Walnut Allelopathy

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Abstract

Eastern black walnut (*Juglans nigra*) roots exude chemicals that can suppress or kill many kinds of plants. Juglone (5-hydroxy-1,4-naphthoquinone), a nonspecific cytotoxin, is the best known and most potent of these chemicals. It suppresses or kills sensitive plants whose roots are exposed to it. Above-ground symptoms include retarded growth, stunted and distorted leaves, wilting, premature leaf senescence, and death. Although juglone is produced in all organs of a walnut tree, the roots are the main source of trouble for other plants. Juglone in soil and dead walnut materials is degraded to nontoxic products, but the supply in soil adjacent to living walnut roots is renewed annually. Walnut allelopathy can be mitigated by killing source trees (and removing large roots for quickest benefit) or placing root barriers between walnuts and sensitive plants. Many kinds of plants are relatively tolerant of juglone and can be grown successfully in the root zones of black walnuts.

Symptoms of juglone poisoning in plants

Affected plants may be stunted, and/or have yellow or brown, undersized or deformed leaves, or may wilt and die. Trees and shrubs undergo decline with external symptoms indistinguishable from those caused by other agents that kill roots. Brownish discoloration of vascular bundles has been noted in tomato. Symptoms may develop rapidly, or perennial plants that are somewhat tolerant may survive for years. Seed germination is less affected than root and shoot growth. Sensitive trees of considerable size (e.g. white pines up to 40 feet tall and 12 inches in diameter) may decline and die as their roots intermingle with walnut roots.

Some sensitive plants and plant groups:

* black alder, alfalfa, apple, asparagus, autumn-olive, azalea, barley, bean, birch, blueberry, brambles, buttercup, cabbage, sweet cherry, chokeberry, chrysanthemum, crimson clover, columbine, corn, crabapple, garden cress, cucumber, eggplant, hackberry, Amur honeysuckle, hydrangea, Japanese larch, lespedeza, lettuce, lilac, lily, linden, lucerne, saucer magnolia, silver maple, mountain-laurel, narcissus, garden pea, peony, pepper, petunia, pine, potato, potentilla, privet, quince, rhododendron, rhubarb, rose, Norway spruce, strawberry, tomato, viburnum, watermelon, wheat, yew.

* Sensitivity may vary among species in a group or cultivars within a species.

Many plants are tolerant. Lists are available in numerous on-line extension publications. The Morton Arboretum has a particularly nice one. www.mortonarb.org/plantinfo/plantclinic/Selection_BlackWalnutToxicity.pdf

Mode of action

Juglone suppresses root oxygen uptake, water uptake and acid efflux. Little is known about juglone uptake by roots and movement within plants. Brown vascular tissue observed in tomato stems poisoned by juglone seems likely to be due to internal movement of the toxin, but could also be caused by mildly pathogenic microorganisms that enter xylem through dead roots.

Side effects

Some beneficial soil bacteria, including *Frankia* spp. and *Bradyrhizobium japonicum*, which induce N-fixing nodules on plant roots, are inhibited by juglone in lab assays. However, studies in Ontario indicated no inhibitory effect of juglone on ammonification or nitrification in soils where black walnuts were growing. Effects of juglone on mycorrhizae have not been reported.

Site aspects

Juglone concentrations in soil are highest adjacent to walnut roots. Walnut toxicity to sensitive plants is usually observed within 50 feet of a walnut trunk, but the hazard zone increases in relation to tree size (and thus in relation to size of rooting zone). Walnut roots can grow many feet beyond the zone overhung by walnut branches.

In theory, fallen walnut fruits and leaves may contribute to the juglone concentration in soil, but no effect of these materials on plant health under natural conditions has been documented.

Juglone has been reported to persist in soil for up to a year after removal of walnut roots, but persistence is conditioned by soil conditions. It persists longest in poorly drained soils and diminishes rapidly in well-drained soils, in which it is oxidized to nontoxic products. Various bacteria and fungi degrade juglone. Addition of 10^{-3} M juglone solution to a silt-loam soil in Ontario suppressed the growth of alder seedlings for only 22 days. In laboratory studies with a fine sandy loam soil, juglone and its inhibitory activity disappeared more rapidly under a 'dry' moisture regime than under a 'wet' regime. In mixed plantations of pines and black walnut growing in Ontario, pines seemed unaffected by the walnut on excessively drained sites, while walnut suppressed or killed the pines on imperfectly drained and poorly drained sites.

Influence of walnut mulch and chips on plants

Composting of walnut materials for a minimum of six months provides a safe mulch even for plants sensitive to juglone. In tests with wood chips, substances eluted from black walnut proved less inhibitory to growth of lettuce seedlings than did substances eluted from red maple, swamp chestnut oak, red-cedar, neem, and magnolia.

Prevention or avoidance of damage

Don't grow eastern black walnut, or don't grow sensitive plants near black walnuts, especially not on soils with impaired internal drainage.

Continued on back

Mitigation of damage

From practical experience, if all walnut roots extending into the root zones of sensitive plants are severed and the larger roots pulled from the soil, sensitive plants can be grown there in the next growing season. Walnut roots will recolonize the area, however. Detection and identification of large black walnut roots is easy because they and the soil around them have a pungent noxious odor.

Root barriers can prevent growth of walnut roots into the root zones of other plants. Polyethylene barriers in soil minimized juglone concentration beyond the barriers to trace levels in one study. In a garden in New York State where "walnut wilt" occurred in tomato and several white pines adjacent to black walnuts declined and died, damage was halted by a 4-step procedure: 1) Dig a trench 1 foot wide and 2 feet deep (deeper than the maximum root depth on the site) between the walnuts and plants to be protected. 2) Detect severed walnut roots in the trench wall, and starting there, pull or dig up all large walnut roots beyond the trench. 3) Line both sides of the trench with polyethylene (held in place with wooden stakes). 4) Refill the trench with soil, and seed it with grass. The rationale for the double barrier was that if a walnut root grew over, under, or through a hole in the first barrier, the root would then grow in the former trench, not beyond the second barrier. The rationale for root removal beyond the barrier was that it would have immediate beneficial effect and would favor the demise of smaller walnut roots left in the soil. How long the procedure may be effective is unknown.

(For a list of literature references for this article please contact *Branching Out* at ddo1@cornell.edu)

Things to Look For in the Upcoming Weeks:

Boxwood Leafminer (94)—The adults of this leafminer should be emerging soon. The adults resemble small, orange gnat like flies. If populations are intolerable a treatment can be made. An imidicloprid soil drench or injection in late summer might be the best IPM approach. The other management option is to spray with a registered pesticide in the first two weeks of June (448-700 GDD_{50}).

Elongate Hemlock Scale (45)—The crawlers of this serious pest will soon be active. In addition to hemlock they also attack yew, spruce, and Douglas-fir. Treat heavily infested plants in late May through mid-June (360-700 GDD_{50}).

Euonymus Scale (186)—Euonymus scale nymphs will soon be present on the new growth of euonymus and pachysandra. If needed, treat during early June (533-820 GDD_{50}) and mid-July (1150-1388 GDD_{50}).

European Red Mite (228)—The adult and immature mites will soon begin feeding on flowering fruit trees and elm. If a miticide is needed, apply in late May through June (240-810 GDD_{50}) and repeat as needed at 10 day intervals.

Oystershell Scale (177)—Crawlers of this pest may be found on apple, lilac, ash, willow, popular, maple, and dogwood in late May. If necessary treat in late May through mid-June (363-707 GDD_{50}). Several treatments may be required.

Pine Needle Scale (47)—We've only seen the overwintering eggs of this scale during our scouting trips but expect the crawlers to hatch soon**.** This scale feeds only on needles of conifers including Scots, mugo, Austrian, and red pines and less often on spruce and Douglas-fir. Treat the affected trees and shrubs in late May (298-448 GDD_{50}). Several treatments are usually required.

Sycamore Anthracnose *(1st Ed-51, 2nd Ed-50)*—Symptoms of sycamore anthracnose should soon become evident. American sycamore is the hardest hit; London plane is more resistant.

Applications of appropriate fungicides will likely reduce anthracnose incidence, but we have noticed that in the last several disease episodes, untreated trees refoliated and recovered nicely as the season progressed.

Twospotted Spider Mite (229)—This mite causes stippling of foliage and can be a serious pest of roses, flowering fruits, azalea, and several other shrubs. Treat from late May through mid-June (363-618 GDD_{50}).

Miscellany

Arborvitae Dieback

Dan Gilrein, Extension Entomologist, Cornell University, Cooperative Extension of Suffolk County

Many people have been noticing problems with dieback on arborvitae and in some cases death of entire plants. This seems to be a widespread problem and so far there seem to be several causes. Based on samples seen here, arborvitae leafminer is one culprit. It has been particularly common on 'Emerald Green' but also seen on other cultivars like 'Nigra'. The larvae are feeding now but should be starting to pupate. Moths will emerge in June and the miners will begin feeding around July through fall. For control options check the Cornell Guidelines or contact Cooperative Extension.

From our observations, it appears many of the problems, especially some very severe cases, stem from the droughts last spring and summer, possibly aggravated by the nearly 20" of rain in October. I have noted more than a few cases of plants with dieback or even killed that are in close proximity to roots of larger trees. Drought or low oxygen stress can set trees up for winter injury-and even our mild '05-06 winter eventually included some sharp temperature dips.

Drought or low oxygen stress can set trees up for winter injury

Some samples here are showing dieback that appears to be due to tarnished plant bug feeding (from last fall). This insect tends to be more common in weedy areas, where they move to the irrigated plants as the weeds nearby dry up. These samples came from nursery fields where this problem is more likely to occur than in a residential landscape.

Other causes for the dieback and damage include bagworm, borers (so far, all associated with drought-stressed locations), deep planting, root or trunk injury, horticultural oil damage (poor timing and/or excess rate), poor root establishment in newly planted trees, and probably more. As far we can determine, foliar disease has not been a major cause of the symptoms of dieback seen on arborvitae. A dieback of just the very tip of branches (½ inch or less) has been associated with the fungus *Pestalotiopsis*, but even this tip blight is more common on drought-stressed arborvitae. This symptom is easily confused with leafminer, but easily distinguished under magnification.

To help determine which of these (or any other) causes might be implicated on particular plants, submit samples to any of the Cornell diagnostic labs.