Study Name: Fall Rye for Integrated Weed Management in Soybean in Western ND.

Location: Dryland No till Research Farm at the Williston REC, Williston, ND.

Year: 2023 – 2024

Principal Investigator: Charlemagne “Charlie” Lim

Introduction

Cover crops prevents soil erosion by to wind and rain splashes, but also promote buildup of organic matter over time, increase water infiltration and reduce surface runoff, improves snow capture, conserve soil moisture, and improve the overall long-term soil condition (Ransom et al., 2021). Another key feature of cover crop is the ability to compete and smother weeds by deprivation of water, nutrients, and sunlight reducing the ability of weeds to cause significant reduction in crop yield. Heavy reliance on herbicides with a single mode of action to control weeds throughout the growing season year after year has led to the development of herbicide resistant populations in the state, not only in soybeans but also in other crops like in small grains like in wheat, pulse crops like in peas and lentils, and other minor broadleaf crops such as in sunflower and canola. With the growing problems and sustainability concerns brought by weed resistance to herbicides, and the slow turnover for new herbicide modes of action, there is a need for a diversified and integrated approach to control and manage weeds and their seedbanks in the soil.

Cover crops need to be well established, at least initially. It suppresses and competes with weeds for its entire duration in the field, and does not have to be too dependent on temperature and weather conditions as one would like to have when applying chemicals to control weeds. Cover crops can also compliment herbicides for weed control. Expriments conducted at NDSU North Central Research Center showed that the combination of a fall cover crop (cultural) and herbicide (chemical) as integrated weed management strategy reduced kochia density by more than 70% (Endres, 2022), leaving chemical weed control programs implemented into the growing season with better spray coverage on smaller weeds and thereby effective in weed control. A four-year study conducted at CREC showed excellent (up to 99%) control of green foxtail and common lambsquarters when cereal rye alone was used as a fall cover crop in front of dry bean, although dry bean yield was reduced when cover crop was terminated close to or after dry bean planting (Endres, 2022).

However, use of cereal rye as a cover crops in northwestern ND to control or suppress annual weeds that emerge in the fall or early in the spring, especially in dryland no till situations where soil moisture is generally thought as the limiting factor in planting a cover crop after the harvest season, has not been thoroughly investigated. Depending on the area, limited yearly precipitation can deter growers to adopt a cover crop program preceding soybean due to soil moisture concerns, either not enough moisture to germinate the cover crop in the fall or the overwintering cover crop such as rye could take up so much moisture in the spring that could affect soybean yield at the end of the growing season. Northwestern, ND receives an average precipitation (rain and snowfall) of 13 inches, with about 2-3 inches fall as rain in the summer months. Additionally, herbicide-resistant kochia populations, particularly to group 9, group 2, and group 14 herbicides have been a huge concern in recent years especially in western ND (Ikley, 2023; Jenks, 2023). This all the more emphasizes the need for integrated approaches to weed control

and management. In wetter regions of North Dakota and in eastern states which receive far more precipitation, rye planted in the fall has been shown to provide control or suppression of weeds that emerge late in the fall and weeds that emerge very early in the following spring (Werle, 2018). However, there is limited information regarding the use of rye as a fall cover crop in combination with fall- or spring-applied herbicides and their effect on kochia and soybean yield under the semi-arid climate in northwestern ND.

This study aimed to determine the effects of increasing seeding rates of a fall rye in conjunction with a fall- and spring-applied pre-emergence herbicides on kochia control, and soybean yield in no till dryland farming conditions in northwestern ND and to provide recommendations for optimum rye seeding rate in conjunction with herbicide use for weed control, and to give light in the trade off in soybean yield, if any. This study also hopes to promote soil conservation practices and soil benefits from the use of cover crops such as rye, where applicable.

Completed Work

The study was conducted in dryland no till research farm at the Williston Research Extension Center, Williston, ND. Cereal rye (ND Gardner C20GRWR) was drill seeded with a no-till drill in early fall of 2023. Rye emerged on September 5, 2023. Cover crop was terminated at 21 days before soybean planting in following spring. To start clean, the entire field trial was sprayed with roundup pmax + gramoxone as preplant burndown application in the spring. The weed-free control plots were maintained with application of the spring burndown herbicides followed by traditional POST herbicides and hand weeding. Visual weed control and weed density for kochia were assessed before rye termination in the spring. Roundup Ready soybean was planted in the spring June 5. POST herbicide applications (raptor or basagran or varisto or glyphosate, and grass herbicides were applied as needed, except in weedy plot treatments). Rye ground cover (using the Canopeo App) and soil moisture (using a soil neutron probe) data were collected in the in the spring before rye termination, at around planting, and throughout the growing season. The experiment was in a randomized complete block. Experimental plots were 10 x 30 ft and treatments replicated four times. Treatments was randomly assigned to the experimental plots. Treatments include cereal rye seeding rates and fall-applied and spring-applied herbicides (Table 1). Visual weed control ratings were taken at cover crop termination, at planting, and at 7, 14, 21 days after soybean planting. Weed density was obtained by counting live kochia plants in a 1 ft^2 quadrat at rye termination, at planting, and at 6 weeks after planting.

Table 1. Fall planted Rye cover crop seeding rates and fall and spring herbicide treatments.

1	Weedy (no herbicide)
2	Weed-free (*spring burndown + POST herbicides + hand weeding)
3	Zidua 3 oz (fall PRE) + *spring burndown only
4	Valor 3 oz (fall PRE) + *spring burndown only
5	Fierce 7.5 fl oz (fall PRE) + *spring burndown only
6	Fierce MTZ (Spring PRE) + *spring burndown only
7	Rye at 90 lbs/A + *spring burndown only
8	Rye at 120 lbs/A + *spring burndown only

9	Rye at 150 lbs/A + *spring burndown only
10	Rye at 90 lbs/A + Fierce MTZ (spring PRE) + *spring burndown only

*spring burndown = Roundup pmax (28 fl oz/a) + Gramoxone (2 pints/a)

Results to date

Due to a planter issue wherein, the all the seeds were planted in one row in each pass (Figure 1), the field was replanted on June 20 but soybean did not emerge until July 1 (Figure 2). Due to late emergence of replanted soybean and the freezing temp (28°F) in October that killed the soybean, no yield data was collected (Figure 3).

Figure 1. Planter planted all the seeds in one row in each pass.

Figure 2. Replanted soybean emerged July 1.

Figure 3. Soybean killed due to freezing temperatures in mid-October.

Rye was terminated 21 days before soybean planting with a burndown application of glyphosate plus gramoxone. Height of rye at termination was two feet tall. Kochia density was determined before rye termination and after rye termination (Table 2).

Before rye termination (Table 2), spring kochia density was lower following a fall planted rye cover crop treatment. Kochia density was significantly lower in the following spring after rye was planted in the previous fall at seeding rates of 90, 120, and 150 pounds seeds per acre. Kochia density per ft^2 were higher in the weedy check, weed-free check, and in treatment with Fierce MTZ (spring-applied preemergence) where there was no fall rye cover crop or fall residual herbicide application, as compared to when there was a fall planted rye cover or a fall residual herbicide application, although not statistically different except for when compared to the weedy check. Kochia in the weed-free check were present since the plots were not fully kept weed-free until right after rye termination. Kochia density was also lower where there was fall application of Zidua SC and Fierce EZ compared to the weedy check. Spring kochia density in fall-applied Valor EZ treatment was comparable to the weedy

check. In this particular field, kochia tissue samples were collected in the spring and tested genetically positive for PPO resistance. A visual assessment of kochia density before rye termination were also taken (Figure 4).

After rye termination (Table 2), kochia density in all treatments was significantly lower when compared to the weedy check.

Table 2. Kochia density before (May 10) and after (June 18) cereal rye termination/preplant burndown. Rye terminated May 14.

Treatment	Rate (per acre)	Timing	Kochia per ft²* (MAY 10)	Kochia per ft²* (JUNE 18)
Weedy check			27.1 a	3.3 a
Weed-free			6.9 ab	0.0 b
Zidua SC	3 fl oz	Fall-applied	3.3 b	0.6 b
Valor EZ	3 fl oz	Fall-applied	6.0 ab	0.6 b
Fierce EZ	7.5 fl 0z	Fall-applied	1.2 b	0.5 b
Fierce MTZ	1.25 pint	Spring-applied pre	9.6 ab	0.1 b
Cereal Rye	90 lbs	Fall-planted	1.0 b	0.2 b
Cereal Rye	120 lbs	Fall-planted	0.1 b	0.1 b
Cereal Rye	150 lbs	Fall-planted	0.0 b	0.0 b
Cereal Rye + Fierce MTZ	90 lbs 1.0 pint	Fall-planted + Spring-applied pre	0.1 b	0.0 b
LSD			11.20	1.40
Total DF			39	39
CV			120*t*	133*t*
Treatment F			2.39	2.867
Probability (F)			0.0387	0.0164

**= means followed by the same letter are not do not significantly differ (P=0.05, LSD).*
t=means descriptions are reported in transformed data units, and are not de-trasformed.
LSD = least significant difference.

Soil moisture availability up to 42 inches depth was also monitored and determined before rye cover crop termination and throughout the soybean growing season (Figure 5). Soil moisture measurements at the center of each plot were taken with the use of a neutron probe. Rye cover crop took a significant amount of water from the soil leading up to cover crop termination. Soil water content (top 24-inch soil profile) in the rye cover crop treatments neared wilting point before rye termination compared to herbicide treatments and control checks (Figure 5 graph dated 2024-06-11). However, scattered rain showers that followed later in the weeks of June replenished the water in the soil and brought the water content back up close to field capacity in plots with rye cover crop treatments. Rye residue on top of the

soil provided a protective cover against soil erosion by rain splash and was also effective in capturing rainwater through improved infiltration. The opposite was true in plots with no rye residue cover (Figure 5 graph dated 2024-07-24).

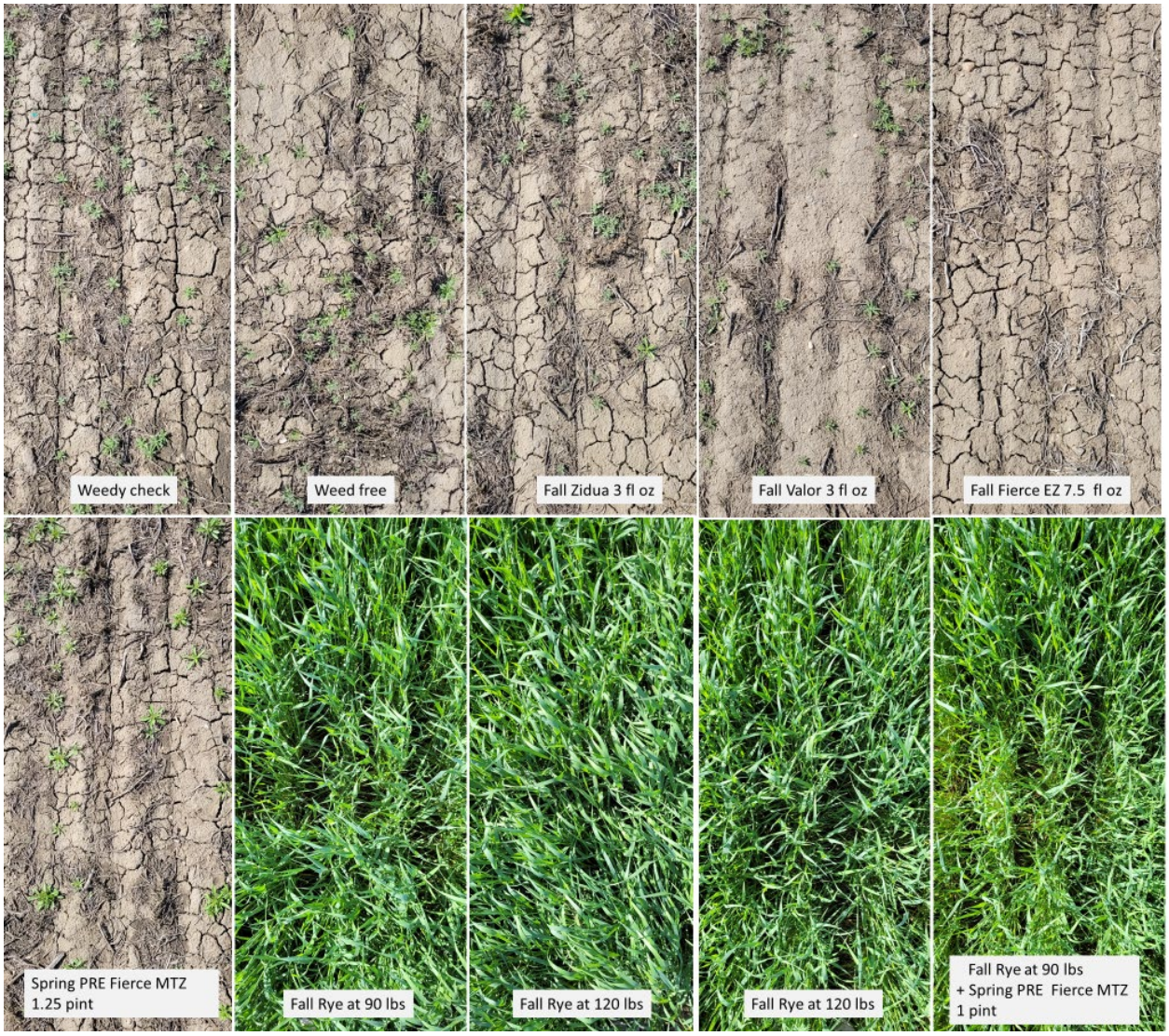

Figure 4. Visual representation of kochia densities in respective treatments before rye cover crop termination in the spring.

With rye terminated, both weeds and soybean used up water through the growing season. However, in treatments with no rye residue cover but weeds present, soil water availability went close to wilting point by August compared to treatments with rye residue cover (Figure 5 graph 2024-08-05 through 2024-08-28). This indicates that although rye before termination used up a significant amount of soil water, having the residue cover on top of the soil throughout the season may be beneficial in terms of rainwater capture that could maintain soybean yield given that subsequent rains occur during the growing season for instance in a wet year compared to a dry year. Unfortunately, due to the late emergence of replanted soybean and the freezing temperatures that killed the soybean in mid-October, no yield data was collected to determine if soybean yield is maintained with the rye seeding rates given western ND climate conditions.

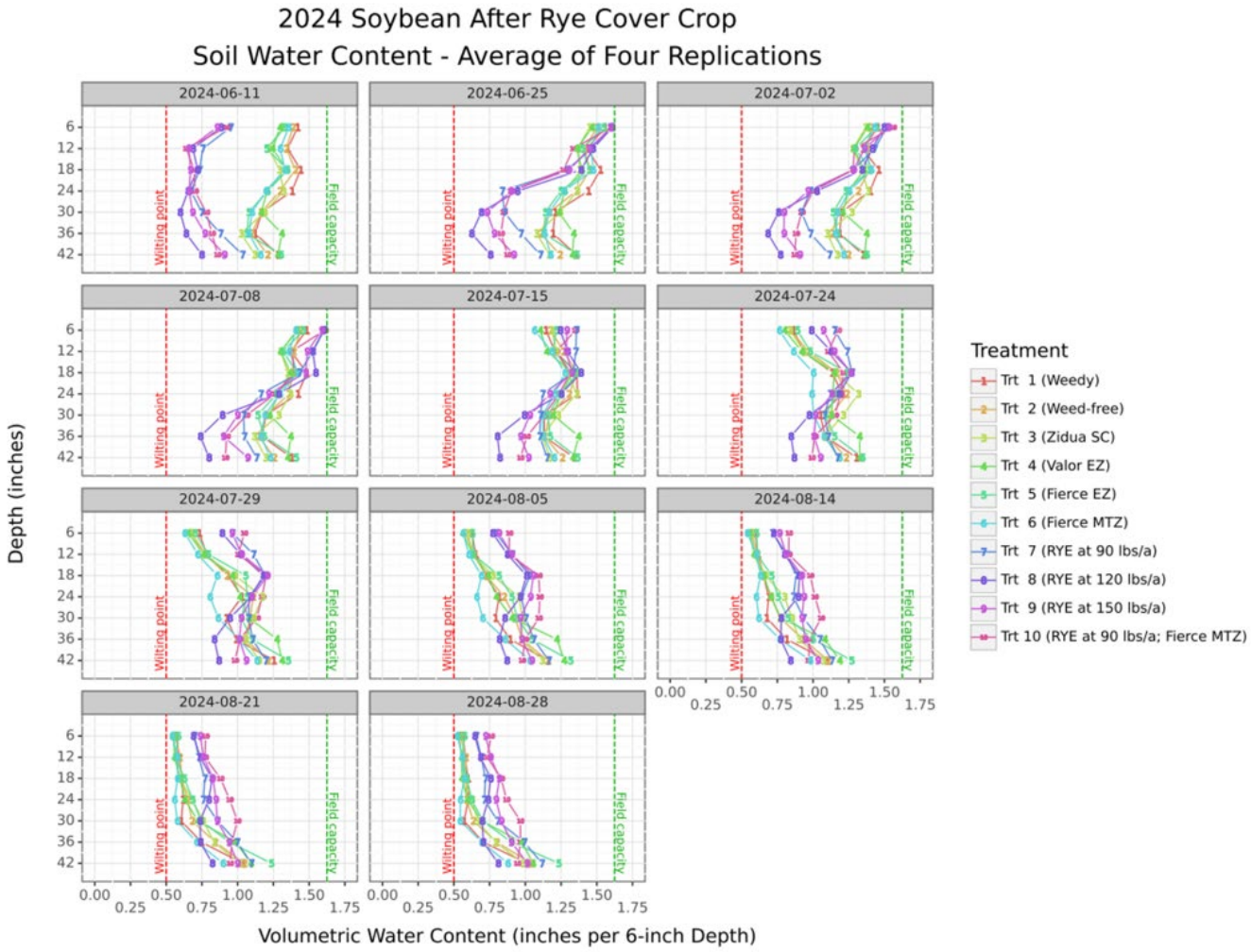

Figure 5. Graph showing fluctuations in soil water content up to the 42-inch depth due to treatment effect from before rye cover crop termination through the soybean growing season.

Work to be completed

Data on weed control and ground cover is yet to be analyzed and presented along with the results.

Other relevant information

Termination of rye cover crop posed a challenge. In some plots, some rye survived the one pass burndown application especially where rye seeding rates are high. Rye seed dormancy may also pose future problems since a small fraction of what was seeded may not emerge immediately and could potentially contaminate the next grass crop in the rotation.

Summary

Kochia density was reduced in treatments with a fall rye cover crop regardless of seeding rates when compared to the weedy check. Integrating rye cover crop with herbicide strategies for weed control also provided comparable results. Additionally, rye leading up to its termination 21 days before planting used up a significant amount of water. However, the residue left after termination provided ground cover as protection from soil erosion and improved rainwater infiltration into the soil. This helped replenish soil water after subsequent rains events during the growing season and helped offset the soil moisture used up by rye early in the spring. Preliminary data and results suggest that rye planted in the fall as a cover crop to help control and manage weeds such as kochia can be a viable tool in drier western ND conditions, possibly, without the perceived tradeoff in soybean yield due to moisture limitations. However, 3 years more of data is needed to determine consistency of findings.