Fungus for managing wireworms on spring wheat in Golden Triangle region of Montana

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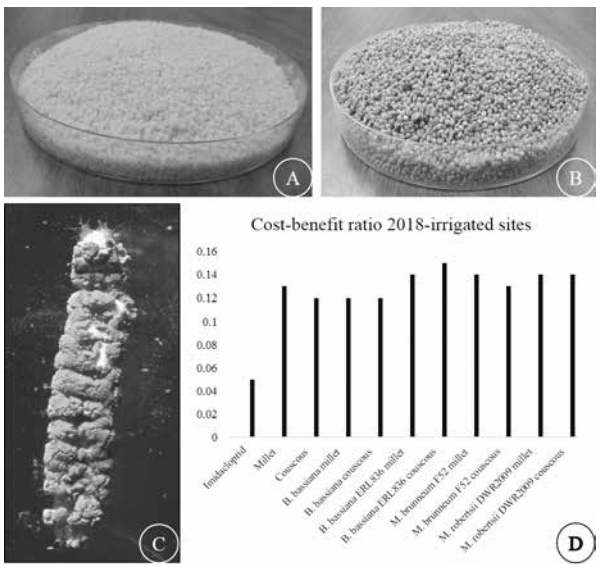

Figure 1: A. Entomopathogenic fungus granules on culinary couscous, B. Entomopathogenic fungus granules on millet carrier. C. Wireworm infested with *Metarhizium robertsii* DWR2009 millet. D. Cost-benefit ratio of fungal treatments used in 2018 in irrigated wheat sites.

Grain production holds an important status for the economics of Montana. Invasive and endemic insect pest infestations can cause a major setback to grain production quality and quantity. One of the major insect pests are wireworms. Wireworms are larvae of click beetles and live beneath the ground, feed on germinating seeds, roots and young seedlings, and cause significant loss to wheat and barley production in Montana. Due to reoccurring patchy damage, it is hard to assess the damage level. There are close to 200 species of wireworms in North America, but in Golden Triangle Area of Montana, three species are predominant, *Limonius californicus*, *Hypnoidus bicolor*, and *Aeolus mellillus*. In the soil, some species have a 2 year life cycle and some have a life cycle of 6-7 years. This discrepancy in life styles makes the assessment and management of wireworms complicated. Wireworms move deep into the soil to avoid harsh winter of Montana. During the spring they come close to the soil surface to feed. In a heavily infested site, they can be found at 4-8 inches depth in the spring. At present neonicotinoid seed treatment (such as imidacloprid) is used to control wireworm infestation. The seed treatment only provides a temporary control, by only repelling the wireworms not killing them and it can also pose an environmental hazard. Since 2012, Western Triangle Agricultural Research Center (WTARC), entomologists have been studying environmentally friendly strategies to manage wireworms in Montana in spring wheat with cooperation from the USDA Northern Plains Ag Research Laboratory in Sidney. At this center, we are presently working on cultural and biological control methods. As cultural control, we are studying the use of attractive 'trap crops' which can divert wireworms away from the spring wheat. For biological control strategies, we are researching the effectiveness of insect-pathogenic fungus (Entomopathogenic Fungi-EPF) and nematodes (predatory nematodes). To generate reliable results, we conduct both field trials and laboratory experiments.

In 2014, three strains of *Metarhizium* (*M. brunneum* F52, *M. robertsii* DWR 346) and *Beauveria bassiana* GHA were found effective by WTARC and USDA when they were applied as granules in furrow compared to seed-coating against three wireworm species of this region. In 2015–2016, the combination of *Metarhizium* and *Beauveria* and combination of fungus with imidacloprid provided significant control of wireworms.

In 2017 and 2018, we tested fungus granules at different rates and different carriers. Millet, polenta (coarse ground corn), and couscous (balls of crushed durum wheat semolina) were used as the carriers. The fungi were grown on millet, so that it served both as food for the fungus in mass production and a subsequent carrier. Fungus spores were simply adhered to the other two types. The carrier on which the fungus is deposited provides a nutritional base to the fungus, allowing it to reproduce in the soil after application and creating a mass of infectious spores around each granule making it an "entomological IED" (entomological improvised explosive device), and the granules can also attract the insect potentially increasing its efficacy. Selection of carrier for fungus formulations depends on the availability, price, and efficiency of the carrier. In 2017, we applied fungus granules at two irrigated locations, *B. bassiana* GHA on polenta, two others on polenta or millet, at two different rates (*M. robertsii* DWR356 and *M. robertsii* DWR2009), i.e. 10 lb/acre and 20 lb/acre. A higher yield was observed with one fungus (*M. robertsii)* on both polenta and millet at the higher rate at one of two sites, compared to no treatment. In 2018, we tested millet and couscous alone along with four fungi on millet or couscous, but only at the 10 lb/acre rate (*B. bassiana, B. bassiana* ERL836, *M. brunneum* F52, *M. robertsii* DWR2009) at two irrigated and two dryland fields. In the irrigated sites *B. bassiana* GHA on millet and couscous performed comparably to imidacloprid and better than other fungus treatments. At non-irrigated sites, however, one fungus on millet and a second on both millet and couscous carriers (*B. bassiana* ERL836 on millet, *M. robertsii* DWR2009 on millet and couscous) gave greater yield compared to the other fungus treatments and equivalent to imidacloprid.

We have also calculated the cost-benefit ratio, for both years. To do this, the cost of the material was calculated per acre. Cost included the cost of seeds (certified Duclair), fertilizers (potash, urea, and monoammonium phosphate), herbicides (RT3® glyphosate), conventional insecticide (imidacloprid), cost of irrigation, and cost of entomopathogenic fungus. Cost of EPF granules was estimated at $5 per pound based on the commercial experience. For calculating the benefit, the market rate of Duclair wheat at the rate of $5.50 per bushel was considered for January 2019 price for spring wheat with 14% protein. The cost-benefit ratio in 2017 was lower for lower rates (10 lb/acre). In 2018 only lower rates were used and the cost-benefit ratio was lower for irrigated fields compared to non-irrigated sites. At irrigated sites, millet, couscous, one of the fungi on millet and couscous yielded greater benefit. At non-irrigated sites, one fungus on millet and a second on millet and couscous generated more benefit. Millet on which the fungi were grown worked better than the other carriers, which is convenient because millet can be used to commercially produce these fungi.

Efficacy of these fungi can be affected by soil moisture and temperature. Soil moisture of 80–100% and temperature 30ºC are considered best for increasing efficacy of the fungi. In our 2017 study soil moisture remained high (55–80%) but temperature remained less than favorable temperature

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Mason bees go to work early in the season before honey bees emerge

By Kym Pokorny, Oregon State University

For mason bees, the wait for their first meal is a long one, nine months or more while they wait for the day to emerge, sun themselves a bit and fly off for an awaited meal.

There's no TV, no smartphone, not even a book to while away the time as these solitary bees hang out in their tight cocoons waiting for the cool temperatures of early spring to break them out of lethargy.

And because honeybees and other pollinators haven't made an appearance yet, there's more sweetness for the native mason bees.

"Mason bees fill a spot in the season when other pollinators like honeybees are not out," said Brooke Edmunds, a horticulturist with Oregon State University (OSU) Extension Service. "They're really important for fruit trees, especially in cool, wet areas."

After emerging in March, the small, bluish bees start foraging for food for the next generation and combing for suitable nesting sites.

"They're solitary, non-aggressive bees, so they're very different from honeybees; they don't form hives," said Edmunds, author of the OSU Extension publication Nurturing Mason Bees in Your Backyard in Western Oregon.

Instead, mason bees, most commonly the native blue orchard mason bee (*Osmia lignaria*), look for cracks and crevices that fit their need for small spaces where they crawl in and lay eggs. They might find the appropriate spots in wood bored by other insects, siding on buildings or nesting blocks filled with tubes containing cocoons.

Gardeners can purchase tubes of cocoons containing adult bees. Keep them in the refrigerator until the weather is appropriate and sufficient food is available. Keep an eye out on the forecast and wait for a dry period and three days of temperatures between 50 and 55 degrees before placing them outside. Also, be aware of what's blooming, starting with willow and big leaf maple, followed by other early-bloomers like fruit trees. Since the bees need a continuous source of food make sure there will be something blooming throughout their three-month lifespan.

You can get elaborate and remove the cocoons each fall, clean them of frass and mites, store them in the refrigerator over winter and reinsert them in the tubes in spring. Or choose the easy way: Hang the tubes and wait for the bees to find them and lay their eggs. Or you can buy new cocoons each year. Instructions for each method are included in Edmunds' guide.

For protection against predators, keep loose cocoons in a small cardboard box or tube with a hole just big enough for the bees to fit through. Then, gently place the container in the "attic" portion of the nesting house, which is the open area above the nesting block. Hang the nest box out in the yard, preferably in morning sun under an eave so that it's sheltered from rain and wind.

The mason bee's preferred food comes from early-blooming fruit trees like apples, pears, plums and cherries. So, plant one or two to attract them to your garden to pollinate other plants. If you've got a small lot, choose columnar or dwarf cultivars.

Though not as dear to the bee's palate, other plants also attract them. Look to crabapples, flowering currant, elderberry, huckleberry, forsythia, Pieris and Oregon grape. They'll head straight for dandelion, Edmunds said, which are in good supply in spring.

Since mason bees travel only short distances, about 200 to 300 feet, their favorite plants need to be planted near nesting spots or away they'll go. You'll also need to provide small patches of clay mud, something in abundance in the Willamette Valley. But if you've covered your soil with mulch, it's a good idea to push away a little bit to create a mud pool for them. If the soil dries out, give it a misting. Alternately, put a tray out and fill it with moist clay soil.

The female mason bees use the clay soil to wall up their eggs, which are deposited in the tubes or crevices with nectar and pollen they've rolled into little balls, Edmunds explained. They'll continue to alternate wall, food, egg and wall until they come to the end of the tube or crevice and then close it up for the next nine months. The eggs develop into small larva that spin cocoons where the adults form. Come spring, the adults break through the cocoon, chew through the clay and fly out to start the process again.

In their short life, these single-minded bees do an important job for gardeners. Most significantly they efficiently pollinate prized fruit trees, giving a markedly increased yield. But consider a more altruistic reason, Edmunds said. Mason bees, like other beneficial insects, help diversify the garden, leading to a healthier backyard ecosystem, healthier humans and a healthier planet.

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(15–20ºC). In 2018, the soil temperatures were higher (25–45ºC) but soil moisture level was much lower (15–45%). These variations in soil moisture and temperature have played a major role in effecting the efficacy of EPFs in the present study. Due to lower soil moisture levels in 2018 compared to 2017, the efficacy of EPF decreased in 2018 and hence cost-benefit ratio increased. In 2018, a lower cost-benefit ratio was observed in irrigated fields compared to dryland fields, which also indicated greater efficacy of EPFs at irrigated sites with stable moisture levels.

Although at this stage, the overall cost-benefit ratio of using EPFs granules was higher in both the years compared to conventional seed treatment, the presence of these beneficial fungal granules in the soil for several years makes them an excellent environmentally friendly option for managing wireworms. In the future further evaluation of the effect of the carrier while applying fungi in-furrow as granules are required. Rigorous efforts and studies will be required to reduce their cost.

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Sense of smell can be more acute in spring as there is usually more moisture in the air.

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Cacao originated in Central and South America more than 4,000 years ago.