PERENNIAL CEREAL/LEGUME - YR 3

This dual-purpose research study, initiated in 2022, focused on both grain production and forage, with plots seeded at Gateway Research Organization and five other research organizations across Alberta, including the University of Alberta's Breton plots, PCBFA in Fairview, MARA in Fort Vermilion, and BRRG in Forestburg. Fieldwork began in 2023 (the first production year) and concluded in the summer of 2024 (the second production year).

The research extensively examined the potential of perennial cereal-legume intercropping systems to provide both high-quality forage and grain yield. Key focus areas included forage productivity and quality, ecosystem functions such as nitrogen fixation by legumes and its transfer to perennial grain yields, as well as the effects of the cropping system on soil properties and overall soil health. By investigating these dual-purpose objectives, the study aims to enhance sustainable agricultural practices, improve long-term productivity, and promote soil health across diverse agroecosystems in Alberta.

Objectives

In 2024, during the final year of this project, the study concentrated on exploring the productivity and ecological advantages of intercropping perennial cereal grains (PCGC) with legumes. The primary goals were:

- To evaluate and comprehensively assess the annual productivity of both forage and grain in intercropping systems, comparing two seeding methods: alternate row seeding and same row seeding.
- To assess the ecosystem services provided by intercropping legumes and PCGC, particularly focusing on nitrogen fixation.
- To examine improvements in soil health by analyzing key indicators such as chemical, physical, and biological properties resulting from the intercropping of legumes with PCGCs.

These objectives were aimed at determining the potential of intercropping systems to enhance agricultural productivity and promote environmental sustainability.

Methodology

The GRO site was seeded in 2022 after previously being in chemical fallow. The experiment followed a randomized complete block design with four replications, using small plots measuring 10 meters by 1.37 meters.

Seeding was conducted with a 6-row Fabro Plot Drill, which featured C-shank openers spaced 23 cm apart and included side banding for precise seed placement.

Fieldwork completed in 2024 on the PCGC project included:

- Bi-weekly NDVI, soil moisture, soil compaction measurements, and temperature
- 15N application for nitrogen fixation measurements in early spring
- Plant tissue analyses on the perennial cereals
- Soil mineral nitrate sampling (sent to CARA soil health lab for analyses)
- Forage and grain yield estimation (dual-purpose utilization)

Strategy

ACE-1 is a variety of perennial rye developed in Western Canada and has low pre-harvest sprouting tendencies and good winter survivability (Acharya et al., 2003). Kernza is a variety of perennial wheat developed in the USA (Culman et al. 2013). Both ACE-1 and Kernza were used as PCGCs in this project.

This project was carried out with a factorial design (2 x 4 x 2 x 2 with 4 replications) consisting of the following treatment factors:

1. Perennial cereal grain crops (PCGC, 2 species/cultivars)
- ACE-1 rye
- Kernza wheat

2. Intercrops with legumes (4):
- Monoculture cereal (PCGC only)
- Alfalfa
- White clover
- Sainfoin

3. Seeding methods (2):
- Same row seeding (mixed method)
- Alternate row seeding

4. Utilization (2):
- Utilization 1: Spring forage harvest + fall combines harvest for grain
- Utilization 2: Summer combines harvest for grain + fall forage harvest

In 2022, this experiment was initiated. The trial was seeded on June 20, 2022. The ground was rather dry, and the soil temperature was 20 degrees Celsius at the seeding time. Therefore, the seeding depth for the cereals was ¾ of an inch, while for the legumes was ¼ of an inch.

The lab recommended no fertilizer at seeding time for growing forage crops. However, to provide a lift at the start, we put 9.26-0-0-10.57 @ 108 lbs/ac at seeding.

Results and Discussion

In 2024, The perennial rye (ACE-1) did not survive the extreme winter conditions of 2023 at the GRO site. Soil temperatures dropped to -15°C without sufficient snow cover, which would have otherwise provided insulation. As a result, ACE-1 experienced significant winterkill, with approximately 99% of the plants perishing and only a few surviving.

Spring Forage – Fall Combine (Utilization 1): The plots were harvested on July 12, 2024. Unfortunately, the short growing season prevented us from using them for dual purposes. While we were able to take two silage cuts in 2023, we managed only one in 2024 due to hail damage and moisture stress later in the season.

As previously stated, the ACE-1 was unable to survive in the trial. Consequently, the data presented in the table reflect measurements taken either from the legume species present in the experiment or from weeds. Therefore, the table's information should not be considered a reliable source for ACE-1 performance.

Throughout the study, perennial wheat (Kernza) consistently demonstrated superior forage yields. The yield outcomes closely followed the same pattern observed in 2023.

The highest production levels were observed in systems where perennial wheat was planted in the same row with sainfoin. Additionally, in the alternative-row system, the combination of perennial wheat and alfalfa outperformed all other treatments.

These findings highlight the significant role that sainfoin and alfalfa play in enhancing perennial wheat forage production potential.

Trt#	Seeding Method	Trt Name *	Yield @ 65% Moisture (tons/ac)		CP		ADF		NDF		TDN		Ca		P		K		Mg	
					% of Dry Matter															
1	Same Row	PW Mono	8.2	bc	9.2	ab	37.5	-	58.7	a	54.1	abc	0.4	d	0.3	-	1.6	-	0.1	b
2		PW - Alfalfa	9.4	ab	10.2	ab	36.6	-	56.8	a	54.9	abc	0.5	d	0.3	-	1.6	-	0.1	b
3		PW - White Clover	8.5	b	8.3	b	39.4	-	58.8	a	53.7	bc	0.4	d	0.3	-	1.6	-	0.2	ab
4		PW - Sainfoin	10.4	a	8.3	b	39.0	-	58.4	a	54.1	abc	0.4	d	0.3	-	1.6	-	0.2	ab
5		PR Mono	1.3	e	12.2	a	37.8	-	46.3	c	56.4	abc	1.0	ab	0.3	-	1.6	-	0.3	a
6		PR - Alfalfa	2.9	e	12.3	a	37.4	-	47.0	c	55.3	abc	1.0	ab	0.3	-	1.6	-	0.2	ab
7		PR - White Clover	2.0	e	13.0	a	34.2	-	47.5	c	57.0	a	0.8	bc	0.3	-	1.7	-	0.1	ab
8		PR - Sainfoin	2.9	e	11.5	ab	35.7	-	49.7	c	56.6	ab	0.8	bc	0.3	-	1.6	-	0.2	ab
9	Alternate Row	PW Mono	6.8	c	8.2	b	38.3	-	58.6	a	53.3	c	0.4	d	0.3	-	1.4	-	0.2	ab
10		PW - Alfalfa	9.3	ab	11.4	ab	36.8	-	51.3	bc	53.9	bc	0.9	bc	0.3	-	1.5	-	0.2	ab
11		PW - White Clover	8.3	bc	7.9	b	38.6	-	58.7	a	54.2	abc	0.4	d	0.3	-	1.5	-	0.2	ab
12		PW - Sainfoin	5.1	d		ab	37.1	-	55.2	ab	54.7	abc	0.6	cd	0.3	-	1.4	-	0.1	ab
13		PR Mono	2.1	e	12.1	a	36.0	-	49.1	c	55.6	abc	0.9	b	0.3	-	1.7	-	0.2	ab
14		PR - Alfalfa	7.9	bc	12.9	a	37.5	-	46.7	c	54.0	bc	1.2	a	0.3	-	1.59	-	0.2	ab
15		PR - White Clover	2.2	e	12.2	a	35.8	-	49.5	c	54.7	abc	0.8	bc	0.3	-	1.8	-	0.2	ab
16		PR - Sainfoin	2.8	e	11.5	ab	37.1	-	47.3	c	55.0	abc	1.0	ab	0.3	-	1.51	-	0.2	ab
LSD P=.05 (% mean diff)			1.1876 (22%)		2.2302 (21%)		3.1427 (9%)		3.9976 (8%)		1.7736 (4%		0.1848 (26%)		0.0281 (11%)		0.1929 (13%)		0.0822 (47%)	
Standard Deviation			0.8339		1.5659		2.207		2.807		1.2453		0.1298		0.0198		0.1355		0.0577	
CV			14.84		14.7		5.94		5.35		2.27		18.1		7.47		8.56		32.87	

* PW= Perennial Wheat; PR = Perennial Rye

Other acronyms used in the tables: CP- Crude Protein; ADF – Acid Detergent Fibre; NDF - Natural Detergent Fibre; TDN – Total Digestible Nutrient; Ca – Calcium; P – Phosphorous; K – Potassium; Mg – Magnesium

Means followed by the same letter or symbol do not significantly differ (P-.05, Student-Newman-Keuls).

Spring Combine – Fall Forage (Utilization 2):

The research site encountered a severe hailstorm on July 24, 2024, which had a notable impact on the grain portion of the trial. The storm caused extensive stem breakage, leading to premature drying of the kernels that had already formed before the damage occurred. Consequently, the grain yield data from this trial was not considered representative or reliable due to the adverse weather conditions.

In 2024, the grain block was harvested on August 23, 2024. The combination of perennial wheat and alfalfa produced the highest yield, reaching 761.5 kg per hectare when perennial wheat and legumes were planted together in the same row. This was a significant improvement compared to planting perennial wheat alone (669.0 kg/ha) or mixing it with other legumes.

However, when planted in alternating rows, the story changed. The yield of perennial wheat mixed with alfalfa dropped significantly to 178.5 kg/ha because the alfalfa outcompeted the wheat for space (this combination produced a lot of forage but less grain). On the other hand, perennial wheat grown alone in alternating rows (571.8 kg/ha) and the combination with white clover (569.0 kg/ha) had much better grain yields.

Perennial Cereal/Legume Trial - Grain Block - 2024

Trt #	Seeding Method	Entry Name*	Yield (kg/ha) @ 13.5% moisture		CP		ADF		NDF		TDN	
					% of Dry Matter							
1	Same Row	PW Mono	669	b	15.4	b	12	-	25.5	-	71.4	-
2		PW - Alfalfa	761.5	a	14.4	b	13	-	27.6	-	70.5	-
3		PW - White Clover	683.8	b	15.7	ab	11.7	-	24.7	-	71.6	-
4		PW - Sainfoin	578	c	15.1	b	11.6	-	25.4	-	71.8	-
5		PR Mono										
6		PR - Alfalfa										
7		PR - White Clover										
8		PR - Sainfoin										
9	Alternate Row	PW Mono	571.8	c	16.6	ab	10.6	-	23.1	-	72.7	-
10		PW - Alfalfa	178.5	e	17.6	a	11.4	-	23.4	-	72.1	-
11		PW - White Clover	569	c	16.4	ab	11.1	-	24.9	-	72	-
12		PW - Sainfoin	362.8	d	16.6	ab	10	-	23	-	73	-
13		PR Mono										
14		PR - Alfalfa										
15		PR - White Clover										
16		PR - Sainfoin										
LSD P=.05			38.04 (14%)		1.433 (9%)		1.7192 (16%)		2.8650 (12%)		1.7431 (3%)	
Standard Deviation			26.71		0.975		1.1691		1.9483		1.1854	
CV			9.77		6.11		10.25		7.89		1.65	

* PW = Perennial Wheat; PR = Perennial Rye

Means followed by the same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls).

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The results of nitrogen fixation and soil health improvements from this cropping system are still being studied. However, the benefits to the ecosystem were clear in the intercropping systems, especially with legumes like alfalfa and clover, which play an important role in fixing nitrogen in the soil. Overall, these findings highlight the trade-offs between yield, quality, and resilience in perennial cropping systems. Perennial wheat has shown to be a good fit for areas with tough winters, providing higher forage yields and better adaptability.

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RDAR
Results Driven Agriculture Research

APR 2024
COSMOS HELPING WITH PLOT PREPARATION

August 2023
regrowth after 1st silage

August 2023
plot left to combine