MICROPLASTICS IN SWEET CORN: POLYMER COATED FERTILIZERS

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ABSTRACT

Polymer coated fertilizers enhance nutrient efficiency and potentially reduce environmental nutrient loss. However, heavy runoff can carry microplastics into waterways and could negatively impact aquatic or terrestrial environments (Alimi, 2018). The objective of this project is to determine the microplastics concentrations in runoff water in sweet corn (*Zea mays* 'sweetness') with various placement methods. The full factorial study design consisted of three fertilizer sources (uncoated dry, coated dry, or liquid slow release) with all combinations of three placement methods (incorporated broadcast, surface broadcast, or subsurface band) compared to an unfertilized control. Two in-season runoff events were simulated and microplastics concentration determined. Although there were no differences in sediment movement, the treatments that received polymer coated fertilizers resulted in significantly higher microplastics with fertilizer placement showing a statistical difference in how many visible fertilizer coatings were found in the runoff water, with the highest at 0.112 lb ac^{-1} when applied to the surface and not incorporated. When the coated fertilizers were placed in the subsoil in a 2x2 band, or broadcast incorporated, the microplastics in the runoff was significantly less at 0.006 and 0.004 lb ac^{-1}, respectively. Both the subsurface band and the incorporated broadcast were effective at nearly eliminating visible microplastic movement in surface runoff. Another year of testing will be done to verify the data.

INTRODUCTION

Whether in large commercial farms or small residential settings, providing nutrition is vital for a sustainable plant system. In general, the law of the conservation of mass requires replenishment of nutrients that are removed (Hopkins, 2020). The development and use of fertilizers as part of the "Green Revolution" greatly improved the availability of food, fuel, and fiber globally, but it has come at great cost of natural resources and nutrient pollution.

Agriculture is the leading cause of water quality problems in developed nations, with nitrogen and phosphorus enrichment resulting in eutrophication. The combined effect of agriculture and urban systems seriously degrades the quality of many lakes and coastal waters. Significant efforts have been made to synergistically allow for efficient fertilization while minimizing negative impacts on water and other natural resources. One of the best solutions has been polymer coated fertilizers. This technology decreased environmental nutrient losses while reducing application rates without hurting growth. However, polymer coatings could negatively impact aquatic and terrestrial ecosystems (Hopkins, 2020).

The objective of this project is to determine the microplastics concentrations in runoff water in sweet corn (*Zea mays* 'sweetness') when fertilized with polymer coated products, compared to uncoated fertilizers and an unfertilized control, using three placement methods (incorporated broadcast, surface broadcast, or subsurface band).

MATERIALS AND METHODS

A field study was conducted in 2021 at Brigham Young University (BYU; 40°16'1.40" N 111°39'28.59" W) in Provo UT to evaluate microplastics loss in sweet corn (*Zea mays* 'sweetness'). The study was conducted on a calcareous sandy clay loam soil. The full factorial study design consisted of three fertilizer sources (uncoated dry, coated dry, or liquid slow release) with all combinations of three placement methods (incorporated broadcast, surface broadcast, or subsurface band) compared to an unfertilized control with four replications. Fertilized plots received 220-80-80-169(S)-3(Zn)-4(Fe)-3(Mn)-0.6(Cu)-1.4(B) in lb/ac. The macronutrients were applied as: 1) Uncoated = urea, monoammonium phosphate, and potassium sulfate; 2) Coated = Environmentally Smart Nitrogen (ESN) (Nutrien, Saskatoon, Saskatchewan, Canada) and Osmocote 14-14-14 (ICL, Dublin, Ohio, USA); 3) Liquid = UFLEXX (Koch, Wichita, Kansas, USA), ammonium polyphosphate, and potassium sulfate. The micronutrients were applied as an elemental sulfur impregnated dry material (Tiger Industries, Huston, Texas).

Each plot was 7.2 foot long by 3.6 foot wide. Plots were built to be gently sloping (~1%) towards the long end where a 9 by 13-inch an aluminum pan with a lid with holes drilled through the tops was buried at the soil surface to allow runoff water collection. Runoff water was collected on July 22 with a simulated large precipitation event until the pan had approximately ~16-32 ounces of water and sediment. The water and sediment was immediately transferred to 32 ounce glass jars and sealed and refrigerated (samples were stored in the dark to avoid microplastics degradation).

The sediment was filtered out (FisherBrand P5 paper, porosity medium, filter rate slow) and measured gravimetrically after drying. A drop of concentrated sodium hypochlorite was added to the remaining water and then a subsample stored for further analysis of nutrient concentrations and non-visible microplastics (data not yet complete).

Visible microplastics coatings were removed manually from the filtered sediment. The coatings were punctured and placed in a vial with deionized water in order to release any fertilizer left in the coatings. After 24 hours, the coatings were removed and rinsed and then dried at room temperature for at least 24 hours. Microplastics concentrations were determined gravimetrically.

Statistical analysis was performed by ANOVA with mean separation by the Tukey Kramer method using SAS software.

RESULTS AND DISCUSSION

Soil sediment loss was considerable, but there were no statistical differences between fertilizer or fertilizer placement treatments (data not shown).

As expected, microplastics were absent from treatments that did not receive polymer coated fertilizer (Fig. 1). Treatments that received polymer coated fertilizers resulted in significantly higher microplastics with fertilizer placement showing a statistical difference in concentration of visible fertilizer coatings found in the runoff water, with the highest when the fertilizer was applied to the surface and not incorporated at 0.112 lb ac^{-1}. When the coated fertilizers were placed in the subsoil in a 2x2 band or broadcast incorporated the microplastics in the runoff with significantly less at 0.006 and 0.004 lb ac^{-1}, respectively. These represent 19 and 28 times decreases in the amount of microplastics that were in the runoff water.

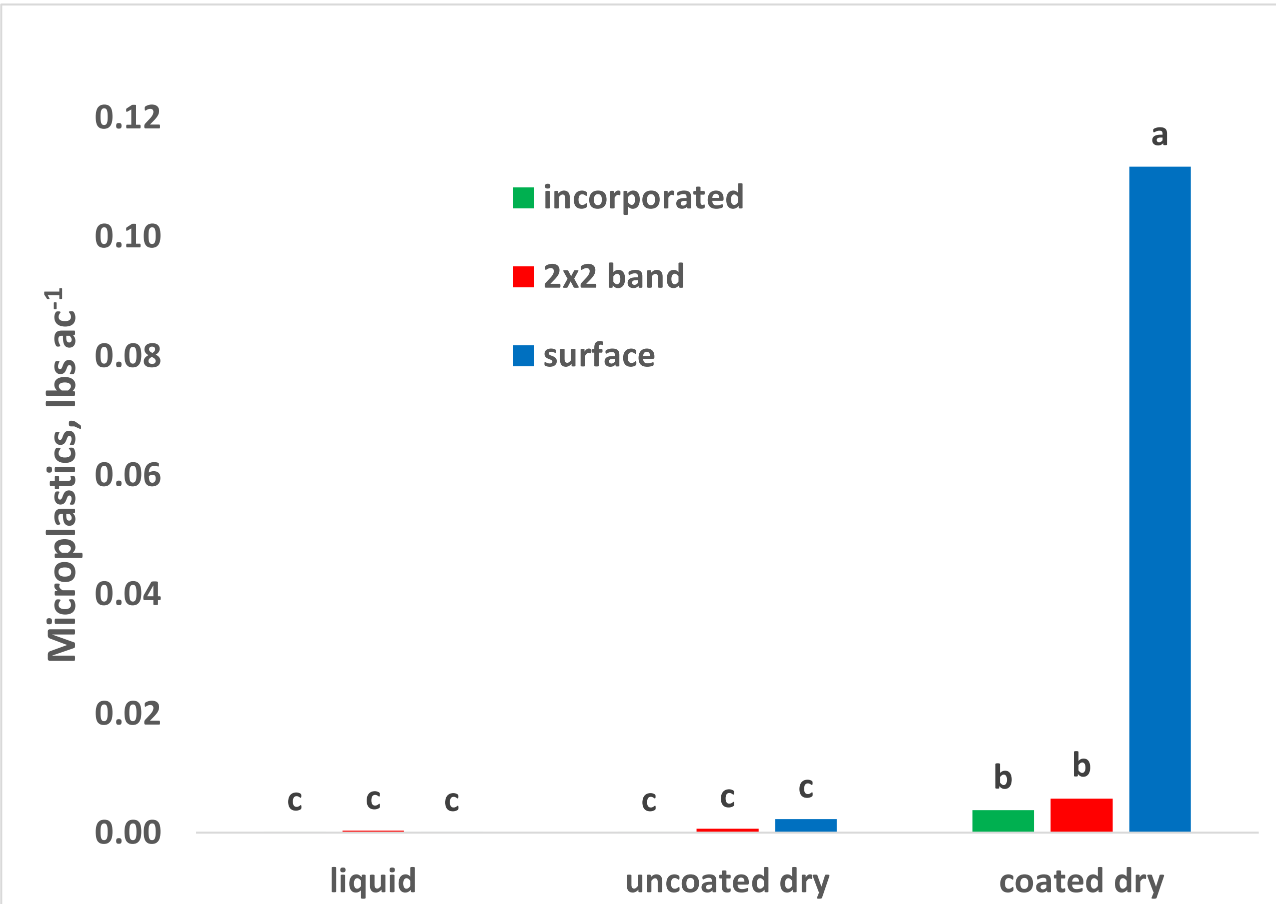

Fig. 1. Microplastics in runoff water for three fertilizer placement methods (broadcast incorporated, surface broadcast not incorporated, or subsurface 2-inch x 2-inch band) with three fertilizer sources (liquid slow release, dry uncoated, dry polymer coated). Bars sharing the same letters on top are statistically identical to one another (P = 0.05).

In terms of quantification compared to the amount of coatings applied, these losses represent 0.62% of the applied polymer coatings for the surface non-incorporated treatment and 0.03% for the 2x2 subsoil band and incorporated treatments. These results show the vast majority of the coatings remained in place, but the losses are nevertheless concerning. From our findings it was clear that both the 2x2 subsurface band and the incorporated broadcast were effective at nearly eliminating visible microplastic transport off site, but that not incorporating the polymer coated fertilizers is not a wise practice.

While more testing needs to be done to further prove these finding, we can assume that correct fertilizer placement greatly prevents movement of microplastics. We will replicate this trial in 2022 and use the data to create a model of polymer coated fertilizer microplastic movement model. We also plan to make a model of microplastic runoff from this data.

REFERENCES

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