INJECTING MANURE INTO A GROWING COVER CROP [1/]

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There is growing interest in using cover crops to improve soil health and protect water quality. In cool, northern climates, however, the short growing season makes it more difficult to get cover crops established in the fall, especially on farms that also fall-apply livestock manure. Traditionally, manure is applied after the cash crop is harvested followed by cover crop seeding. This leaves little time - and growing degrees - for the cover crops to successfully establish. Interseeding cover crops into a cash crop allows more time for growth and is becoming popular. But how can manure be applied into a living cover crop without damaging it? Newer injection technologies allow liquid manure application beneath a living cover crop with minimal disturbance, but many questions about the practice remain. Our primary goals for this project were to develop and demonstrate best management practices for the integration of cover crops and manure injection. Secondarily, we evaluated whether the combination of practices has added beneficial effects when compared to each practice alone.

Field trials were initiated in fall 2019 and again in the fall of 2020 in separate fields at the University of Minnesota West Central Research and Outreach Center (WCROC) near Morris, MN and the Southern Research and Outreach Center (SROC) near Waseca, MN. Each study was laid out in a randomized complete block design with split plots. Phosphorus and potassium fertilizers were applied if needed (according to soil test results) to plots prior to planting and 40 pounds of nitrogen (N) fertilizer as urea were applied at pre-plant across the entire field. All remaining fertilizer and manure application rates were adjusted to account for the pre-plant fertilizer N. In the spring for each study, the cover crops were chemically terminated (if necessary) and tilled into the soil prior to planting, usually 1 to 2 weeks ahead of time. Corn was planted and managed according to typical practices for the region. Remaining details for each study are as follows:

- A soybean (*Glycine max* Merr.) – corn (*Zea mays*) rotation using fall-applied liquid swine manure or spring applied fertilizer prior to corn was completed at both research locations at two different sites at the SROC and one site at the WCROC for a total of three site-years. Subplots included a cover crop mixture of annual ryegrass (*Lolium multiforum*) and winter cereal rye (*Secale cereale*) overseeded into soybean near leaf drop or drilled after harvest. A no-cover crop control was included. Main plots included swine manure sweep injected after soybean harvest or spring applied nitrogen (N) fertilizer. Cover crop growth by the spring was low in both years, though higher for the overseeded cover crop (97 to 256 pounds/acre) compared to the drilled cover crop (17 pounds/acre in 2020 to 71 pounds/acre in 2021). We did not find an effect of nutrient source or cover crop on yield when averaged over both years. This indicates that over the short-term, cover crops did not reduce yield and that manure and fertilizer resulted in comparable corn yield.

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- At the WCROC, a continuous corn system was evaluated using fall-applied liquid dairy manure or spring applied fertilizer over two site-years. Subplots included a cover crop mixture of annual ryegrass (*Lolium multiforum*) and winter cereal rye (*Secale cereale*) interseeded around the V4 (4^{th} leaf collar) corn growth stage, the R6 (black-layer) corn reproductive stage, or drilled after harvest. A no-cover-crop control was also included. Main plots included dairy manure sweep injected in the fall when soil temperatures were above 50ºF (usually late September to early October) or after soil temperatures had fallen below this level (usually late October to early November). These were compared to spring-applied N fertilizer. Above-ground cover crop biomass in the spring tended to be negatively affected by fall manure application, though differences from the spring fertilizer plots that had not been disturbed were not significant. Biomass was low in 2020 (ranging from 31 to 73 pounds/acre) compared with 2021 (ranging from 50 to 125 pounds/acre). Cover crop application timing influenced silage yield. Covers interseeded at V4 resulted in significantly higher yield than when interseeded at R6 or drilled after harvest, though none of the treatments were significantly different than where no covers were seeded. This was likely due to the higher ratio of winter rye that established at the later seeding dates that survived into the spring. Dairy manure, regardless of when it was applied in the fall, increased yield by approximately 2 tons/acre over the spring-applied fertilizer.

- At the SROC, a sweet corn-corn rotation was evaluated using fall-applied liquid swine manure or spring applied fertilizer over two site-years. Subplots included a winter rye cover crop, a forage oat (*Avena sativa*) cover crop, or a winter rye-oat-radish (*Raphanus sativus*) mix that was drilled after harvest of the sweet corn in early to mid-August. There was also a no-cover-crop control. Main plots included swine manure from a finishing barn that was sweep injected in the fall when soil temperatures were above 50ºF (usually mid- to late-September) or after soil temperatures had fallen below this level (usually late October to early November). These were compared to spring-applied N fertilizer. Above-ground cover crop biomass in the spring of 2020 was higher where manure had been applied in the rye plots compared to the spring fertilized plots, though biomass was similar across nutrient sources in the cover crop mix (oat had winter killed and had no spring biomass). The early, fall-applied manure in 2021 also resulted in higher cover crop biomass in the rye and mixed cover crop plots than the spring fertilized plots, though the late, fall-applied manure had significantly lower biomass produced. The late manure application and corresponding disturbance of the cover crop did not allow enough time for the cover crop to recover in that year. Corn grain yield was affected by nutrient sources and cover crops. In both 2020 and 2021, the early-applied manure resulted in a 15 bushel/acre yield penalty compared with the spring fertilized treatment (the standard practice in the region). The late-applied manure resulted in a significant yield increase (by 33 bushel/acre) in 2020 to a slight yield decrease (by 8 bushel/acre) though the difference was not significant compared to the spring fertilized plots in 2021. There was no interaction with cover crops, suggesting that the cover crops did not limit nutrient losses enough to improve yield when manure was applied too early. Regardless of nutrient source, cover crops that included winter cereal rye tended to cause a 20 bu/acre yield reduction compared to the no-cover-crop control plots. This is likely because rye had vigorous growth in the spring (ranging from 312 to 1,634 pounds/acre of above-ground biomass) and despite being terminated and plowed under 1 to 2 weeks prior to planting, may have tied up nitrogen in the soil due to its high carbon to nitrogen ratio or caused problems with the planting bed, limiting seed to soil contact.

Overall, we found that planting cover crops as early as possible in the fall (or even the late summer) consistently resulted in more cover crop biomass than waiting to plant after harvest. Once cover crops are established, low disturbance manure injection is key to minimize damage to the cover crops. We observed that the same equipment had more or less disturbance depending on soil moisture conditions. Making adjustments to equipment (i.e., depth of injection, changing the angle of the coulter if possible, etc.) depending on soil conditions will likely be important moving forward. And finally, these results suggest that cover crops used in a field for the first time may not reduce the risk of nutrient losses from manure applied too early in the fall. Research in Iowa suggests that consistent use of cover crops may change this trend, but more long-term research is needed.