Enhancing sustainable benefits of perenniality in agricultural systems through adaptive crop management practices and technologies

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Agricultural runoff and leaching through subsurface tile drainage in the upper Midwest contributes significantly to severe NO$_3$-N levels in the Mississippi River, municipal water supplies, and ultimately to hypoxic conditions in the Gulf of Mexico (Mitsch et al., 2001). This movement of NO$_3$-N through leaching and runoff occurs primarily in the spring and fall, prior to planting and following harvest in annual corn rotations, when fields are left fallow (Dinnes et al., 2002). Minnesota corn growers apply an average 140 kg N ha$^{-1}$. An estimated 25 kg N ha$^{-1}$ is lost through subsurface drainage from mid-September through May in conventional systems (Feyereisen et al. 2006), associating negative economic repercussions with fertilizer nitrogen loss in addition to environmental impacts. NO$_3$-N leaching and runoff are tremendously reduced in the presence of living vegetation (Zhou and Shangguan, 2007) such as cover crops and perennial forages.

Integration of cover crops in these agricultural systems can significantly reduce nitrogen loss through utilization of excess N and water during times of high leaching/runoff vulnerability (Wilson et al., 2012; Qi and Helmers, 2010). Cover crops have not been widely adopted in the upper Midwest due to climatic challenges in establishment and a lack of effective management practices that do not interfere with primary crop productivity (Strock et al., 2004). We hypothesize that cover crop species selection combined with appropriate interseeding technologies will enable effective establishment and enhanced ecosystem benefits in upper Midwestern corn systems. This research investigates the suitability and potential benefits of different planting technologies and cover crop functional groups interseeded into standing corn, compared with a conventional winter-fallow (no cover crop) system. Cover crop species include cereal rye, red clover, hairy vetch, pennycress, and a fall green manure mix (oat, pea, and tillage radish). Planting technologies implemented are a high clearance drill, directed broadcast, and directed broadcast with light incorporation. Treatments are planted into corn at the V-7 growth stage in Waseca and Lamberton, MN. Cover crop biomass, N content, and corn stover N are assessed at corn physiologic maturity (R-6). Cover crop measurements indicate the high clearance drill achieved the most successful establishment and greatest fall biomass in cereal rye, hairy vetch, and red clover treatments at both locations. In year 1, directed broadcast with incorporation resulted in greater red clover biomass in Waseca and greater red clover and pennycress biomass in Lamberton than directed broadcast without incorporation. The fall green manure mix exhibited strong establishment and initial growth, but senesced under the corn canopy prior to corn maturity. Cover crop species affected corn grain yield in Lamberton, with cereal rye treatments yielding slightly less than other cover crops and the ‘no cover’ control. Main effects were not significant for grain yield in Waseca. This is the first year of a three year study.

Perennial forage crops such as alfalfa also provide valuable ecosystem services in the preservation and quality of soil, water, and nutrient resources (Franzluebbers et al., 2014), and are particularly noted for building soil organic matter (De Deyn et al., 2011). Deep and extensive root structure promotes aeration, water infiltration, and improves water holding capacity (Seobi et al., 2005), resulting in greater nutrient retention and availability. Alfalfa grown in northern climates is at particular risk of winter injury or winterkill (Leep et al., 2001), which can cause serious consequences for producers, as well as regional livestock industries in Minnesota. Alternative warm season annual forage crops can be planted in response to winterkill (Peterson et al., 2005), although the best suited species,
cutting frequency, and fertility management need to be evaluated. We hypothesize that improved species selection and management practices can serve as viable, supplemental forage options in alfalfa winterkill situations. This work assesses the viability and production potential of seven warm-season annual grasses and one clover-grass mixture no-till planted into simulated, winter-killed alfalfa at locations in Waseca and Rosemount, MN. Three nitrogen fertilization rates (0, 56, and 112 kg ha$^{-1}$) were applied as sub-plot treatments. Harvesting intervals began 30-days after planting across all treatments, including assessment of forage biomass and quality. Preliminary observations indicate teff and annual ryegrass treatments to yield the greatest annual herbage mass. Economic analysis will help identify ideal management options for alfalfa winterkill situations. This is the first year of a two year study.

Accurate assessment of alfalfa stand health and persistence, yield, and quality are critical for timely management decisions to realize full economic and ecologic potential. Kalu and Fick (1981) identified alfalfa maturity as a valid predictor of quality. However, achieving true representation through traditional, destructive sampling methods can be extremely difficult and time-consuming considering spatial variability, particularly in large scale systems. Modern remote sensing technologies (i.e. measurement of canopy reflectance) have potential to facilitate accurate predictions and informed management decisions (Post et al., 2007; Mitchell et al. 1990), although this technology has not been specifically developed to assess alfalfa maturity. We hypothesize that spectral vegetative indices can be used, or new indices developed, to remotely predict alfalfa maturity. A pilot study conducted in 2014 identified potential for existing spectral vegetative indices to predict alfalfa maturity. Strong predictive power (as high as $R^2 = 0.92$) was associated with multiple known indices, however, possibilities exist for development of an alfalfa-specific index for optimum utilization in management decisions. A calibration gradient, expressing a wide range of alfalfa maturity will be established through cutting and removal of biomass in individual plots on 3-4 day intervals (twice a week) during typical alfalfa growth cycles (between harvests 1 and 2, and harvests 2 and 3). At the conclusion of each cutting cycle, spectrophotometers and remote sensing instrumentation will be used to scan all treatments, capturing the range of maturity stages. Treatments will then be harvested and analyzed for yield, quality, and relative maturity. Intensive processing of reflectance data linked to physical measurements will identify significant wavebands to formulate an optimized index for integration into current management practices.

**Literature**


