Rutgers New Jersey Agricultural Experiment Station - Cooperative Extension

PLANT & PEST ADVISORY

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Adult chinch bugs
Source: University of Rhode Island

INSIDE

New Products for Surface Feeding Insect Pests in Turfgrass

Albrecht M. Koppenhöfer, Ph.D., Turfgrass Entomology

Over the last few years several new products have become available for the control of surface feeding insect pests in turfgrass. Some of these new products are simply combinations of previously available active ingredients, others are new members of already available insecticide classes, and two actually belong to new insecticide classes.

Clothianidin (Arena) and **thiamethoxam (Meridian)** are two new neonicotinoids that, like imidacloprid (Merit), are primarily white grub products but can also be effective against billbugs by killing the younger larvae when feeding inside the grass stems (Table 1). Both also claim chinch bugs on their label, although thiamethoxam with the caution that it only provides suppression. However, both would not exactly be my first choice for chinch bug control. Among the neonicotinoids, clothianidin has the best environmental profile as it is (based on EPA standards) 'practically non-toxic' to mammals, birds, and fish, and also has the lowest water solubility. Thiamethoxam is 'slightly toxic' to mammals and birds, 'practically non-toxic' to fish, but has a fairly high water solubility. Therefore, it has to be used carefully in situation where groundwater contamination potential exists. In comparison, imidacloprid is 'moderately toxic' to mammals, 'practically non-toxic' to birds and fish, and is only slightly more water soluble than clothianidin.

Two newer products are combinations of the pyrethroid bifenthrin and a neonicotinoid: **Allectus** (bifenthrin + imidacloprid) and **Aloft** (bifenthrin + clothianidin). These combination products simultaneously provide control of white grubs (through the neonicotinoid) and surface feeding insects (through bifenthrin). Both provide control of almost all the common turfgrass insect pests (Table 1). However, along the same lines, they will also be very 'effective' against most non-target insect in turfgrass such as predators and parasites of turfgrass pests. Before applying these combinations, consider how likely both white grubs and surface insect pests are to occur in the same turfgrass area, let alone damage it. If a turfgrass area has the potential for problems with white grubs and surface feeders, make sure not to apply the combination more than 3–4 weeks before the surface feeders should be controlled to avoid the loss of bifenthrin activity. These combinations can be considered 'moderately toxic' to mammals and 'practically non-toxic' to birds. Because the bifenthrin component is 'very highly toxic' to fish

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New Products from page 1 but essentially not water soluble, these products have to be applied with care wherever there is a chance of surface water contamination.

Another recent addition to the turfgrass insecticides is the oxadiazine insecticide **indoxacarb (Provaunt)** which is highly effective against caterpillar pests (sod web-, cut-, armyworms) and annual bluegrass weevil larvae (Table 1). Indoxacarb also has a good environmental profile being 'slightly toxic' to mammals, 'practically non-toxic' to birds and fish, and essentially not soluble in water.

The anthranilic diamide insecticide **chlorantraniliprole (Acelepryn)** just received registration in New Jersey. It is not only highly effective against all the important white grub species, but also controls the caterpillars (sod web-, cut-, armyworms) and larvae of billbugs and annual bluegrass weevil (Table 1). Against chinch bugs it only provides suppression. Ongoing research indicates that chlorantraniliprole will control caterpillars for 2-3 months, i.e., cover at least two generations. Chlorantraniliprole has an exceptional environmental profile being 'practically non-toxic' to mammals, birds, fish, and honey bees, and essentially not soluble in water.

See Table 1 for a summary of the efficacy of the discussed insecticides along with other insecticides labeled in turfgrass.

Table 1. Insecticides for turfgrass (2008)

Common name	(Class)[a]	Trade name	ABW ad / lv	Ants	Army-worms	Bill-bugs ad /lv	BTA ad	CChi-nch bugs	Cut-worms	Fleas	Green bug	Leaf hop-per	SWW	Ticks	White grubs	Wasps
Acephate	(1)	Address, Orthene	- / -	X	X	- / -	X	X	X	X	X	X	X	-	-	X
Chlorpyrifos[b,d,e]	(1)	Dursban	- / -	X	X	- / -	X	X	X	X	X	X	X	X	-	-
Trichlorfon[d]	(1)	Dylox	- / -	-	-	- / -	-	-	X	-	-	-	X	-	X	-
Carbaryl	(2)	Sevin	- / X	X	X	- / X	-	X	X	X	-	X	X	X	X	-
Bifenthrin[b]	(3)	Talstar	X / -	X	X	X / -	X	X	X	X	-	X	X	X	-	-
Cyfluthrin[b,d]	(3)	Tempo	X / -	X	X	X / -	X	X	X	X	-	X	X	X	-	X
Deltamethrin[b]	(3)	Deltagard	X / -	X	X	X/ -	X	X	X	X	-	X	X	X	-	-
Lambda-cyhalothrin[b,d]	(3)	Battle, Scimitar	X / -	X	X	X / -	X	X	X	X	-	-	X	X	-	X
Permethrin	(3)	Astro	- / -	X	X	- / -	-	X	-	X	-	X	X	-	-	X
Halofenozide	(5)	Mach 2	- / X	-	X	- / X	-	-	X	-	-	-	X	-	X	-
Clothianidin	(6)	Arena	- / X	-	-	- / X	-	X	-	-	-	-	X	-	X	-
Imidacloprid	(6)	Merit	- / X	-	-	- / X	-	-	-	-	-	X	-	-	X	-
Thiamethoxam	(6)	Meridian	- / -	-	-	- / X	-	-	-	-	-	-	-	-	X	-
Indoxacarb	(7)	Provaunt	- / X	-	X	- / -	-	-	X	-	-	-	X	-	-	-
Chlorantraniliprole	(8)	Acelepryn	- / X	-	X	- / X	-	-	X	-	-	-	X	-	X	-
Spinosad	(9)	Conserve	- / -	-	X	- / -	-	-	X	X	-	-	X	-	-	-
Hydramethylnon	(10)	Amdro, Maxforce	- / -	X	-	- / -	-	-	-	-	-	-	-	-	-	-
Abamectin	(11)	Advance	- / -	X	-	- / -	-	-	-	-	-	-	-	-	-	-
Bacillus thuringiensis	(11)	e.g. Dipel, Javelin, Xentari	- / -	-	X	- / -	-	-	-	-	-	-	X	-	-	-
Heterorhabditis bacteriophora	(11)	e.g., Nemasys G, Heteromask	- / -	-	-	X / X	-	-	X	X	-	-	X	-	X	-
Steinernema carpocapsae	(11)	e.g., Ecomask, Millenium	- / -	-	-	- / X	-	-	X	X	-	-	X	-	-	-
Bifenthrin+imidacloprid	(3+6)	Allectus	X / -	X	X	X / X	X	X	X	X	-	X	X	X	X	-
Bifenthrin+clothianidin	(3+6)	Aloft	X / -	X	X	X / X	X	X	X	X	-	X	X	X	X	-

Ad = adult; lv = larva; BTA = black turfgrass ataenius; ABW = annual bluegrass weevil (Hyperodes); SWW = sod webworms;

[a] Class: (1) organophosphate; (2) carbamate; (3) pyrethroid; (4) phenyl pyrazole; (5) insect growth regulator; (6) neonicotinoid; (7) oxadiazine; (8) anthranilic diamide; (9) spinosyn; (10) hydrazone; (11) biological.

[b] Restricted use insecticide; may be purchased and used only by certified applicators. c Not for use on golf course turf. d Not for use on sod farm turf. e Not for residential turf.

NOTE: no endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned

Weather Effects on Plants & Insects/Mites

Steven K. Rettke, Ornamental IPM Program Associate

The old saying that "everyone talks about the weather" is certainly true when it involves landscape plant managers. Professional landscapers/arborists and their clients are always discussing how their plants are being affected by various weather factors. The New Jersey weather trends can often be variable from one growing season to the next. How do rain, wind and temperature changes impact plants and their corresponding insect/mite pests?

Hot-Dry Weather Pests

Some of the common landscape pests that are most active in Hot-Dry conditions are listed in the Table below under column "A". It is well known that **lacebugs** reach their highest populations on plants located in sunny-dry locations. There are few predators in these areas, and the shallow rooted azalea is often under drought stress. Lacebugs typically thrive under these conditions.

Scale insects also generally will do better in hot-dry weather primarily because the immatures are not knocked off the plants by raindrop "bombs." Recently hatched scale crawlers are unprotected for several days as they move about the plant looking for a place to settle down. If rains do cause the crawlers to fall to the ground, it is unlikely they will be able to climb back up the plant before they die (their short-stubby legs do not work very well). The timing of the rainfall to suppress the scale crawlers is critical, because they typically are active for only a few days. Once they settle down and insert their mouthparts into the plant tissue, they are less vulnerable to the raindrops.

Various **leaf beetles** and **caterpillars** usually prefer hot-dry conditions not because they may get knocked off the plants (they will often simply climb back up), but since they can be infected by fungal diseases if a lot of free moisture is present. For example, the *Entomophaga* fungus that has been decimating most of the Gypsy Moth populations for more than a decade does an excellent job of keeping these caterpillar populations in check in cool, moist springs. However, when warm and dry springs occur, this pest typically returns to become a problem again in certain areas.

One of the most common of the warm season pests is the **two-spotted spider mite**. These pests thrive in very dry conditions, and they will reproduce more rapidly when it is warmer. Mites are vulnerable to being dislodged by heavy rains unless they are under protective leaf covering. Invariably, the worst spider mite populations within the landscape occur when plants are sited under over-hanging structures. In the landscape, two-spotted spider mites can have between 10 to 15 generations per year.

Cool Weather Pests

The insects listed in column "B" in the Table below are some of the common landscape pests most active during cool weather. Many **aphids** are the earliest insects noticed in the spring, feeding on new, soft and succulent plant growth. Additionally, some species of aphids are more active in the cooler weather in order to avoid predation (many common beneficial insects [i.e., lady beetles and lacewings] perform best in hot temperatures!). Some of these aphid species will disappear when warmer weather persists, but will return the following fall season as the cooler conditions develop again.

Most of the **adelgids** will do well in cool weather. The immature spruce gall adelgids, for example, overwinter on the terminal buds and are not adversely affected by extremely cold temperatures. Also, pine bark adelgids seem to have their greatest populations on those pines that are in shaded locations. Often, a mass planting of pines too closely spaced in the landscape will have these adelgids infested on the interior trees.

The **root weevil grubs** (e.g., black vine weevils) actually prefer cool-moist conditions within the soil. If the soils become too wet, however, they become susceptible to fungal and bacterial infections. The larvae will often be forced to feed higher up the stem of the plant, where it is not as wet. This may cause the stem to be girdled, causing death to the plant.

The **cool season mites**, such as the spruce spider mite, are happiest when temperatures are 60° F. or less. During the late spring, populations explode and webbing may be highly noticeable. By summer, conifer foliage damaged by mites during the spring often desiccates, turning the inner needles from yellow to brown or orange in color. Only new tip growth remains.

Come the hot summer months, spruce spider mites usually become inactive (However, if the daily high temperatures remain consistently below 85° F. for extended periods of time, then spruce spider mites may continue activity). These cool season mites begin to rebuild their populations in September, and reach their peak in November. The last active spruce mites may be present into the month of December, and the overwintering eggs are not laid until nighttime temperatures consistently drop below freezing. Spruce spider mites can have between 7 to 10 generations per year.

Some of the **eriophyid mites**, such as the hemlock rust mite, are adapted to temperatures even colder than the spruce spider mite. They may actually begin activity as early as late-February in some situations. Look for them on the sunny side of conifers during late winter weeks.

Insects Damaged by Excessive Rains

The insects and mites listed in column "C" are some of the pests that may be adversely affected by excessive rains. These pests have already been discussed in the above sections. Rain can be detrimental to pest survival

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and proliferation because of the insect disease fungus it promotes, as well as the physical impact it causes (direct kill).

Stressed Plant Pests

The insects listed in column "D" are examples of pests that are actually attracted to plants under stress. **Aphids** and **whiteflies** are apparently drawn to plants with yellowing foliage. Plants under stress often lose some of their chlorophyll and become yellowish in color. Yellow sticky cards are often hung in greenhouses to monitor for some of these pests.

Some species of **caterpillars** (not gypsy moth) are "samplers" when they feed. These caterpillars will sample individual leaves to determine if they contain plant defensive chemicals such as tannins or alkaloid toxins. If these toxins are contained within the leaves, the caterpillar may find it distasteful and move on to sample other leaves. A weakened plant under stress may not have enough energy to produce these defensive chemicals and therefore, be more attractive for these caterpillars.

The greatest concern with stressed plants in the landscape is from **borer infestations**. The best examples of borer-prone plants are when drought conditions and high temperatures stress non-native plants. Pine bark beetles, bronze birch borers, and the two-lined chestnut borers are all encouraged when stressed tress are forced to "shut-down" their vascular systems (xylem & phloem tissues). When trees have low sap pressure, the borers can easily penetrate and cut through vascular tissue. Furthermore, trees with compromised vascular systems cannot readily transport defensive chemicals to areas invaded by borers.

Source: Adapted from a presentation delivered by Dr. David Shetlar (The Ohio State University Extension) @ the RCE IPM Symposium, Nov. 1995

Plant Diagnostic Lab Highlights

Richard J. Buckley, Director, Soil Testing and Plant Diagnostic Services

Turf

Winter dormancy in zoysiagrass lawn

Turfgrass is consistently flowing into the laboratory with a myriad of summer problems. **Brown patch** submissions were common in the period just after the last newsletter, but have waned as the weather dried out over the last week. I suspect that the disease will begin to flare with the rain today and the generally moist period anticipated over the weekend. Brown patch was submitted from landscape turf and golf courses in Atlantic, Bergen, Burlington, Somerset, and Union Counties. The most interesting sample diagnosed with active *Rhizoctonia*; however, came from a horse farm in Monmouth County. The clover in their pastures was being hammered by the fungus. The fungal infection does little damage to the clover and is not really a concern for the pasture. The problem comes when the horses actually eat the diseased clover. The fungus *Rhizoctonia leguminicola* causes a disease in clover called **black patch**. When horses feed on black patch infected clover an alkaloid is released by the fungus in the digestive tract of the horse. The alkaloid causes a salivary syndrome in the horse that literally has them foaming at the mouth. Excessive feeding causes more severe symptoms like frequent urination and diarrhea. It seems that a messy pasture equals a messy horse!

Summer patch continues to be a primary problem in both golf and landscape turfgrass. The disease has been showing up on both annual and Kentucky bluegrass since early June. This week the samples came from several locations in New Jersey, Pennsylvania and New York. **Anthracnose** has been found on golf turf from New Jersey, New York, and Pennsylvania as well. Other diseases of note include: **dollar spot**, **fairy ring**, **take all**, **pythium root dysfunction**, and a lot of **heat stress**. We also had a sample of zoysia that was loaded with **chinch bugs**. Anytime we have zoysia samples the diagnosis is always chinch bugs, brown patch, or we get the question "how do I get ride of this stuff?"

Ornamentals

Oriental fruit moth, Grapholita molesta under the bark of a quince.

Phytophthora crown and root rot samples have started to come in from local nurseries. This disease is most common in the heat of the summer when the shrubs need frequent irrigation. This spring we saw a bunch of quince with rust diseases, this time it was the **Oriental fruit moth**. A residential client in Bergen County submitted branches from his quince with a significant dieback. After carefully dissecting the limb, we found a lone pupa that was reared into an adult Oriental fruit moth. These critters attack the twigs and fruit of apple, stone fruits, quince, and many other plants in the Rosaceae. There are 4 to- 5 generations per year in New Jersey. ❑

Table: Pests Affected by Specific Conditions

"A" Hot/Dry Weather Pests	"B" Cool Weather Pests	"C" Pests Damaged by Excessive Rains	"D" Pests Attracted to Stressed Plants
Lacebugs	Aphids (some)	Lacebugs (fungus)	Aphids (some)
Scales	Adelgids	Aphids/Mites (impact)	Scales (some)
Leaf Beetles	Root Weevils	Scale Crawlers (impact/wind)	Whiteflies
Caterpillars	Cool Season Mites	Caterpillars (fungus)	Caterpillars (some)
Warm Season Mites	Eriophyid Mites (some)	Black vine Weevils (fungus)	BORERS!!!

Diseases of Turfgrass

Bruce B. Clarke, Ph.D., Specialist in Turfgrass Pathology

General

Gray leaf spot just started to develop on perennial ryegrass in Central New Jersey. This is a very early occurrence for this disease, so 2008 could be a bad year for Gray Leaf Spot**. Anthracnose**, **copper spot**, **brown patch**, **pythium blight**, **dollar spot**, **summer patch**, **fairy ring**, and **slime mold** are also active. Refer to recent issues of this newsletter for complete disease control information.

Brown Patch

This disease, caused by the fungus *Rhizoctonia solani,* is very common on fine turf and home lawns due to the continuing hot, humid weather. To reduce the incidence and severity of **brown patch,** avoid excessive nitrogen applications (not more than 0.25lb N/1000 sq ft) during hot weather, irrigate between midnight and 8 a.m. (to reduce the period of leaf wetness), and spray turf with Armada, Banner, Chipco 26GT, chlorothalonil, Compass, ConSyst, Disarm, Eagle, Endorse, Headway, Heritage, Insignia, mancozeb, Medallion, Prostar, Spectro, Tartan, thiophanate-methyl or Trinity per manufacturer's recommendations

Gray Leaf Spot

Gray leaf spot, caused by the fungus *Pyricularia grisea,* has started to develop in Central New Jersey. This disease has devastated many new perennial ryegrass and tall fescue plantings throughout the Mid-Atlantic States in the past. Symptoms start as tiny, brown leaf and stem lesions within a 1 to 2 inch patch. In severe cases, the leaves curl and lesions may extend the entire width of the blade. As the disease progresses, patches coalesce into large (one to two feet diameter) areas of blighted turf. Extensive foliar blighting may occur during warm (75-85^{0}F days and 60-75^o F nights), wet weather. Newly established seedings are more susceptible to infection than mature plantings. When conditions are conducive to disease development, the pathogen produces abundant two to three-celled, pear-shaped spores (conidia). To suppress this disease, avoid high rates of nitrogen during July and August and extended periods of leaf wetness (i.e. water in the early morning hours). Fungicide studies have shown that Armada, Compass, ConSyst, Disarm, Headway, Heritage, Insignia, Spectro, Tartan, and thiophanate-methyl were most effective when applied on a preventive basis every 14 to 28 days beginning in mid-July. Chlorothalonil (e.g., Daconil) and the DMI (sterol-inhibiting) fungicides, such as propiconazole (e.g., Banner), may provide effective control when disease pressure is moderate. Isolates of *P. grisea* resistant to the QoI (Strobilurin) fungicides and strains with reduced sensitivity to the DMI's have been reported in New Jersey.

Pythium Blight

Pythium blight has been very prevalent on golf and landscape turf during the past four weeks. Since pythium thrives in low or poorly drained areas, especially when night temperatures are above 70^{0}F, we should see a lot more of this disease as the "hot muggy" weather continues this summer. For best results, improve drainage, water in the early morning hours, avoid over fertilization (not more than 0.25 lb N/1000 sq ft), and apply Alude, Banol, Chipco Signature, Disarm, Headway, Heritage, Insignia, Koban, Magellan, Prodigy, Quell, Subdue MAXX, Terrazole or Vital Sign, according to the manufacturer's recommendations. Apron may be applied as a seed treatment to prevent damping-off. Mancozeb can be used to control Pythium Blight but it is generally less effective than the products mentioned above. Koban or Terrazole should be watered into the thatch on greens due the potential for foliar burn during hot weather. However, the use of these products on fairways is prohibited.

Summer Patch

Summer patch has been very severe on many turf areas containing Kentucky bluegrass, annual bluegrass, and fine fescues. To control existing infections, apply Armada, Banner, Bayleton, Compass, Disarm, Eagle, Headway, Heritage, Insignia, Rubigan, Tartan, thiophanate-methyl (e.g. 3336, Fungo 50 etc.), or Trinity in 4 to 5 gal of water/1000 ft^2. Repeat every three to four weeks (every two weeks if using thiophanate-methyl). If fungicides cannot be applied with this much water, irrigate them into the thatch immediately with 1/16 to 1/8 inch of water. Aerification (when symptoms are not present) and improved drainage will also aid in disease suppression. Soil pH should be maintained at or slightly below 6.0 for optimum disease control.

Yellow Tuft

This disease, caused by the fungus *Sclerophthora macrospora*, has started to appear on greens and irrigated landscape turf. **Yellow tuft** (=Downy Mildew) occurs on almost all cool-season turfgrasses; however, it is usually only a serious problem on turf maintained at a low cutting height. Poorly drained or heavily irrigated sites are often associated with disease development. Infected turf appears stunted, off color (yellow to light green), and may exhibit slightly broadened leaf blades and dense clusters of shoots. Patches ranges in size from 0.25 to 1 inch in diameter for bentgrass and red fescue turfs, and 0.5 to 3 inches for Kentucky bluegrass and perennial ryegrass areas. Tufts are easily removed from the soil due to the absence of adventitious roots. To control, improve drainage, avoid overwatering, mow only when the grass is dry, apply iron sulfate to mask symptom expression, and spray turf with Chipco Signature, Insignia, Prodigy or Subdue MAXX now or on a preventive basis from late March to early June.

Turf Field Day

Rutgers Turfgrass Research Field Days which will be held on Tuesday, July 29, 2008 (Golf and Fine Turf Research Field Day at Horticultural Farm II, New Brunswick, NJ) and Wednesday, July 30, 2008 (Landscape Turf Research Field Day at the Adelphia Research Farm, Freehold, NJ). Registration information and directions to each location can be obtained at http://www.njturfgrass.org. ❑

Pollution Injury in New Jersey Landscapes

Ann B. Gould, Ph.D., Specialist in Plant Pathology

Polluted air occurs when products from human activities (burning of fossil fuels and industrial manufacturing) contaminate the atmosphere. Plants affected by air pollutants may exhibit a range of symptoms depending on the pollutant and the plant species itself. Many times, symptoms on the foliage may not be obvious, but a significant impact to plant growth or yield may occur. Damage may be the result of a single (**acute**) exposure to a high concentration of a given pollutant, or may be due to longer-term (**chronic**) exposure to lower concentrations.

Some of the more common air pollutants are listed in Table 1. Of these, ozone appears most commonly in New Jersey landscapes, primarily during the summer months. Air pollutants are classified as "primary" or "secondary" pollutants. **Primary pollutants** (also called point-source pollutants), such as hydrogen fluoride, sulfur dioxide, and nitrogen oxides, are released directly into the air from the source. Vegetation facing the pollution source will commonly sustain the most damage. In addition, these compounds may combine with water in the air to form acid (pH lower than 5) precipitation (as fog, rain, or snow). **Secondary pollutants**, such as ozone and PAN, are formed high in the atmosphere as exhaust from internal combustion engines combine with sunlight. Such pollutants filter down to cause damage to exposed plant tissues. Ozone, PAN, and smoke combine to form "smog."

Three pollutants, **ozone**, **fluoride**, and **sulfur dioxide**, are the most common causes of air pollutant problems in New Jersey landscapes. Prolonged or repeated exposure to these pollutants may result in foliar discoloration and decreased growth and vigor of vegetation. Within any plant group, there is often a wide variation in sensitivity. For instance, white pines vary greatly in their response to most common air pollutants.

To diagnose pollution injury, compare the affected vegetation with other vegetation in the vicinity. Generally, more than one species of plant will be affected. Visually examine the plants and compare the symptoms with those described in the literature. In the cases of fluoride and sulfur dioxide, verify the existence of a pollution source in the area. Symptoms due to fluoride pollution are more prominent on the side of the plant facing the pollution source.

In general, deciduous species develop symptoms more rapidly than conifers, but they do not accumulate toxic levels of pollutants from year to year because affected leaves are shed. Although conifers develop symptoms more slowly, they can accumulate pollutants to lethal levels because affected needles may persist for several years. Ultimately, the type of injury that results from pollution depends on the pollutant, its dose (concentration x time), the time of year, the plant species involved, the genetic make-up of the vegetation, and the age of the foliage affected.

Ozone

The pollutant that most commonly causes injury to vegetation in New Jersey is ozone. During hot and humid summer days, ozone can be particularly troublesome to vegetation around the state. Ozone is a by-product of automobile and industrial combustion. Ozone is formed when nitrous oxides and hydrocarbons released from incomplete combustion undergo chemical reactions in the presence of sunlight. Injury to vegetation from ozone can occur at long distances from the hydrocarbon source. As a result, ozone injury is becoming more prevalent each year in rural as well as in urban areas.

In deciduous trees, ozone pollution results in a breakdown of chlorophyll causing small "flecks" on the upper leaf surface between the larger veins. These flecks range in color from white to orange-red. In conifers, yellow flecks (1/8- to 1/4-inch in diameter) frequently occur on affected needles. Yellow bands that girdle the needle may also form, causing the tip of the needle to turn brown and die. In general, herbaceous plants are

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Table 1. Common sources of air pollution and symptoms of injury to plants

Air pollutant	Source	Symptoms
Primary		
hydrogen fluoride	industrial processes (aluminum, glass, brick manufacturer)	marginal and tip chlorosis and necrosis of leaves; necrosis is often "reddish" in color
sulfur dioxide (SO_2)	combustion of fossil fuels; industrial processes; burning of coal to generate electricity	interveinal (between the veins) necrosis (broadleaf plants) and tip burn (conifers)
nitrogen oxides (NO_x)	combustion of fossil fuels; industrial processes	leaves appear bronzed or copper-colored
ethylene (also a natural plant growth regulator)	incomplete combustion; industrial processes; very common in greenhouses where heaters do not work properly	defoliation, senescence, deformed leaves, fruit drop
Secondary		
ozone (O_3)	from internal combustion engine exhaust as it interacts with sunlight	on leaf tissue exposed to atmosphere: fleck, stipple, mottle; tip burn (conifers), stunt, defoliation
peroxyacetyl nitrate (PAN)	from internal combustion engine exhaust as it interacts with sunlight	lower leaf surface appears bronzed or bleached

**Adapted from Schumann, G. L., and C. J. D'Arcy. 2006. Essential Plant Pathology. APS Press, St. Paul, MN.*

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more sensitive to ozone than are woody plants. White pine can serve as an "indicator plant" since most plants within this species are highly sensitive to this pollutant.

Plants sensitive to ozone: ailanthus, alder, ash (green, white), boxelder, boxwood, carnation, catalpa, chrysanthemum, crabapple, grape, honeylocust, larch, lilac, linden, maple (silver), mulberry, oak (white), petunia, pine (Austrian, Scotch, white), poplar, privet, snowberry, spirea, sweetgum, sycamore, tuliptree, willow (weeping), zelkova.

Plants tolerant of ozone: birch (European white), boxwood, Douglas-fir, locust (black), maple, pine (Japanese black, red), oak (red), spruce (blue, Norway), walnut (black).

Fluoride

Fluoride is a natural component of soil, rocks, and various minerals. Toxic quantities of fluoride may be released into the atmosphere when materials containing fluorides are heated or treated with acid during industrial processing. The primary sources of fluoride pollution in New Jersey are by products of glass and brick manufacturing. Interestingly, fluoride is one of the few pollutants that can accumulate in plant tissues. Animals grazing close to the source of this pollutant may ingest fluoride-contaminated foliage, developing fluorosis (weakened teeth and bones).

Fluoride damage on Gingko

In deciduous species, tissue along leaf margins turn light green and appear water soaked when first exposed to fluoride. These areas later turn brown.

A dark-brown band may appear where the toxin accumulates between the affected and green, inner leaf tissue. Eventually, the entire leaf turns brown. In conifers, fluoride injury is most evident on first-year needles. The tips of these needles turn reddish-brown from the tip toward the needle base. Older needles are rarely affected. Gladiolus, one of the most susceptible plants to fluoride, is often used as an "indicator plant" for fluoride pollution. Utilize fluoride tolerant species in areas with known fluoride toxicity problems.

Plants sensitive to fluoride: apricot, ash, boxelder, Douglas-fir, gladiolus, grape, larch, mahonia, maple, oak, peach, pine (mugo, Scotch, white), poplar, redbud, rhododendron, spruce (blue), sumac, tulip, walnut (black), yew.

Plants tolerant of fluoride: ailanthus, birch, cherry (flowering), dogwood, elm (American), hawthorn, juniper, linden (American), mountain ash, mulberry, pear, pyracantha, sassafras, spirea, sweetgum, sycamore, Virginia creeper, willow.

Sulfur Dioxide

Sulfur dioxide is released into the atmosphere by the combustion of fossil fuels and by the smelting and refining of ores. The primary source of sulfur dioxide pollution in New Jersey is the burning of coal to generate electricity. Most damage to vegetation occurs in urban areas and in the vicinity of large power plants.

Sulfur dioxide enters leaves through natural openings in the plant called stomata. Plants are able to utilize small amounts of sulfur dioxide, but accumulations can cause injury and death. Acute injury occurs when plants are exposed to high levels of sulfur dioxide for a short time. In deciduous species exposed to sulfur dioxide, tissue between the leaf veins turns yellow, white, or brown. The veins, however, remain green. Unlike ozone, where injury appears only on the upper leaf surface, injury due to sulfur dioxide is evident on both the upper and lower surfaces of affected leaves. In conifers, a reddish-brown discoloration begins at the needle tip and progresses toward the needle base.

Chronic injury occurs when plants are exposed to low levels of sulfur dioxide for long periods of time. In most deciduous species, this type of injury is characterized by a general yellowing, or chlorosis, of the leaves. Older conifer needles turn yellow and are shed prematurely. Blackberry, raspberry, pumpkin, and squash are useful "indicator plants" for this pollutant.

Plants sensitive to sulfur dioxide: apple, ash, aster, birch, catalpa, elm (American), larch, mulberry, pine (white), poplar, spruce (blue), violet, zinnia.

Plants tolerant of sulfur dioxide: ash, boxelder, dogwood, gum (black), juniper, maple, spruce, sycamore, tuliptree. ❑

Weather Summary for the Week Ending 8 am Monday 7/21/ 8

	RAINFALL			TEMPERATURE				GDD BASE50		MON
WEATHER STATIONS WEEK	TOTAL	DEP	MX	MN	AVG	DEP	TOT	DEP	%FC	
BELVIDERE BRIDGE	.54	17.35	-.83	94	61	79.	6	1622	316	69
CANOE BROOK	.34	18.41	-.86	97	59	77.	3	1603	293	76
CHARLOTTEBURG	.39	17.29	-2.16	92	58	76.	5	1404	340	58
FLEMINGTON	.38	17.68	-.92	96	57	78.	4	1602	250	75
NEWTON	.87	16.78	-.97	92	60	77.	5	1619	451	68
LONG BRANCH	.03	15.65	-2.36	94	64	79.	4	1572	192	28
NEW BRUNSWICK	.16	18.31	.37	97	60	80.	4	1696	157	67
TOMS RIVER	.12	14.63	-3.77	96	60	78.	4	1642	254	33
TRENTON	.49	16.46	-.61	96	62	79.	3	1772	171	45
CAPE MAY COURT HOUSE	.00	12.49	-3.49	93	62	78.	2	1716	235	30
DOWNSTOWN	.25	16.25	-.47	94	59	78.	2	1779	165	40
GLASSBORO	.05	16.09	-1.66	96	65	79.	3	1917	324	43
HAMMONTON	.29	12.86	-4.81	96	59	79.	3	1858	270	32
POMONA	.00	14.89	-1.04	97	58	79.	4	1819	344	26
SEABROOK	.06	15.18	-.98	94	63	80.	4	1908	287	34
SOUTH HARRISON	.09	14.05	-3.87	94	63	81.	NA	1896	NA	NA

WES KLINE -- GDD BASE 40 PINEY HOLLOW LAST WEEK 257 (Ending 7/14/08) THIS WEEK 165 (Ending 721/08)

RUTGERS
New Jersey Agricultural Experiment Station
Plant & Pest Advisory
Rutgers School of Environmental and Biological Sciences
ASB II, 57 US Hwy. 1
New Brunswick, N.J. 08901

FIRST CLASS
POSTAGE PAID
PERMIT #576
MILLTOWN, NJ 08850

PLANT & PEST ADVISORY
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