Integrated Pest Management
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Intensive Gardening: More from less (space) *by David Trinklein*

Home vegetable production is riding a wave of popularity that began during our nation's last economic recession ten years ago. The desire to grow produce with limited space and time has resulted in a renewed interest in an old gardening technique known as intensive gardening. Today often referred to as 'square-foot gardening', a term coined in 1981 by author Mel Bartholomew, it is a method that allows for maximum production in a minimal amount of space through intensive management.

Square-foot gardening gets its name from dividing intensively managed, small plots into one-foot squares. The concept basically is a modern version of a production method developed in France in the late 19th century that became known as the 'French Intensive Method'. At that time, the gardening method consisted of putting well-aged, composted horse manure in mounds about 18 inches deep, or in small rectangular structures (boxes) capable of retaining the compost. Vegetables were spaced very closely together in this structures to the point that plants would touch one-another as they approached maturity.

Whatever name it is given, intensive gardening today is not that much different from the method practiced by the French over 100 years ago. The main points to consider include: 1) A raised area (bed) is needed to provide for excellent drainage and good aeration to the roots of plants being grown; 2) The medium in which the plants are grown should be high in organic matter and fertility to promote maximum yields; and 3) Plants should be grown closely together, but not crowded.

Growing plants close to one another makes the exposure of the intensive garden very important. It must be located where plants get direct sunlight for a minimum of six hours each day. Inadequate light results in lower plant growth and yields. While shading from trees or buildings should be avoided, even the vegetables should be planted so they do not shade one another. Therefore, locate taller plants on the north side of the plot and smaller, short plants on the south.

In spite of the need plants have for light, there are occasions when shade can actually be beneficial. Cool season vegetables such as lettuce benefit when they receive shade from taller vegetables such as staked tomatoes. Additionally, afternoon shade cast on cool season crops can prolong their period of productivity.

Although most gardeners today do not have access to well-aged horse manure, the same results can be achieved with other sources of organic matter. Composted manure from other animals may be used when mixed liberally with existing soil. The organic component of the mixture should be at least 50 percent, by volume. For heavier, clay soils, the percent should be increased. Peat moss also may be used as a source of organic matter as can composted leaves.

Soil acidity is very important to vegetable nutrition. Since most vegetables grow best in the 6.0 to 6.5 pH range, limestone often must be added to the mix. As a general rule, if peat moss is used as the source or organic matter or native soil is very acid, about four to five pounds of dolomitic limestone should be added per 100 square feet. Add the limestone when the soil mixture is being prepared and incorporate thoroughly. Soil tests can be helpful in determining whether or not enough limestone was added, as well as the status of other essential mineral elements in the mix.

Plant growth during the course of the season also is a good indicator of soil fertility and pH. Therefore, observe plants carefully. Pale green color along with 'spindly' growth usually indicates that more nitrogen is needed. Also, watch carefully for leaf damage, pests or insect eggs on leaves. Destroying pests and removing diseased leaves as soon as they are detected can reduce pest severity and make the garden season more successful.

Plants growing in close proximity to one another need a lot of water. Although the leaf density of closely-spaced plants in the intensive garden form a living mulch, addition mulch can reduce water loss from the surface of the soil. Choose organic forms of mulch whenever possible.

In spite of this, additional water often is necessary. This especially is true during hot, dry periods in mid to late summer. Even though plants may survive without supplemental irrigation, production will be greater and quality better if plants receive adequate moisture. Drip irrigation systems are ideal for apply water where it is needed yet keeping leaves dry. The latter tends to discourage foliage diseases.

Deciding what crops to plant in a square foot gardening probably should be based on economics. In short, vegetables with the highest market dollar value represent the best candidates for intensive gardens. Examples of the latter include tomatoes, peppers, carrots, onions and leafy 'salad greens' such as lettuce. Avoid the temptation to grow family favorites (e.g. melons or sweet corn) which represent low-value crops given the amount of space they require.

Authorities on the subject differ in their estimates of the economic value of an intensively managed vegetable garden. Results vary according to crops grown, spacing, use of succession planting, etc. Suffice to say, however, if intensive vegetable gardening doesn't lower your grocery bill, you are doing something wrong. Add to the economic aspects the health, psychological, social and environmental benefits of gardening and it becomes obvious why the popularity of home food production continues to remain high.

Weed Control in Greenhouses *by Michele Warmund*

Unwanted plants or weeds can become problematic beneath benches and around walkways of greenhouses. These plants can harbor aphids, whiteflies, thrips, and mites that will damage desirable plants. Weeds can also be a source of viruses, such as tomato spotted wilt virus or impatiens necrotic spot virus, which are transmitted to crop plants by thrips. Weeds and seeds are easily transported into greenhouses by animals, people, and tools, or in infested growing media. Weed seed can also be dispersed inside greenhouses by water dripping from hoses or plant containers.

Several simple measures can be used to prevent weed dispersion in greenhouses. Maintaining a weed-free zone around the outside perimeter of the greenhouse will minimize seed brought inside by foot traffic. Also, fine-meshed screens on greenhouse vents or other structural openings will reduce entry of wind-blown weed seed and insects. Also, the use of sterile media will help limit weed infestations. When bringing container-grown plant material inside, especially for overwintering, make sure pots are weed-free before placing them in the greenhouse. Also, clean tools after each use to minimize weed seed dispersion or disease transmission.

Always try to control weeds at a young stage before they flower and produce seed. Just one common chickweed plant can produce and release as many as 800 seeds (Figure 1). The three common types of pigweed usually produce 10,000 to 30,000 seeds per plant. Thus, just one or two uncontrolled seed-bearing weeds can result in rapid multiplication of these unwanted plants in a greenhouse.

Weed block fabric can be used to cover areas beneath benches and walkways and prevent weed emergence. If the fabric is covered by gravel, spilled potting media, or plant debris, this provides an environment conducive for weed seed to collect and germinate. Thus, periodic sweeping of the fabric to remove spilled media and plant debris will aid in weed control.

When weeds become problematic in a greenhouse, they can be removed manually or eliminated using a post-emergent herbicide. Few herbicides are labeled for use in enclosed structures, such as greenhouses due to the potential for crop injury to desirable plants or harm to human health. Some formulations of herbicides, labeled for outdoor use only can volatilize (change from a liquid to a gas) and then drift away from the target area, causing harm to other crops. However, herbicides labeled for greenhouses are usually low-drift products and are applied when air-circulating fans are turned off.

A good time to apply a herbicide is when a crop production cycle is completed and the greenhouse is empty. Roundup® Pro (glyphosate) may be used for weed control at this time. When the greenhouse is weed-free, a preventative pre-emergent herbicide such as Marengo® (indaziflam) can be applied to gravel or the ground beneath benches before ornamental (non-edible) crops are placed in a greenhouse.

Most post-emergent herbicides labeled for greenhouse use are non-selective (i.e., will kill any plant contacted with spray), except for Fusilade® II (fluazifop-butyl) and Envoy ®Plus (clethodim) which control grasses only. Also, some herbicides, such as Finale® (glufosinate) and Reward® (diquat) may only be applied in greenhouses where ornamental (non-edible) crops are grown. In contrast, Axxe® (ammonium nonanoate), Scythe® (pelargonic acid), Reward® (diquat), and WeedPharm® (acetic acid) can be applied in greenhouses where edible crops are grown. Also, Sporatec® fungicide, which contains rosemary, clove, and thyme oil as active ingredients, can be used to control mosses, liverworts, and hornworts in greenhouses where edible crops are grown.

Figure 1 A common chickweed (*Stellaria* media) plant with flowers and a capsule containing many seeds. Photo credit: Kevin Bradley

Groundcovers Curb Soil Erosion *by David Trinklein*

Soil erosion is a major problem in areas of the landscape having steep topography. In addition to making the landscape attractive, groundcovers are excellent at minimizing soil erosion. While grasses provide the quickest and most effective groundcovers, there are many areas where grasses do not grow well. This often is the case in areas that are too shady or wet. In other areas, mowing may be difficult to impossible, making other groundcovers a logical choice.

By definition groundcovers are (relatively) low, dense-growing plants requiring minimal maintenance that establish a monoculture in areas of the landscape. Â In short, they cover the ground in an attractive manner. They can be classified according to several criteria. Among them are shade tolerance, persistence of foliage, height and rate of growth.

One of the most popular groundcovers is vinca or periwinkle (Vinca minor). It has a growth habit that trails along the ground, roots easily and grows to a height of about six inches. Although it produces attractive, light-blue flowers early in the spring, its dark, evergreen leaves are the plant's main attraction. It is fairly shade-tolerant which makes it a suitable choice for the north sides of buildings or under the light shade of trees. It tolerates full sun, if given adequate moisture. Vinca does not tolerate wet soils.

Another common groundcover is purple wintercreeper euonymus (Euonymus fortunei var. coloratus). The species is a woody vine that creeps over the ground until it finds a tree or fence to climb. It produces orange-red berries and is sometimes referred to as evergreen bittersweet. The species is on Missouri's invasive plant list. The botanical variety coloratus rarely blooms. Thus it seldomly produces berries and is much less likely to be spread to the wild. Euonymus scale is an insect pest that commonly plagues but rarely kills this plant.

On dry, sunny locations the creeping junipers (Juniperus spp.) make excellent groundcovers. Most achieve a mature height of only six to ten inches and spread widely. Although there are many cultivars available; blue rug juniper (J. horizontalis 'Wiltonii') is one of the best and most popular. Andorra juniper (J. horizontalis 'Youngstown'), sargent juniper (J. chinensis 'Sargentii') and Japanese garden juniper (J. procumbens 'Nana') are slightly taller cultivars.

Ajuga or bugleweed (Ajuga reptans) is another popular groundcover for shady areas where adequate moisture or irrigation is available. It can be damaged severely to the point of partial die-out during severe winters without snow cover. Several cultivars are available with bronze, nearly black or variegated leaves. All bear blue flowers in the spring. The leaves form a dense, low-growing mat; the flowers may reach a height of between six to eight inches.

English ivy (Hedera helix) is attractive alone or when mixed with other groundcovers such as vinca. It survives winters best when planted near structures or given some protection. 'Baltica' and 'Thorndale' are considered to be the most winter hardy of the many cultivars that exist. Snow cover or a mulch is needed to protect English ivy when grown in exposed sites or colder areas.

Certain flowering perennials also can be used as groundcovers. Lily-of-the-valley (Convallaria majalis) is an excellent choice for light or heavy shade. It spreads by producing underground stems called rhizomes and normally requires about two to three years to cover an area when planted on six-inch centers. Essentially pest free, lily-of-the-valley produces fragrant flowers on small, arching racemes in the spring.

Hosta or plantain lily (Hosta spp.) is well-suited to shady locations under trees or near buildings. Depending on cultivar chosen, leaves may be large or small. Hosta cultivars are available with solid green, blue, yellow or variegated leaves in various color patterns. Hostas are planted mainly for their foliage. However, attractive flowers are produced on scapes at various times of the year, depending upon cultivar. Although hosta leaves die back to the ground during the winter, its spreading roots hold soil in place and prevent erosion.

Daylily (Hemerocallis spp.) arguably is America's most popular flowering perennial. To date, over 70,000 named cultivars have been registered with the American Hemerocallis Society. Daylilies tolerate a wide array of soil conditions and exposures, although flowering is reduced by shade. Vigorous in growth habit, daylilies hold soil well once established making for a very colorful, although somewhat tall, groundcover.

Aggressive growth is an attribute common to most groundcovers. This is understandable since, by definition, groundcovers are plant species that will form a monoculture in an area of the landscape.Â At times, however, some species may become invasive.

Bishop's goutweed (Aegopodium podagraria) is a good example of the latter. It is an excellent groundcover for shady locations with either moist or dry soil. Once established, however, this attractive plant with variegated leaves spreads rapidly and can invade other areas of the landscape. The same is true for houttuynia or chameleon plant (Houttuynia cordata 'Chameleon'), a plant that derives its name from its colorful leaves. Its aggressive growth habit and ability to tolerate a wide array of conditions, makes it a good choice for remote, isolated problem areas in the landscape. Left unchecked, it has the tendency to get out of control very quickly and must be monitored regularly.

Groundcovers should be established in the landscape much the way other perennials are established. Adequate soil preparation through the incorporation of organic matter will help to encourage root growth and ease stress on newly planted groundcovers. This, along with adequate water and fertility, should cause them to establish themselves faster.

Trees with heavy canopies often shed water (especially during light rains) thereby reducing the availability of moisture to plants below. Hence, frequent watering of newly planted groundcovers under trees is needed for rapid establishment. Even after establishment, watering becomes a necessity, especially in periods of dry weather.

The accumulation of leaves is yet another problem for groundcovers under trees to contend with, especially if the trees are large. Groundcovers should never be allowed to be totally covered with leaves. This is especially critical for evergreen groundcovers during the fall and winter. While a thin covering in the winter is not harmful, it should not be so think as to totally block light which evergreen plants need year around.

Finally, while groundcovers tend to choke out competing weeds once established, shade-tolerant weeds can be problematic while the groundcover establishes itself. Mulching between plants as they establish themselves can help prevent weeds. If weeds do appear, they should be removed promptly to prevent them from slowing the development, speed of cover and general attractiveness of the desirable groundcover.

Understanding Your Lawn and Garden Soil Test Reports and Calculating Fertilizer Requirements Based on Soil Test Recommendations *by Manjula Nathan*

Soil testing is an important tool for growing healthy lawns and gardens. To get reliable results and appropriate fertilizer and lime recommendations, it is important that you submit a representative soil sample from your lawn or garden. For guidelines in taking a representative sample and submitting to the lab for testing, visit MU Soil and Plant Testing Lab's website at http://soilplantlab.missouri.edu/soil. Once the soil test is conducted and the results are available, the ability to interpret the results and follow the recommendations is an important consideration in correcting the deficiency or imbalance, and growing healthy lawns and gardens.

Example of Soil Test Report from MU Soil Testing Labs for Lawns and Garden Fertility Test:

University Extension
University of Missouri
Columbia

Soil Test Report
For Lawns and Gardens

----------MU Laboratories----------

23 Mumford Hall
Columbia, MO 65211
(573) 882-0623

or

P.O. Box 160
Portageville, MO
(573) 379-5431

Serial No.	County	Region
H46109H-1	Boone	
Submitted	**Processed**	
3/27/2018	3/29/2018	

http://www.soiltest.psu.missouri.edu/

Sample ID: Home garden 1

Lab No: CO185997

This report is for:
Lawn Garden
1000 Univ. Ave
Columbia, MO 65201

Last Limed: unknown

SOIL TEST RESULTS			RATING					
			Very low	Low	Medium	High	Very high	Excess
pHs	5.5		**********					
Phosphorus (P)	7	lbs/a	***					
Potassium (K)	191	lbs/a	**********					
Calcium (Ca)	5253	lbs/a	**********					
Magnesium (Mg)	495	lbs/a	**********					
Organic Matter:	2.6 %		**Neutr. Acidity:**	2.0 meq/100 g		**CEC:**	16.0 meq/100g	

Fertilizer & Limestone Recommendations (lbs/1000 sq ft)

Crop	Nitrogen(N)	Phosphorus(P_2O_5)	Potash (K_2O)	Zinc(Zn)	Sulfur(S)	LIME
1 vegetables	0.5	4.0	0.5			100
2 blueberries	1.0	4.0	1.0		50	0

Comments:

*** Fertilizerrates are given in pounds of actual nutrient per 1000 sq. ft to be applied

*** The soil needs additional organic matter for gardens and crops other than lawns. See MU Publication G6950, "Steps in Fertilizing Garden Soil" and G6956, "Making and Using Compost".

*** Lime takes two to three months to react with the soil. Apply lime three to six months before planting.

*** For blueberries soil needs to be treated with 50 lbs of elemental S per 1000 sq. ft to acidify the soil. It takes 3 months for S to react with the soil and acidify the soil.

--- The soil should be tested every 2 to 3 years to determine the effects of your fertilization practices and to develop a new set of fertilizer and limestone guidelines.

Explanation of Soil Test Report Form

Sample ID: This is information you provided upon submitting your sample. The fertilizer suggestions are based on this.

Ratings indicate how high or low your soil is considered in each category.

pHs is an indication of the acidity or alkalinity of soil. A pH of 7 is neutral, while values below 7.0 are acidic and values above 7 are alkaline or basic. Vegetables and flowers grow best from pHs of 6.0 to 7.0. Most lawns grow well in pHs range of 5.5 -7.0. However, acid loving plants like azaleas, rhododendrons, blueberries and raspberries prefer pH below 5.5.

Phosphorus, potassium, calcium, and magnesium tests results are listed in lbs/a in the next four lines. These are some major essential elements required for plant growth. However, these numbers have little meanings for home owners. The ratings, however, indicate if these nutrients are considered low or high.

Organic Matter is the percent of organic matter found in your sample. Soil organic matter is essential in the formation of soil structure, reducing compaction, and for retaining plant nutrients. It helps in improving the water holding capacity of the soil, aeration, and tilth. While soil organic matter levels between 2% and 3% are fine for lawns, 4% to 6% is better for vegetables and flowers.

Neutralizable Acidity (NA) is a measurement of reserved acidity in soil and reported in mille- equivalents per 100 grams of soil (meq/100 g soil). This number along with pHs is used in calculating the lime requirement in soil.

Cation Exchange Capacity (CEC) is the ability of the soil to withhold positively charges nutrients and is reported in meq/100 g soil. While soils with high CEC values can retain more nutrients, low CEC soils can only retain fewer nutrients.

Fertilizer and Limestone Recommendations indicate how much nitrogen, phosphate, and potash (potassium), Zinc, Sulfur and lime your soil needs for each selected crop option of your choice. This is the most important part of the report for home owners. These rates are in pounds needed per 1000 square feet. Depending on the garden size specific amount of nutrient requirements needs to be calculated and fertilizers to be selected accordingly.

Comments: The soil test reports have comments at the end of the reports with notes on soil test in general, with additional notes for specific recommendations for your soil.

Calculating the fertilizer requirements based on soil test recommendations

All fertilizer recommendations given in a soil test report are based on the amount of nutrient (N, P2O5, and K2O) to apply for a given area. Lawn and garden recommendations are given in pounds per 1000 sq. ft. From the given recommendations it is necessary to select an appropriate fertilizer grade and determine how much of this fertilizer to apply to the garden area. Numbers on fertilizer bags indicate the exact percentages of nutrients by weight: 100 lb. of 5-10-10 fertilizer contains 5 lb. of nitrogen (N), 10 lb. of phosphate (P2O5), and 10 lb. of potash (K2O). Because it is difficult to achieve the exact amount of all recommended nutrients from the garden fertilizer blends available in the market, it is important to match the nitrogen requirement.

Example

A soil test recommendation for your vegetable garden calls for 2 lb. of N/1000 sq. ft., 0 lb. of P2O5 /1000 sq. ft. and 1 lb. of K2O. The garden is 40 ft. by 10 ft.

Step 1: Calculate the area to be fertilized. Multiplying length by width, the area of the garden is 40 x 10 = 400 sq. ft.

Step 2: Select the fertilizer to be used. Match the ratio of nutrients recommended to the fertilizer grades available. The N-P-K nutrient ratio based on the soil test is 2-0-1. Ideally, a fertilizer such as 10-0-5 or 20-0-10 or 30-0-15 should be selected. At the local garden store, fertilizer bags marked 20-10-10, 27-3-3 and 25-0-12 are available. The one marked 25-0-12 best matches the ratio of 2-0-1 recommended by soil test.

Step 3: Determine the fertilizer amount to apply: Divide the recommended amount of nutrient by the percentage of the nutrient (on a decimal basis) in the fertilizer.

- First calculate the fertilizer recommendation for the garden area: 2 lb. of N/1000 sq. ft. x 400 sq. ft. / garden = 0.8 lb. of N per 400 sq. ft. garden. 100 lb. of the 25-0-12 garden fertilizer blend will have 25 lb. of N and 12 lb. of K2O.
- To provide 0.8 lb. of N for the 400 sq. ft. garden you would require: 100 lb. for fertilizer blend /25 lb. of N x 0.8 lb. of N = 3.2 lb. of the fertilizer blend required to provide the N requirement of the garden. Since the fertilizer blend ratio is almost the same as the recommended ratio, it will provide the required amount of K (1.6 lb. of K2O) to the garden.

Note

The weight of 2 cups of dry fertilizer is approximately 1 pound. Therefore to meet the garden fertilizer recommendation, you will need about 6 cups of the fertilizer blend (25-0-12) material for the 400 sq. ft. area.

Recommended application rate for various granular fertilizers to apply one pound of nitrogen.

	Application rate		
	Per 1000 square feet		Per 10 square feet
Source	Pounds	Cups	Tablespoons
10-10-10	10	20	4
8-8-8	12.5	25	5
12-4-8	8	16	3
16-4-8	6	12	2
20-10-10	5	10	2
12-6-6	8	16	3

Catfacing Injury on Apples and Peaches *by Michele Warmund*

Several types of insets with piercing-sucking mouthparts cause catfacing injury on peaches and apples, including tarnished plant bugs and many types of stink bugs. The term "catfacing" describes the distorted fruit shape, resembling the puckered cheeks of a cat. Early-season feeding damage from these insects appears as sunken corky areas free of fuzz on the surface of the peach fruit (Figure 1). On apples, catfacing symptoms are discolored depressions on the fruit surface (Figure 2) and irregular necrotic spots about 2 to 3 mm-wide in the flesh (Figure 3). As apples and peaches enlarge, fruit shape becomes severely distorted with deep sunken areas (Figure 4).

Tarnished plant bugs (*Lygus lineolaris*) feed on a wide variety of crops, weeds, and ornamental plants (Figure 5). This insect feeds on developing flower buds, fruit, and seeds. Adults are about ¼ inch-long with mottled brown wings folded over the abdomen and a yellow-tipped triangle occurs in the middle of their back. Adults feed on young peach tissue, causing blossom drop and early-season fruit drop

More than 45 species of stink bugs occur in North America in the genera *Acrosternum*, *Euschistus*, *Nezara*, *Halyomorpha*, and *Thyanta*. The southern green stink bug (*Nezara virdula*) andthe green stink bug (*Acrosternum hilare*) are common plant bugs in the Midwest. Adults are bright green with an elongated, shield-shaped body about ½ inch-long. Adult Euschistus stink bugs (Figure 6), as well as the brown marmorated stink bugs (Halyomorpha halys) are brown-colored with shield-shaped bodies. All stink bugs release a strong, foul odor from glands between the legs when disturbed.

Unlike most stink bugs that have been here for many years, the brown marmorated stink bug (BMSB) was first introduced into the U.S. in 1998 and by 2011 became a significant pest in eastern orchards. By 2013, BMSB was found in Missouri. Adult BMSB are distinguished from other species by their 5/8 inch-long, marbled brown body, with white triangles along the margin of the abdomen and brown and white bands on the last two antennal segments. In addition to feeding on many types of outdoor plants during the growing season, BMSB seek sheltered indoor sites where they congregate for overwintering.

Plant and stink bugs are difficult to control in orchards because they fly in and out of orchards quickly. However, since they are attracted to blooming plants, these pests can be managed by maintaining a vegetation-free area underneath fruit trees. Also, reducing or eliminating flowering weeds in tree row-middles or in the surrounding ground cover will limit these insects. Avoid mowing during bloom to limit insect flight to flowers of orchard trees.

An insecticide application at the pink stage of flowering for peaches and apples will reduce the population of plant and stink bugs feeding in orchards in early spring. Since these insects have multiple generations per year, additional pesticide applications are usually applied.

Figure 1 Early-season catfacing injury on the surface of a developing peach with sunken tissue devoid of fuzz. Â *Photo credit: Bruce Barrett*

Figure 3 Damaged cells in apple flesh underneath sunken depressions on skin caused by stink bug feeding. *Photo credit: Bruce Barrett*

Figure 2 Sunken depressions on the surface of an apple from stink bug feeding. *Photo credit: Bruce Barrett*

Figure 4 Catfacing damage on apple caused by early-season tarnished plant bug feeding. *Photo credit: Bruce Barrett*

Pyrethroid products, such as Asana, Danitol, Mustang Maxx, and Warrior provide control against these insects. Other products, including Actara and Assail are somewhat less effective against these pests, but should be alternated with pyrethroid type products to prevent insecticide-resistant biotypes. For a full listing of labeled insecticides with application rates see: https://ag.purdue.edu/hla/Hort/Documents/ID-465.pdf.

Figure 5 Adult tarnished plant bug with mottled wings and yellow triangle in the middle of its back. *Photo credit: Lee Jenkins*

Figure 6 A brown, shield-shaped adult stink bug on apple foliage. *Photo credit: Bruce Barrett.*

Ants on Peony Flowers: An Example of Biological Mutualism *by Michele Warmund*

Peonies, the "king of all flowers", are currently providing a spectacular display of blossom color in Missouri. However, with the development of flowers on peony plants, ants also arrive. While ants on the buds and flowers can be a nuisance, they do no harm (Figure 1). Once bloom is complete, ants will disappear from peony flowers and move on to find a food source elsewhere.

It is a myth that peonies require ants to bloom. The relationship between peonies and ants is a type of mutualism in which two organisms of different species benefit from the activity of one another. Peony flowers provide food for ants and in turn, the ants protect the blossoms from other floral-feeding insects.

Nectaries are present at the base of the green sepals that surround peony flower buds. Later, nectaries are visible on sepals on the back side of the blossoms near the stem. These plant organs secrete nectar, which is composed of sugars (sucrose, glucose, and fructose), amino acids, lipids, and other organic compounds that are a food source for ants. When a scout ant finds the nectar on the peony, she emits a pheromone or odor trail on the way back to her nest. At the nest, the scout alerts other ants of the food source. The recruited ants then follow the odor trail back to nectar on the peony flowers.

While the ants are feeding on the nectar, they protect their food source by swarming and chasing away other insects that come to feed on the flower buds. As each ant feeds on the peony nectar, the odor trail is reinforced until their food is gone. This type of insect behavior is an efficient means of utilizing a temporary food resource.

Because the presence of ants on peony floral tissues is only temporary, the application of an insecticide is unnecessary. When cutting peonies at full bloom for use indoors, hold them upside down by the stem just below the flower and shake the ants off outdoors or gently rinse the ants off before arranging them. To ensure ant removal, cut plant stems when flower buds are at the "marshmallow stage" and rinse off any ants with water before bringing them indoors (Figure 2). At this stage, flower buds are still closed but showing some color. Flower buds will also be soft when gently squeezed between the forefinger and thumb. When buds cut at marshmallow stage are brought indoors, full bloom typically occurs in 8 to 48 hours when stems are placed in water. Cut stems with flower buds can also be stored in refrigeration to produce blooms later.

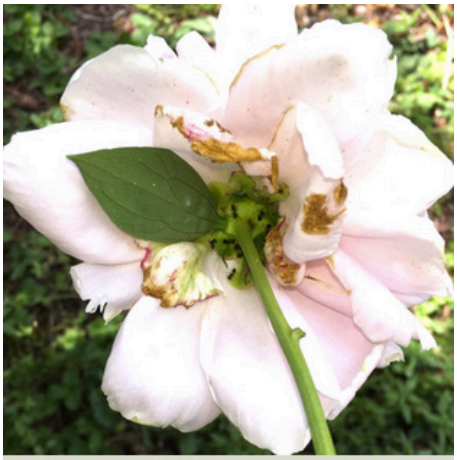

Figure 1 Ants searching for nectar on a peony flower.

Figure 2 Peony flower bud at marshmallow stage.

Unlike ants, thrips are a common insect found feeding on peony flowers. These small (1 to 2 mm-long), slender insects pierce the flower petals with their mouthparts and extract liquids from the plant tissues, causing discolored or blemished blossoms. However, heavy infestations that destroy peony blossoms are a rare occurrence. For more information about growing peonies, see a recent IPM article: Plant Peonies in September.

Amazingly Graceful Grasses *by David Trinklein*

The wispy foliage and delicate panicles of many ornamental grasses add almost constant motion to the landscape. Even the slightest breeze can make species such as maiden grass sway gracefully. Alternatively, their flexibility allow them to endure strong winds without damage. Ornamental grasses have enjoyed a resurgence in popularity in recent years, thanks in large part to their graceful, user-friendly nature.

Most ornamental grasses are quite vigorous, require minimal care and add aesthetic virtue in terms of color, form, texture to the landscape. They are available in sizes ranging from as short as six inches to tall as fifteen feet and can tolerate a wide array of exposures and soil types. Most are reliably winter hardy at our latitude which makes annual re-planting unnecessary. Add to this their ability (in many cases) to tolerate hot, dry weather and it is no wonder that ornamental grasses are being more widely used in the landscape today.

Ornamental grasses usually are classified first according to their temperature preference: cool-season or warm-season. Cool-season grasses (e.g. blue fescue) prefer temperatures in the 60 to 75 degree F range. They make significant growth early in the spring (April and May) and again later in the fall (September and October). Unfortunately, they are not well-suited to hot, dry conditions and frequently go dormant during the heat of summer.

Alternatively, warm-season grasses (e.g. maiden grass) thrive at temperatures in the 80 to 95 degree F range. They are a bit late to emerge in the spring (late April and May) and make their major growth when temperatures are warm. Warm-season grasses tolerate hot weather very well and remain attractive well into the fall, when many of them have added interest because

of their delicate panicles. Warm-season grasses die back to the ground after the first hard freeze of the fall but retain ornamental value in a dried state well into the winter.

Another method of classifying ornamental grasses is according to their growth habit. Most ornamental grasses are clump forming, rendering them non-invasive and suitable for use as specimen plants or for massing. These grasses exhibit a wide array of architectural forms including tufted, mounded, upright, upright divergent, arching and upright-arching. The shortest ornamental grasses usually exhibit a tufted habit of growth while the tallest are upright-arching in form.

A second growth habit classification is spreading or running. These grasses creep or spread thanks to above-ground structures called stolons or below-ground structures called rhizomes. They can be quite invasive and choke out neighboring vegetation. While this is undesirable as a companion plant in the ornamental garden, it is a preferred trait for a plant to be used as a ground cover or for soil stabilization.

Spreading ornamental grasses can be contained in mixed plantings by cutting the bottom out of a five or seven gallon nursery container, sinking the container into the ground until its top is level with the surface of the soil and planting the grass in the center of the container.

Species belonging to the genus Miscanthus are among the showiest and most dependable ornamental grasses for our climate. Many of our more useful grasses can trace their parentage to the species Miscanthus sinensis, commonly known as Chinese silver grass. Popular selections from this species include maiden grass ('Gracillimus'), variegated silver grass ('Variegatus'), porcupine grass ('Strictus') and zebra grass ('Zebrinus'). All are warm-season, clump-forming grasses that achieve a height (without inflorescence) of between 30 to 40 inches.

Other useful grasses for our area include feather reed grass (Calamagrostis x acutiflora 'Karl Foerster'), fountain grass (Pennisetum alopecuroides), plume grass/hardy pampas grass (Erianthus ravennae) and switch grass (Panicum virgatum). Pampas grass, well-known for its showy panicles, is not reliably hardy at our latitude. Although plants may survive our winters, their flower primordia rarely do.

As a rule, ornamental grasses are tolerant of soil conditions, although most prefer a well-drained garden loam fairly high in organic matter. Most ornamental grasses are full-sun plants and should receive at least six to eight hours of direct sun each day for best growth. Application of between one and two pounds per 100 square feet of a complete, general purpose garden fertilizer such as 5-10-5 or 10-10-10 before planting should supply adequate nutrients for quick establishment.

Once established, ornamental grasses should not be heavily fed; application of about one-fourth to one-half cup per plant of the afore-mentioned fertilizers is sufficient. Apply fertilizer in the spring just as new growth emerges. Excessive fertility (especially in the form of nitrogen) encourages lush, weak growth unable to stand on its own. Additionally, late applications of fertilizer to warm season grasses tend to reduce their winter hardiness.

Cool-season ornamental grasses can be planted during the spring or fall; warm-season grasses should be planted only in the spring. Fall-planted grasses benefit from a light mulch applied after several hard freezes have occurred their first winter. Winter protection during succeeding years usually in not warranted.

Spacing ornamental grasses is a matter of personal preference and intended function in the landscape. For small groupings, spacing them a distance apart equal to their mature height is considered satisfactory.

Grasses should be watered regularly during their first season of growth to encourage the establishment of a deep, vigorous root system. Once established, ornamental grasses usually require supplemental irrigation only during periods of hot, dry weather. This especially is true for warm-season grasses. The amount of water to apply depends on several factors including species, exposure, soil type and size. Additionally, most ornamental grasses are remarkably pest-free and usually do not warrant the application of pesticides.

Routine maintenance procedures include cutting back ornamental grasses in late winter or early spring to remove old, unsightly growth and to allow new growth to develop without being shaded by the old. Clump-forming grasses should be divided regularly to keep the clump "young" and attractive. Older clumps tend to die in the center leading to an unattractive shape and appearance. Frequency of division depends on species, soil fertility and exposure but dividing every third year is a safe "rule-of-thumb" for most species.

Ornamental grasses have many uses in the landscape. Their graceful foliage adds interesting form and texture to both beds and borders. Taller species make effective screens while medium-sized species combine well with foundation plantings around the home. Shorter species can be incorporated into plantings of annuals or perennials, or planted in masses for an interesting carpet bed effect. Spreading or running species are quite effective in stabilizing soil on steep banks or attractively occupying an area that is difficult to maintain.

Spotted Laternfly: An Invasive Pest with a Wide Host Range *by Michele Warmund*

The spotted laternfly (*Lycorma delicatula*) is an exotic pest that feeds on more than 70 woody plant species, including, blueberries, lilac, birch, maple, poplar, Virginia creeper, forest trees, etc. Nymphs apparently feed on a wide range of hosts, but adults prefer specific hosts, such as apple, stone fruit, grapes, black walnut, and tree of heaven (*Ailanthus altissima*). Large populations of egg-laying adults congregate on tree trunks to suck plant sap from the phloem. Symptoms of spotted lanternfly feeding are sap oozing on a trunk, wilting of foliage, branch dieback, and in severe cases, mortality of young trees and vines. This insect also secretes honeydew (sticky, sugary substance) on which sooty blotch grows. Sooty blotch, caused by several fungal pathogens, also develops on bleeding sap and blackens plant tissue. On tree of heaven, black streaks of sooty mold may be visible on tree trunks or mats of fungal growth at the base of trees. Although sooty mold is superficial, discolored fruit is unmarketable.

Spotted laternfly is native to northern China, but is also found in Taiwan, Viet Nam, Japan, and South Korea. From there it was introduced into southeastern Pennsylvania in 2014 and spread to Virginia, New York, and Delaware by 2018. Although spotted laternfly has not yet been reported in Missouri, it may only be a matter of time. Females lay their eggs on tree bark, rocks, metal and wood posts, outdoor equipment, vehicles, shipping containers, or any hard surface. Because the spotted laternfly is actually a leafhopper, only adults have a limited ability to fly great distances. Thus, this insect is generally spread to new sites when egg cases are transported on objects to another location.

There is only one generation per year of spotted laternfly. In Pennsylvania, overwintering eggs hatch in May. The first three instars (immature nymphs) have a black body with white spots and are about 3.6 to 9.4 mm-long. These instars can be mistaken for ticks, however, laternfly crawlers jump whereas ticks do not. The fourth instar has a red body with white spots and is 6.9 to 9.4 mm-long. Nymphs crawl up trees after they emerge and fall off when they meet an obstacle or are windblown, but resume their ascent up the plant.

Adults are easily mistaken for moths in the fall. Spotted laternfly adults range from 20 to 27 mm-long and when congregated on tree trunks, their gray forewings with distinctive black spots and wing tips with reticulated black and gray blocks are visible (Figure 1). When extended, red hind wings of the insect can be seen (Figure 2). In the fall, adults congregate on trunks or sometimes on warm surfaces of buildings. Unlike Asian lady beetles, spotted laternflies do not seek indoor shelter. Also, laternflies do not bite humans, but contain cantharidin which can cause blistering on humans and animals. Ants and stinging

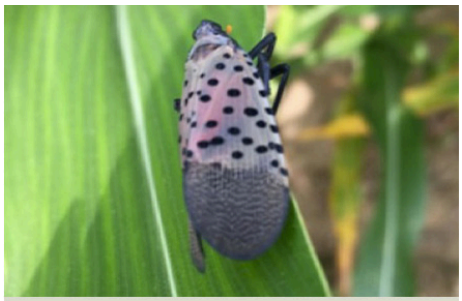

Figure 1 Adult spotted lanternfly with folded gray-spotted forewings. *Photo credit: Pennsylvania Department of Agriculture*

Figure 2 Adult spotted lanternfly with red hind wings visible. *Photo credit: Penn State Extension*

insects, such as bees, hornets, wasps, and yellow jackets, collect excreted honeydew and may cause injury to humans. Natural enemies of the spotted laternfly include spiders, praying mantis, and assassin bugs.

Females lay 30 to 50 eggs aligned in rows. Egg masses are covered in a waxy substance which dries, cracks, and may look like a splash of mud. An individual female can lay at least two egg masses per growing season. Thus far, spotted lanternfly egg masses have survived cold temperature exposure in North American sites, but failed to hatch in colder regions of South Korea.

To manage the spotted laternfly, a quarantine of susceptible plant host has been imposed in Pennsylvania. Egg masses are scraped from objects, placed in alcohol or hand sanitizer to kill them or sealed with two bags for disposal. Brown-colored sticky bands placed around the base of susceptible trees are used to collect nymphs, whereas blue or yellow bands are less effective. The Pennsylvania Department of Agriculture lists insecticides label for use in home landscapes and gardens at: http://www.agriculture.pa.gov/Plants_Land_Water/PlantIndustry/Entomology/spotted_lanternfly/Documents/SLF%20Control%209-13-2017.pdf. In some situations, Ailanthus trees are removed or killed with a systemic herbicide. Alternatively, an attract and kill strategy is used, whereby Ailanthus trees attract lanternflies, but insects are killed after feeding on trunks treated with a systemic insecticide such as dinotefuran. Laternflies are susceptible to several insecticides commonly used in commercial orchards and vineyards, including products such as Actara, Assail, Sevin, Malathion, and Imidan. Application of neem oil or insecticidal soap to trees produced variable results and required several days to determine the effect of the spray.

If you have a tree of heaven growing on your property, inspect the trunk routinely in the summer for spotted laternfly crawlers and in the fall for adults that tend to aggregate. These trees are usually medium-sized with a spreading form and their compound leaves have 11 to 42 leaflets. A complete description and images of tree of heaven, as well as species similar in appearance, can be found at: https://nature.mdc.mo.gov/discover-nature/field-guide/tree-heaven.

If you find a laternfly at any life stage, please do not destroy it. Collect specimens in a sealed container and submit it to your local Extension office. Also record precisely where the specimen was found and include GPS coordinates if possible. Exercise caution when collecting a specimen as sap from tree of heaven can cause headaches, nausea, and heart problems for some individuals.