COVER CROPS FOR THE IRRIGATED SPECIALTY CROP PRODUCTION IN THE NORTHERN HIGH PLAINS

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ABSTRACT

Irrigated specialty crop growers in the Northern High Plains (NHP) face multiple production challenges. These include low productivity soils, 125-day growing season, and extreme weather. For organically certified producers, additional difficulties include limited weed control strategies, incorporating biodiversity and implementing rigorous soil building strategies. One way to help improve these agroecosystems is to include cover crops as an off-season or relay crop. Cover crops have been widely studied in other climates on large-scale production, but careful design of cover crop mixes for producers facing the abovementioned challenges is needed. The main objective of this study was to evaluate suitability of selected cover crops to effectively compete with weedy species while not compromising plant available soil water needed to grow specialty crops and build up soil plant available nitrogen (N). Two monocultures, berseem clover and phacelia, along with three cover crop mixes (soil building mix, nitrogen fixer mix and mycorrhizal mix) were tested under irrigated conditions at the University of Wyoming Laramie Research and Education Center, in Laramie, Wyoming. Results suggested that large biomass producing cover crops provided an effective smothering of weedy species while not significantly depleting soil moisture. All cover crop mixes performed well but mycorrhizal mix likely provided additional benefits in form of rhizosphere associated simple organic N that facilitated healthy microbial communities.

INTRODUCTION

There is a growing interest in local food production in the Northern High Plains. Urban farmers in small towns of southeaster Wyoming, however, must face multiple challenges associated with very demanding growing conditions such as low precipitation, poor soil quality and short growing seasons. In addition, many farmers are interested in transitioning to organic certified production which brings even greater production challenges. These include chemical-free weed control, diversifying crop production and deploying soil management strategies to improve soil health, protect natural resources and conserve biodiversity (USDA, 2016). One way to help these producers is by incorporating cover crops. Cover crops are monocultures or mixes of fast-growing species, grown during non-crop periods or as a relay crop that can provide multiple benefits, including soil organic matter (SOM) increase, improved soil aggregation, increased plant biodiversity, soil surface cover, and weed competition/smothering (Blesh, 2018). Research has been conducted on the benefits cover crops add to large-scale production world-wide, but cover crop design and incorporation has not been researched on the local organic producer scale. Due to the short growing season present in Wyoming, designing cover crop mixes is of particular importance. These mixes should contain species that germinate quickly at low soil temperatures and produce large amounts of biomass that can smother competing weeds, build SOM, and prevent soil erosion. Designing the correct mixes and sharing that information with producers is a vital need that can be met with this research.

The main objective of this study was to evaluate suitability of selected cover crops to: (1) effectively smother weedy species, (2) not compromise plant available soil water needed to grow specialty crops and, (3) build up soil plant available nitrogen (N).

MATERIALS AND METHODS

The study was done at the University of Wyoming Laramie Research and Education Center Student Farm in Laramie, WY (41° 18′ 4″ N and 105° 35′ 28″ W, elevation 2,184 MASL). Cover crops were planted on May 14, 2020, and terminated on July 21, 2020. The experiment was affected by a June 8th snowstorm. The soil is sandy loam with a pH of 7.6 and an EC of 320 µS cm^{-1}. Seeds from three cover crop mixes and two cover crop monocultures (Table 1), plus a no cover crop control were planted in a randomized complete block design. The cover crops were obtained from Green Cover Seed (Grow Your Future » Green Cover). Each treatment was replicated six times resulting in a total of thirty-six, 6 m^2 plots.

Four 0-15 cm depth soil cores were collected at cover crop termination (July 21, 2020) using a step-down auger probe. Once excavated, soils were homogenized, stored in a plastic zipper bag, sealed, and placed in a cooler with icepacks until processing within 24 hours of collection.

In the lab, soils were sieved through a 2 mm sieve and analyzed for: (1) gravimetric soil water content (Gardner, 1986); (2) electrical conductivity (EC) and soil pH on a 1:2 soil-to-water ratio; (3) inorganic N (sum of NH_4-N and NO_3-N) on an extract obtained from placing 10 g of fresh soil to 25 ml of two molar potassium chloride (2 *M* KCl) and analyzed using Doane and Horwath method (2003) (Doane & Horwáth, 2003) on a spectrophotometer microplate reader (UV-VIS Biotek Instruments, Highland park, USA); (4) total dissolved nitrogen (TDN) on an extract obtained from placing 10g of fresh soil to 25 ml of one half molar potassium sulfide (K_2SO_4) using the Newcomb-Carrillo method (2011).

Plant biomass (cover crops and weeds separately) were collected from a .44 m^2 area within each plot using a PVC quadrat (33cm by 33cm) thrown two times at random and then flipped on one side for a total area measuring .44m^2. The plant biomass was cut at ground level and separated into cover crops and weeds. The plant biomass was then placed in a paper bag and oven-dried at 65°C for 48 hours to determine dried biomass.

All statistical analyses were performed in R version 3.6.2 (The R Foundation for Statistical Computing). The effects of cover crop treatment on soil gravimetric and chemical characteristics along with plant biomass comparisons were assessed using two-way Analysis of Variance (ANOVA) with significance at a minimum of $P \leq 0.05$. Data were tested for normality using the Shapiro–Wilk test. Transformations were used to achieve normality for data that were not normally distributed. If data were unable to normalize, a Kruskall-Wallis rank sum test was used for statistical analysis followed by the Dunn test to determine treatment significance. Regression analyses was performed on plant biomass data to assess weed suppression by cover crop treatment (Kutner, et.al., 2004).

Table 1: Cover crop mixes

Species	Scientific Name	C3/C4 Plant	Lifeform	Berseem Clover	Phacelia	Soil Building Mix	Nitrogen Fixer Mix	Mycorrhizal Mix
Chick Pea	*Cicer arientinum*	C3	Legume				X	
Spring Pea	*Pisum sativum*	C3	Legume			X	X	
Spring Lentil	*Lens culinaris*	C3	Legume			X	X	X
Chickling Vetch	*Lathyrus sativus*	C3	Legume				X	
Common Vetch	*Vicia sativa*	C3	Legume			X	X	X
Berseem Clover	*Trifolium alexandrinum*	C3	Legume	X				X
Crimson Clover	*Trifolium incarnatum*	C3	Legume			X	X	
Persian Clover	*Trifolium resupinatum*	C3	Legume					X
Mung Bean	*Vigna radiata*	C3	Legume					X
Rapeseed	*Brassica napus*	C3	Broadleaf			X	X	
Sunflower	*Helianthus annus*	C3	Broadleaf			X	X	X
Flax	*Linum usitatissimum*	C3	Broadleaf			X	X	X
Phacelia	*Phacelia tanacetifolia*	C3	Broadleaf		X			X
Safflower	*Carthamus tinctorius*	C3	Broadleaf					X
Barley	*Hordeum vulgare*	C3	Grass			X		X
Oats	*Avena sativa*	C3	Grass			X	X	X
White Wonder Millet	*Setaria italica*	C4	Grass					X
Proso Millet	*Panicum miliaceum*	C4	Grass					X
Brown Top Millet	*Urochloa*	C4	Grass					X

RESULTS AND DISCUSSION

1. Cover crops competition with weedy species

All cover crops except for berseem clover produced biomass large amounts of biomass. Berseem clover is typically grown in warm environments with mild winters (Piano & Pecetti, 2010). A late, June 8th snow prevented a well-established stand of inoculated berseem clover (Figure 1A). This was demonstrated in the reduction of weed biomass in the well-established cover crop treatments (Figure 1B). Phacelia has a cold tolerance of -7.78°C (Kilian, 2016) and develops a dense canopy that made the biomass production of this monoculture similar to the biomass production of the cover crop mixes (Figure 1A) while also providing similar weed suppression (Figure 1B).

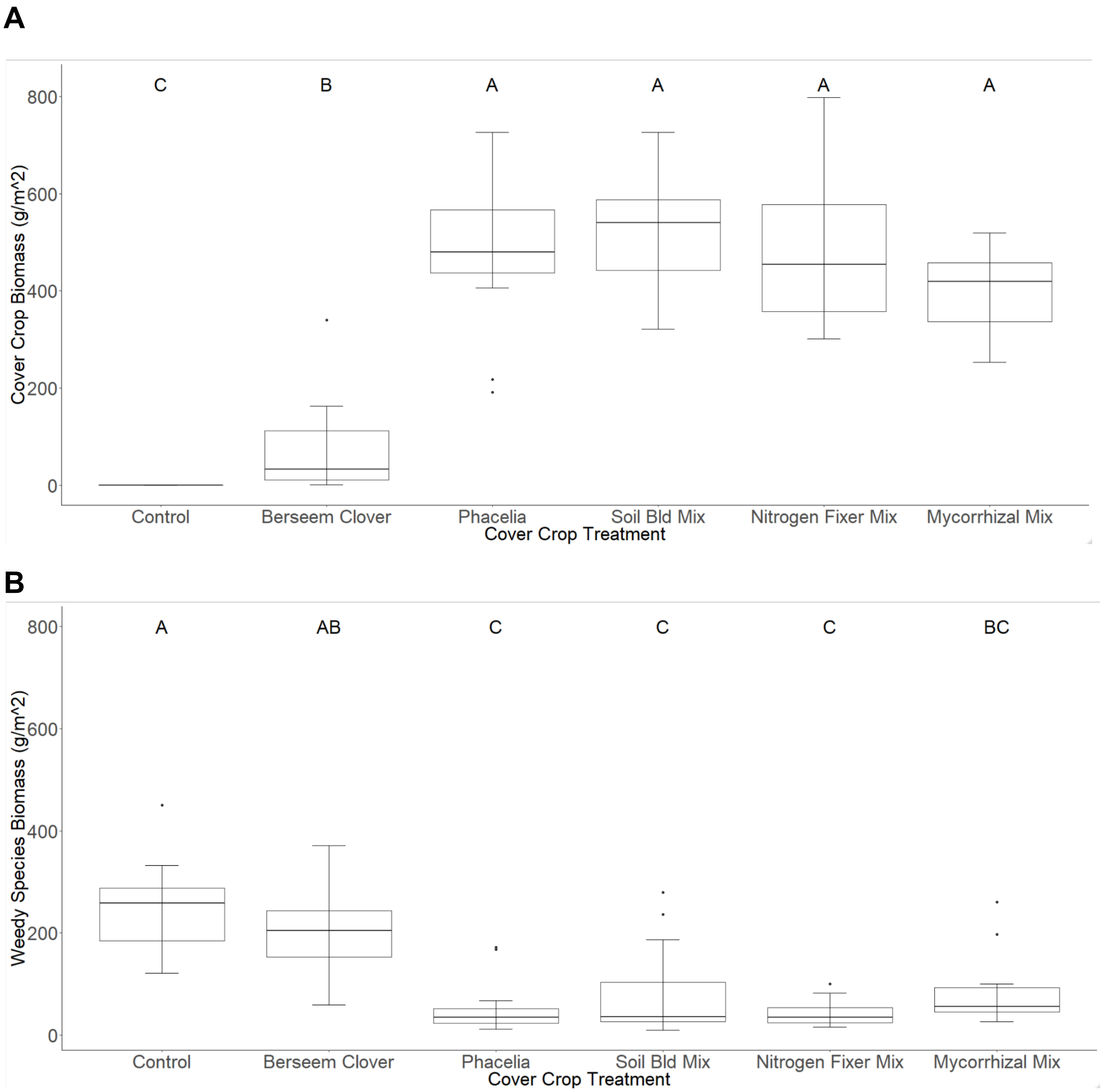
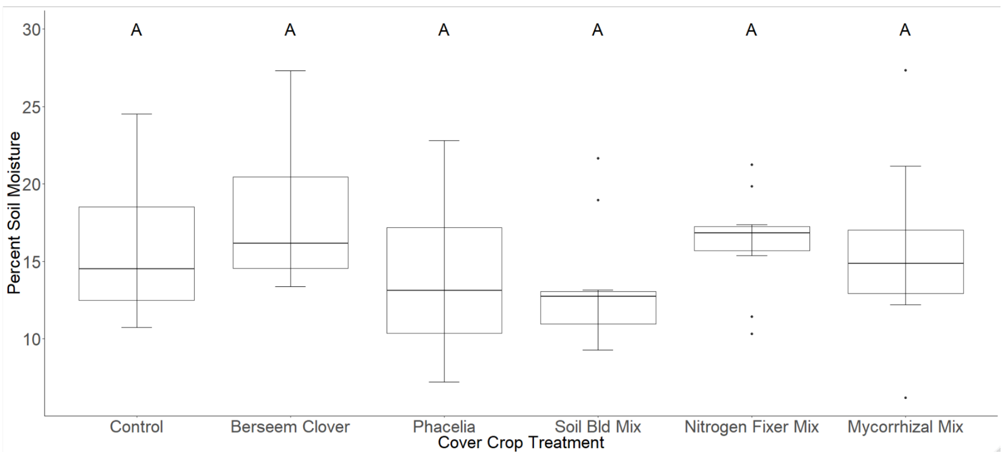


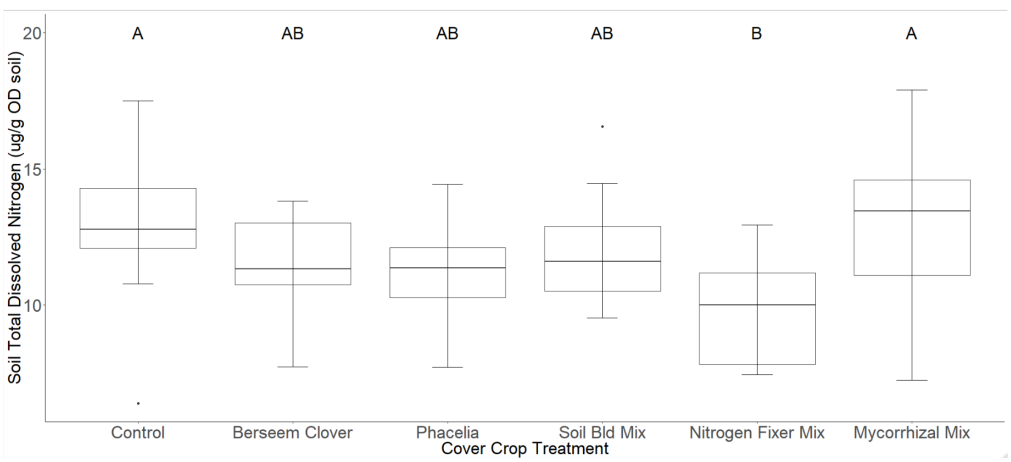
Figure 1: Cover crop (A) and weedy species (B) biomass

2. **Plant available water and nitrogen in soil following cover crops termination.**

A



B



C

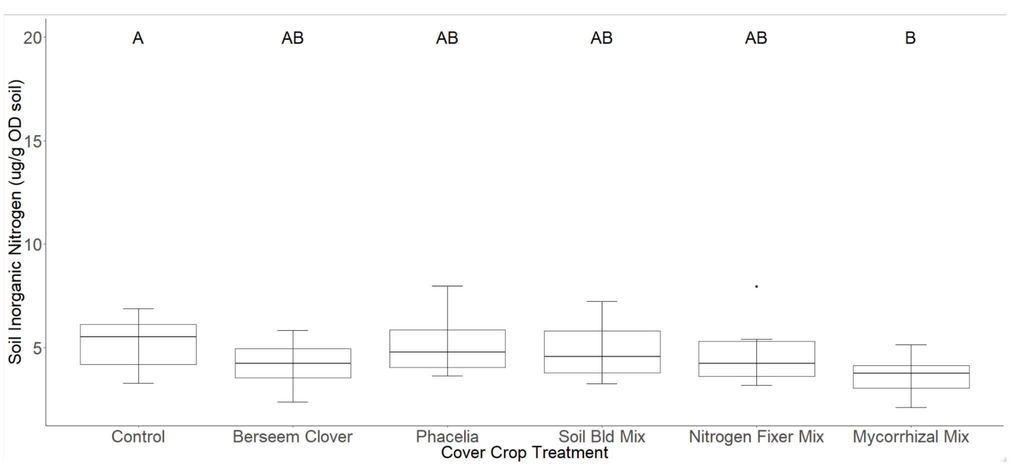


Figure 2. Soil water content (A) total dissolved nitrogen (B) and inorganic nitrogen (C).

Soil water was not significantly reduced by growing cover crops despite greater biomass production compared to weedy biomass produced in the control (Figure 2A). Total dissolved N was the highest in soils beneath mycorrhizal mix while the lowest TDN was in soils beneath N fixer mix (Figure 2B). In contrast, inorganic N was the lowest in soil beneath mycorrhizal mix. Mycorrhizal mix contained the highest number of cover crop species (Table 1) and contained the most grass species. Fibrous roots of grasses acted as good scavengers for inorganic N (Shelton et al., 2018) and successfully competed with weeds for soil N (Finney et al., 2017) (Figure 4B). High TDN and low inorganic N concentrations in mycorrhizal mix also suggested large contributions of simple organic N possibly root exudates, that supported active microbial communities in the rhizosphere.

CONCLUSIONS

Under water unlimited conditions, cover crops were effective at weed suppression in an organic system. Soil moisture was not compromised by growing high biomass producing cover crops. Once incorporated into the soil, cover crop biomass will become a source of plant available nutrients, increase soil organic matter, and improve soil health. Cover crop mixes containing grass species and producing large amounts of biomass effectively smothered weedy species. All cover crops selected for this experiment performed equally well but there were emerging trends that mycorrhizal mix may provide more benefits in the long term. Soil sampling immediately following cover crop termination might not reflect the prolonged benefits incurred by cover crop planting and later soil sampling would be required.

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