Integrated pest management can still deliver on its promise, with help from the bees

Rufus Isaacs[a,b,1]

Farmers must juggle a myriad of decisions for their farms to be economically and environmentally sustainable. Doing this over successive growing seasons requires keeping pest populations below thresholds to avoid significant yield loss (1). Control programs to prevent these losses from pests can include crop rotation, resistant crops, biological controls, and insecticides targeting pests that may also kill natural enemies and pollinators (2, 3). In crops where pollination is needed, such as most fruits and vegetables, it is important to conserve the insects that visit flowers, including bees, hoverflies, and beetles, since they move pollen and enhance yields (4, 5). However, these insects are at risk from exposure to pesticides, with particular concern raised in recent years about field crop systems where there has been widespread adoption of seeds treated with neonicotinoid insecticides (6). With almost all corn seed treated with pesticides, it is worth asking whether the integrated pest management (IPM) approaches developed in the 1950s (7) remain relevant to modern-day agriculture and the current challenges of balancing pest control and pollinator conservation. In PNAS, Pecenka et al. (8) show that, for the corn–watermelon rotation system they study, the adoption of IPM can reduce costs and pesticide residues by reducing insecticides by 95%, limiting pest populations despite this savings in pesticide use, enhancing wild bees, and increasing crop yields. This is a powerful case study in integrated pest and pollinator management (IPPM) which has been proposed as a more holistic way to consider economically important insects in bee-pollinated crops (9, 10).

Is IPM Still Relevant?

Pests have robbed crop yields since the dawn of agriculture, and they continue to limit food and fiber production (11). Synthetic insecticides were developed in the 1950s to prevent this damage, but negative effects on the environment and human toxicity led to greater regulation and the development of IPM which promoted nonchemical approaches and pesticide use only when economically justified (12). As agriculture and the world around it have changed, this concept has continued to be updated to incorporate sustainability as well as social and business contexts (13). However, the expansion of genetically modified crops and insecticide-treated seeds has led some to question whether IPM is still relevant (14).

Over the past two decades, there has been a transition of insecticide use in the United States to neonicotinoids (15), resulting in a ninefold increase in the potential risk to pollinators (16). With such widespread use, various environmental fate studies have found negative effects of neonicotinoid use in field crops on pollinators. These have documented off-target aerial drift of planting dust into nearby foraging areas for honey bees (17), neonicotinoids in bee diets associated with weed flowers in habitats adjacent to treated crops (18), and field margins having detectable neonicotinoid residues with fewer species of generalist bees (19).

Implications of IPPM in a Maize-Watermelon Crop Rotation

Crop management approaches that reduce neonicotinoid use may support wild bees and their pollination services to agriculture. Pecenka et al. (8) use research stations across Indiana to explore a rotation system of corn and watermelon without using these insecticides over four growing seasons. They explore whether removing the seed treatments and only spraying the watermelon plants when needed would save money, maintain pest populations below economic thresholds, and allow pollinators to visit the watermelon flowers. By combining field sampling of insects with

[a]Department of Entomology, Michigan State University, East Lansing, MI 48824; and [b]Program in Ecology, Evolution, and Behavior, Michigan State University, East Lansing, MI 48824

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[1]Email: isaacsr@msu.edu.

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measurements of the treatment costs and crop yields, this team has gained important insights into the entomological and economic implications of adopting IPPM for the corn–watermelon system in the US Midwest region.

The team studied paired sites with conventional management (thiamethoxam-treated corn seeds and imidacloprid-treated watermelon seeds coupled with calendar-based insecticides applied to watermelon) compared with an IPM-based approach of untreated corn and watermelon seeds, and making treatments to watermelon only if sampling for insect pests revealed a need. Over the first three growing seasons, corn plants in both treatments had similar stands with very little damage from western corn rootworm, but there was some increased root damage in year 4 in the IPM treatments. Corn yields were similar in both treatments, providing no evidence of untreated plants being vulnerable to pest attack, in agreement with other studies showing limited benefit of prophylactic seed treatments for pest control (20). While pest populations could build over time with continuous corn–watermelon rotation, farmers also have access to crop rotation with soybean and pest-resistant maize plants. Still, the results here indicated no pest outbreaks despite using untreated corn seed for a few years.

Insecticide-treated seeds have previously been shown to reduce wild bee nesting, growth, and reproduction, for example, in canola in Sweden that was studied in one growing season (21). The present study covers multiple crop rotations, with the IPM program fields needing only four treatments for striped cucumber beetles compared with 77 treatments in all the watermelon fields under standard management. Secondary pests were controlled by natural enemies and did not require sprays in the IPM plots. The largest economic benefit came from the response of pollinators to the IPM program, with a 26% jump in yields in watermelon fields managed this way. Wild bees were twice as abundant in these fields as in the standard fields, translating into more than twice as many flower visits, including the important movement from male to female flowers that were 3 times as common. In future studies, it would be interesting to tease apart the relative importance of stopping using neonicotinoid seed treatments, which reduce nesting by bees as shown in recent studies of hoary squash bees (22), versus the greatly reduced foliar application of insecticides (which can reduce activity of adult bees foraging on watermelon flowers).

Beyond the response of insects reported in PNAS by Pecenka et al. (8), the study also demonstrates that the IPM program reduces neonicotinoid residues in soil and in plant tissues, including pollen and nectar collected from the IPM-managed fields. Their economic analysis of the insecticide inputs and revenue from yields also makes a compelling case for IPM adoption. First, the cost of the neonicotinoid seed treatments was not recouped for any of the studied fields in any of the years. Secondly, average insecticide costs dropped from $100.98 per hectare in the watermelon fields managed with the conventional program to $3.35 per hectare in the IPM program, and the conventional fields never recouped the value of those applications from changes in yield. Lastly, the 26% increase in watermelon yield in IPM program fields was worth $4,513 per hectare, a very significant increase in revenue.

Towards IPPM Adoption

As mentioned above, IPM systems are more knowledge intensive and require regular sampling to know whether pest populations require treatment (12). Training in IPM programs can transfer research-based information to farmers, extension educators, crop consultants, and others to implement need-based pesticide applications. This will take a commitment to using research-based information to guide crop management decisions, but the benefits seem clear from the Pecenka et al. (8) study in PNAS. These results should stimulate discussions among various groups related to field crop agriculture. For growers who produce corn and watermelons (or other seed-treated crops and other pollinator-dependent crops), the results beg the question: Why are seed treatments being used so widely if they reduce (or at least do not increase) revenue? For applied entomologists, this study provides an example of how to measure the biological, chemical, and economic implications of transitioning crop systems back to an information-based pest management system, adding to the examples of where an IPPM approach can balance farm profits while also conserving pollinators (10, 23).

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