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Neonic Seeds are Not Needed

By William Quarles

Neonicotinoids (neonics) are the most widely used insecticides in the world. They are used in field crops, orchards, parks, landscapes, backyard gardens, on ornamentals, lawns, pets, and in structural pest control. Neonics are applied as foliar sprays, soil drenches, granules, tree injections, and as seed treatments. They are not benign. They can kill pollinators and biological controls. Because they are water soluble and extremely persistent they can pollute water, killing aquatic invertebrates.

Neonics have been implicated in insect decline. Loss of insects leads to impacts on bird, frog, and bat populations. Neonics may well be the new DDT because of their persistence and effects on wildlife (Hladik et al. 2018; Hallmann et al. 2014; Sanchez-Bayo and Wyckhuys 2019; Quarles 2019; Quarles 2008).

Neonic seed treatments are especially objectionable because in many cases they do not lead to increased yields. About half the time, neonic seeds are not needed to control pests. Preemptive use of these chemicals can lead to pest resistance. Better and often less expensive pest control can be achieved by IPM methods such as monitoring and using insecticides only when a problem develops. Neonic seeds have been banned in European field crops, and crop yields have not been affected (Alford and Krupke 2018; Douglas and Tooker 2015; Hladik et al. 2018).

This article briefly reviews the effects of neonicotinoid seed treatments on crop yields and wildlife.

Photo courtesy of the USDA/NRCS

Planting machines produce large amounts of toxic seed dust. The dust is blown over the fields, killing bees, and leaving residues on soil, wild vegetation, and in water. No-till agriculture can reduce some of the dust.

Amount of Insecticide

Neonicotinoid seed treatments are used on at least 65 million ha (160 million acres) of U.S. crops each year (Krupke et al. 2017a; Douglas et al. 2015). Neonics on seeds are more than 20% of the total insecticide active ingredient used on corn, soybeans, wheat, and cotton. Imidacloprid, clothianidin and thiamethoxam are used most often (Douglas et al. 2015).

On average, about 5% of a neonicotinoid seed treatment is absorbed by plants. About 1-2% is blown into the air by planting machines, leading to contamination of vegetation, soil and water 100 meters (328 ft) or more from a crop field (Hladik et al. 2018; Mogren and Lundgren 2016).

Since neonics are persistent and not volatile, about 93-94% of neonics on seeds contaminate soil and water (Hladik et al. 2018). Toxic pollution of surface water has led to the collapse of aquatic insect populations (van Dijk et al. 2013; Quarles 2019; Sanchez Bayo and Wyckhuys 2019). Application to the same field each year leads to a buildup in soil. Ground nesting wild bees can be affected (see below) (Wood and Goulson 2017).

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Update

Crop Yields

Amazingly little has been published on the benefits of neonicotinoid seed treatments and crop yields. To some degree, effects are dependent on crop, climate, and insect challenge. When biocontrols are killed, seed treatments may actually lead to crop loss (Wood and Goulson 2017; Difonzo et al. 2015).

Generally, little effect is seen on late season pests. Yields may be improved when there is an extensive challenge from early season pests. But IPM methods could control these pests without the use of seed treatments. And there is some evidence that "pest resistance is increasing with increasing neonicotinoid use" (Hladik et al. 2018).

Major treated crops are corn and soybeans. Nearly 100% of U.S. corn seeds are treated with neonics (Hladik et al. 2018). About 34-44% of U.S. soybeans had neonic seed treatments in 2011 (Douglas and Tooker 2015). Crop seed treatments are generally unnecessary (see below).

Soybeans

An EPA review in 2014 found that neonicotinoid soybean seed treatments generally "provide negligible benefits to soybean production in most situations" (EPA 2014). Reviews by the Institute for Agriculture and Trade Policy (Kleinschmit and Lilliston 2015) and the Center for Food Safety (Stevens and Jenkins 2014) came to the same conclusion.

Other publications confirm the conclusions of these reviews. In a 2-year field study, IPM methods controlled soybean aphids, *Aphis glycines*, and led to yield increases, but thiamethoxam seed treatments did not (Krupke et al. 2017a). In Kentucky, imidacloprid seed treatments did not affect soybean yields and had no effect on pests (Penn and Dale 2017). In Pennsylvania neonicotinoid seed treatments travelled through the soil food chain, killing biocontrols and reducing soybean yields by 5% (Douglas et al. 2015).

Neonics did not consistently suppress pests in Iowa soybeans (Clifton et al 2018). Neonicotinoid seed treatment had no effect on soybean yields in South Dakota, did not protect against the soybean aphid, but disrupted biocontrols of nabis bugs and lacewings (Seagraves and Lundgren 2012). In a 3-year field experiment, neonic seed treatments had no effect on yields or herbivorous insects in corn and soybeans. Biocontrol was affected, as predators were killed soon after planting (Atwood et al. 2018).

Though imidacloprid and thiamethoxam suppressed soybean thrips, there was no significant effect on yield in North Carolina (Reisig et al. 2012). Soybean yields with thiamethoxam or imidacloprid were not significantly different from untreated controls in Nebraska (Magalhaes et al. 2009).

While independent publications generally show little effect on yields, a survey funded by Bayer, Syngenta, and Valent showed that farmers who used treated soybean seeds had 4% increased yields over those who used untreated seeds. Surveys of this type are subject to recall bias, and other crop protection methods that farmers might have used to increase yields were not part of the analysis (Hurley and Mitchell 2017).

Corn

Krupke et al. (2017a) found that neonic corn seed treatments affected honey bees and non-target organisms, but did not have a consistent effect on yields. Alford and Krupke (2018) suggest that neonic seed treatments in corn should be used only when stands are challenged by the corn rootworm, *Diabrotica* sp. The result would be lower cost and less insecticide resistance. Wilde et al. (2007) found that corn seed treatments were effective for early season pests. But no consistent effect on yields were noticed where "insects were not observed in damaging populations."

Sappington et al. (2018) found the treatments were effective for sporadic pests in corn, but these pests generally had little effect on yields. However, this was not true for all regions and all pests. Ding et al. (2018) found treatments stopped corn yield losses due to early season thrips. In Indiana, where the corn rootworm is a major pest, seed treatments increased yields by 8.7%, but IPM and other methods gave similar yield increases. The authors suggest using seed treatments in rotation with other methods to reduce pest resistance (Alford and Krupke 2018).

Corn field tests at 19 locations in Kansas found no significant effect on yields, but pest insect populations were low (Wilde et al. 2007). In the South, economically viable corn yield increases were seen in 8 of 14 years (North et al. 2018a).

Effect on Bees

The effect of corn and soybean neonicotinoid seed treatments on bees can be considerable. Krupke et al. (2017b) found that 42% of the State of Indiana was contaminated with residues from neonic corn seed. About 92% of Indiana bee foragers were exposed to residues from these treatments. Bee exposures, some of them lethal, were from 2.27 to 28 ng/bee. The oral lethal dose of the neonics imidacloprid, clothianidin, and thiamethoxam ranges from 1-5 ng/bee. The LD50 by contact is about 20-50 ng/bee (Hladik et al. 2018). [A nanogram (ng) is one-billionth of a gram.]

Bees are exposed to toxic dust from planting machines, to toxic crop pollen and nectar, to contaminated non-crop vegetation on field edges, and by contaminated water. Contact with planting dust can lead to large scale bee destruction (Krupke et al. 2012; Schaafsma et al. 2018). Where corn seed is treated, pollinator strips adjacent to the field and up to 140 m (460 ft) away accumulate clothianidin. Bee exposure leads to a concentration of 6 ppb in honey, and 41 ppb in bee bread, causing impaired bee nutrition (Mogren and Lundgren 2016).

Photo by Kathy Keatley Garvey

Honey bees, *Apis mellifera*, are exposed to toxic neonic dust from planting machines, to toxic pollen and nectar, to contaminated vegetation near crop fields, and to contaminated water. Bumble bees and other soil nesting bees are also at risk.

Health of both honey bees and wild bees can be affected by sublethal exposure. Sublethal effects of field realistic doses include impaired memory and learning, damaged immune systems, and reduced longevity. Honey bee colonies in treated corn fields can have higher levels of varroa mites and viruses (Goulson 2013; Alburaki et al. 2015; Alburaki et al. 2017).

Wild bees may feel more of an impact than honey bees. Soil residues can kill ground nesting bees. Bumble bees have reduced colony growth, and reduced numbers of queens (Hladik et al. 2018; Godfray et al. 2014; Wood and Goulson 2017).

Biocontrols

Seagraves and Lundgren (2012) found that neonic soybean seed treatments had little effect on pests such as soybean aphids, but significantly reduced numbers of generalist predators such as nabid bugs and adult lacewings, *Chrysoperla* sp. Soybean yields were not improved, and thiamethoxam reduced the beneficial predator population by 25%.

Seed treatments can kill ladybugs that supplement their diets by feeding on the developing plants. About 72% of *Harmonia axyridis* ladybug larvae on treated corn plants developed neurotoxic symptoms, and most of them died. Plants grown from clothianidin treated corn seeds killed 80% of the exposed larvae; thiamethoxam plants killed 53% (Moser and Obrycki 2009).

There was 100% mortality in 17 of 18 species of beneficial carabid ground beetles exposed to corn seedlings sprouted from neonicotinoid seeds. Ground beetles such as *Harpalus pensylvanicus* are predators of the corn rootworm and many other destructive pests (Mullin et al. 2005).

Thiamethoxam bean seed treatment led to increased damage and depressed yields, probably due to negative effects on biocontrols (Difonzo et al. 2015).

Birds

Neonicotinoids may be affecting seed eating birds. Birds may eat treated seeds, leading to death. One imidacloprid treated corn seed is enough to kill a bird (Mineau and Palmer 2013; Quarles 2014). Populations of the bobwhite, *Colinus virginianus*, are lower in areas of Texas where crops are being raised with neonicotinoid treated seeds. As neonicotinoid use goes up, bobwhite populations go down, in all regions surveyed (Erti et al. 2018).

Bird populations are also starving due to reduced numbers of insects. Neonics accumulate in soil, then wash out into ground and surface water. In the Netherlands, when water neonic concentrations exceeded 19 ng/liter, 14 of 15 insectivorous bird species studied had reduced populations (Hallmann et al. 2014). In the U.S. 23-75% of water samples in corn and soybean regions are contaminated with neonics. Maximum amounts range from 43 to 257 ng/liter. These concentrations are greater than those associated with bird decline in the Netherlands (Hladik et al. 2014).

Sunflowers and Canola

Other crops have seen little or no benefit from neonicotinoid treated seeds. Thiamethoxam seed treatments had no impact on pest numbers or yields in cultivated sunflowers (Bredeson and Lundgren 2015), but killed aboveground biocontrols and pollinators (Bredeson and Lundgren 2018).

In a UK survey 72% of growers opposed restrictions to neonicotinoid seed treatments in canola. Growers believed neonics were needed to manage the cabbage stem flea beetle (Zhang et al. 2017). But canola can compensate for up to 20% of flea beetle damage. When wheat and canola were intercropped in Canada, thiamethoxam seed treatments did not increase canola yields (Hummel et al. 2009). Neonic seed treatments gave no significant yield increase in canola despite a 10-week reduction in aphid populations (Dewar et al. 2011).

In Europe where neonicotinoid seed treatments are banned, yields of canola, sunflower and corn have remained at or above previous levels (Hladik et al. 2018).

Photo by Jonathan Lundgren courtesy USDA

Ground beetle predators, such as *Cyclotrachelus alternans* can be killed by exposure to neonicotinoid treated plants.

Photo by Scott Bauer courtesy USDA

Large numbers of lady beetles such as *Harmonia axyridis* can be killed.

Cotton

Neonic treated cotton seed are used to protect against thrips. But cotton thrips are getting resistant to neonics (D'Ambrosio et al. 2018). Strip till methods can reduce cotton thrips, but when cultivation is used, seed treatments and foliar sprays can provide higher yields (Lahiri et al. 2019).

In the South, neonicotinoid seed treatments in cotton were economically viable in 8 out of 15 years (North et al. 2018b). About half the time, seed treatments were unnecessary. When needed, IPM methods could have been used to protect the crop.

Sugarbeets, Rice, Beans

Seed treatments reduced root aphids in sugarbeets, but not enough to consistently increase yields (Pretorius et al. 2017). Because thiamethoxam seed treatments reduced populations of rice water weevils, *Lissorhoptrus* sp., yields were increased by 13% compared to no treatment (Lanka et al. 2017). But low rice seeding rates led to less control of the rice water weevil (Hamm et al. 2014). Neonic seeds can control infestations of Mexican bean beetles, *Epilachna varivestis*, and increase bean yields if invasion occurs within 2-3 weeks after planting, otherwise there is no effect (Nottingham et al. 2017). Thiamethoxam seed treatments reduced yields in Michigan dry bean crops, probably due to effects on biocontrols (Difonzo et al. 2015).

Wheat

There is more evidence for neonic seed effectiveness in wheat, but even here effects on yields are not consistent. Neonicotinoid seed treatments protected winter wheat against aphids. Yields were increased due to reduced pest damage (Zhang et al. 2016). Wheat was protected from aphids. Soil microbes were initially affected but recovered from transient damage (Li et al. 2018). Neonic seeds reduced aphids and increased yields by 5.3-7.2% in Tennessee wheat (Perkins et al. 2018). But neem sprays were economical and just as effective as imidacloprid for control of wheat aphids (Aziz et al. 2013).

Neonic wheat seeds controlled the wireworm *Limonius californicus*, but not *L. infuscatus*. Cultural methods were also needed to protect the crop (Esser et al. 2015).

In Canadian fields infested with white grubs, *Rhizotrogus majalis*, neonicotinoid seed treatments led to yield increases in winter wheat (Renkema et al. 2015).

Water Pollution

Overuse of neonicotinoids has led to extensive water contamination. Starner and Goh (2012) found imidacloprid in 89% of water samples taken from California rivers, creeks and agricultural drains. Concentrations exceeded EPA guidelines in 19% of the cases.

At least one neonic is found in 76% of agricultural water samples in the Midwest. Toxicity thresholds of aquatic organisms (35-200 ng/liter) are exceeded 74%-81% of the time (Hladik et al. 2018; Morrissey et al. 2015). [A nanogram (ng) is one-billionth of a gram.]

Neonic seeds are widely used in Canada, and residues are frequently detected in wetlands of the Canadian prairie pothole region (Main et al. 2014). Neonicotinoids drain into wetlands, killing aquatic insects and depriving birds and amphibians of food (Main et al. 2015).

Neonics may be involved in the drastic reduction of aquatic insect populations. Mayflies and caddis flies have seen a 68% population reduction. Fewer insects mean less food for birds, bats, and frogs. These populations have seen severe decline (Quarles 2019; Sanchez Bayo and Wykhuys 2019).

Human Exposure

Neonics are systemic and residues cannot be washed off the food we eat. Fruit and vegetable samples in the U.S. are contaminated 21-58% of the time. In North America, 86% of honey samples tested were contaminated. Neonicotinoids have low acute toxicity to mammals, but new research is finding that chronic exposure may cause endocrine disruption (Craddock et al. 2019). Neonicotinoids are not removed by standard water treatment methods and are found in drinking water in concentrations up to 57.3 ng/liter. Neonics can react with water treatment chemicals leading to new and possibly more toxic products (Klarich et al. 2017; Klarich et al. 2019; Wood and Goulson 2017).

Mitigation

If seed treatments are used, mitigation processes should be employed. Seeds should be properly treated with adhesives, modification of planting machines and no-till planting can reduce dust. Planting should be avoided on windy days and beekeepers should be alerted to planting dates. Prairie strips of vegetation can be used to stop neonicotinoid runoff into surface water in row cropped watersheds (Stoner 2015; Krupke et al. 2012; Hladik et al. 2017).

One sure way to mitigate effects of neonic seeds is to ban them. Neonics have been banned in European field crops, and a lawsuit by the Center for Food Safety recently forced the EPA to cancel registrations of 12 neonic products containing thiamethoxam and clothianidin. But nearly identical formulations remain available. And new pesticides, such as sulfoxaflor, that have similar effects on pollinators are being registered (Beyond Pesticides 2019).

Conclusion

Neonic seed treatments do not consistently increase crop yields, especially in soybeans and corn. IPM methods can give better results, often with less cost. Neonic treatments can lead to increased pest resistance, widespread pollution, impacts on pollinators and biocontrols, and widespread human exposure in food and drinking water. Since benefits are not outstanding, and destructive effects on wildlife are widespread, neonic seed treatments especially in corn and soybeans should be reduced or banned.

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Update

Is Agriculture Killing Whales?

By William Quarles

Application of synthetic fertilizers to U.S. crops is excessive and increasing. For instance, in the 6-year period between 2006 and 2012, fertilizer use in GMO soybeans increased by 50-70% (Quarles 2017). Storms and floods associated with climate change wash the fertilizers into surface water, then into the oceans. Estimated runoff into the Gulf of Mexico this year is 343 million pounds of nitrate, which is 18% above the historical average, and 55.7 million pounds of phosphate, which is 49% above the 38-year average (1980-2018). Nutrients cause explosive algae blooms. Algae blooms in the Gulf of Mexico are expected to reach a record 8,000 square miles this year. This is an area the size of Massachusetts (NOAA 2019a).

Large algae blooms are also found along the East and West coasts. Warming ocean temperatures associated with climate change encourage them and increase their toxicity (Zhu et al. 2017).

Ocean algae such as *Pseudo-nitzschia* secrete the toxins domoic acid and saxitoxin. These toxins are then concentrated by shellfish, anchovies and other aquatic creatures. Accumulated toxins have caused deaths of sea lions, pelicans and other seabirds. Whales have also been affected (Lefebvre et al. 2015).

There have been 70 "unusual mortality events" involving gray whales on the West Coast so far this year. This is six times the 18-year average (NOAA 2019b). The Atlantic right whale population is down to about 400 individuals. In July six of them died. Causes were either unknown or ship strikes, net entanglement or other encounters with humans (NYT 2019).

Photo courtesy Christin Khan and NOAA Fisheries

An Atlantic right whale mother and her calf are shown here. Atlantic right whales, *Eubalaena glacialis*, and other whale species are exposed during feeding to chronic doses of domoic acid.

North Atlantic right whales are exposed during feeding to small amounts of domoic acid over a six month period (Leandro et al. 2010). Humpback, blue, and gray whales are also exposed (Lefebrve et al. 2002; Lefebrve et al. 2015).

Domoic acid can destroy spatial memory and short term memory. Large exposures leave brain damage that is irreversible. But small chronic exposures can also cause neurological problems (Grattan et al. 2018).

Whales may be especially vulnerable due to deep ocean dives. During dives, whales are able to increase blood flow in the brain and lungs, while reducing flow in liver and kidneys. Under these circumstances, domoic acid can concentrate in the brain, while bypassing detoxification in the liver. Brain damage is cumulative and neurological problems may be leading to ship strikes, net entanglement, starvation and other mortality events (Lefebrve et al. 2002).

This is a grim picture, but fertilizer runoff can be mitigated by cover crops, strip-till production, and other techniques of regenerative agriculture (Quarles 2018).

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Trump's War on Pollinators

The Trump administration has declared war on bees and other insect pollinators. The pollinator friendly actions of the Obama administration are being reversed. For instance, Trump has restored neonicotinoid pesticide applications in wildlife refuges. Trump's EPA has also approved use of the bee killing insecticide sulfoxaflor on 13.6 million acres of crops.

Citing budget cuts, Trump's USDA has recently dropped the annual honey bee colony count. The annual count is necessary to provide critical information about honey bee colony health. Now, we will not know how many honey bee colonies are dying each year from pesticide misuse and other factors.

One consequence of dying pollinators is increased pollination costs. The USDA Cost of Pollination Survey has also been suspended.

If science is blindfolded through lack of funding, we do not know how bad the problem is, and political action is more difficult.

See "NASS suspends data collection for honey bee colony survey." July 1, 2019. https://www.nass.usda.gov/Newsroom/Notices/2019/07-01-2019.php.

Trump and GMO Deregulation

Donald Trump signed an executive order called "Modernizing the Regulatory Framework of Agricultural Biotechnology Products" on June 11, 2019. This Order is supposed to deregulate the agricultural biotechnology industry. In fact, the Order turns the U.S. government into a propaganda arm of the biotechnology industry.

For instance, Section 7 of the Order requires the government "facilitate engagement with consumers in order to build public confidence in, and acceptance of biotechnology in agriculture." Section 8 requires the government to "encourage international acceptance of biotechnology."

When making decisions based on science and technical evidence, the Order requires that economic considerations be given equal weight to possible hazards and other problems.

The Order requires that regulatory determinations be based on risk, but does not specify how risk should be determined. A key provision removes regulatory barriers to gene-edited plant products.

USDA Deregulates GMOs

The USDA has used the Executive Order to make a new Proposed Rule about genetic engineering. The Rule represents a major regulatory overhaul. One consequence is that biotechnology companies in some cases would be allowed to regulate their own products ("a self-determination").

Another big change is in the definition of GMO. Gene-editing uses enzymes and nucleic acid templates to modify genes. Problems with the technique include off-target genetic changes. Clearly, gene-editing is genetic modification, and the result is a genetically modified organism—a GMO.

In an Orwellian move, the Trump USDA has sidestepped this problem by changing the definition of genetic engineering. "We would define genetic engineering (GE) as techniques that use recombinant or synthetic nucleic acids to modify or create a genome." If gene-edited products are not genetically engineered by definition, companies may try to incorporate them into organic agriculture. The public is allowed to comment on the new Proposed Rule. (see https://www.aphis.usda.gov/brs/fedregister/BRS_20190606.pdf)

We have seen the results of Trump administration deregulation in two deadly airplane crashes where there was not sufficient government oversight in airplane manufacturing. We hope the USDA is not courting a similar disaster.

USDA Promotes GMOs in Organic Agriculture

GMOs are currently excluded from organic agriculture. According to the Cornucopia Institute, this may be changing. The USDA may intend to allow genetically engineered products in organic agriculture. An Assistant USDA Undersecretary recently testified before Congress that gene-edited crops should be used in organic production. There is considerable resistance to GMOs in the organic community, and the USDA may be fouling the Organic Brand. About 70% of consumers surveyed say they buy organic to avoid GMOs. (see Cornucopia Press Release, "GMO-friendly USDA Ogling Organic," https:www.cornucopia.org/2019/gmo-usda-ogling-organic/).

Trump EPA, Pyrethroids, and Children

The Food Quality Protection Act requires that an extra 10-fold safety factor be used if children are exposed to pesticides. This factor is needed because children and infants may metabolize pesticides differently, and their exposures may be higher due to their smaller bodies.

The Trump EPA has split the danger into two components: intrinsic toxicity and the detoxification rate. They have used "new data" to tweak the kinetic transformation models, and have concluded that pyrethroids should be equally toxic to both children and adults. As a result, the EPA has proposed to lower the pyrethroid safety factor to 1X. The public will be allowed to comment at EPA-HQ-OPP-2008-0331.

Conference Notes

ESA 2018 Meeting Highlights

By Joel Grossman

These Conference Highlights were selected from among 3,000 presentations at the Nov. 11-14, 2018 joint Annual Meeting of the Entomological Societies of America (ESA), Canada (ESC) & British Columbia (ESBC). The next ESA annual meeting is November 17-20, 2019 in St. Louis, Missouri. For more information contact the ESA (3 Park Place, Suite 307, Annapolis, MD 21401; 301/731-4535; http://www.entsoc.org).

Neonics Multiply Slugs

Although no-till farming may mean more slug damage, the advantages over tillage include prevention of massive soil erosion losses during heavy rains, thereby protecting water resources from pollution, said John Tooker (Penn State Univ, 501 ASI Bldg, University Park, PA 16802; tooker@psu.edu). Pennsylvania is "a no-till state," as 75% of soybeans and 65% of corn are no-tillage production. Pennsylvania farmers also extensively utilize preventive and insurance treatments, namely transgenic BT crops and neonicotinoid seed treatments against infrequent and sporadic pests. For instance, European corn borer, *Ostrinia nubilalis*, is historically low on Pennsylvania corn; fall armyworm, *Spodoptera frugiperda*, is infrequent; western corn rootworm, *Diabrotica virgifera virgifera*, is still stopped by crop rotations; corn earworm, *Helicoverpa zea*, is not a problem; wireworms, grubs and aphids are occasional pests.

But preventive treatments have food chain consequences: slugs survive neonicotinoid seed treatments, and predators eating poisoned slugs are killed, leading to higher slug populations. Neonicotinoid seed treatments and pyrethroid sprays can reduce beneficial insect populations by 20%. To avoid this, Tooker advocates a return to IPM.

Growers are increasingly hiring grad students to scout fields. Corn and soybean fields with slugs and occasional wireworms have the greatest pest problems, but IPM with conservation biocontrol protects slug predators such as ground beetles and wolf spiders. "IPM seems to be a reasonable alternative," said Tooker. "The Pennsylvania No-Till Alliance, Farmers Improving Soil Health," has adopted IPM, because without insecticides soil biota diversity and functional abilities increase.

Excess Nitrogen Impairs Biocontrol

Nitrogen (N) fertilizer pumped into rice production has "once again" turned brown planthopper (BPH), *Nilaparvata lugens*, into "a major pest threatening the sustainability of rice production in Asia" by impairing the ability of natural enemies to provide biocontrol, said Pingyang Zhu (Jinhua Plant Protection Stn, Jinhua 321017, China; zpy85@163.com). Although important for productivity, N fertilizer "is costly and can be polluting," and "in rice has been considered a crucial trigger in shifting rice planthoppers from minor to major pests in Asia." Heavy application of N fertilizer impairs natural enemy performance by at least two distinct mechanisms: 1) changed foliage reflectance of light impairs the host-finding ability of gravid parasitoids, particularly the key egg parasitoid, *Anagrus flaveolus*; 2) "both parasitoids and predators exhibited greater handling times and reduced daily consumption when feeding on plants with high N regimes, so dampening their ability to check pest buildups."

Predators with reduced searching efficiency and reduced prey consumption on high N plants included *Cyrtorhinus lividipennis* (Miridae), a specialist in dining on BPH eggs and young nymphs; and generalist predators like the wolf spider, *Pardosa pseudoannulata*. This "highlights the need to moderate the global use of N fertilizers in order to maintain effective biological control of pests and thereby reduce dependence on insecticides," said Zhu. It also "opens a new dimension for the effects of nitrogen in crops," and invites inquiry into how this might generalize for IPM in other cropping systems.

Easy *Drosophila* Traps

"Early detection of spotted wing drosophila (SWD), *Drosophila suzukii*, adult flies is necessary for growers to accurately time insecticide applications and predict fruit infestation," said Kevin Cloonan (Rutgers, 125a Lake Oswego, Chatsworth, NJ 08019; raynecloonan@gmail.com). "Commercially available traps rely on non-selective volatiles hung over liquid drowning solutions and can be difficult to handle in a field setting." IPM programs need SWD traps that are more user friendly, and that account for crop and regional differences in when the first SWD are caught.

Standard liquid traps and dry red panel sticky traps, unbaited or with commercially available Scentry lures, were compared in New Jersey, New York, Maine, North Carolina and Oregon blueberry, raspberry and blackberry fields. "First captures of *D. suzukii* did not differ statistically between Scentry-baited liquid and dry traps in all states except for New York," said Cloonan. In New York, fruit was infested a week before dry red panel sticky traps captured the first SWD. In New Jersey and Maine, liquid baited traps captured the first SWD adults a week earlier than dry red panel traps. Outside New York, dry red panel traps are sufficient to detect SWD before fruit is infested.

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Monarch Butterfly Waystations

Monarch Waystations, small urban and suburban monarchic-centric butterfly gardens networked across the landscape, provide connectivity and "restore enough milkweed, *Asclepias* spp., to sustain the eastern migratory monarch butterfly, *Danaus plexippus*," said Adam Baker (Univ Kentucky, S-225 Ag Sci North, Lexington, KY 40546; heresadamb@uky.edu). By Sept. 2018, 22,000 Monarch Waystations with milkweed plants for monarch caterpillars and nectar plants for adult butterflies were registered with MonarchWatch. Monarch friendly gardens, along with USA Midwest and Great Plains roadsides and conservation reserve farmland milkweed plantings, help mitigate monarch habitat loss to agricultural intensification and urbanization.

All eight milkweed species tested supported similar caterpillar growth. But taller broad-leaved milkweeds support more monarch eggs and larvae. For small butterfly gardens, "stay put" milkweeds are recommended over aggressively tillering milkweeds. Garden design is also important. "Placing milkweeds around the perimeter (with nectar plants in the center) resulted in 2-3 fold more monarch eggs and larvae," said Baker. Reduced vegetation around milkweeds increased monarch egg laying. The goal is "to *increase* colonization by a specialist herbivore, while reducing impact of natural enemies." This is the reverse of conservation biocontrol, which uses mixed plantings to attract predators and parasitoids and camouflage host plants. The same principle works with other diurnal specialist butterflies such as swallowtails, which also "more readily locate host plants when surrounding vegetation is removed."

Ozone Rain Zaps *Drosophila*

Ozone (O_3) is well known as a fumigant against stored product insect pests and pathogens, but dissolving ozone in purified distilled water as an aqueous pesticidal spray against spotted wing drosophila (SWD), *Drosophila suzukii*, is a new IPM technique, said Benjamin Savage (Michigan State Univ, 578 Wilson Rd Rm B11, East Lansing, MI 48824; savagebe@msu.edu). Ozone is valued for its "high oxidative potential and biocidal characteristics," and soft-bodied SWD are highly susceptible to environmental challenges. Distilled water was used, because water without impurities reaches higher concentrations of dissolved O_3.

Ozonated water at 0, 5, 10 and 20 ppm (parts per million) was sprayed on SWD from a potter spray tower at 25°C (77°F) and 75% relative humidity. SWD mortality was 100% and instantaneous at 20 ppm dissolved O_3. At 0, 5 and 10 ppm dissolved O_3, SWD mortality was zero. The paradigm of less than a second for lethality with dissolved O_3 is very different than for most pesticide sprays, where chemicals reach targets after carrier evaporation and lethality is not instantaneous. No sublethal O_3 effects over time have been observed, though studies are looking for delayed effects on SWD fecundity and egg laying.

Submerging adult SWD in ozonated distilled water had no effect on male or female attraction to wine lures ("known semiochemical attractants"), indicating odor receptors were unaffected. Ways to increase ozone perfusion into SWD tissues are being explored. "We hypothesized that higher concentrations of (aqueous) dissolved ozone combined with longer exposure duration will yield higher mortality rates as well as intensify sub-lethal effects," said Savage. In agricultural settings, ozonated water is being applied with fruit crop air blast sprayers.

Orius for Thrips Biocontrol

In Taiwan, *Orius strigicollis* (Anthocoridae), a pirate bug providing biological control of *Frankliniella intonsa*, an important thrips pest of horticultural crops, is being mass reared on various hosts for potential use in biocontrol programs against thrips, mites and other arthropod pests, said Shu-Jen Tuan (National Chung Hsing Univ, 250 Kuo-Kwang Rd, Taichung 402, Taiwan; sjtuan@dragon.nchu.edu.tw). During its lifetime, one adult pirate bug eats 107 thrips; one pre-adult pirate bug eats 60 thrips. Thus, releasing adult pirate bugs "offers the most promising control efficacy."

Citrus Root Weevil EPN

Citrus root weevil, *Diaprepes abbreviatus*, larvae feed on plant roots, and can cause severe damage and allow entry of plant pathogens, said Diana Londoño (BASF Corp, Durham, NC 27709; diana.londono@basf.com). Adult D. *abbreviatus* emerge from the soil in spring and again during Florida's late summer rainy months. *Steinernema riobrave*, an entomopathogenic nematode (EPN) formulated in an easy-use water dispersible gel as Nemasys®, is "produced in industrial scale exclusively by BASF" via liquid fermentation in Littlehampton, UK.

The EPN uses cues such as CO_2 to locate and enter natural openings in root weevil larvae. "Once inside the host, the nematodes release entomopathogenic bacteria that are carried in a receptacle in the nematode intestine, causing the death of the weevil larvae by septicemia, normally 3-5 days after nematode application," said Londoño. "Between 70-90% control of weevil larvae is generally achieved in Florida's citrus groves when following the recommended label rates of Nemasys." Nematodes "fit very well in IPM programs," being compatible with many chemicals and biologicals and without residue problems.

UV-C Destroys Mites & Insects

Nightly 60-second bursts of ultraviolet-C (UV-C) light are standard in plant pathology to stop fungal plant pathogens such as Botrytis (grey mold) and powdery mildew, and 15 seconds of UV-C light at night can stop mite and insect

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pests, said Brent Short (USDA-ARS, 2217 Wiltshire Rd, Kearneysville, WV 25430; brent.short@ars.usda.gov). "No phytotoxic effects were observed on UV-C irradiated plants" from short duration nightly UV-C bursts. However, fungal pathogen DNA repair mechanisms are not active at night; so fungal UV-C injuries are not repaired.

In potted strawberry experiments with 100 (50:50, adult:immature) two-spotted spider mites, *Tetranychus urticae*, and four weeks of nightly 60-second UV-C doses: *T. urticae* levels dropped to near 0, well below the economic threshold of 5 mites/leaf. In contrast, untreated control plants had 200 mites/leaf, and the strawberry plants died.

In tomato experiments with 20 greenhouse whiteflies, *Trialeurodes vaporariorum*, per plant and 15 seconds of UV-C light (standard doses) per night for six weeks: adult and nymph whiteflies rapidly declined. However, longer exposure periods resulted in tomato leaf deformities.

In "on-off" experiments switching between light and dark, strawberries were also subjected to 15-second nightly UV-C exposures. Twenty mature female spotted wing drosophila (SWD), *Drosophila suzukii*, were released per plant, and three berries were hung on each plant. With UV-C exposure, SWD emerged from only 1 of 48 infested fruit. Longer term effects on strawberry plants are not known. Further experiments are being conducted with aphids, thrips and varying UV-C doses and frequencies.

Essential Oil Mosquito Synergists

Plant essential oils synergize synthetic pyrethroids such as permethrin, which is used in controlling mosquitoes such as the malaria vector *Anopheles gambiae*, said Edmund Norris (Iowa State Univ, 112 Insectary Bldg, Ames, IA 50011; ejnorris@iastate.edu). Essential oils can interfere with detoxification enzymes such as monooxygenases and glutathione S-transferases. Candidate essential oils (5%) include clove leaf and bud oils, patchouli, basil, oregano and geranium.

"Plant essential oils are capable of enhancing diverse synthetic pyrethroids for multiple mosquito species," including insecticide-resistant species, said Norris. "A majority of plant essential oils enhanced permethrin as well as piperonyl butoxide (PBO)," a widely used pesticide synergist.

Infected Mosquitoes Resist Repellents

Aedes aegypti and *Aedes albopictus* mosquitoes infected with viruses such as Zika and La Crosse are more likely to land, probe and blood feed on surfaces treated with low levels of common repellents, said Kevin Chan (Virginia Polytech, 216A Price Hall, Blacksburg, VA 24061; kchan90@vt.edu). Repellents evaluated included DEET, picaridin and oil of lemon eucalyptus (p-menthane-3,8-diol, or PMD). "Infected mosquitoes are less sensitive to low concentrations of repellents and concentrations of at least 10% are able to provide better protection against Zika virus and La Crosse virus-infected *Aedes albopictus*."

Mesh Soil Weevil Traps

Modified square trap nets (MSTN) made of nylon netting were developed "for entangling and immobilizing soil-emerging weevils in order to reduce their impact," said Kailang Yang (Beijing Forestry Univ, 35 Tsinghua East Rd, Haidian Dist, Beijing 100083, China; yangkl0423@163.com). MSTN, "an environmentally-friendly simple tool," were successful against "one of the most damaging forestry pests in China," the weevil *Eucryptorrhynchus scrobiculatus*, whose larvae destroy roots, weaken and even kill tree of heaven, *Ailanthus altissima*. Weevil adults escape from the soil, climb the tree, and later in the season climb back down the tree.

"Nets were 2 × 2 m (6.6 x 6.6 ft) with a reinforced border and a Velcro-closable, radial slit which

Calendar

June 18-June 21, 2019. PCOC Annual Expo, Carlsbad, CA. Contact: PCOC, 3031 Beacon Blvd., W. Sacramento, CA 95691; www.pcoc.org

July 28-31, 2019. 74th Annual Meeting Soil Water Conservation Society. Pittsburg, PA. Contact: www.swcs.org/19AC

August 3-7, 2019. American Phytopathological Society Conference, Cleveland, OH. Contact: APS, 3340 Pilot Knob Road, St. Paul, MN 55121; 651-454-7250; aps@scisoc.org

August 11-16, 2019. 104th Annual Conference, Ecological Society of America, Louisville, KY. Contact: ESA, www.esa.org

October 15-18, 2019. NPMA Pest World, San Diego Conference Center, San Diego, CA. Contact: NPMA, www.npmapestworld.org

October 15-18, 2019. California Invasive Plant Council Symposium. Riverside, CA. Contact: California Invasive Plant Council, 1442 Walnut St., No. 462, Berkeley, CA 94709. www.cal-ipc.org

November 10-13, 2019. Annual Meeting, Crop Science Society of America. San Antonio, TX. Contact: https://www.crops.org

November 10-13, 2019. Annual Meeting, American Society of Agronomy. San Antonio, TX. https://www.acsmeetings.org

November 10-13, 2019. Annual Meeting, Soil Science Society of America. San Antonio, TX. Contact: www.soils.org

November 17-20, 2019. Annual Meeting, Entomological Society of America, St. Louis, MO. Contact: ESA, 9301 Annapolis Rd., Lanham, MD 20706; www.entsoc.org

November 20-22, 2019. Association of Applied Insect Ecologists. Visalia Convention Center, Visalia, CA. Contact: www.aaie.net

January 22-25, 2020. 40th Annual Eco-Farm Conference. Asilomar, Pacific Grove, CA. Contact: Ecological Farming Association, 831/763-2111; info@eco-farm.org

February 27-29, 2020. 31st Annual Moses Organic Farm Conference. La Crosse, WI. Contact: Moses, PO Box 339, Spring Valley, WI 54767; 715/778-5775; www.mosesorganic.org

March 2-5, 2020. Annual Meeting Weed Science Society of America. Maui, HI. Contact: www.wssa.net

March 15-18, 2021. 10th International IPM Symposium. Denver, CO. Contact: https://ipmsymposium.org allowed the net to be arranged around the base of the tree while producing an unbroken barrier beneath the soil surface," said Yang. Also useful in mark-release-recapture experiments, MSTN netting is available in 11 mesh sizes. The small mesh, 5-7 mm (0.2-0.3 in), captured significantly more *E. scrobiculatus* emerging from the soil than the larger 9-11 mm (0.35-0.43 in) mesh. MSTN trials against other pests are ongoing, and "there could be potential application to control other pests" (e.g. plum curculio) emerging from the soil as adults.

Fire Ant Baits

Red imported fire ant (RIFA), *Solenopsis invicta*, a well-known stinging pest in the southern USA, is spreading in California's Los Angeles, Orange and Riverside Counties, particularly on irrigated lawns, said Siavash Taravati (UCCE-Los Angeles, 700 W Main St, Alhambra, CA 91801; staravati@ucanr.edu). RIFA can be monitored by counting foraging ants, as there are not ant mounds on irrigated lawns. No long-term means of elimination is known, but granular baits provide some relief in the southern states.

Baiting a 9 meter (30 ft) circle with 1% boric acid in a 25% sucrose solution was tested in southern California. Bait containers, which had a small hole (keeps out water), were buried so children could neither see nor access. However, RIFA recover quickly, and the boric acid treatment was repeated 42 times. Indoxacarb was more effective.

Volatile compounds released by "quorum sensing" bacteria such as Proteus mirabilis can be used in IPM programs for red imported fire ant (RIFA), *Solenopsis invicta*, either as repellents to protect vulnerable electrical equipment or as bait attractants, said Robert Puckett (Texas A&M Univ, 2556 F&B Rd, College Station, TX 77840; rpuck@tamu.edu). Quorum sensing bacteria use volatile compounds for cell to cell signaling, triggering gene expression in populations, and microbe-host communications. For example, both ants and flies hone in on microbial signals indicating food sources are ready.

Microbial signals repellent to RIFA can be impregnated into gel plastics to keep the ants out of air conditioning and electrical systems. In lab arena trials with starved (24 hrs without food) ants, 5 nanograms of indole, a microbial signaling compound attractive to RIFA, boosted recruitment to granular Advion® (indoxacarb) fire ant bait. To recruit other ant species, indole and intoxicants are being impregnated into a malleable, sugar-based biodegradable polymer bait matrix called Sugar Plastics™.

Essential Oils vs Bed Bugs

Since the essential oils thymol, carvacrol and eugenol individually have "neuroinhibitory impacts on bed bugs," different ratio mixtures of all 3 were tested and shown to interact synergistically, said Sudip Gaire (Purdue Univ, 901 West State St, West Lafayette, IN 47907; sgaire@purdue.edu). "Synergistic interactions between the compounds are proposed to be caused by pharmacokinetic factors that lead to changes in their solubility and spreadability." Interestingly, "the positive control mixture of bifenthrin and imidacloprid also showed synergism in bioassay and neurophysiology experiments." However, the three essential oils inhibited the bed bug nervous system, whereas bifenthrin and imidacloprid were neuroexcitatory. Bed bug IPM programs can use target site and neurological effects information when mixing compounds.


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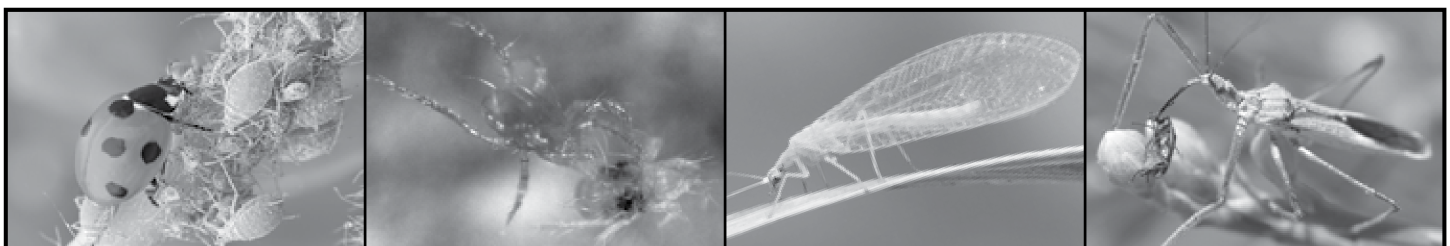

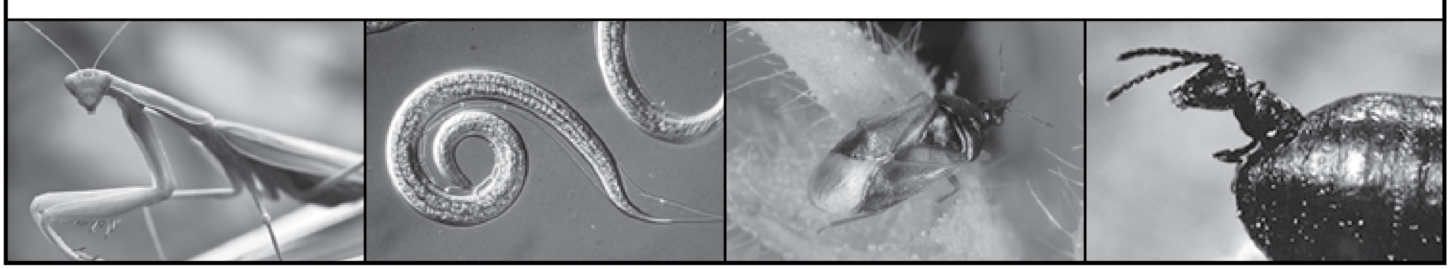

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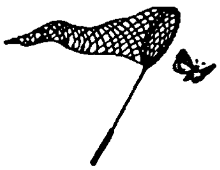
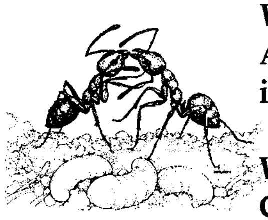


Classified Ads



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