Capturing Deep Nitrogen – A Resource for Sustainability in Northeast Farms

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Introduction and background

Summer annual crops are fertilized with (corn) or fix (soybean) large amounts of nitrogen (N). In addition, decomposition of organic matter releases mineral N during most of the year. Nitrogen not used by a summer crop, *particularly in deeper soil layers,* is apt to leach into groundwater during fall and winter when there is minimal uptake and transpiration. If N leaches, farmers lose a valuable nutrient resource and society suffer environmental damage a N can enter eutrophication-sensitive waters such as the Chesapeake Bay. We hypothesized that deep rooted cover crop species (e.g., brassicas, cereal grasses) can grow roots over 1 m deep during the fall months and recover N from deep soil layers before it is lost to groundwater.[1,2].

Hypotheses:

1. Summer crops do not access and take up all of the mineral N in the soil profile, and agronomically meaningful amounts of N remain in the soil after summer crop N uptake ceases, particularly in deeper layers.
2. Cover crops planted by early September can capture N from at least 120 cm deep by early December.
3. Spring immobilization of N by cereal cover crops will be mitigated by including brassicas and/or legumes in the mixture.

Objectives:

1. Measure soil NO_3 and NH_4 pools in the profile following corn and soybean (Hyp 1).
2. Evaluate the ability of various cover crop species and planting dates to capture deep soil N in the fall and spring (Hyp 2).
3. Assess corn growth (early season and yield) and N content following various cover crops (Hyp 3).

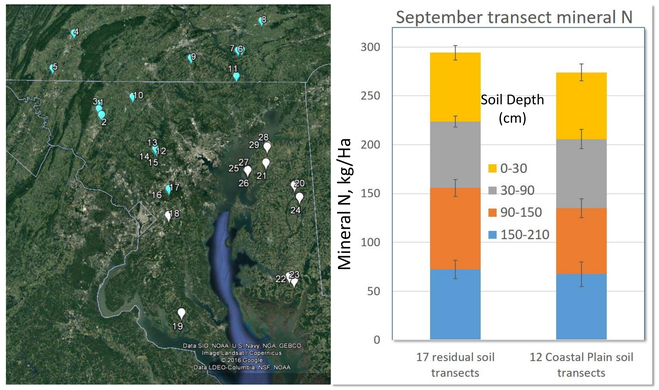

Figure 1. (Left) Location of crop fields sampled by transect of 7 ft deep cores. (Right) Mineral N (nitrate + ammonium) measured in upper 7ft of soil under 29 crop fields with soils formed from coastal plain sediments or residual rocks.

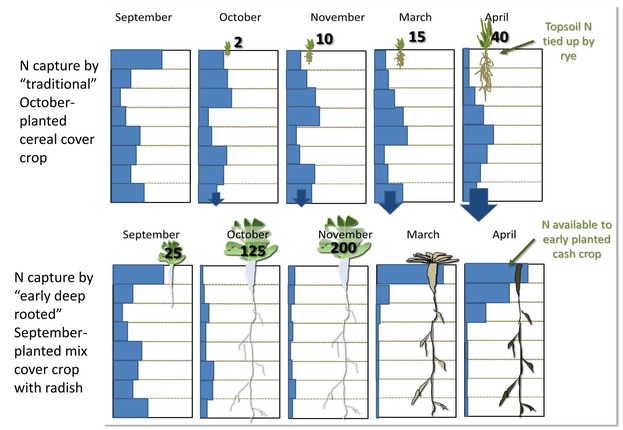

Figure 2. Conceptualization of N capture recycling potential of typical late plated rye cover crop and proposed early planted deep rooted cover crops.

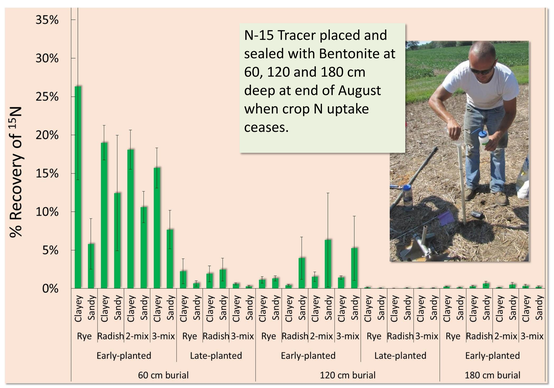

Figure 3. Fall recovery of 15-N from various depths by cover crop planted early (Sept 01) or late (Sept. 30).

Figure 4. Procedures for taking deep soil cores using Veihmeyer probes (photo 3 taken during early spring sampling, data not shown)

Methods

- **Soil survey of deep soil N content**: 210 cm (7 ft) deep soil cores taken in transects on 29 fields (in 13 different counties) in late summer after summer crop N uptake ceased (Fig 1)
- **On-farm cover crop trials**: Replicated plots of four cover crop species treatments: 1) radish, 2) winter cereal, 3) radish + winter cereal + clover, 4) no cover crop control. Soil cores (0-210 cm deep) taken and cover crop biomass sampled in fall and spring to determine N content. Corn planted following cover crops; corn V5 weight and yield measured.
- **15N isotope study**: Assessed N15 content in cover crop biomass planted over buried 15N; treatments included N15 burial depth (60, 120, 180 cm), cover crop species (radish, rye, radish + rye, radish + rye + clover), cover crop planting date (3-Sept, 8-Oct). Assessed N15 content in subsequent corn following cover crops.
- From all studies, soil was sampled using hand-driven Veihmeyer probes and assessed for NO_3-N and NH_4-N using 0.5 M K_2SO_4 extraction and LATCHET colorimetric analysis

On farm N capture and cycling for crop production. Although highly variable spatially and between sites, on farm experiments generally indicated that all early planted cover crops did a good job of cleaning the deep profile of nitrate in fall. However, cover crops dominated by radish in the fall resulted in a high-nitrate topsoil with low nitrate deep layers at spring planting, thus avoiding the yield drag from immobilization of N experienced with cereal dominated cover crops (Fig 3).

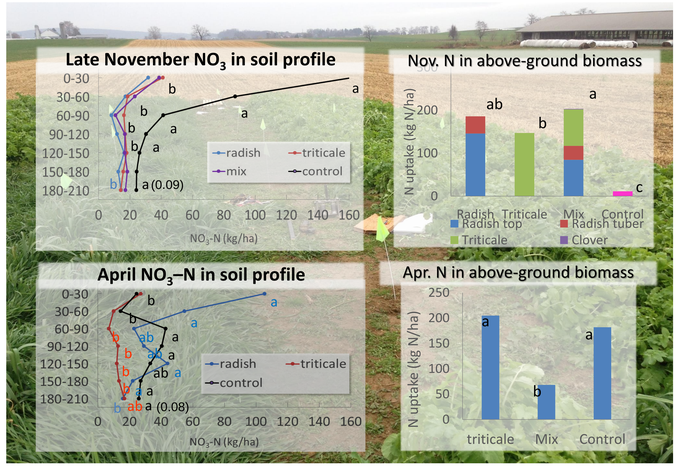

Figure 5. Soil NO_3-N and N in above-ground cover crop biomass for four cover crop species treatments in Nov and in Apr for on-farm trial in Lancaster, PA. Fields had history of heavy manure application. Cover crop was planted 2-Sept 2015. (Letters indicates significantly more N than other covers)

Results and discussion

- Across 29 farm fields, there was on average 253 kg/ha of mineral N (115 kg/ha of NO_3-N; 138 kg/ha of NH_4-N) remaining in the 0-210 cm soil profile in September after crop N uptake had ceased; 22% of the mineral N was 0-30 cm deep, 23% 30-90 cm deep, 27% 90-150 cm deep, and 28% 150-210 cm deep (fig 2). There were higher levels of NO_3 in soil after growing soybean than after corn.
- Early September planted radish, winter cereal, and mixed species cover crops reduce soil NO_3 from 0-180 cm deep by December; by April, the radish cover crop released NO_3 on surface layers, while the triticale cover crop immobilized the NO_3 (fig 3).
- Early September planted cover crops captured NO_3 from at least 180 cm deep by December. Early October planted cover crops were unable to capture NO_3 from 120 cm deep by December or after spring growth by April (fig 4; fig 5). Traces of NO_3 from the 3-way species mix were found in corn plant in June.

Figure 6. Interactive field days with farmers and State government officials helped early planted mixed species cover crops become accommodated by the Maryland cover crop program and adopted by farmers.

Conclusions:

Agronomically and environmentally significant amounts of N (averaging 253 kg N/ha) remain in the soil profile after growing both corn and soybean crops. The deeper the N is in the profile, the greater the risk that it will leach out of the soil and into groundwater over the winter. Growing deep rooted, early-planted fall cover crops can capture and bring this pool of deep soil N back to the surface, reducing N loading into bodies of water and providing a nutrient source for the following spring planted crop.

References: 1. Dean, J.E. and R.R. Weil. 2009. Brassica cover crops for nitrogen retention in the Mid-Atlantic Coastal Plain. Journal of environmental quality 38: 520-528. 2. Thorup-Kristensen, K. 2006. Effect of deep and shallow root systems on the dynamics of soil inorganic N during 3-year crop rotations. Plant and Soil 288: 233-248.