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Evaluating Benefits and Non-Target Impacts of Repeated Use of Neonicotinoid Treated Seed in Grain Crop Rotations

By Aditi Dubey, Kelly Hamby, and Galen Dively
Department of Entomology, University of Maryland

Neonicotinoids are a class of systemic, broad-spectrum insecticides that are applied as foliar sprays as well as soil or seed treatments. The latter treatments are one of the most convenient and economical ways to protect a variety of crops from insect damage. Compared to older classes of insecticides, neonicotinoids have low toxicity to fish and mammals, and have become the most widely used classes of pesticides in the US, since their introduction in the 90s. Seed treatments are a safer and less invasive way to apply pesticides, minimizing off-site drift of the active ingredient. They play an important role in grain crops, as they are used to control soil and seedling pests on the majority of corn and about half the soybean grown in the country. They can also be used on wheat (Figure 1). This is not as common, but usage is growing. In the mid-Atlantic regions, these grain crops are typically grown in a crop rotation.

Figure 1. Wheat seeds that have been treated with Cruiser and fungicide.

Previous research on the effects of neonicotinoids has shown that seed treatments may improve yield under high pest pressure; however, treatment decisions are made before target pest populations are known. Therefore, treatment may not improve yield over untreated seed. Repeated exposure to neonicotinoids could also lead to insect pests developing resistance against them. Additionally, research has found some negative impacts of neonicotinoids on beneficial insects. When neonicotinoids are used as seed treatments, the majority of the insecticide active ingredient leaches into the soil. Because neonicotinoids are slow to degrade, using treated seeds year after year as part of a crop rotation system could lead to an accumulation of neonicotinoid residues within the soil. This could impact the soil microorganism community, which provides valuable ecosystem services such as improving fertility by increasing the quantity of nitrogen in the soil. Therefore, we are conducting a three-year study to better understand both the benefits and risks of using two neonicotinoid seed treatments, Cruiser ® 5FS (Syngenta) and Gaucho 600 Flowable (Bayer) (thiamethoxam and imidacloprid, respectively) in a 3-year grain crop rotation.

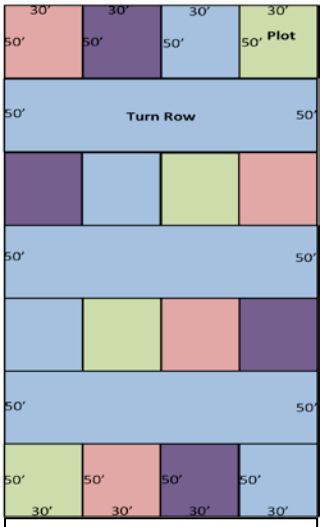

Figure 2. Plot Map. Blue is untreated seed, green is fungicide treated seed, red is Gaucho + fungicide treated seed, and purple is Cruiser + fungicide seed.

The study is being conducted at the Central Maryland Research and Education Center in Beltsville, MD, and at the Wye Research and Education Center in Queenstown, MD. At each site, we are planting four replicate plots of each treatment using no-tillage practices. Treatments include: Cruiser and fungicide treated seed, Gaucho and fungicide treated seed, fungicide treated seed, and untreated seed (Figure 2). The same active ingredients will be planted into the same physical location for each grain in the rotation in each plot every year. Standard mid-Atlantic seeding rates, varieties, irrigation, and fertilizer programs are used to achieve plots that best

represent mid-Atlantic grain production. We planted full season soybeans this last growing season and will soon be planting wheat. We will plant double cropped soybean in 2016 and corn in 2017.

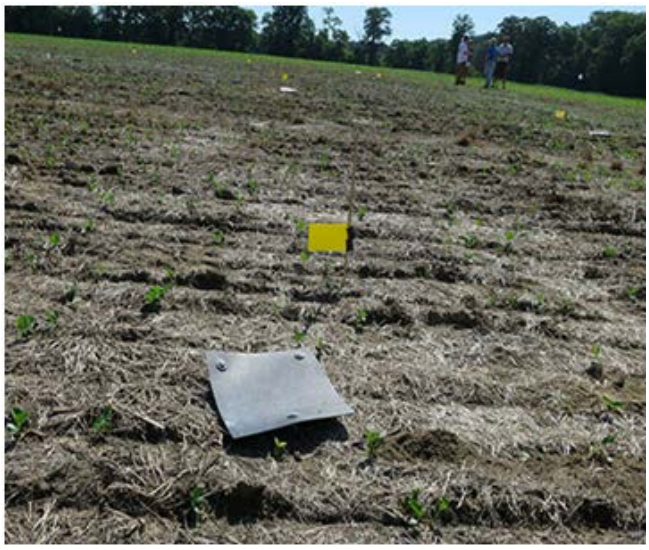

Figure 3. Sticky card and pitfall trap (with a cover to prevent entry of water) to capture arthropods in a soybean field.

At each site, the abundance and diversity of invertebrate communities on plants and in the soil are determined throughout the season using various sampling methods, such as sweep-net samples, sticky cards (Figure 3), pitfall traps (Figure 3, 4), litter samples, and visual counts (Figure 5). This allows us to measure both pest and beneficial communities present in the field. We are also sampling the soil for earthworms and measuring soil microbial activity to determine whether neonicotinoid residues in the soil impacts soil fauna. To see if seed treatments increase yield by reducing pest damage or increasing plant growth and establishment, we will measure grain yield and stand density. The neonicotinoid residue from the soil may also be taken up by weedy plants, and be present in pollen and nectar, representing a potential route of neonicotinoid exposure to pollinators. In winter wheat, we will analyse for the presence of neonicotinoids in winter annual flowers, such as chickweed, which serves as an early spring source of pollen and nectar for beneficial pollinators. Physical properties of the soil like carbon, available nitrogen, mineralized nitrogen, and pH were measured at the beginning of the study and will be measured again at the end.

Figure 4. Pitfall trap set up in soybean field to capture ground-dwelling arthropods such as beetles.

Neonicotinoid seed treatments play an important role in grain crop systems and can be very beneficial. Although they provide a convenient and economical ways to protect crops, long-term use of these pesticides could have undesirable effects. This study looks at the effects of neonicotinoids in two novel ways. First, we are not studying the use of seed treatments in a single crop but are addressing potential cumulative effects over a back-to-back three-year rotation. Second, this is one of the first studies to consider the effects of neonicotinoid seed treatment not on a few select species or a single type of organism, but on a wide range of organisms, including soil and plant dwelling arthropods, soil microbes and winter annual plants. Through this study, we plan to investigate both the positive and negative effects of using neonicotinoid seed treatments over several consecutive years. We hope that the information we collect will help producers make the best use of neonicotinoid seed treatments and make informed management decisions about protecting seeds and seedlings in a sustainable and cost-effective way.

First year funding for this study was provided by the Maryland Grain Producers Utilization Board and the Maryland Soybean Board. We would like to thank Maggie Lewis, Terry Patton, Emily Zobel, and the many undergraduate students who have helped with sampling this year.

Figure 5. Visual inspection of soybean trifoliate leaf for insect pests such as thrips and beneficial insects such as minute pirate bugs.