Penn State Sustainable Cropping Systems Research

Cover Crop Cocktails to Enhance Nitrogen Management

Nitrogen (N) is an essential nutrient for crop growth, and providing sufficient N in cropping systems is vital to meeting the food, fiber, and energy needs of a growing global population. At the same time, N losses from agriculture contribute to the critical environmental issues of greenhouse gas emissions, biodiversity loss, and water pollution, making N loss prevention paramount.

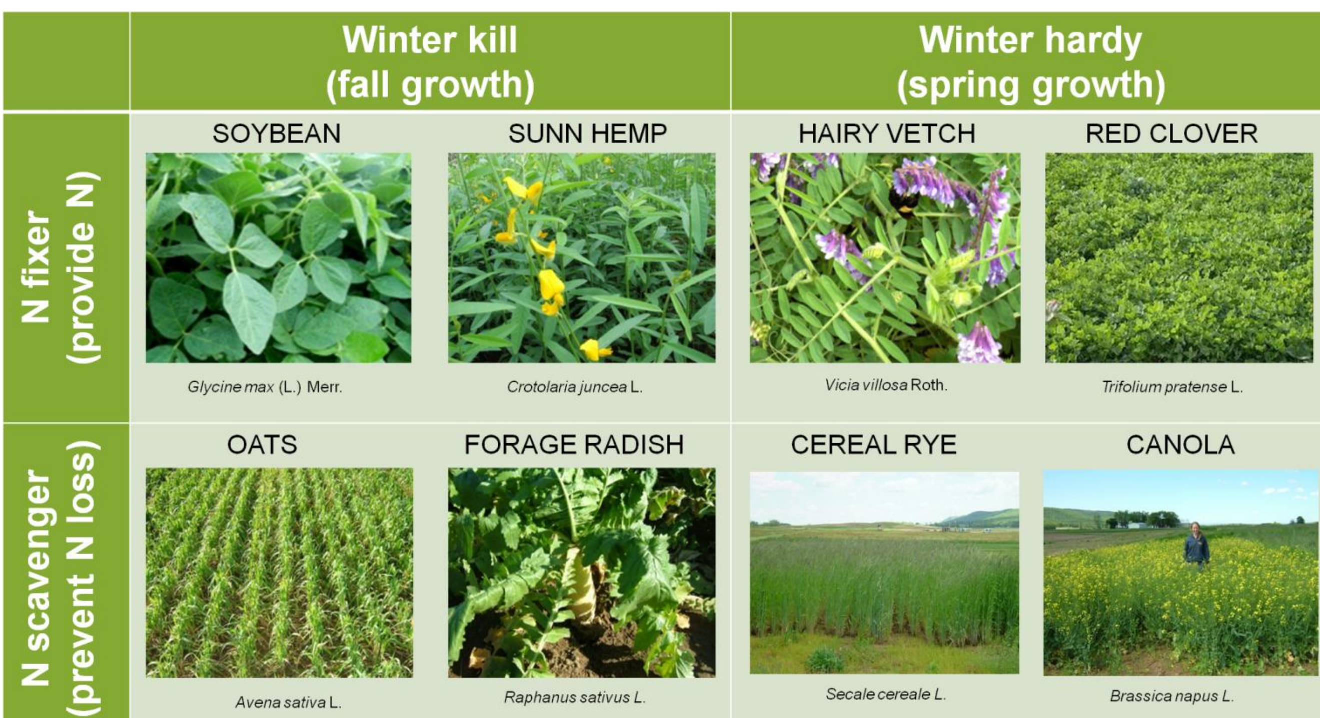
One approach to meeting these divergent N goals is to increase biodiversity in agroecosystems. Cover crops, for example, can be planted between cash crops to provide N (ie legumes) or scavenge residual N (ie grasses). Further diversity can be achieved by planting multi-species cover crop cocktails. Though traditional agricultural practices included mixed cropping to enhance productivity and other functions, this strategy is not widely applied to cover cropping systems. **Our research indicates that multi-species cover crop cocktails can provide sufficient N to maximize yields while also limiting N losses to the environment.**

Designing Cocktails for N Management

Ecological studies suggest several ways that increased diversity enhances ecosystem functions:

- Insurance: many species assure that a function will continue even if one or more species does not thrive
- Complementarity: multiple species may take advantage of more resources in a given area and perform more functions because they occupy different niches

We applied both of these principles in designing cover crop cocktails for N management. First, we defined four cover crop niches (categories) determined by timing of growth and nitrogen function (see figure below). We then selected two species that vary by growth habit and other physical features to fill each niche. Using various pairs of niches, we created seven 4-species cocktails. In addition, our experiment contains eight monocultures (each of the species listed below), an 8-species cocktail, and a no cover crop control.



Testing Cocktails in the Field

We are conducting a two year field study of seventeen cover crop treatments planted after oats and before corn.

Field/sampling Activity	Approximate Timing
Cover crop planting	Late August
Resin bag burial	2 weeks after planting
Cover crop biomass collection	Mid-October
Removal of fall anion resin bags	November
Cover crop biomass collection	Early May
Removal of spring anion resin bags	Mid-May
Cover crop termination (moldboard plow)	Mid-May
Corn planting	Late May
Corn grain harvest	November

Species (seeding rate, lbs/ac)	Niches represented*	Cost/ acre ($)
No cover crop	None	0
Sunn hemp (20)	WK-NF	50
Soybean ‘Laredo’ (80)	WK-NF	40
Red clover ‘Medium’ (12)	WH-NF	24
Hairy vetch ‘Purple Bounty’ (25)	WH-NF	62.50
Forage radish ‘Tillage Radish’ (10)	WK-NS	33
Oats ‘Viking’ (112)	WK-NS	40
Canola ‘Wichita’ (11)	WH-NS	27.50
Cereal rye ‘Huron’ (120)	WH-NS	42
Forage radish (3) + oats (64) + foxtail millet (15) + sorghum sudan (20)	WK-NS	67.50
Canola (4) + cereal rye (60) + ryegrass (14) + barley (48)	WH-NS	53.50
Forage radish (3) + oats (64) + canola (4) + cereal rye (60)	WK+WH-NS	63.50
Sunn hemp (10) + soybean (40) + forage radish (3) + oats (64)	WK-NF+NS	77.30
Red clover (5)+ hairy vetch (10) + canola (4) + cereal rye (60)	WH-NF+NS	66
Sunn hemp (10) + soybean (40) + canola (4) + cereal rye (60)	WK-NF, WH-NS	76
Red clover (5) + hairy vetch (10) + forage radish (3) + oats (64)	WH-NF, WK-NS	67.30
Sunn hemp (10) + soybean (40) + red clover (5) + hairy vetch (10) + forage radish (3) + oats (64) + canola (4) + cereal rye (60)	All	143.30

* WK = winter kill, WH = winter hardy, NF = nitrogen fixer, NS = nitrogen scavenger

Results – Aboveground Cover Crop Biomass & Nitrogen

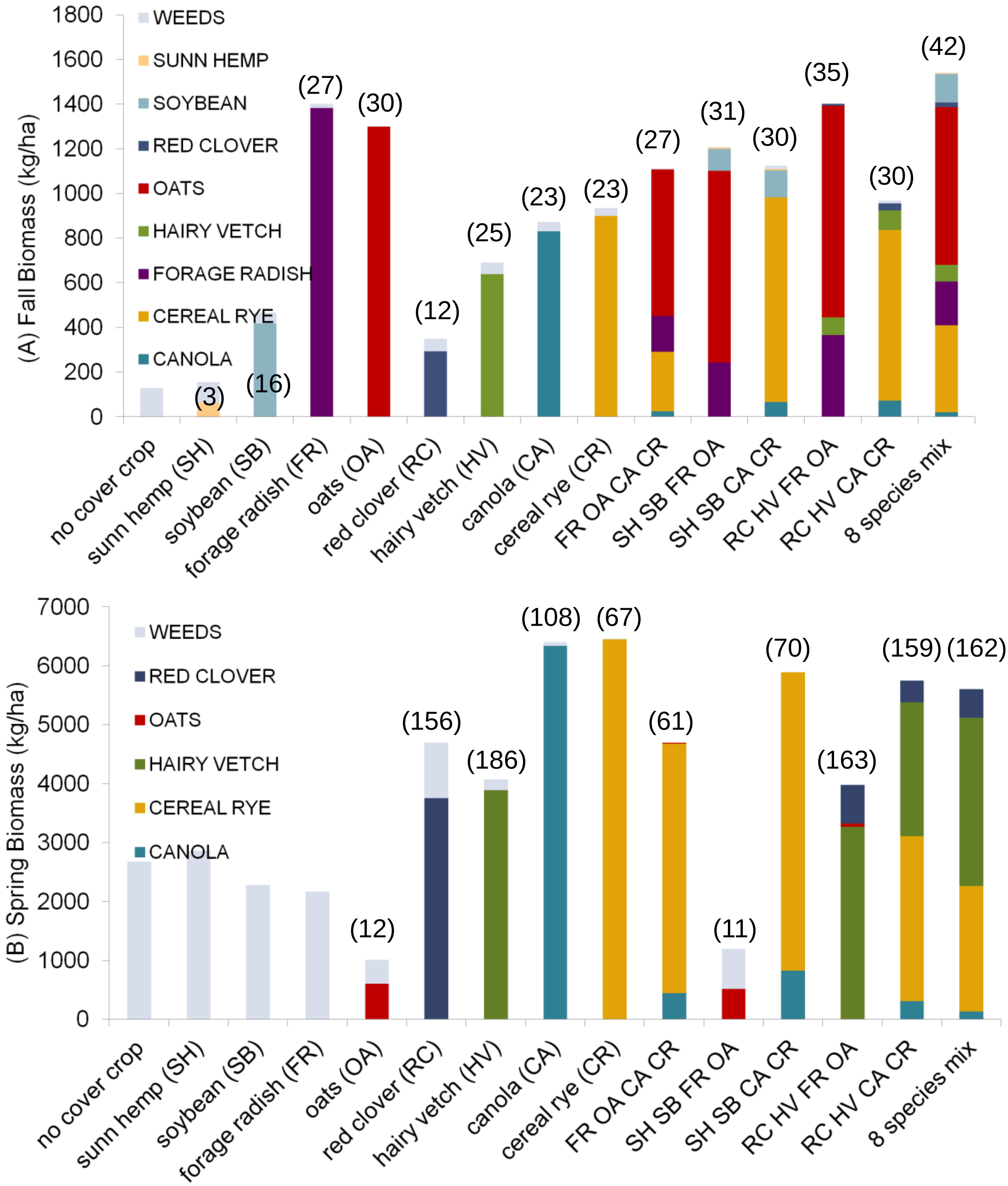


Figure 1 Fall (A) and spring (B) cover crop and weed biomass production. Biomass was cut on 15 October 2011 (fall) and 11 May 2012 (spring), dried, and weighed to measure aboveground production. Low production by sunn hemp and soybean was likely due to below optimum temperatures for these warm season species. These results indicate that biomass production by cocktails is similar to that achieved by the highest performing monocultures in a given growing season. Numbers in parentheses indicate cover crop N content in kg N/ha (for equivalent lbs/ac, multiply by 0.89).

Results – Nitrogen Services

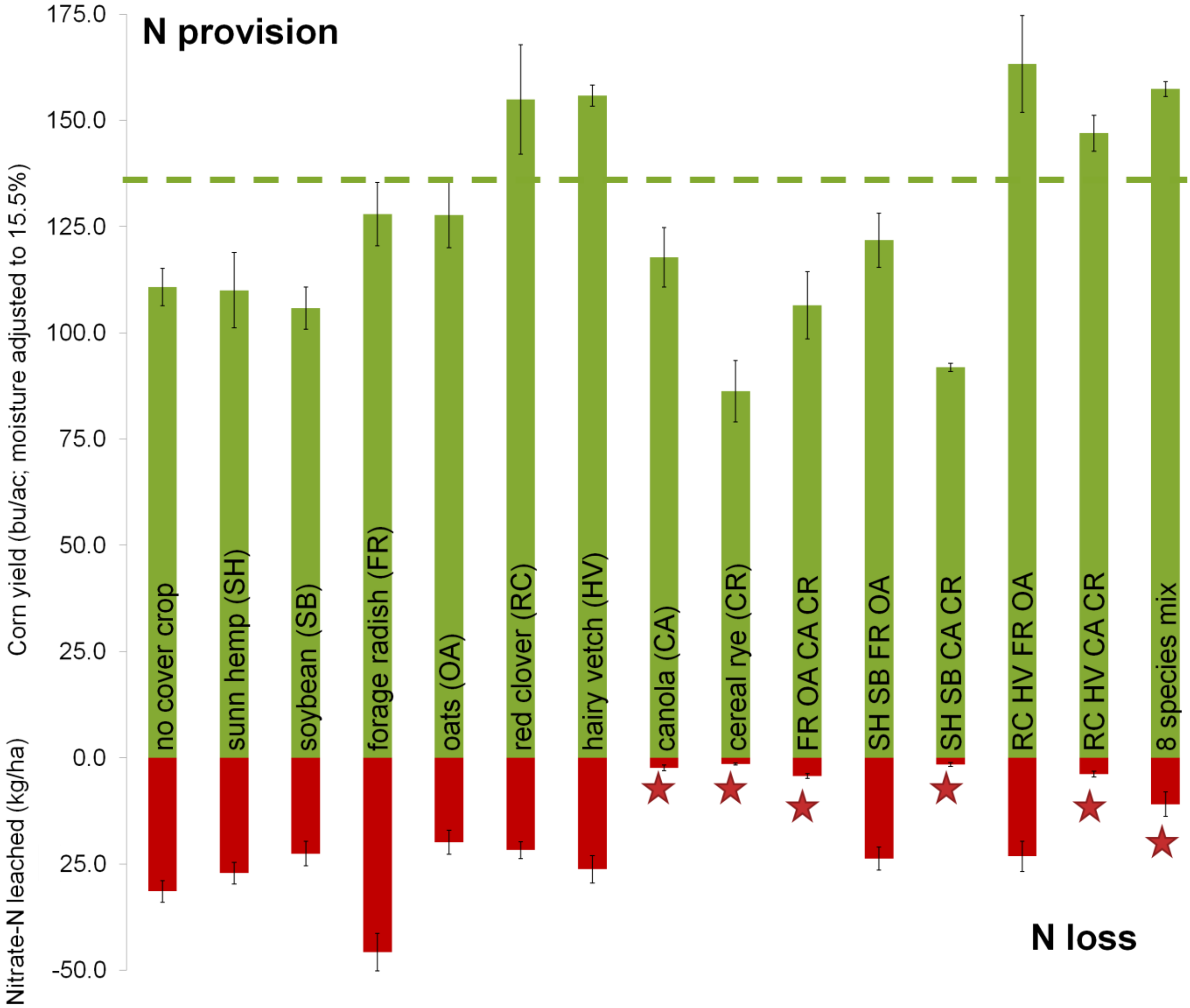


Figure 2. Corn yield without nitrogen addition (green bars), an indicator of N provision, and quantity of nitrate-N leached from November-May (red bars), a measure of N loss. Five cover crop systems achieved yields above a no cover crop control that received135 lbs N/ac (133 bu/ac; indicated by the dashed green line): red clover and hairy vetch monocultures and three cocktails containing these species. Lowest rates of N leaching occurred under canola and cereal rye monocultures and cocktails containing these species (red stars indicate treatments with significantly lower N leaching than the no cover crop control, determined by Tukey's HSD at a 95% confidence level). The four and eight species cocktails mixing winter hardy N-fixers (red clover, hairy vetch) with winter hardy N-scavengers (cereal rye, canola) maximized yields while limiting N losses.

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