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MOFGA FACT SHEET #2

Organic Strawberry Production

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Introduction

Similar to any organic crop production, producing strawberries organically entails a system approach to the whole farm. Many of the practices are the same in organic and conventional strawberry systems, but the fundamental approach to soil husbandry and pest management may be quite different. Successful organic strawberry production depends on building a biologically active soil with good structure and reservoirs of nutrients, and ridding the site of weeds and soil borne pests BEFORE the strawberries are planted. After that, management of a successful organic strawberry farm depends on crop rotation to distant fields and the use of cover crops to maintain soil health and fertility and prevent build-up of weeds and pests. Although conventional systems are able to maintain strawberry beds for five or more years controlling weeds, diseases and pests with chemicals, organic growers rely on crop rotation.

This fact sheet is a guide to farm scale organic strawberry production of June bearing varieties in a perennial matted row system. There are day neutral varieties that produce strawberries in the fall, and many other production systems such as annual beds, raised bed plasticulture or ribbon row, but the matted row is still the most common system in the Northeast for early summer berries. In a matted row system of growing strawberries bare root plants are typically planted in the early spring. Blossoms are removed and the plants are allowed to establish runners forming filled rows by the fall of the first year. Strawberry picking begins in June and early July the second year.

The demand for strawberries is the greatest in the early summer, whether it is from pick-your-own or farm stand customers, or even the local wholesale markets. Of course, anyone planning a commercial enterprise should start with an investigation of the market because the local market may be saturated, or favor one way over another for reaching customers. But remember that organic strawberries may attract a special segment of any market, and also attract customers from far away.

The labor requirement for strawberry production is high. Novice commercial growers may want to start with as few as a 1,000-2,500 plants (a quarter acre or less) and gradually expand after the management and soil systems are well developed and the labor demand is understood. Pick-your-own operations have another consideration that is less of a concern for folks who



market from a stand or at farmers markets. The planting has to be large enough so you are not picked out quickly and forced to turn away customers who may have planned a whole day around picking. This would probably be a customer forever lost. I believe that a quarter of an acre is the minimum for a PYO strawberry operation open to the public. Another option for small scale commercial growers would be to allow PYO only on an invitation basis where you can match berry abundance with the number of customers.

Site Selection

Soil Type

Strawberries will grow on most soil types but very sandy soil may lead to drought problems and heavy, clay soils with poor drainage may lead to disease problems such as red stele. Strawberries will do best in soil with the following characteristics:

- 1) High in organic matter
- 2) High level of fertility
- 3) Well drained, yet able to hold a continuous supply of moisture.
- 4) pH 5.7-6.2

Air Drainage and Frost Protection

Strawberry blossoms are killed by cold temperatures. Ideally, a strawberry bed should be slightly higher than the surrounding land so that cold air will drain away to lower ground. A few feet of elevation often will be enough to protect delicate blossoms from a late spring frost, which will kill them. Strawberry blossoms can tolerate temperatures from 32° to 29° F, depending on the stage of development, but remember this is the temperature of the blossom not the air and radiational cooling can cause the blossom temperature to be significantly colder than the air. If the conditions favor radiational cooling, air temperatures even slightly above 32° F could induce frost damage. A frosted blossom will develop a dark center in a day or so, and not produce fruit.

A slight slope to the land often will aid air drainage. Berries on a southern slope may be more susceptible to late spring frost because blossoms may open earlier than those on a northern slope. On the other hand, berries on a southern slope will ripen earlier.

Commercial growers should not attempt strawberry production without some means of frost protection. Some growers use floating row covers and cover the fields on nights when frost is predicted and uncover during the day to allow pollination. Most commercial growers use overhead irrigation to protect the blossoms from low temperatures. Irrigation is started as the air temperature approaches 32° F, and as the temperature drops ice forms over the blossoms. As long as liquid water is applied to the field the temperature of the blossom will not drop below 32° F because as ice forms heat is released from the water. Once irrigation begins, it should not be shut off until the sun comes out in the morning and the ice melts. This is important because just as liquid water turning to ice gives off heat, ice turning to liquid water will take heat from the blossom and could cause the blossoms to get colder than the air.

Preparing the Soil

Soil must be prepared well before strawberries are planted in order to build fertility, organic matter, and soil structure, as well as get rid of pests and weeds. Once strawberry plants send out runners and form the matted row the only weed control for an organic grower will be by hand pulling. Since weeds can quickly out compete and take over a strawberry field it is important to have a field free of weeds and a reduced weed seed bank BEFORE the berries are planted. Grubs (larvae of June beetle, Japanese beetle and others) that live happily under sod are another reason to prepare a field well in advance of strawberry production. Organic growers rely on starving the grubs out by getting rid of the sod at least a year before planting the strawberry plants. Most important in preparing land for organic strawberry production is the need to build fertility and soil health in advance. Organic growers create a farm system where soil structure, cation exchange capacity and reservoirs of plant nutrients are built and then the soil supports the crop. A successful strawberry grower should begin improving the soil at least a year ahead of planting. (See MOFGA Fact Sheet #1 for a more detailed discussion of organic soil fertility.)

Organic growers will benefit from preparing at least three distinct fields that are distant from each other. How distant is a matter of how far strawberry pests such as the clipper can fly and that is not that predictable, but even 500 feet helps and more is better. Over a year or two of strawberry production weeds and pests begin to build up and organic growers manage this build up by rotating out of fields. With three fields a grower can have one in strawberry production, one with establishing plants and one out of strawberries either lying fallow or growing green manures. Four separate fields could allow for two years of picking before rotating out of strawberries with one field in first year picking, one field in second year picking, one field in establishment and one field out of production. I would not recommend more than two years of picking before rotation in organic production because of build up of disease and insect pests. I also recommend more fields because more fields could allow for more time out of production, and the more time in cover crop the greater the benefit for the soil.

Preparing New Land (Pasture, Fields, etc.), or fields in weedy condition

The following is an example of how one could prepare sod ground starting a year and a half before planting the berries:

- 1) Plow in late summer (a year and a half before planting berry plants)
- 2) Soil test and apply the recommended amount of lime

Note: See MOFGA Fact Sheet #1 for a more in depth discussion on reading the soil test results and meeting nutrient needs with natural amendments. And MOFGA Fact Sheet # 11 for a list and description of natural sources of crop nutrients. Fact sheets are available on the MOFGA website, www.mofga.org.

- 3) Plant a winter cover crop in early September. Winter rye works well for those with tractor implements to till in all the plant matter, while oats or annual rye grass are recommended for those working with a tiller or by hand because they will be winter killed and easy to till in the spring.
- 4) The following spring, till in the fall cover crop and add the recommended amounts of rock powders such as Sul-Po-Mag for magnesium and potassium, and rock phosphate for phosphorus. Also, this is an ideal time to add manure and/or compost.

Common rates of manure applications are:

- Poultry & rabbit: 5-8 tons per acre (35 lbs./ 100 square feet)
- Cow: 10-15 tons per acre (65 lbs./ 100 square feet)

If you use poultry manure you need less lime and rock phosphate. Poultry manure will supply approximately 15 pounds of phosphorus per ton.

5) The spring a year before planting strawberries, plant a green manure crop or series of crops for the season. The choice of green manure is complicated by many factors such as your major goal. Usually, when trying to bring sod ground into condition for strawberry production, your primary concern is weed control. The following is a good plan in most cases:

- a) In the spring, plant oats
- b) Plow oats under in early summer. For a summer cover, plant sorghum-Sudan if you use tractor implements, buckwheat if you use a tiller or turn by hand.
- c) Plow summer crop under late in August or very early September and plant a cover crop of oats for the fall and winter.

Note: If your land is in really weedy condition, then you will need to be much more aggressive in getting rid of perennials such as quackgrass and depleting the seed bank of annual weeds. See MOFGA Fact Sheets "Using Green Manures" and "Controlling Garden Weeds" for details on using a series of green manures alternating with fallow periods to get weeds under control. You must do this BEFORE you plant the berries.

- 6) Plow under oats as early as possible in the spring, wait a few weeks, cultivate and plant strawberries.

Varieties

The choice of strawberry varieties is based on factors including taste, use of berry, winter hardiness, disease resistance, and ripening date. The University of Maine Cooperative Extension Bulletin #2184, "Strawberry Varieties for Maine" describes the characteristics of most of the varieties suitable for New England and is available by calling your local Extension office.

Planting

Strawberries should be planted early in the spring. Late spring plantings may have problems when hot, dry weather arrives because they did not have time to develop adequate roots. Depth of planting is extremely important. The crowns should be just level with the ground.

In the matted row planting system, plants are set 18-24 inches apart in rows 4 feet apart. All runners are allowed to root, but the beds are kept 18-24 inches wide by cutting off runners that extend into the alleys with a hand hoe, rolling colter wheel, cultivator or rototiller.

To ensure early runners and vigorous plants, all blossoms should be removed the planting year. Failure to do this may result in weaker plants which may not be able to produce as high a yield.

Fertility

As pointed out above, for the most part fertility is established prior to planting based on soil testing and is primarily maintained with a good rotation of legume green manures. However, since June-bearing strawberries set their buds for the following year's fruit in the fall it is crucial to have adequate fertility, especially nitrogen, available at that time. To get a good bud set nitrogen fertilizers are applied in the mid-late summer before the bearing year, giving organic fertilizer materials enough time to break down and become available by early fall. A common practice is to apply enough high nitrogen materials such as fish meals, seed meals or alfalfa meal to supply 30 pounds of actual nitrogen per acre. Compost can be used as a supplement and serves well to condition the soil and balance nutrients, but does not serve well to provide enough available nitrogen at the time needed. An inch of compost and the appropriate amount of a high nitrogen organic material directly over the rows is recommended. Less can be used if a good legume cover crop was growing the year before.

Mulching

Strawberries should be mulched over the winter to protect the plants from extreme cold and, more importantly, from damage by rapid freezing and thawing of the soil. Although threshed straw is the most commonly used mulch, any material that will provide protection without matting can be used. This includes marsh hay, Sudan Grass, pine needles, or coarse wood shavings (not sawdust). Mulch should be applied after 15-20 frosts, but before the temperature drops below 20°F. The exact time will vary from year to year and place to place. In central Maine, growers lay the mulch around the week before Thanksgiving.

Mulch should be applied 4-6 inches deep over the rows. This will take 100-150 bales of straw per acre.



In a typical matted row system strawberry rows are allowed to get no more than 18 inches wide and the aisles are at least a foot wide.

Mulch should be removed in the spring as soon as possible, and is usually raked into the aisles where it can serve to suppress weeds and conserve moisture. Many growers like to leave it on the plants somewhat longer in order to delay blossoming (hoping to delay it beyond the danger of a late frost). This may work, but has been shown to reduce total yield.

Renovate or Rotate?

Conventional growers keep fields in production for many years and renovate their fields after harvest. Within a week after harvest they mow the old foliage to one inch above the crown and narrow the rows to 10-12 inches with a rotovator or tiller. This practice is questionable for organic growers because without herbicides the weeds often are the better competitor and take over when released from the shade of the strawberry foliage. Organic growers may be better off not mowing and just narrowing the rows and fertilizing at this time.

Better yet, growers with enough land may find their most profitable system is one in which strawberries are picked for only one year and then the field rotated. Growers are going to have to decide for themselves what works best for them but it is unlikely that organic growers will be able to harvest more than two years from a field before weed and pests become unmanageable.

Crop Rotation for Insect, Disease and Weed Management

Crop rotation is the best tool organic growers have against insects, diseases and weeds. As soon as the final crop is harvested the land should be plowed. Deciding what to do next depends on which problem is the worst, e.g., insects, weeds, disease, or fertility. It is important to learn the biology of the weeds and pests that have become major problems during strawberry production and practice a rotation of crops that best interrupts their success. If no problem has gotten out of hand, then green manures should be used that will best improve the soil and reduce the need for off farm sources of fertility.

Weeds

It cannot be said too often that crop rotation is the best tool organic strawberry growers have against weeds. Once the field is established the only alternative is hand weeding and that is

futile on any large scale of production. Deciding on the type of rotation depends on the type of weeds in the field. The key to using crop rotation for weed control is to starve out perennial weeds by repeated tillage during fallow periods and using competitive cover crops, and to diminish the weed seed bank by repeated tillage that stimulates weed seeds to germinate and then kill them before they produce new seeds. (See the MOFGA fact sheet "Garden Weeds" for details on weed control.) Scout your fields and determine if your weeds are perennial or annual weeds, if they are spring, summer or fall flowering and when they germinate. Then use this information to decide on which green manure crops to use and when and how long your fallow periods should be.

An example of a strawberry rotation that works well on organic farms in New England is to plow under the strawberries just after harvest and then bare fallow the land until late August. Then plant a winter rye/hairy vetch mix in late August. Allow that to over winter and grow into mid-late May the following year and then plow it. Bare fallow the field for two to four weeks and plant a summer cover crop (cow peas or soy beans if a legume is desired, sorghum-Sudan grass or buckwheat if not). Then in late August take down the summer cover crop, bare fallow again for a few weeks to kill weeds and use up the seed bank of fall germinating weeds, and then plant an oat cover for the fall. Then back to strawberries the following spring. If you have the land, the soil will benefit and the pests will suffer more with a longer rotation out of strawberries. Two to three years out of strawberries is recommended.



The strawberry clipper lays an egg in a bud and then clips off the bud. Each female can lay 300 eggs this way.

Common Insect, Mite and Disease Problems in New England

While there are several insects, mites and diseases that can become problems in organic strawberry production they can usually be kept at tolerable levels by selection of resistant varieties, good site selection, and crop rotation. As with any organic system an understanding of the pest biology helps a grower choose the management practices.

Insects

White grubs

White grubs are the larvae of various beetles, such as the June beetle and Japanese beetle, who live in the soil and feed on roots. These and other species are very common and occur in very large populations under sod feeding on roots, often with little evidence of them being there. If a field of sod is tilled and planted directly to strawberries they can wipe out the whole planting because you have taken away the large amount of food and only planted relatively a small amount of food. This is one of the most important reasons to prepare strawberry ground a year in advance of planting. If the problem persists after good preparation it may be worth trying beneficial nematodes. Grubs move up and down in the soil and so it is recommended that two species of nematodes be used. The species *Steinernema carpocapsae* will infect its host near the soil surface while *Heterorhabditus bacteriophora* will attack grubs deeper. A search of the internet will provide lots of suppliers. Two relatively local suppliers of beneficial insects and nematodes are IPM Labs in New York and The Green Spot in New Hampshire.

Strawberry clipper (*Anthonomous signatus*)

The strawberry clipper can build up to tremendous populations in just a few years and is often the cause of low yields in strawberry fields in production two or more years. It is a small, copper to black colored snout nosed beetle. This pest overwinters as an adult in the soil or plant debris in the strawberry field or nearby woods. They emerge in the spring and the female finds strawberry flower buds and lays an egg inside the bud. Each female can lay up to 300 eggs and that is how a population can explode in just a few years. After laying the egg, she girdles the bud just below its attachment and it hangs there for a while then drops to the soil. The eggs soon hatch into larvae and the tiny grubs pupate in the soil. Adults emerge early in the summer and feed on pollen. These adults are the ones that find overwintering sites later in the summer to wake up the following spring and start the cycle over.

There are no chemical controls that are allowed in organic production for the clipper. If left uncontrolled for years clipper damage can destroy 50% or more of the buds. Since the clipper seems to come into a new field from the edges and advances into the field only about 30 feet per year, only a portion of the field suffers initially and more and more is infested each year. Crop rotation after one or two years of picking is the only truly effective means organic growers have of limiting damage by this pest. Good weed control in and near the field will help because the summer adults feed on pollen, especially broadleaf weeds. There is recent evidence that the plant compensates for



It is highly recommended that ground for strawberries be prepared a year in advance of planting to get rid of the large population of grubs that live under sod.

the clipped bud by producing larger fruit from the remaining buds. If the clipper takes king berries (the first berry in a cluster to mature) the damage can be severe because of the loss of such large berries, especially in varieties where the primary bud produces the only large berry such as Sparkle. But, loss of the later small buds is often not serious because of compensation. On a garden scale, going out every morning during the season when the strawberry buds are there and collecting all the dangling buds that have eggs in them will keep populations of the clipper small. Of course, this is not feasible at a commercial scale.

Tarnished Plant Bug (*Lygus lineolaris*)

The tarnished plant bug is a good example of a pest for which crop rotation has little value. The bug feeds on hundreds of crops and native species of plants and whether strawberries are in your field or not does not effect the pest population size. It is a small, bronze colored insect with a triangular marking on its back. Both the adults and nymphs feed on developing flowers and fruit by piercing the tissue and sucking out juices. Their feeding results in deformed fruit that are seedy at the end and referred to as "cat-faced" or "button" berries.

The adults hibernate over winter in weeds, crop debris in fields, under bark, etc., and emerge in the spring. Managing the land around the strawberry field to diminish hibernation habitat and feeding areas is the key to minimizing damage for organic growers. Most important is to keep in mind that fields of their favorite plants, such as alfalfa or mixed hay ground, harbor large populations. So if such a field is mowed while your strawberries are flowering the tarnished plant bugs will move to your fields. If possible, keep fields near strawberry beds mowed short during the year to keep populations small, but do not mow any fields during the time berries are flowering. Keeping a perimeter 10-30 feet wide of very short ground cover around the strawberry field helps hide the bed.

Trap crops of their favorites such as alfalfa have been shown to work in California for a related Lygus bug. You need to have a perimeter trap crop around the strawberries about 30 feet away that attract the bugs, and then kill them or vacuum them off the trap crop. ATTRA has a good publication called Bug Vacuums for Organic Crop Protection (<http://www.attra.org/attra-pub/summaries/bugvacuums.html>).

Research conducted by Maine's Small Fruit Specialist Dave Handley found variation in susceptibility to the tarnished plant bug among 20 strawberry cultivars. Honeoye, Sparkle, Veestar, and Canoga suffered the least from feeding, while Kent, MicMac, Scott, Blomidon, and Redchief suffered most.

Somewhat promising is an enemy of the tarnished plant bug, a Braconid wasp called *Peristenus digoneatis*, that was released by USDA/ARS researchers back in the 80s and it is spreading. It was released with hopes of reducing tarnished plant bug damage to alfalfa but is helping strawberry growers in a wide area now, including northern New England. Parasitism of tarnished plant bugs by this wasp has been noted as high as 70% of the tarnished plant bug populations on some farms. However, some farms are not this lucky, and even 30% of a tarnished plant bug population is large enough to cause more than tolerable damage. On the other hand, this wasp along with cool, wet springs like the ones we have had lately delay development of the pest and push its activity later in the season. This has greatly reduced the damage strawberry growers are seeing.

Another wasp that is a lygus bug egg parasitoid, *Anaphes ioles*, has been reared and has been used in California with some success against the Lygus bug. But it is not commercially available at this time and it would not survive the winters here in the northeast so would have to be released year after year, which could be expensive.

There is a fungus called *Beauveria bassiana*, which attacks tarnished plant bugs and it is available in commercial products (OMRI listed products include Mycotrol O and Naturalis). These have been tested in university trials and show significant control (up to 50%). Farmers have to make the management decision as to whether it makes economic sense, and this decision is difficult because it is hard to predict the level of damage considering variable parasitism by *Peristenus digoneatis* and the influence of weather.

Strawberry Rootworm (*Paria fragaria*)

The strawberry rootworm is a tiny, round, dark brown-black beetle that eats holes in the leaves reminiscent of damage caused by flea beetles. Usually you never see the beetle because it feeds at night. The feeding damage is first seen in May and continues through June. During this period the females are also laying eggs. The eggs hatch shortly after and for about two



Strawberry rootworm adult.



Gray mold spreads fast in wet fields. Keep your aisles wide for good air flow.

months the larvae are feeding on the roots. A second generation of adults are seen in July and feed until summer ends when they go into hibernation for the winter.

Root feeding by the larvae can cause serious damage especially when associated with root diseases. Organic growers have no good method of controlling this pest and keeping root feeding to a minimum other than crop rotation to non-host crops or better cover crops. Plow fields after the last harvest and locate new fields as far away as possible. Parasitic nematodes may be effective in limiting the population, and some native carabid and staphylinid beetles really help.

Root Weevils

There are a lot of different species of root weevils that attack strawberries. The black vine weevil, strawberry root weevil, and the rough strawberry weevil are the most common. These are brown to black oval beetles with little "puncture" marks along their backs. The adults feed on the leaves at night and eat notches out of the edge of the leaves. The larvae feed on the roots and cause the serious damage. Large populations can cause big patches of the field to wilt and die. Crop rotation to non-host crops or cover crops is key to managing this pest for organic growers. Since the adults do not fly but walk, rotation to distant fields works well. If the new strawberry field is close to the infested field, then leave a row in the infested field when plowing it to host the population and deter them leaving the field searching for your new field. Then, fall plow that last row late enough so there is no time for them to migrate. Parasitic nematodes may be effective in limiting the population, and some native carabid and staphylinid beetles really help.

Diseases

Similar to organic insect management there are no silver bullet materials that organic growers can use for disease management. Fungicides play a major role in conventional strawberry production, and some growers still fumigate their soil. But organic growers primarily depend on crop rotation to keep diseases at bay, and use resistant varieties when deemed necessary for a particular problem that is hard to avoid in their system. Many diseases of strawberries are minor and have little effect on pro-

duction. Here is some discussion of the common problems that may greatly reduce production if ignored.

Grey Mold (*Botrytis cinerea*)

Gray mold is the most common disease. It is caused by a fungus that is ubiquitous and whether the disease gets out of hand or not is greatly dependent on weather conditions rather than the presence of spores because for the most part they are there. The fungus grows best in humid, wet conditions and hardly is seen if there is dry weather during critical periods of crop development.

The problem is seen as a powdery gray mold growing over ripe berries. By the time you see this it is obviously too late to do anything. Gray mold overwinters on old strawberry leaves and during wet weather in the spring it produces millions of spores that infect strawberry blossoms. If it is dry during blossoming and dry during fruit development you probably will not see the problem. The key to organic management are all the cultural practices that promote quick drying of plant tissue. For example, good weed control, do not let strawberry plants get too crowded, orient rows in direction of prevailing wind, avoid wide plant rows, etc. Some biorational products such as Serenade and Mycostop have been shown to be somewhat effective, but it is a difficult management decision to make whether to spray these when with good weather and through good cultural practice you will probably not have a problem anyway.

Verticillium Wilt (*Verticillium dahliae*)

This is not a common problem but you want to pay attention because if you get it you cannot do anything but plant resistant varieties in that field. It is a soil borne fungus that also effects tomatoes, peppers and potatoes so you should not grow these crops in a strawberry rotation. The symptoms are the outer leaves of the infected plants turn brown around the edges and between the veins, especially during warm weather. As the disease progresses the outer leaves die while the inner ones remain green. If you have it then you should grow resistant varieties such as Earliglow, Allstar and Scott.

Red Stele (*Phytophthora fragariae*)

Red Stele is an important disease to manage if you are trying to grow berries on poorly drained ground. Symptoms appear just before harvest. The plants are very stunted and the leaves wilt and have an off-color. Often you see it in patches in the wettest sections of a field. Once you get it the fungus will persist for many years. If you grow on wet soils you should only use resistant varieties such as Earliglow, Allstar, Annapolis, Cavendish.

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