Integrated Pest Management
University of Missouri

June/2016

Missouri Environment & Garden

Weed Control in Ornamental Beds

by David Trinklein

Someone once mused, "It takes a lot of water to grow a garden, much in the form of perspiration". Quite likely, that remark was made after pulling or hoeing weeds on a warm, humid summer day. Along with death and taxes, weeds are an inevitability in the life of a gardener.

One of the first steps in effective weed control is to "know the enemy". In general, weeds can be grouped into three categories: grasses, sedges and broadleaved weeds. A knowledge of the life cycle (e.g. annual versus perennial), reproductive habit, rate of spread, etc. of a weed is helpful when attempting to control it. A number of good pictorial guides are available on the internet to help with weed species identification.

The majority of weeds that plague ornamental plantings are annuals and emerge from seeds in the soil. For the average flower garden where a wide range of flowers are planted, weed control via mulching should be considered. Mulches control weeds by depriving them of light. They provide an easy, safe and "environmentally-friendly" way to accomplish weed control of an entire bed planted with a number of different ornamental species. To control weeds using mulch, it should be applied uniformly to a depth

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of at least one to two inches. Mulches should be from materials dense enough so they are not easily blown away. Pine bark, leaf mold or pine needles represent good choices.

In more permanent beds, landscape (weed control) fabric may be placed beneath the mulch to provide even more effective weed control. After carefully placing the fabric over the bed to be planted, cut an "H" into the fabric where plants are to be placed. After planting, fold the flaps of the H back toward the plant, taking care not to allow any disturbed soil to remain on top the fabric for fear of weed seed contamination. After plants have been installed, the fabric is ready to be covered with an organic mulch.

Perennial weeds such as quack grass, horse nettle and field bindweed not removed before planting a bed may push their way through even deep mulches. Using the afore-mentioned landscape fabric beneath mulches with help to deter them. However, some might still emerge through holes created in the fabric when it was put in place or when the mulch was applied to cover it. At such times, either hand weeding or the use of some type of herbicide may be needed to control them.

Unfortunately, there is no safe and effective herbicide that controls all types of weeds mixed among garden plants without damaging the garden plants also. The use of a nonselective herbicides (i.e. one that kills every plant it contacts) very carefully applied to the weeds often is the only alternative to hand removal. Perhaps the most widely used nonselective herbicide today is glyphosate, which is available in several different trade names (e.g. RoundUp®). For those who prefer organic weed control, horticultural vinegar (20% acetic acid) is an option worth consideration as a non-selective herbicide.

When nonselective herbicides are used as "spot treatments" among desirable plants, extreme care must be taken during application to avoid contacting desirable plants. First, keep the sprayer pressure low and use a coarse spray to make drift less likely. Apply herbicides when the air is very still. Early morning or late even are good times. Finally, a shield of some type placed between target weeds and desirable plants is a good idea. If the shield is moved during the treatment of a large bed, make certain to keep the same side toward target weeds, since herbicide accumulated on the shield can damage desirable plants.

Wick applicators are a novel and relative new way to safely apply nonselective herbicides. These devices feature materials such as a sponge that is kept continually moist with herbicide as it passes from a small bottle atop the applicator through its hollow handle. The herbicide-laden sponge is rubbed against the leaves of target weeds while desirable plants are avoided. Spray drift thus is not a problem.

Some of the most difficult and invasive weeds to control in ornamental beds are annual grasses, such as crabgrass. Several pre-emergent herbicides that may be used among garden plants to prevent the germination of annual weed seeds are available commercially. Examples of materials available for this purpose include trifluralin (Preen®), DCPA (Dacthal®), oryzalin (Surflan®), pendimethalin (Halts®) and isoxaben (Gallery®). Unfortunately, some of the previous are not readily available to home gardeners, since their primary use is by professional applicators. In all cases, careful reading of the herbicide label is important, since not all herbicides can be used among all ornamental plants and certain herbicides require special application techniques. For example, trifluralin must be soil incorporated within 24 hours after application.

Among those pre-emergent chemicals more readily available to homeowners, DCPA and trifluralin have been two of the most widely used in ornamental beds of annuals and perennials. As in the case of all pre-emergent herbicides, they must be applied to the garden after ornamental plants are established and before weed seedlings have emerged. Pre-emergent herbicides act by forming a chemical barrier that prevents weed seeds from germinating and emerging. If the barrier is disrupted in any way, the herbicidal action in that immediate area is lost.

There are relatively few selective herbicides (i.e. ones that kill only certain types of plants) that can be used in ornamental beds to control grasses after the grasses have emerged. Classified as post-emergent herbicides, they are applied uniformly across the planting and kill only grasses, leaving broadleaved plants unharmed. Examples include, sethoxydim (Poast®), fluazifop (Fusilade II®), fenoxaprop (Acclaim®) and clethodim (Envoy®). Check the labels of each herbicide before using for labeled bedding plants, susceptible weeds and any precautions that should be observed.

Although herbicides control a wide array of weeds, none is able to control them all. Therefore, total weed elimination through the use of chemicals probably is not a realistic goal for gardeners. However, even though herbicides may not control all weeds, they do control a large number of them and can be real "labor savers" for many gardeners.

The Dangers of Drought on Fruit Crops

by Michele Warmund

This growing season has been abnormally dry in many parts of Missouri, which is especially damaging to non-irrigated fruit plantings. Moisture deficits at different times of the season will result in varying plant responses depending on the type of fruit. During plant establishment, the availability of water is always critical due to the small size of the root system after planting. Lack of water generally reduces plant growth, affects fruit size during the growing season, and can reduce fruit set the following year.

Small fruit plants, such as strawberries and blueberries, have shallow root systems and are particularly susceptible to extended drought. When strawberry plants are severely water-stressed from the beginning of the growing season, total fruit production can be decreased by about 80%. Also, drought stress before strawberry harvest accelerates ripening and reduces fruit size substantially. When strawberry plants are stressed after harvest, runner production in matted-row fields is delayed during the current season and results in yield loss the following year. When drought occurs at renovation, it may be helpful to throw a half-inch of soil over non-irrigated plants at that time to promote higher rooting on the crowns of older plants and enhanced fruiting the next season.

Blueberry plants are very susceptible to drought because most of their roots are in the upper 8 to 12 inches of the soil. While blueberry roots lack root hairs, which are used by other plants to maximize the uptake of soil moisture and nutrients, endomycorrhizal fungi associated with roots perform these functions. However, severe drought conditions for 20 to 30 days can lead to blueberry fruit loss and/or plant mortality.

For blackberry, raspberry, and elderberry, droughty conditions just before harvest cause the fruit to shrivel or completely dry up. After harvest, the primocane growth of June-bearing blackberries or raspberries will be stunted during a prolonged drought, resulting in reduced fruit yield in the subsequent growing season.

Moisture is also critical for the production of high quality stone fruits. Early season thinning of peaches, leaving at least six inches between each fruit, promotes large fruit. Also, in the three weeks before harvest, fruit size is greatly increased with the uptake of water and is called the period of final fruit swell. Late season drought stress reduces flower bud development of peaches and can lead to fruit defects, such as "doubles" or "triples" where fruit are fused together the following growing season. When drought is prolonged, scaffold branches of peach trees may be cut back severely (e.g., dehorned) to prevent tree mortality. Dehorned trees can two or more subsequent growing seasons to recover.

For apple, fruit buds for the following season are generally initiated about the first 50 days after bloom. Thus, heavy crop load due to lack of fruit thinning and early season drought stress results in poor cropping the subsequent season. Early-season water stress also restricts fruit cell division, contributing to small fruit during the current season and reduces starch accumulation, which shortens the storage life of the fruit after harvest. Because drought is often associated with abnormally high temperatures, red apples fail to color properly under these conditions and are brownish in color and are prone to preharvest fruit drop.

Shoots on young and mature apple trees usually grow for about 100 and 50 days, respectively. Thus, inadequate moisture during May and June can severely reduce vegetative growth of young trees. Drought during late summer and fall adversely affects trunk enlargement and root growth. For trees on dwarfing rootstocks, which tend to have relatively small root systems, water stress is particularly harmful. It is essential that dwarf trees develop a good root system for adequate tree anchorage and uptake of nutrients. Because calcium uptake by roots requires adequate moisture, this nutrient is often deficient during dry seasons, resulting in fruit disorders such as corkspot and bitterpit. Images of these disorders are available at: http://ohioline.osu.edu/factsheet/plpath-fru-01.

During drought, the best way to prevent reduced fruit yield, tree growth, and mortality is have a properly installed irrigation system in a commercial orchard or access to water for hand-watering in a backyard planting. Maintenance of a vegetation-free strip down the planting row or around the base of individual fruit trees will help conserve soil moisture. Weeds also compete with fruit plants for soil moisture, so weed control is especially important during droughty periods. In berry plantings, sawdust or bark mulch will reduce weeds and retard soil moisture loss. Additionally, effective control of defoliating insect pests and diseases will promote leaf retention, thereby enhancing photosynthesis and carbohydrate production for better drought resistance during stressful periods.

A novel mass trapping system to control cucumber beetles in cucurbit crops

by Dr. Jaime C. Pinero and Rusty Lee

Striped and spotted cucumber beetles are two key insect pests of cucurbit crops. Without proper management, adult beetles can transmit bacterial wilt, defoliate plants and cause cosmetic damage to fruits. Larvae of the striped beetle also cause damage by feeding on cucurbit roots and stems. Managing these two pests in gardens and small farms can be challenging. Insecticides can be an effective control option, however, harvest interruption due to pre-harvest intervals, and the potential impact on beneficial/pollinator species must be considered. Many of these insecticides will also be "restricted-use", requiring private pesticide applicator training and licensing. To address these concerns, the Lincoln University (LU) IPM program developed a simple, mass trapping system that has proven to be an effective component of an IPM strategy. When deployed in the cucurbit field, the cucumber beetles are drawn to the traps and away from the cash crop. Upon entering the trap, beetles are killed by their consumption of a carbaryl-laced bait.

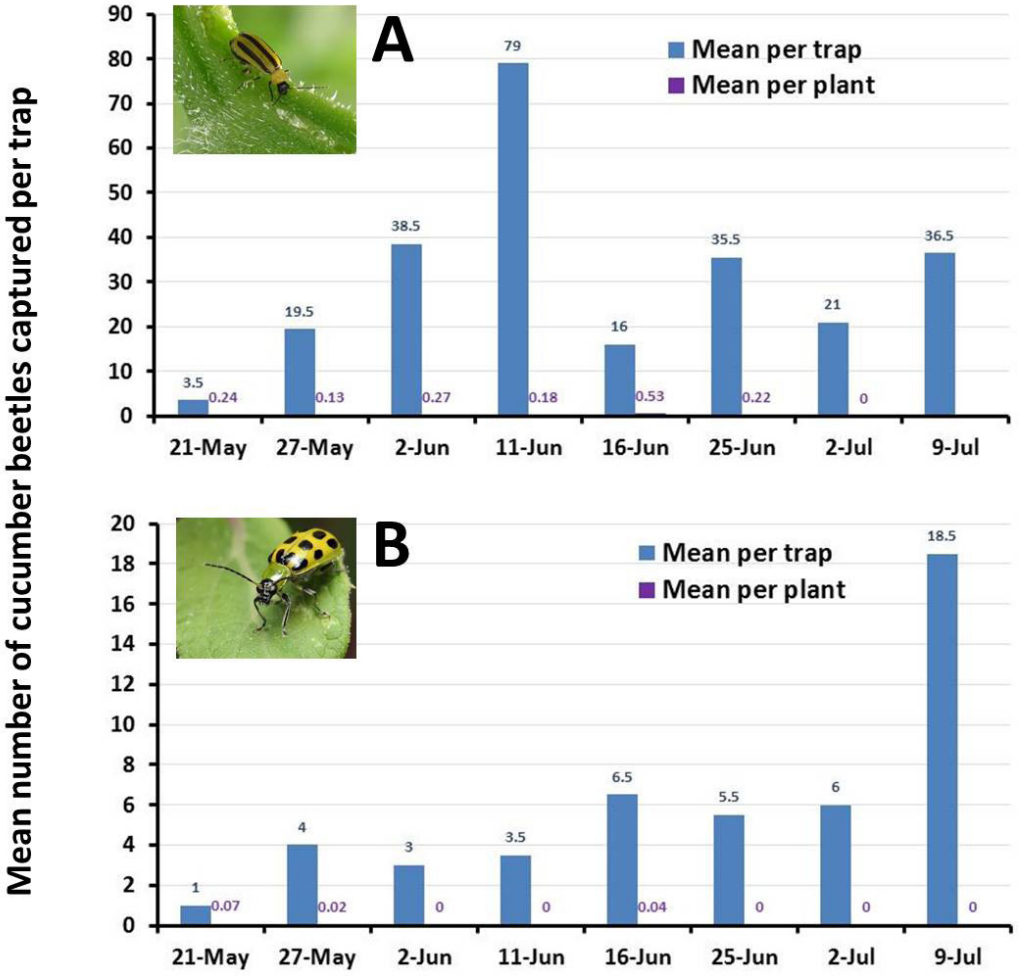


FIGURE 1. Captures of (A) striped, and (B) spotted cucumber beetles in yellow-painted traps in a zucchini plot in Truxton, MO (2015 data). For each trapping date, blue bars show the mean number of beetles captured per trap. Purple bars denote mean number of beetles observed per plant. At each trapping date, 45 plants were inspected thoroughly for cucumber beetles.

The three components of the trap are: (1) a juice / milk jug, (2) a commercial, floral-based lure , and (3) a stun pill composed of carbaryl (Sevin), paraffin wax, and powdered buffalo gourd. For additional trap details, see section 'Trap Construction Using 1 Gallon Milk or Juice Container' later in this article.

Results from research conducted (2011-2013) at the LU George Washington Carver Farm indicated that yellow-painted traps baited with the AgBio lure performed best. In 2011, 28 baited traps, maintained for a 9 day period, killed 2,531 cucumber beetles in a watermelon crop. This combined reduction of spotted and striped cucumber beetles reduced the need for an insecticidal spray while maintaining production of marketable fruit.

2015 on-farm study

On-farm research on mass trapping conducted at one commercial vegetable farm in Truxton MO, indicated that 28 traps killed 3,715 cucumber beetles (combining striped and spotted) over an 8-week period (21 May – 9 July, 2015). Comparatively high numbers of striped (Figure 1A) and spotted (Figure 1B) cucumber beetles were captured by yellow traps in a zucchini plot whereas very few adults were found on plants. Similar results were found in the cucumber plot (Figure 2A,B).

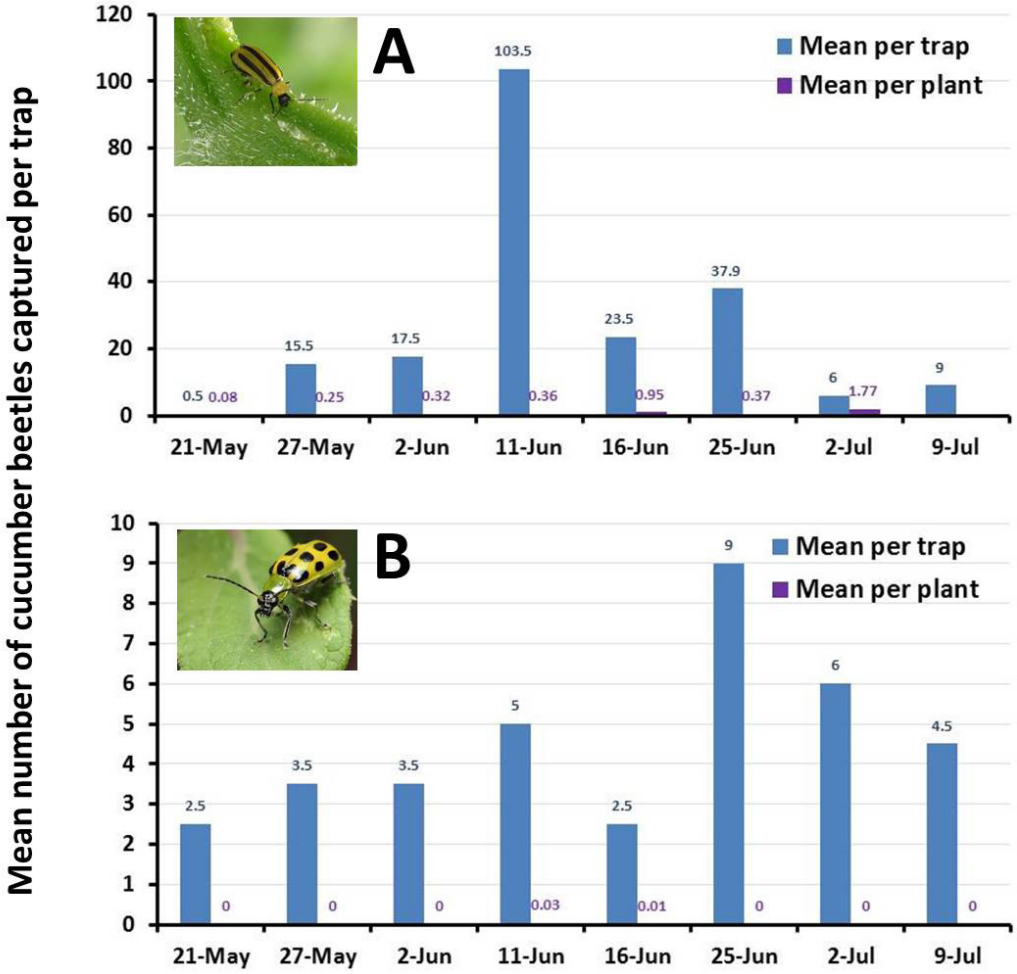


FIGURE 2. Captures of (A) striped, and (B) spotted cucumber beetles in yellow-painted traps in a cucumber plot in Truxton, MO (2015 data). For each trapping date, blue bars show the mean number of beetles captured per trap. Purple bars denote mean number of beetles observed per plant. At each trapping date, 75 plants were inspected for cucumber beetles.

Overall, the level of beetle suppression was so effective that the number of insects found on plants averaged 0.42 per plant, a number that is below what is called an economic threshold (= pest density at which insecticide applications are justified). Overall, our 2015 data indicate that, across the entire trapping period, for each cucumber beetle found on a plant, there were 26 cucumber beetles killed by a trap.

Mass trapping for Fall Sanitation

When cucumber harvest ended on September 25, 2015, a mass trapping system was deployed at the Truxton farm. This consisted of 15 yellow traps baited with the AgBio lure and one stun pill per trap. The goal was to kill as many cucumber beetles as possible to reduce the over-wintering population. When trapping concluded on December 2nd, 2015, a total of 2,043 cucumber beetles had been removed. These results are encouraging and two additional producers are evaluating the mass trapping system at their farms.

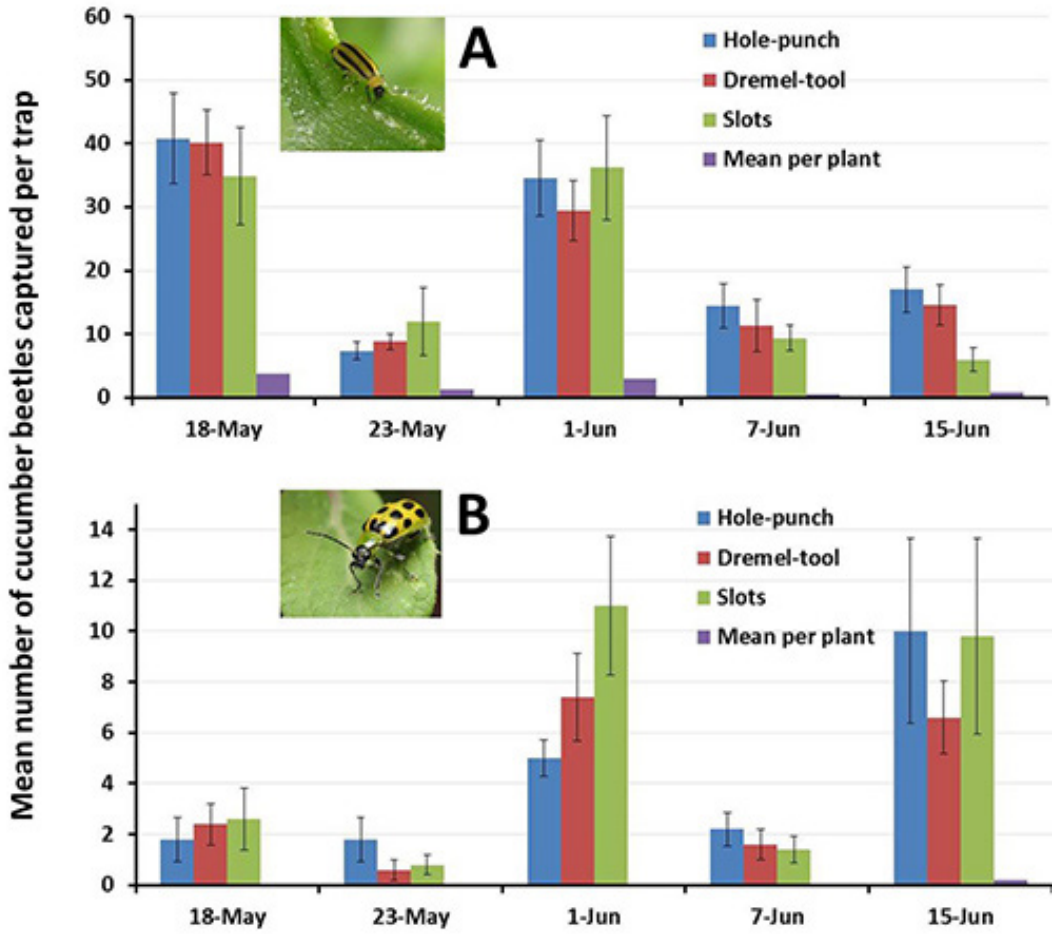
2016 on-farm study

The floral-based AgBio lure used in the traps and the yellow color of the trap can attract honey bees. Therefore, entrances should be sized big enough to allow cucumber beetle access, but exclude the honey bee. On April 29, 2016, 15 yellow-painted traps (Fig 3A) baited with the AgBio lure were deployed in a 2 acre planting of zucchini, yellow summer squash, and cucumbers in Truxton, MO. The objective of the replicated study was to measure the effectiveness of three different slot construction methods: (1) A high-speed cutoff disk mounted on a dremel-type tool made a uniform width slot, but blade thickness limited slot width to 1/8" width, (2) Cutting the slot with a knife allows it to be any width desired, but the difficulty of maintaining a consistent width often created a slot too wide, and (3) A hand-held paper-hole punch that made a ¼" diameter hole. A horizontal knife slit allows the hole puncher to be inserted and when completed, the container sides spring back to close the slit.

FIGURE 3. (A) View of the cucumber beetle mass trapping devices deployed in a summer squash plot in Truxton, MO, (B) The three types of entrance holes for cucumber beetles that were evaluated. The entire surface area is similar across opening types.

Overall, the 15 traps killed 3,217 striped cucumber beetles in a 6-week period. The table below shows the combined beetle counts for all 15 traps, and the average number of beetles killed by traps and seen on plants. The ratio of beetles collected in traps versus beetles found on plants ranged from 7:1 to 23:1. The highest ratio of beetles per trap versus observed on plants, was recorded three weeks after insecticide application, when the pesticide suppression effect should have diminished. This supports the observation that traps have the potential to keep cucumber beetles below the economic threshold for pesticide application.

DATE	Total no. striped cucumber beetles	Average no. striped beetles per trap	Average no. striped cucumber beetles per plant	Ratio*
April 29 - May 12	1,632	108.8	11.9	9.1
May 13- 17	579	38.6	3.7	10.4
May 18-22	141	9.4	1.3	7.2
May 23-31	501	33.4	2.9	11.5
June 1-6	176	11.7	0.5	23.4
June 7-14	188	12.5	0.75	16.7
Total captured	**3,217**			



The new mass trapping system developed by the Lincoln University IPM program can be used as part of a broader IPM program aimed at managing cucumber beetles.

FIGURE 4. Captures of (A) striped, and (B) spotted cucumber beetles in yellow-painted traps according to type of entrance hole in a summer squash plot in Truxton, MO (April 29 – June 15, 2016). Purple bars denote the mean number of beetles observed per plant. At each trapping date, 45 plants were inspected thoroughly for cucumber beetles.

Overall, the conclusions of this study in terms of performance of the entrance hole are: (1) The 1/8" horizontal slot made with the dremel tool seems to be too narrow, (2) the free-handed knife slot would be too variable – yet effective if width can be kept at around ¼", and (3) hole punch entrances excluded honey bees, and allowed maximum cucumber beetle captures. Only one honey bee (by a trap that had slots made with dremel tool) was captured over the entire 6-week trapping period.

Overall, results indicate that the mass trapping system developed is effective at suppressing cucumber beetles from cucurbit plants. Some producers in a couple of Missouri locations are currently evaluating the performance of this mass trapping system.

Trap Construction Using 1 Gallon Milk or Juice Container.

Step 1: Trap entrances can be a series of round holes made by a paper punch tool, or horizontal slots cut with a knife or dremel-type power tool (see results described above). If using the paper-hole punch method, a horizontal knife cut will give tool access. Entrances on all sides of container aid in dispersion of lure scent. Remember, the scent can also be attractive to honey bees so keep the entrance small enough to exclude the honey bee, but still allow access to the cucumber beetle. A hole diameter or slot width of ¼" maximum has performed well.

Step 2: Drop stun pill into trap. Unfold scent-lure and attach short piece of string/wire. Removal of the two protective white flaps (see picture on the right) also aids in scent dispersal. Insert through mouth of trap and catch string under screw-top lid such that the lure is suspended inside trap.

Step 3: Drive a post along edge of vegetable row and suspend trap, with additional wire from container handle, so that trap is upright and approximately 4-6" above the ground.

Step 4: Spray painting traps with yellow high-gloss paint has proven to increase effectiveness. Once installed, it can be easily sprayed in place.

The commercial lure used is produced by AgBio, Inc. (Address: 9915 Raleigh St, Westminster, CO 80031; phone:(303) 469-9221; e-mail: agbio@agbio-inc.com.

The stun pill can be purchased from Trece, Inc. (Address: 7569 OK-28, Adair, OK 74330; phone: (918) 785-3061; e-mail: custserv@trece.com).

JULY GARDENING CALENDAR

Category	Week				Activity
	1	2	3	4	
Ornamentals	x	x	x	x	Provide water in the garden for the birds, especially during dry weather.
	x	x	x	x	Remove infected leaves from roses. Pick up fallen leaves. Continue fungicidal sprays as needed.
	x	x	x	x	While spraying roses with fungicides, mix extra and spray hardy phlox to prevent powdery mildew.
	x	x	x	x	Newly planted trees and shrubs should continue to be watered thoroughly, once a week.
	x	x	x	x	Fertilize container plants every 2 weeks with a water soluble solution.
	x	x	x	x	Keep weeds from making seeds now. This will mean less weeding next year.
	x	x	x	x	Keep deadheading spent annual flowers for continued bloom.
	x	x	x	x	Perennials that have finished blooming should be deadheaded. Cut back the foliage some to encourage tidier appearance.
	x	x			Plant zinnia seed by July 4th for late bloom in annual border.
	x	x			Spray hollies for leaf miner control.
	x	x			Prune climbing roses and rambler roses after bloom.
	x	x			Apply final treatment for borers on hardwood trees.
	x				Apply no fertilizers to trees and shrubs after July 4th. Fertilizing late may cause lush growth that is apt to winter kill.
	x				Hot, dry weather is ideal for spider mite development. With spider mite damage, leaves may be speckled above and yellowed below. Evergreen needles appear dull gray-green to yellow or brown. Damage may be present even before webs are noticed.
		x	x		Fall webworms begin nest building near the ends of branches of infested trees. Prune off webs. Spray with Bt if defoliation becomes severe.
		x			Divide and reset oriental poppies after flowering as the foliage dies.
			x	x	Semi-hardwood cuttings of spring flowering shrubs can be made now.
			x	x	Summer pruning of shade trees can be done now.
			x		Powdery mildew is unsightly on lilacs, but rarely harmful. Shrubs grown in full sun are less prone to this disease.
				x	Divide bearded iris now.
		x			Don't pinch mums after mid-July or you may delay flowering.

*Gardening Calendar supplied by the staff of the William T. Kemper Center for Home Gardening located at the Missouri Botanical Garden in St. Louis, Missouri, (**www.GardeningHelp.org**)*

JULY GARDENING CALENDAR

Category	Week				Activity
	1	2	3	4	
Lawns	x	x	x	x	Water frequently enough to prevent wilting. Early morning irrigation allows turf to dry before nightfall and will reduce the chance of disease.
			x	x	Monitor lawns for newly hatched white grubs. If damage is occurring, apply appropriate controls, following product label directions.
Vegetables	x	x	x	x	Blossom-end rot of tomato and peppers occurs when soil moisture is uneven. Water when soils begin to dry; maintain a 2-3 inch layer of mulch.
	x				To minimize insect damage to squash and cucumber plants, try covering them with lightweight floating row covers. Remove covers once plants flower.
		x			Dig potatoes when the tops die. Plant fall potatoes by the 15th.
			x	x	For the fall garden, sow seeds of collards, kale, sweet corn and summer squash as earlier crops are harvested.
			x	x	Set out broccoli, cabbage, and cauliflower transplants for the fall garden.
			x		Sweet corn is ripe when the silks turn brown.
			x		Keep cukes well watered. Drought conditions will cause bitter fruit.
			x		Harvest onions and garlic when the tops turn brown.
				x	Sow seeds of carrots, beets, turnips, and winter radish for fall harvest.
	x	x	x	x	Cover grape clusters loosely with paper sacks to provide some protection from marauding birds.
	x				Prune out and destroy old fruiting canes of raspberries after harvest is complete.
	x				Blackberries are ripening now.
		x	x		Apply second spray to trunks of peach trees for peach borers.
			x	x	Early peach varieties ripen now.
				x	Thornless blackberries ripen now.

*Gardening Calendar supplied by the staff of the William T. Kemper Center for Home Gardening located at the Missouri Botanical Garden in St. Louis, Missouri. (**www.GardeningHelp.org**)*