Effects of winter cover crops on nitrogen use and performance of corn and soybean

Ronghao Liu [1,2], Alex Hummel Jr. [1], and Axel Garcia y Garcia [1,3]

[1]Department of Agronomy and Plant Genetics, St. Paul, MN, USA; [2]Taiyuan University of Technology, China;
[3]University of Minnesota Southwest Research and Outreach Center, Lamberton, MN, USA.

INTRODUCTION

- Excess nitrogen in the soil after harvests of main crops is prone to loss to the environment during the fallow period.
- It is reported that much of the nitrate in surface waters of the Midwest comes from land used for corn-soybean production.
- Using cover crops in the fallow period is recognized as an effective practice for sustainable crop production as they may provide agronomic and environmental benefits.
- Winter rye is a dominant cover crop in the corn belt of USA; however, some researchers observed that rye has negative impacts on the following corn yield.
- Winter camelina and field pennycress are regarded as attractive winter oilseed crops due to their excellent winter survival and potential as edible oil and biodiesel for aviation.
- Research on nitrogen use of cover crops and its impact on the following main crops is limited.

OBJECTIVES

The objectives of this study were to determine the effects of (i) the three cover crops on biomass nitrogen accumulation and release and (ii) cover crops on the subsequent corn and soybean growth and yield in the Northern Corn Belt, USA.

MATERIALS AND METHODS

- **Location:** The University of Minnesota Southwest Research and Outreach Center in Lamberton, MN, USA (Fig. 1).
- **Period:** April 2015 to October 2017
- **Experimental design:** Randomized complete block design with four replications on a moderately well-drained Normania clay loam.
- **Treatments:** Field pennycress (FP), winter camelina (WC), and winter rye (WR) in a corn-soybean rotation. The traditional rotation without cover crop was used as control (NC).
- **Fertilization:** 84 and 67 kg N ha^{-1} were applied for corn as basal and top dressing fertilizer, respectively.
- **Cover crops establishment:** Hand seeded and incorporated on August 31, 2015 and September 10, 2016.
- **Plant measurements:** The cover crops biomass was obtained before soil freezing in the fall and prior to being herbicide-terminated in the spring.
- **Incubation:** Soil samples in the top 6 cm were collected and placed into plastic bags which were placed in the same holes after termination.
- **Soil nitrate:** Samples were obtained at the beginning and end of the season.
- **Soil solution:** The leachate samples were collected weekly from ceramic cups installed at 100 cm depth.

Figure 1. Location of the experiment site.

Winter Camelina

Winter annual with potential as an alternative edible oil and biofuel source.

Field Pennycress

Winter annual crop being developed by U of MN. Potential as a source of biofuel.

Winter (Cereal) Rye

Winter hardy dominant cover crop in the corn belt of USA. Well adapted to Minnesota.

RESULTS AND DICUSSION

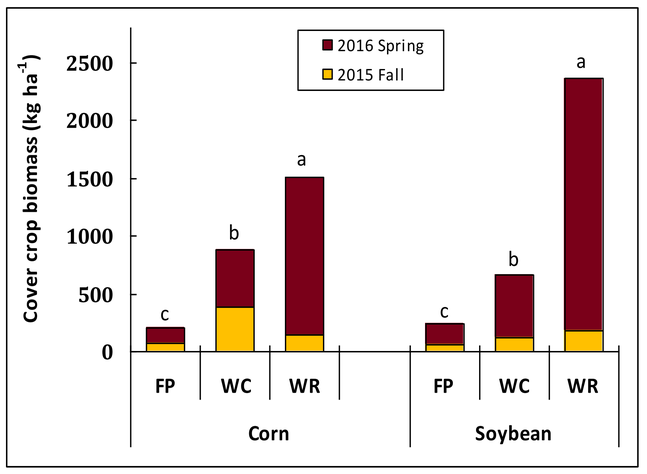

Figure 2. The aboveground biomass of cover crops in fall and spring (FP = field pennycress; WC = winter camelina; WR = winter rye. Within a year and following a crop, different letters represent significant differences at $P < 0.05$).

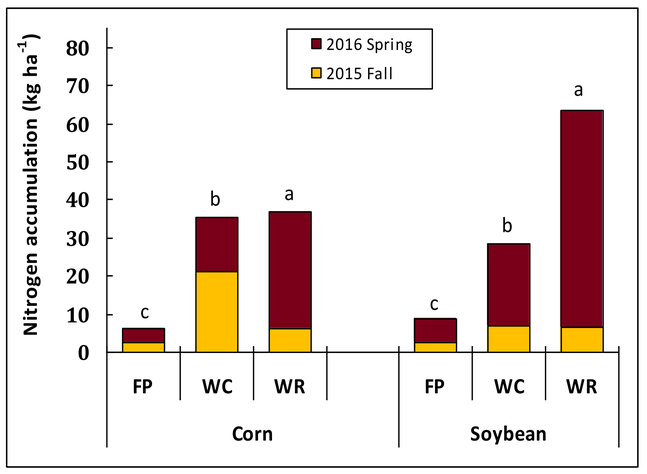

Figure 3. The nitrogen accumulation in biomass of cover crops before winter and in spring (FP = field pennycress; WC = winter camelina; WR = winter rye).

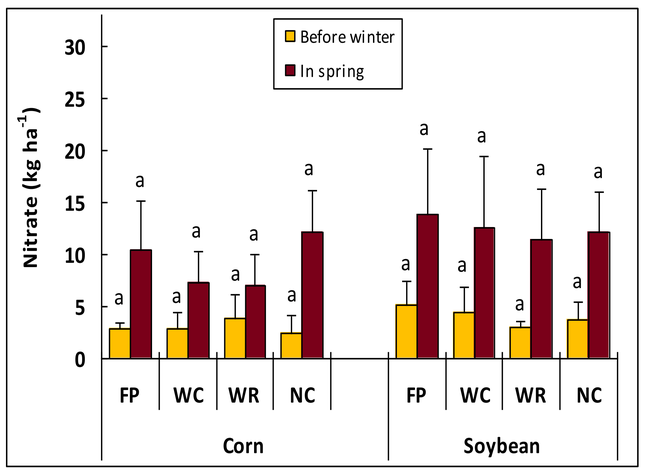

Figure 4. The soil nitrate content in 0-30cm before winter and in spring (FP = field pennycress; WC = winter camelina; WR = winter rye; NC = no cover crop).

Table 1. The nitrogen concentration and C:N of cover crops before winter and in spring.

Main crop	Year	Cover Crop	N concentration (%)	C:N
Corn	2015 Fall	FP	3.8c	10a
		WC	5.4a	7b
		WR	4.2b	10a
	2016 Spring	FP	2.7a	17ab
		WC	2.9a	15b
		WR	2.3a	19a
Soybean	2015 Fall	FP	4.0b	10b
		WC	5.7a	7c
		WR	3.5b	13a
	2016 Spring	FP	3.4a	13b
		WC	4.0a	11b
		WR	2.6b	17a

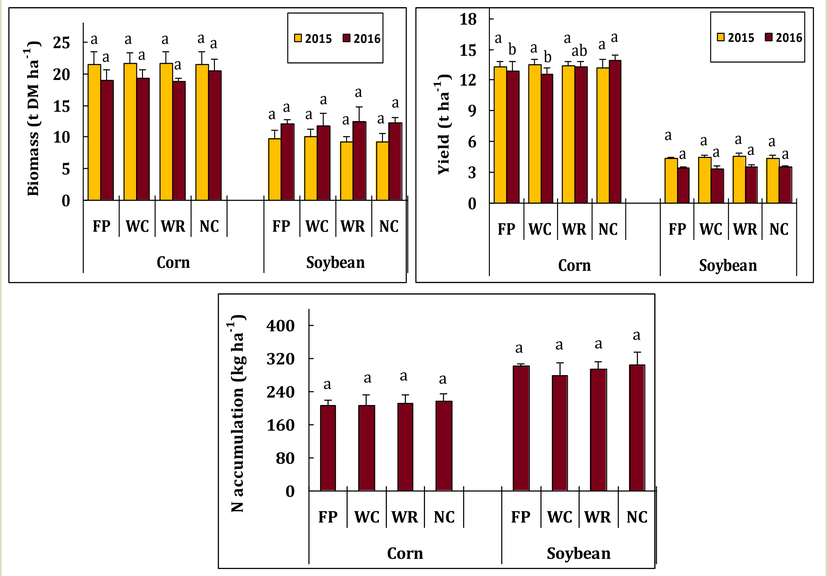

Figure 5. The aboveground biomass, yield and nitrogen accumulation of corn and soybean in 2015 and 2016 (FP = field pennycress; WC = winter camelina; WR = winter rye; NC = no cover crop).

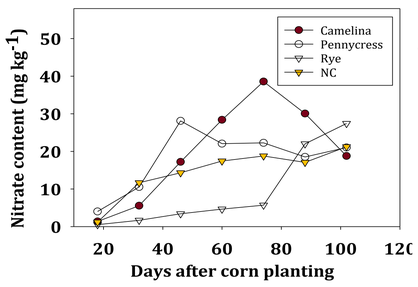

Figure 6. The soil nitrate content during the incubation in 2016 (NC = no cover crop).

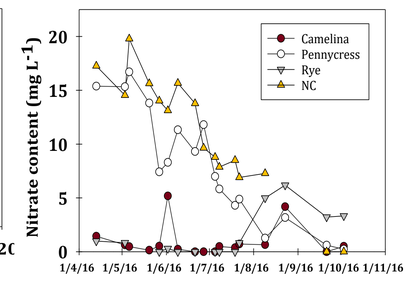

Figure 7. The nitrate content in in leachate during the growth of corn (NC = no cover crop).

- The WR biomass production was significantly higher than FP and WC.
- All cover crops in fall contained less than 7 kg N ha^{-1} except WC in 2015. The total WR nitrogen uptake was significantly higher than FP and WC.
- Winter rye had lower soil nitrate concentrations compared to the NC from 18d to 78d probably due to N immobilization.
- Soil in the FP, WC and WR treatments had less nitrate in the spring before main crops planting compared with NC in 2016.
- The cover crop treatments reduced the NO_3–N concentrations in the leachate before August compared with NC.
- Corn grain yield and biomass were less with cover crop than NC.
- Total N removal in corn was similar for all treatments in 2016 but was lower in cover crop treatments than NC.
- No significant treatment effects in soybean biomass, grain yields and N uptake were observed.

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More information:
liu00185@umn.edu
axel@umn.edu