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Bulletin 359 Revised 2012

Total Plant Management of Herbaceous Perennials

With an emphasis on plant nutrition, managing growth, and breaking the cycle of weeds, insects and diseases through Integrated Pest Management (IPM)

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This publication is a joint effort of the University of Maryland, Virginia Tech and Cornell University and their specialists in various environmental fields

Integrated Pest Management for Commercial Horticulture
University of Maryland Extension

http://ipmnet.umd.edu

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Preface

Herbaceous perennial plant use in residential and commercial landscapes has increased dramatically in the past 25 years. Consequently, demand has increased for nursery and greenhouse produced herbaceous perennials. Customers often request large plants in high quanitites and of the highest quality. The challenge for growers and managers is to produce and maintain high quality by managing fertility, irrigating correctly, controlling weeds, and preventing insects and diseases from destroying the beauty of the plants.

This manual is designed for use by herbaceous perennial growers, greenhouse and nursery managers, and Extension educators involved with the floriculture industry. Our goal with this manual is to help growers and landscape managers produce and maintain the highest quality plants with minimal loss. This publication is based on the extensive experience of Maryland growers, independent Total Plant Management and Integrated Pest Management (TPM/ IPM) scouts, and faculty and specialists of the University of Maryland Extension, Virginia Tech and Cornell University. It is our intent that this manual serve as a valuable tool for improved management of herbaceous perennial crops. We have created charts for easy access to information and text for more in-depth information on key subjects.

Disclaimer

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Appendix A
Selected Resources

Resources Available for Herbaceous Perennial Production

The following is a selection of resources for commercial horticulture production. Included here are books, fact sheets, magazines, and websites applicable to perennial production and pest management. This list is by no means complete. Land-grant university websites have publications sections with a wealth of information about commercial horticulture. Internet searches can be an effective way to find additional information.

Perennial IPM Publications

Guide to Insects and Related Pests of Floriculture Crops in New England
New England Vegetable Management Guide
UMass Extension Bookstore: http://umassextensionbookstore.com/catalog/

Herbaceous Perennials Production: A guide from propagation to marketing (NRAES-93)
http://www.nraes.org/

New England Greenhouse Floriculture Guide: A Management Guide for Insects, Diseases, Weeds, and Growth Regulators:
http://www.umass.edu/umext/floriculture/pest_management/ne_pest_manage_guide.html

Pests and Diseases of Herbaceous Perennials: The Biological Approach, Gill, S. A., Cloyd, R.A., Baker, J. R., Clement, D. L., Dutky, E., 2nd edition.

Rutgers Greenhouse Cost Accounting and Software
http://aesop.rutgers.edu/~farmmgmt/ghcasestudies/RMACostAcct.pdf

Websites

University of Maryland College of Agriculture and Natural Resources: http://agnr.umd.edu

IPMnet: Commercial Horticulture, University of Maryland Extension: http://ipmnet.umd.edu

Home and Garden Information Center, University of Maryland Extension: http://hgic.umd.edu

California Department of Pesticide Regulation, Environmental Monitoring and Pest Management
Suppliers of Beneficial Organisms in North America:
http://www.cdpr.ca.gov/docs/pestmgt/ipminov/bensuppl.htm

Crop Data Management Systems (CDMS) - Pesticide labels online
http://cdms.net (labels are listed under the 'services' link)
Biological Control—A Guide to Natural Enemies in North America (Cornell University)
http://www.nysaes.cornell.edu/ent/biocontrol/

Maryland Greenhouse Growers Association: www.mdgga.org

Maryland Department of Agriculture— Plant Industries and Pest Management
Links to pesticide regulation, plant protection, and weed control
http://www.mda.state.md.us/plants-pests/

Disease Test Kits

Test kits for Pythium, Rhizoctonia and Phytophthora
Neogen Corporation
620 Lesher Place, Lansing, MI 48912
800-234-5333, neogen-info@neogen.com
Website: http://www.neogen.com

INSV Test Kits

Agdia, Inc.
30380 County Road 6, Elkhart, Indiana, 46514
800-622-4342, webmaster@agdia.com
http://www.agdia.com.

Hydros, Inc. Envrionmental Diagostics - Disease test kits:
http://www.hydros.cc/

Substrate Testing Laboratories

University of Delaware Soil Testing Program, 302-831-1392, 152 Townsend Hall, 531 S. College Avenue, Newark, DE, 19717-1303, http://ag.udel.edu/other_websites/DSTP/

Virginia Tech Soil Testing Laboratory, 540-231-6893, 145 Smyth Hall (0465), Blacksburg, VA 24061, http://www.soiltest.vt.edu/

A&L Eastern Agricultural Laboratories, Inc., 804-743-9401, 7621 Whitepine Road, Richmond, VA 23237, http://www.al-labs-eastern.com

Pennsylvania Agricultural Analytic Services State University Laboratory
University Park, PA 16802
http://www.aasl.psu.edu/

JRPeters Laboratory
6656 Grant Way, Allentown, PA 18106
866-522-5752, http://www.jrpeterslab.com/

North Carolina State University Horticultural Substrates Laboratory
152 Kilgore Hall, Box 7609, Raleigh, NC 27695-7609
919-515-5368, http://www.ncsu.edu/project/hortsublab/

Disease Testing Laboratories:
A sample of any plant suspected to be infected with disease can be sent to a commercial laboratory. Viruses can be detected via laboratory assays, such as Tomato spotted wilt virus and Impatiens necrotic spot virus, both transmitted by thrips. These two viruses can cause disease in many plants, with symptoms that can be mistaken for nutritional disorders, fungal diseases, or other problems. Other viruses that most often occur in ornamentals are cucumber mosaic virus (transmitted by aphids), and tobacco and tomato ringspot viruses (transmitted by nematodes), seeds or by propagating infected plants.

Agdia Testing Services: ELISA and PCR disease testing
30380 County Road 6
Elkhart, Indiana 46514
800-622-4342, testing@agdia.com, www.agdia.com

Penn State Plant Disease Clinic
Sara May, Coordinator, and John Peplinski, Diagnostician
220 Buckout Laboratory, University Park, PA 16802
814-865-2204, srm183@psu.edu, http://www.ppath.cas.psu.edu/Plant_Disease_Clinic.htm

University of Delaware Plant Diagnostic Clinic
Nancy Gregory, Diagnostician, and Robert Mulrooney, Plant Pathologist
151 Townsend Hall, Newark, DE 19716
302-831-1390, http://ag.udel.edu/extension/pdc/index.htm

University of Maryland Plant Diagnostic Lab
Karen Rane, Director
4112 Plant Sciences Building, College Park, MD 21742
301-405-1611, http://plantclinic.umd.edu

VPI Plant Disease Clinic
Mary Ann Hanson and Elizabeth Bush, Co-Directors
Department of Plant Pathology, Physiology, and Weed Science
106 Price Hall, Blacksburg, VA 24061-0331
540-231-6758, clinic@vt.edu, http://www.ppws.vt.edu/~clinic

Sources for Pesticide Information, Biologicals
- Chemical & Pharmaceutical Press, Inc.'s Greenbook Pesticide labels (www.greenbook.net)
- Crop Data Management Systems, Inc. Pesticide labels (www.cdms.net)
- EXTOXNET – The EXtension TOXicology NETwork Pesticides: Toxicology, Technical Information from UC Davis, Oregon State Univ., Michigan State, Cornell Univ., Univ. of Idaho
- Environmental Protection Agency's Office of Pesticide Programs
- Beneficial Insects: http://www.library.illinois.edu/envi/beneficialinsects.html
  http://www.nysaes.cornell.edu/ent/biocontrol/

Appendix B
Sample Scouting Forms

The following are sample templates that can be used to record scouting data. When developing a form, be sure to include the **date**, **reporting person** (if an additional scout is hired) and the **greenhouse**. Different areas within a greenhouse can be identified as 'Greenhouse Management Units (GMU). Examples include 'Greenhouse Area 1 (left side)', 'Greenhouse Area 2 (back)', and 'Greenhouse Area 3 (front)'. Be sure to make a map of each greenhouse to be able to track the progress of each crop and insect, disease and cultural problems.

Crop Information Form:

Plant Species	Number of Plants or Containers	Planting Date	Expected Harvest Date

Fertility Information Form:

Application Date	Applicator	Plants or Areas Treated	Fertilizer Source	Applicaton Rate (PPM)	Comments

Insect Control Information Form:

Date Applied	Greenhouse Designation	Product Applied	Applicator	Application Rate	Evaluation Comments	Evaluation Method (Card count decrease or reduction of pests on plants)

Disease Control Information Form:

Date Applied	Greenhouse Designation	Product Applied	Applicator	Application Rate	Evaluation Comments	Evaluation Method (Card count decrease or reduction of pests on plants)

Weed Control Information Form:

Application Date	Greenhouse Designation (or outdoors)	Applicator	Product Applied	Application Rate

Electroconductivity (EC) and pH Levels Form:
Date: _____

Plant Species	EC Levels	pH Levels	Reasons For Testing

Note pH and EC testing method (i.e. 1 = saturated pest method or 2 - PourThru Method

Root Health Form:
Date: _____

Location	Plant	Rating (good, fair, poor)	Comments

Insect and Mite Activity Form: Sticky Card Counts
Date: _____

Location	Card Number	Whitefly Count per Card	Thrips Count per Card	Fungus Gnat Count per Card	Shorefly Count per Card	Winged Aphid Count per Card
	1					
	2					
	3					
	4					
	5					

Insect and Mite Activity Form: Whole Plant Counts
Date: _____

Location	Plant	Numbers of Plant Sampled	Pest	Number of Pests Found per Plant	Average Number of Pests Found	Increase or Decrease from Previous Count	Plant Damage Noted (%)

Disease Activity Form:
Date: _____

Location	Plant	Disease	Increase or Decrease in Severity	Plant Damage (%)

Appendix C
Conversion Factors

Multiply	By	To Obtain	Multiply	By	To Obtain
Acres	0.4047	Hectares	Kilograms	1,000	Grams
Acres	43,560	Square feet	Kilograms	2.2046	Pounds
Acres	4,840	Square yards	Kilograms per meter^2	.2048	Pounds per foot^2
Acres	0.001562	Square miles	Kilograms per meter^2	.001422	Pounds per inches^2
Acres	4,047	Square meters	Kilograms per meter^3	.001	Grams per centimeter3
Acres	0.4047	Hectares	Kilograms per meter^3	.06243	Pounds per foot^3
Atmospheres	14.7	Pounds per inch2	Kilograms per meter^3	.0003613	Pounds per inches^3
Atmospheres	10,333	Kilograms per meter2	Kiloliters	1,000	Liters
Centimeters	.03281	Feet	Kilometers	100,000	Centimeters
Centimeters	.3937	Inches	Kilometers	3,281	Feet
Centimeters	.01	Meters	Kilometers	1,000	Meters
Centimeters	10	Millimeters	Kilometers	.6214	Miles
Centimeters	393.7	Mils	Kilometers	1,093.6	Yards
Cubic centimeters	.0000353	Cubic feet	Kilowatt hours	3,415	BTUs
Cubic centimeters	.016102	Cubic inches	Kilowatt hours	1.341	Horsepower hours
Cubic centimeters	.0001	Cubic meters	Kilowatts	56.92	BTUs per minute
Cubic centimeters	.000001308	Cubic yards	Kilowatts	1.341	Horsepower
Cubic feet	28,316.84	Cubic centimeters	Kilowatts	1,000	Watts
Cubic feet	1,728	Cubic inches	Liters	1,000	Cubic centimeters
Cubic feet	.02832	Cubic yards	Liters	.03531	Cubic feet
Cubic inches	16.387	Cubic centimeters	Liters	62.02	Cubic inches
Cubic inches	.00001639	Cubic meters	Liters	.001	Cubic meters
Cubic inches	.00002143	Cubic yards	Liters	.001308	Cubic yards
Cubic yards	764,600	Cubic centimeters	Liters	.2642	Gallons
Cubic yards	27	Cubic feet	Liters	1.057	Quarts (fluid)
Cubic yards	.7646	Cubic meters	Lux	.0929	Foot-candles
Feet	30.48	Centimeters	Meters	100	Centimeters
Feet	12	Inches	Meters	3.2808	Feet
Feet	.3048	Meters	Meters	39.37	Inches
Feet	.333	Yards	Meters	.001	Kilometers
Foot-candles	10.76	Lux	Meters	1,000	Millimeters
Gallons	3.785	Liters	Meters	1.0936	Yards
Gallons	128	Ounces (fluid)	Milligrams	.001	Grams
Gallons	8	Pints (fluid)	Milligrams	.000001	Kilograms
Gallons	4	Quarts (fluid)	Milligrams per liter	1	Parts per million
Gallons per minute	.134	Cubic feet per minute	Milliliters	1	Cubic centimeters
Gallons per minute	.002228	Cubic feet per second	Milliliters	.001	Liters
Gallons per minute	.06308	Liters per second	Millimeters	.1	Centimeters
Grams	.001	Kilograms	Millimeters	.03937	Inches
Grams	1,000	Milligrams	Millimeters	.001	Meters
Grams	.002205	Pounds	Ounces (fluid)	1.805	Cubic inches
Grams per liter	.1336	Ounces per gallon	Ounces (fluid)	.0078125	Gallons

Multiply	By	To Obtain	Multiply	By	To Obtain
Grams per liter	.0334	Ounces per quart	Ounces (fluid)	.02957	Liters
Grams per liter	1,000	Parts per million	Ounces (fluid)	29.57	Milliliters
Hectares	2.471	Acres	Ounces (fluid)	2	Tablespoons (fluid)
Hectares	107,000	Square feet	Ounces (fluid)	6	Teaspoons (fluid)
Inches	2.540	Centimeters	Parts per million	.001	Grams per liter
Inches	.08333	Feet	Parts per million	1	Milligrams per kilogram
Inches	.0254	Meters	Parts per million	1	Milligrams per liter
Inches	.02778	Yards	Parts per million	.013	Ounces per 100 gallons
Parts per million	.0083	Pounds per 1,000 gallons	Quarts (fluid)	.9463	Liters
Pints (fluid)	473.167	Cubic centimeters	Quarts (fluid)	946.3	Milliliters
Pints (fluid)	.0167	Cubic feet	Quarts (fluid)	32	Ounces (fluid)
Pints (fluid)	28.875	Cubic inches	Quarts (fluid)	2	Pints (fluid)
Pints (fluid)	.125	Gallons	Square centimeters	.00107	Square feet
Pints (fluid)	.4732	Liters	Square centimeters	.1550	Square inches
Pints (fluid)	16	Ounces (fluid)	Square centimeters	.0001	Square meters
Pints (fluid)	.5	Quarts (fluid)	Square centimeters	100	Square millimeters
Pounds	453.594	Grams	Square feet	.00002296	Acres
Pounds	.453594	Kilograms	Square feet	929	Square centimeters
Pounds	16	Ounces	Square feet	144	Square inches
Pounds per cubic foot	.01602	Grams per centimeter^3	Square feet	.0929	Square meters
Pounds per cubic foot	16.02	Kilograms per meter^3	Square feet	.111	Square yards
Pounds per cubic foot	.0005787	Pounds per inch^3	Square inches	6.452	Square centimeters
Pounds per cubic inch	27,680	Kilograms per meter^3	Square inches	.006944	Square feet
Pounds per cubic inch	27.68	Pounds per centimeter^3	Square inches	645.163	Square millimeters
Pounds per cubic inch	1,728	Pounds per foot^3	Square meters	.000247	Acres
Pounds per foot	1.488	Kilograms per meter	Square meters	10.764	Square feet
Pounds per inch	178.6	Grams per centimeter	Square meters	1.196	Square yards
Pounds per square foot	4.882	Kilograms per meter^2	Square millimeters	.01	Square centimeters
Pounds per square foot	.006994	Pounds per inch^2	Square millimeters	.00155	Square inches
Pounds per square inch	.070307	Kilograms per centimeter^2	Square millimeters	.000001	Square meters
Pounds per square inch	703.1	Kilograms per meter^2	Square yards	.0002066	Acres
Pounds per square inch	144	Pounds per foot^2	Square yards	9	Square feet
Quarts (fluid)	.0334	Cubic feet	Square yards	1,296	Square inches
Quarts (fluid)	57.75	Cubic inches	Square yards	.8361	Square meters
Quarts (fluid)	.25	Gallons			

Appendix D
Images of Insects, Diseases, Abiotic Problems and Weeds

Insects:

Beneficial Insects and Organisms

Aphids

Beetles

Bugs, True

Caterpillars

Fungus Gnats and Shoreflies

Leafminers

Mites

Mealybug and Scale

Thrips

Whitefly

Diseases:

Foliar Diseases

Root Rots

Abiotic Problems:

Weeds:

Aphidius **wasp 'mummy' (parasitized aphid)**
Photo: Suzanne Klick

Aphidoletes **(fly midge) feeding on oleander aphids**
Photo: Suzanne Klick

An assassin bug adult (*Zelus* sp.)
Photo: Suzanne Klick

A wheel bug is one of the assassin bugs (*Arilus* sp.)
Photo: Suzanne Klick

Lacewing, *Chrysoperla* sp., larva
Photo: Suzanne Klick

Lacewing, *Chrysoperla* sp., adult
Photo: Suzanne Klick

Lady bird beetle larva
Photo: Suzanne Klick

Lady bird beetle adult (*Harmonia axyridis*)
Photo: Suzanne Klick

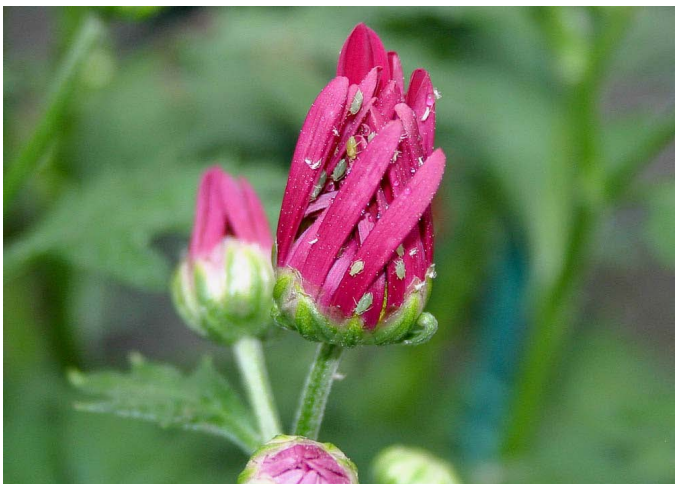
***Orius* sp. (minute pirate bug) adult and nymphs**
Photo: John Davidson

Syrphid fly larva
Photo: Suzanne Klick

Syrphid fly adult
Photo: Suzanne Klick

Soldier beetle (Pennsylvania leatherwing)
Photo: Suzanne Klick

Distorted foliage from aphid feeding on zinnia
Photo: Suzanne Klick



Aphids and cast skins on mum
Photo: Shannon Wadkins

Sooty mold from aphids on celosia
Photo: Suzanne Klick

Root aphids on aster roots
Photo: Shannon Wadkins

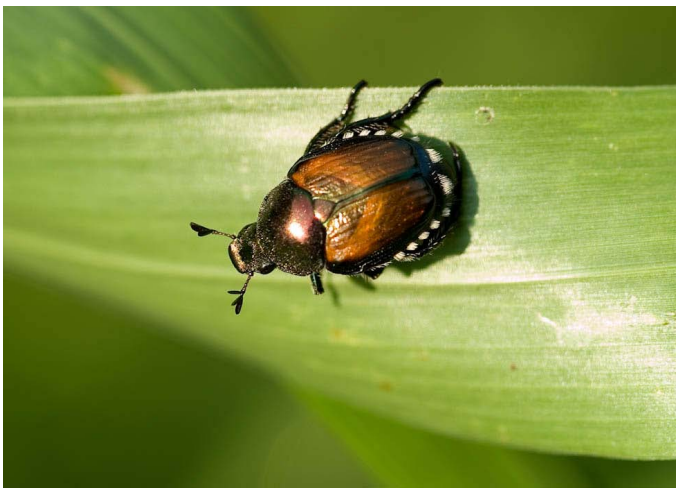
Heavy infestation of oleander aphids on milkweed
Photo: Suzanne Klick

Aphids on sedum
Photo: Suzanne Klick

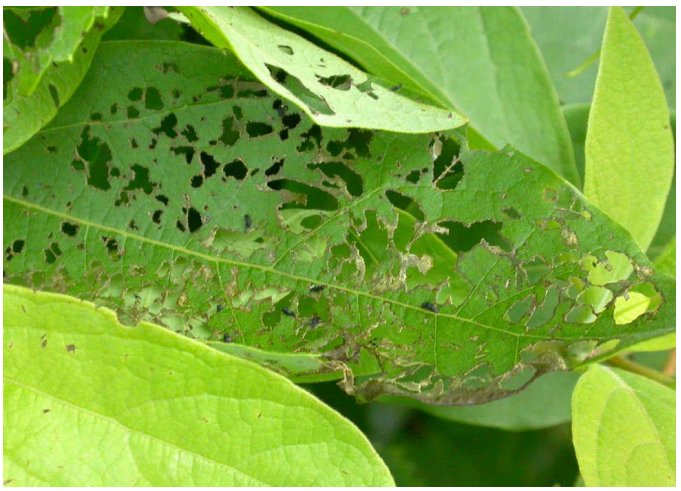
Black vine weevil larva
Photo: Suzanne Klick

Flea beetles and damage on hibiscus leaf
Photo: Suzanne Klick

Golden tortoise beetle adult
Photo: Suzanne Klick



Japanese beetle adult
Photo: Suzanne Klick



Japanese beetle damage
Photo: Suzanne Klick

Sap beetles (*Carophilus* sp.) on yucca
Photo: Suzanne Klick

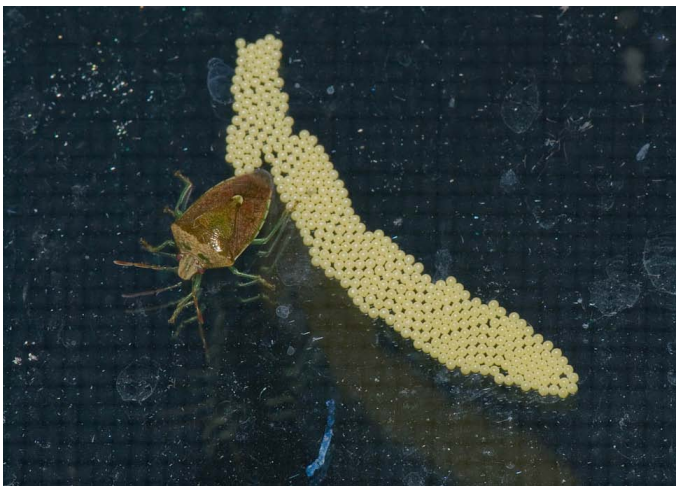
Damage from brown marmorated stink bug
Photo: Suzanne Klick

Newly hatched brown marmorated stink bug nymphs
Photo: Suzanne Klick

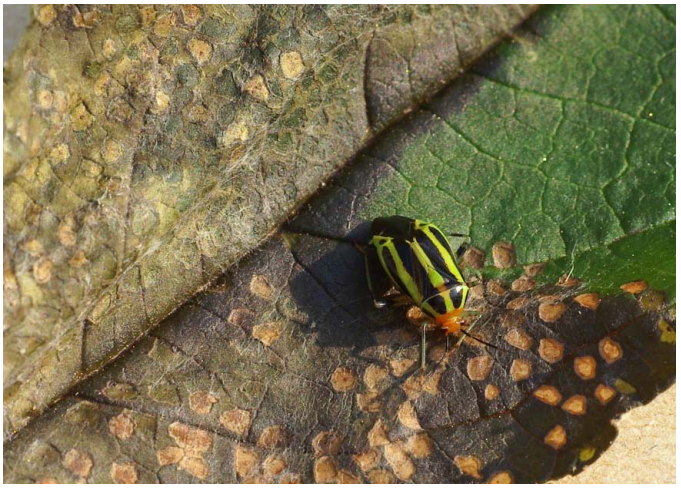
Brown marmorated stink bug nymphs
Photo: Suzanne Klick

Brown marmorated stink bug adult
Photo: Suzanne Klick

Green stink bug nymph and old flea beetle damage
Photo: Suzanne Klick

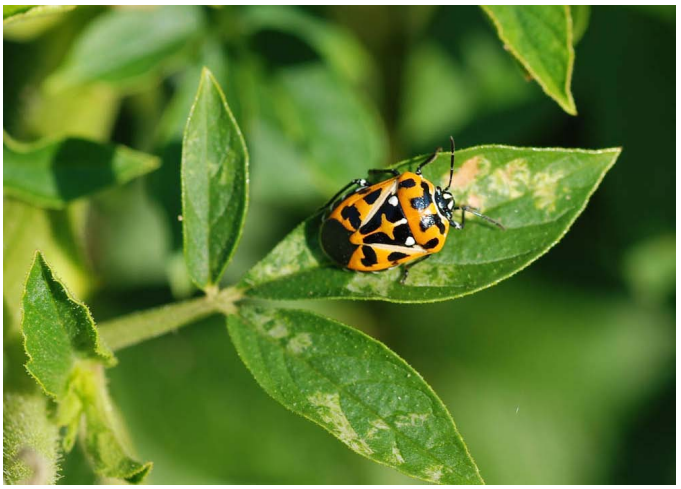


Stink bug (*Banasa* sp.) adult female laying eggs
Photo: Suzanne Klick



Fourlined plant bug and damage on rudbeckia
Photo: Suzanne Klick

Newly hatched harlequin bug nymphs
Photo: Suzanne Klick



Harlequin bug adult and damage
Photo: Suzanne Klick

Phlox plant bug damage
Photo: Suzanne Klick

Phlox plant bug adult
Photo: Suzanne Klick

Tarnished plant bug
Photo: Suzanne Klick

Fern leafroller (*Herpetogramma theseusalis*) damage
Photo: Suzanne Klick

Fern leafroller (*Herpetogramma theseusalis*) larva
Photo: Suzanne Klick

Early instar iris borer larva
Photo: Suzanne Klick

Sunflower moth caterpillar on echinacea
Photo: Suzanne Klick

Sunflower moth caterpillar boring into flower
Photo: Shannon Wadkins

Yellowstriped armyworm on mum
Photo: Suzanne Klick

Fungus gnat larva feeding on pansy at base of stem
Photo: Suzanne Klick

Shorefly adult
Photo: Suzanne Klick

Grasshopper adult
Photo: Suzanne Klick

Grasshopper damage on dahlia flower
Photo: Suzanne Klick

Blotch leafminer damage on columbine
Photo: Suzanne Klick

Leafhopper on *Monarda* stem
Photo: Suzanne Klick

Heavy webbing on dahlia from spider mites
Photo: Suzanne Klick

Tarsonemid mite damage on echinacea
Photo: Suzanne Klick

Twospotted spider mites and eggs
Photo: Shannon Wadkins

Miscanthus mealybug in miscanthus stem
Photo: Suzanne Klick

Citrus mealybug on rudbeckia
Photo: Shannon Wadkins

Fern scale on liriope
Photo: Suzanne Klick

Heavy damage from hibiscus sawfly larvae
Photo: Suzanne Klick

Hibiscus sawfly larvae and feeding damage
Photo: Suzanne Klick

Slug leaving slime trail on canna leaf
Photo: Suzanne Klick

Slug feeding on iris flower
Photo: Suzanne Klick

Streaking from thrips feeding on gerbera daisy
Photo: Shannon Wadkins

Thrips damage on milkweed foliage
Photo: Shannon Wadkins

Adult gladiolus thrips
Photo: Stanton Gill

Female western flower thrips
Photo: Stanton Gill

Greenhouse whitefly, *Trialeurodes vaporariorum*
Photo: Shannon Wadkins

Greenhouse whitefly, *Trialeurodes vaporariorum*
Photo: Suzanne Klick

Greenhouse whitefly, *Trialeurodes vaporariorum*
Photo: Suzanne Klick

Pupal stage of *Bemesia tabaci* whitefly
Photo: Suzanne Klick

Anthracnose leaf spots
Photo: Karen Rane

Bacterial leaf spot on chrysanthemum
Photo: Stanton Gill

***Botrytis* on geranium foliage**
Photo: Suzanne Klick

***Botrytis* on dahlia flower**
Photo: Shannon Wadkins

***Botrytis* on vinca stem and foliage**
Photo: David Clement

Hosta Virus X on hosta
Photo: Suzanne Klick

Daylily leaf streak
Photo: Shannon Wadkins

Downy mildew on rudbeckia foliage
Photo: Suzanne Klick

Damage on phlox from downy mildew
Photo: Suzanne Klick

Impatiens necrotic spot virus (INSV) on orchid
Photo: Suzanne Klick

Powdery mildew on dahlia
Photo: Suzanne Klick

Pythium root rot on blue fescue
Photo: Rondalyn Reeser

Chrysanthemum white rust on topside of foliage
Photo: Karen Rane

Chrysanthemum white rust on bottom of foliage
Photo: Karen Rane

Rust on topside of mayapple leaf
Photo: Suzanne Klick

Rust on aster leaf
Photo: Suzanne Klick

Septoria leaf spot on *Veronicastrum virginicum*
Photo: Ethel Dutky

Foliar nematode on anemone
Photo: Rondalyn Reeser

Root knot nematode on *Acanthus*
Photo: Stanton Gill

Bird's nest fungus in pot
Photo: Suzanne Klick

Moss growing in pot
Photo: Suzanne Klick

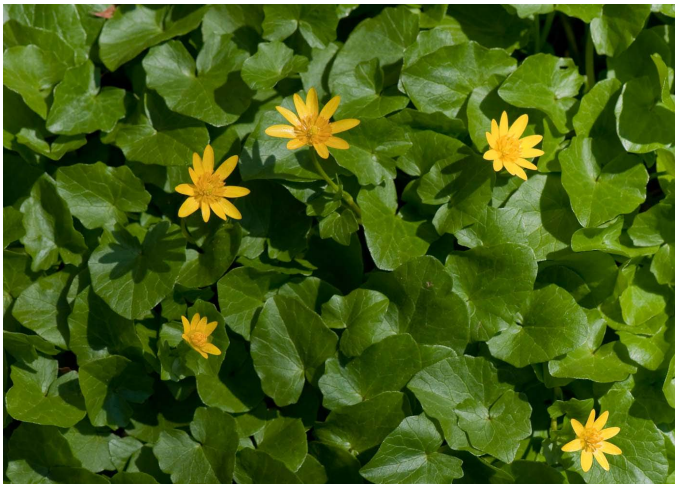
Leaf scorch on heuchera foliage
Photo: Shannown Wadkins

Nitrogen deficiency on astilbe
Photo: Rondalyn Reeser

Pesticide damage on pentas foliage
Photo: Stanton Gill

Groundsel growing outside of greenhouse
Photo: Suzanne Klick

Horseweed growing through landscape fabric
Photo: Suzanne Klick



Lesser celandine (*Rananuculus ficaria*) in bloom
Photo: Suzanne Klick

Close-up of lesser celandine root system
Photo: Suzanne Klick

Purple deadnettle (*Lamium purpureum*)
Photo: Suzanne Klick

Woodsorrel (*Oxalis* sp.) in bloom
Photo: Suzanne Klick