Evaluating Cover Crop Integration in a Prairie Crop Rotation: Cover Crop and Cash Crop Productivity

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Introduction

- Early adopter farmers are introducing cover crops (CCs) to crop rotations in the Canadian Prairies to enhance soil health, organic matter, and soil biology.[1]
- Short growing season and lack of moisture constrain CC adoption across the Canadian Prairies.[1] Intercropping CCs with cash crops is a new strategy for fall cover being tested in the Prairies.
- CC productivity and their impact on cash crop productivity can vary with site-specific management, precipitation, type of CC species, tillage system.[2,3]

Objective

- Evaluating the agronomic potential of CC in an annual prairie crop rotation and their impacts on cash crop biomass and grain yield production.

Material and Methods

- A fully phased long-term experiment managed under no-tillage.
- Two research sites:
  - Carman, Manitoba – Sandy loam soil
  - Glenlea, Manitoba – Clay soil
- Experimental design: Randomized complete block design
- Treatments:
  - 4-yr annual crop rotation with CCs (4yr+CC)
  - 4-yr annual crop rotation without CCs (4yr-CC)
- Wheat, canola, oats, and soybean included as cash crops in the 4-yr annual crop rotation.
- Subterranean clover, fall rye, and Italian ryegrass as CCs with wheat, oat, and soybean, respectively. A mixture of red clover, white clover, and Italian ryegrass (Mix) as a CC in canola (Figure 2).
- Herbicides and hand weeding were implemented as weed management practices.
- In 2024, CC in canola phase was reseeded due no survival of CC from herbicide injury. Herbicide management system in canola was switched from Glyphosate in 2024 to Glufosinate in 2025.
- Cash crop biomass collected before harvest. Cash crop grain yield harvest using a small plot combine. Grain yield adjusted for moisture and harvested area.
- CC and cash crop volunteer biomass collected before the first fall frost using a 0.75 m x 0.75 m quadrat.

Statistical Analysis

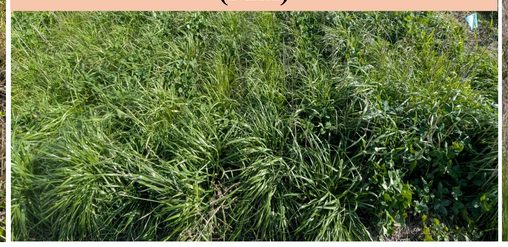
- Cash crop data analysed using PROC GLIMMIX procedure in SAS OnDemand for Academics. Treatment and site year were fixed effects in the model and Block nested within site year was a random effect. Data followed a normal distribution.
- CC data analysed using PROC GLIMMIX with site year as a fixed effect and Block nested within site year as a random effect. Fall rye, Italian ryegrass, and volunteer wheat biomass data was log-transformed.
- LS-Means were calculated at 0.05 level of significance using Tukey's multiple comparison method.

Table 1. Cumulative monthly precipitation (Apr-Oct, mm) in 2024 and 2025 compared to the 30-year normal (1981-2010, mm)[4] at Carman and Glenlea, Manitoba.

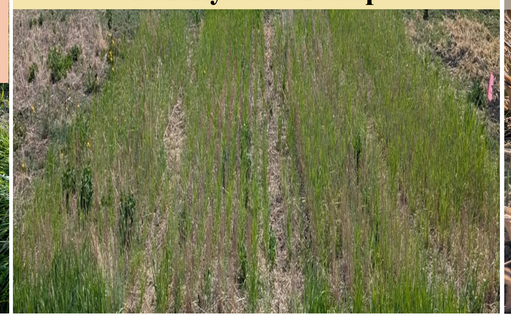
Carman			
Month	**2024**	**2025**	**Normal**
April	38.3	23.8	29.5
May	130.3	36.4	69.6
June	144.2	33.7	96.4
July	38.3	39	78.6
August	73.7	46.1	74.8
September	50.9	70.3	49
October	10.9	102.6	43.4
Glenlea			
Month	**2024**	**2025**	**Normal**
April	40.7	12.9	27.7
May	114.8	21.4	61.5
June	116.8	51.9	99.7
July	84.4	49.2	91.7
August	42.7	105.3	72.4
September	33.8	51.1	49
October	14.1	99.5	43.1

(A) Wheat cash crop
Subterranean Clover cover crop

(B) Canola cash crop
Red Clover, White Clover, and Italian Ryegrass cover crop mixture (Mix)



(C) Oat cash crop
Fall Rye cover crop



(D) Soybean cash crop
Italian Ryegrass cover crop

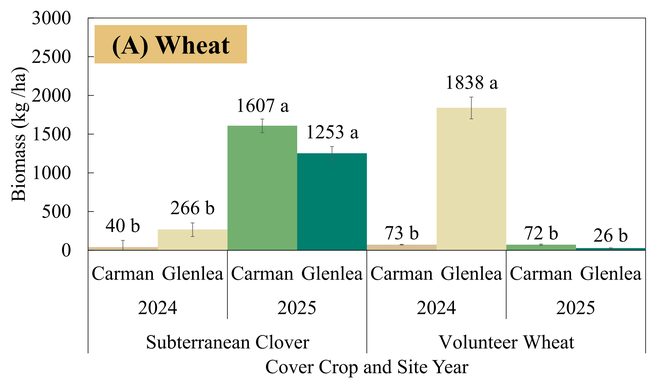
Figure 1. Cover crop species grown with wheat (A), canola (B), oat (C), and soybean (D). Cover crop combinations evaluated in this project include wheat-subterranean clover, canola- mixture of red clover, white clover, and Italian ryegrass (Mix), oat- fall rye, soybean- Italian ryegrass.

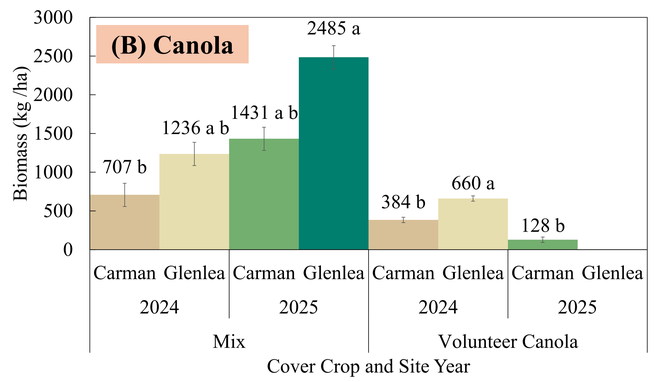
Results

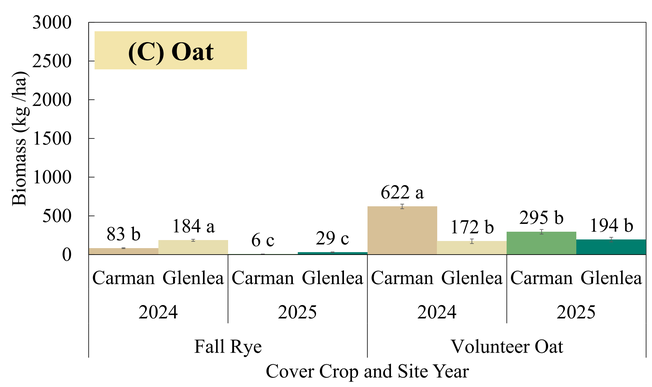
Table 2. F-test probability from Type III ANOVA for cover crop biomass, cash crop biomass yield, and cash crop grain yield.

Cover Crop Biomass							
Effect	**Wheat Phase**		**Canola Phase**		**Oat Phase**		**Soybean Phase**
	Subterranean Clover	**Volunteer Wheat**	**Mix**	**Volunteer Canola**	**Fall Rye**	**Volunteer Oat**	**Italian Ryegrass**
Site Year	***<.0001***	***<.0001***	***0.0089***	***0.0015***	***<.0001***	***0.0006***	***<.0001***

Cash Crop								
Effect	**Biomass Yield**				**Grain Yield**			
	Wheat	**Canola**	**Oat**	**Soybean**	**Wheat**	**Canola**	**Oat**	**Soybean**
Treatment	0.5117	0.0147	0.001	0.194	***0.0101***	0.0011	***0.0003***	0.1124
Site Year	***0.0016***	<.0001	<.0001	***0.0016***	0.14	<.0001	0.3674	***0.001***
Treatment*Site Year	0.3627	***0.0181***	***0.0015***	0.2049	0.1834	***0.0043***	0.1958	0.6696







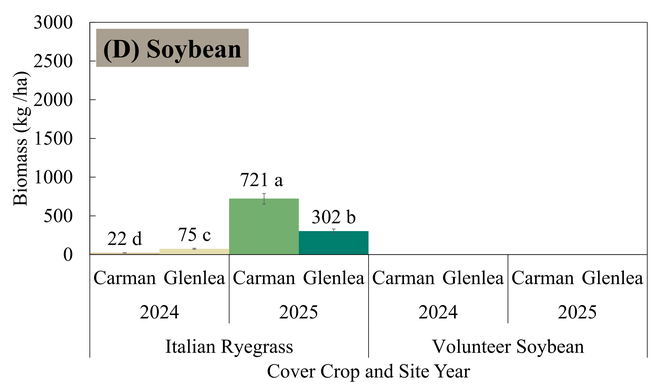


Figure 2. Comparison of biomass productivity for CC and cash crop volunteer species in wheat (A), canola (B), oat (C), and soybean (D) rotation phases at Carman and Glenlea over two years (2024, 2025). Cover crop combinations evaluated in this project include wheat-subterranean clover, canola- mixture of red clover, white clover, and Italian ryegrass (Mix), oat- fall rye, soybean- Italian ryegrass.

Table 3. Comparison of cash crop biomass (kg/ha) and grain yield (kg/ha) with (4yr+CC) and without cover crop (4yr-CC) at Carman and Glenlea over two growing season (2024, 2025). Cells with same letters indicate no significant difference between treatment, site year, and treatment*site year within respective cash crop at α=0.05 according to Tukey's multiple comparison test.

Effect		**Biomass Yield (kg/ha)**				**Grain Yield (kg/ha)**			
		Wheat	**Canola**	**Oat**	**Soybean**	**Wheat**	**Canola**	**Oat**	**Soybean**
Treatment									
4yr+CC		4298	3705 b	3611 b	2399	3370 b	1536 b	2625 b	2392
4yr-CC		4427	4108 a	4363 a	2548	3700 a	1835 a	3188 a	2546
Treatment*Site Year									
Treatment	**Site Year**								
4yr+CC	**Carman 2024**	5149	6168 a	5125 b	2878	3187	1268 c	2421	2758
4yr-CC		4877	5864 a	4800 b	2642	3268	1420 c	2761	2722
4yr+CC	**Glenlea 2024**	N/A	4726 a b c	5110 b	2045	N/A	1581 c	2393	1963
4yr-CC		N/A	4814 a b	7377 a	2234	N/A	1438 c	3361	2156
4yr+CC	**Carman 2025**	4132	1760 d	2356 c	2535	3566	1766 b c	2502	2503
4yr-CC		4437	2558 c d	2765 c	2999	3888	2173 a b	3128	2697
4yr+CC	**Glenlea 2025**	3615	2168 d	1852 c	2136	3357	1530 c	3182	2345
4yr-CC		3967	3198 b c d	2511 c	2316	3943	2310 a	3500	2609

Findings

Wheat

- Subterranean clover biomass production was significantly higher at Carman and Glenlea in 2025 compared with 2024 (Figure 2), which may be attributed to the doubled seeding rate, delayed in-crop herbicide application and greater fall precipitation in 2025.(Table 1).
- Intercropping the subterranean clover CC (4yr+CC) did not change wheat biomass but significantly reduced wheat grain yield by 9 % when averaged over the two study years (Table 3).
- In 2024, prolonged wet conditions after seeding led to wheat crop failure at Glenlea; consequently, wheat was treated as a CC and not harvested for grain.

Canola

- Biomass of the red clover, white clover, and Italian ryegrass mix at Glenlea 2025 was 2.5× higher than at Carman 2024, but not significantly different from Glenlea 2024 or Carman 2025 (Figure 2). The higher biomass at Glenlea 2025 likely due to greater CC persistence associated with no in-crop herbicide use and higher fall precipitation (Table 1). Changes in herbicide management and delaying in-crop herbicide applications may have also contributed to differences in CC biomass between the two growing seasons.
- No significant differences in canola biomass yield were observed between the 4yr+CC and 4yr–CC treatments at both sites in 2024 and 2025 growing season (Table 3).
- A significant 33% reduction in canola grain yield was observed in Glenlea 2025 under the 4yr+CC treatment compared with the 4yr-CC treatment. However, no significant differences in canola grain yield were observed in Glenlea 2024, Carman 2024, and Carman 2025 (Table 3).

Oat

- Fall rye biomass was significantly higher at Carman 2024 and Glenlea 2024 than at both sites in 2025 (Figure 2) due to higher fall precipitation in 2025 (Table 1), which limited field trafficability and necessitated the use of broadcasting instead of drill seeded system.
- Greater biomass from volunteer oat likely reduced the growth potential of the fall rye CC through competition.
- Oat grain yields were significantly lower by 18 % under the 4yr+CC treatment as compared to the 4yr-CC treatment (Table 3), which may be associated with spring soil moisture use of overwintering mixture of red clover, white clover and Italian ryegrass.

Soybean

- Italian ryegrass biomass produced in the 2025 growing season was significantly higher than the 2024 growing season at Carman and Glenlea (Figure 2) due to better establishment and higher fall precipitation at both sites in 2025 relative to 2024 (Table 1).
- Intercropping the Italian ryegrass CC did not reduce crop biomass and grain yield for the soybean cash crop (Table 3).

Next Steps

- Analyse soil moisture data to understand the impact of CC on cash crop productivity.
- Analyse cash crop plant count, CC plant count, CC persistence data to help explain the trends in the cash crop and CC productivity.
- Develop CC management strategies applicable to prairie cropping system based on these results.

References

[1]Morrison, C.L., and Y. Lawley. 2021. 2020 Prairie Cover Crop Survey Report. https://umanitoba.ca/agricultural-food-sciences/make/make-ag-foodresources#crops.
[2]Garba, I.I., Bell, L.W. & Williams, A. 2022. Cover crop legacy impacts on soil water and nitrogen dynamics, and on subsequent crop yields in drylands: a meta-analysis. *Agron. Sustain. Dev.* **42**, 34. https://doi.org/10.1007/s13593-022-00760-0
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[4]Government of Canada. (2025, June 10). Government of Canada. Canadian Climate Normal. https://climate.weather.gc.ca/climate_normals/index_e.html