter), as well as in which to multiply each growing season. Many of these beneficials move into the crops each year and provide some degree of biological control. On the other hand, numerous pest species also move into the crops each year from adjacent wilder areas. There are no easy solutions to this conflict. In general it is likely best to keep a bare soil or mowed sod strip of at least 5-10 meters on all sides of vegetable gardens and fruit plantings. On a hobby farm the area under agriculture will usually be surrounded by non-agricultural areas and these should be landscaped, maintained or left alone as more diverse areas. As adults, many beneficials require nectar so flowering plants can be planted right in the crops, to partially balance the above need to push wilder areas back. Dense evergreens and hedgerows nearby will provide nesting locations for songbirds, which will then forage for insects in the crops. Other beneficials are favoured below ground by healthy soil with lots of organic matter and high biological activity, a key objective of sustainable agriculture. Predatory ground beetles (both adults and larvae), for example, will be more common in these soils than in degraded, low organic matter soils.

There is no specific list of insecticides that are approved for sustainable insect pest management. In general, the broad spectrum synthetic insecticides would be avoided because the disruptive impact on the overall pest/beneficials balance would be more costly than the value of any pest damage prevented in the near term. The use of pyrethrum, insecticidal soaps, diatomaceous earth and dormant oil are discussed in the *Introduction to Sustainable Vegetable Production* and *Introduction to Sustainable Fruit Production*. Growers who are certified to purchase and apply commercial pesticides (hold a valid Pesticide Applicator's Certificate) have access to more innovative products such as the kaolin barrier film and pheromone dispensers for male confusion. Any insecticide approved for use in certified organic production would tend to be acceptable under sustainable agriculture, if needed (see the *Directory of Organic Inputs* mentioned earlier).

While the routine use of insecticides will be avoided in sustainable insect pest management, it is likely that treatments will be required occasionally to save a crop. An appropriate product will not destroy the overall natural control obtained via all the procedures covered in these modules.

Understanding the Economic Threshold

It is recognized almost universally today that a pesticide does not need to be used as soon as the first evidence or the first individual pests are seen. In mainstream agriculture, simple economics (and environmental concerns) dictate that a pesticide will not be used when the total application costs of applying that pesticide exceed the expected loss prevention. It is also recognized that pesticide-induced outbreaks of secondary pests, and any subsequent controls against them, must also be added to the total application costs. The entire science of integrated pest management has arisen around this knowledge and is firmly in place in mainstream agriculture. The narrow-to-absent profit margins do not allow any other approach.

To capture this concept, the term economic threshold has been defined as that pest population level at which treatment can be justified economically, based on a reasonable estimate of damage to be prevented plus the negative value of secondary results such as pesticide-related outbreaks of other pests, and the secondary cost of their control. The economic threshold will never be zero, or even that close to zero, with one exception. This would be a new or foreign pest that is under formal government regulation with every infested crop or planting subject to destruction. This is a rare, specific case and not really all that relevant.

Under sustainable agriculture and sustainable pest management it is less likely that formal, numerical economic thresholds will be either available or applied as is. It is very difficult to quantify how much loss each individual committed to sustainable agriculture is prepared to accept before choosing active control over natural control. However, a good understanding of the economic threshold concept is helpful as it emphasizes that doing nothing is a valid choice. But we also need to remember that the specific pesticides that would actually be used under sustainable pest management will, by definition, have

fewer secondary impacts and secondary costs than most mainstream pesticides. In this sense, the actual decision whether or not to take active control is simpler to evaluate, from an economic viewpoint.

As a related point, it should be intuitive that a pest that attacks the part of the crop that will be harvested and eaten is more important than one that attacks a non-harvested part of the crop. On apples, apple maggots and codling moths are much more serious than leaf-eating caterpillars. Any active control decisions will reflect this logic.

Impact on the Environment

The impact on the environment from sustainable agriculture and sustainable pest management approaches as outlined in this publication should be neutral to positive. The objective is to maintain the soil in the most fertile and biologically active condition possible. There may be less plant diversity than under wild vegetation but the diversity compared to commercial agriculture is very high. The insecticides mentioned would have minimal impact on beneficial insects (they would need to be sprayed directly to be affected) and no impact on birds and mammals. Additional flowering plants in or around the garden were recommended for beneficial insects and specific plantings were recommended as nesting locations for songbirds. The home garden or sustainable hobby farm as discussed here will provide good feeding habitat for native songbirds such as robins, song sparrows and chipping sparrows. It is often necessary to exclude certain mammals like deer and raccoons from the crop area but they won't be harmed. The diverse suburban / rural habitat actually appears to be optimal for both of these species.

Sources of Further Information

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