IRRIGATED AND RAINFED FIELD TRIALS TO MAXIMIZE BIOLOGICAL NITROGEN FIXATION:

Assessing the Legacy Impact of Soybean and Peas on Residual Soil Nitrogen and Yield of Cereal and Oilseed Crops

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Background

- Soybean and field peas are important nitrogen fixing grain legumes within Manitoba cropping systems. Both crops provide economic and environmental benefits to growers by reducing nitrogen (N) fertilizer costs and greenhouse gas emissions across the crop rotation.
- Agronomists, growers and extension specialists also recognize the legacy impact soybean and peas have on succeeding crops, including apparent nitrogen credits (or altered soil nitrogen dynamics) that enable fertilizer rates to be reduced for crops that follow these legumes.
- Nitrogen credits following pea or soybean often vary between jurisdictions with modifications linked to crop yields achieved or also the nutrient supply capacity of soil type(s) (e.g. clay versus sand).
- With incremental gains in the yield potential of modern soybean and field pea varieties, or even year-to-year and field-to-field variation of on-farm yields (e.g. 25 to 65 bu/acre soybeans), there is merit to continued evaluation of the legacy impact of peas and soybean to crop rotations in Manitoba.
- The objective of this 3 year study is to characterize the relationship between soybean and pea yields (2024), residual soil nitrogen (N) levels, and the fertilizer replacement value (FRV) of legume residue(s) towards wheat (2025 year) and canola (2025) crops that follow these legumes in rotation.

Methods

- In the spring of 2024 at two locations in Manitoba (Warren, Carberry) with irrigation capabilities, paired rainfed and irrigated pea and soybean research trials were established on sites with low residual soil nitrogen (N) (Table 1).
- Each rainfed or irrigated "sub-trial" encompassed a replicated and randomized variety block accommodating three (3) commercial pea varieties (AAC Carver, CDC Lewochko, CDC Inca) or three (3) soybean varieties (Akras R2, S007-Y4, BY Hector XT). (n = 8 per variety, n = 24 per crop type).
- Adjacent to each variety block of soybean or peas, one of the 3 commercial varieties (AAC Carver, Akras R2) was similarly managed to form a future fertility block, to receive incremental levels of nitrogen fertilizer in 2025 and 2026.
- Wheat, barley, in addition to *non-nodulating* and *nodulating* soybean isolines were also included as reference crops to monitor soil nitrogen transformations.
- Beyond irrigation scheduling, intensively managed ***irrigated*** variety and fertility blocks of pea and soybean were seeded at a higher rate, received supplemental PKS fertility, and fungicide applications.

TABLE 1. SUMMARY OF FIELD SITE OPERATIONS, PRECIPITATION AND SOIL PROPERTIES AT WARREN AND CARBERRY IN 2024

YEAR	SEEDING DATE	HARVEST DATE(S)	Precipitation (rain)	Historical Mean	Irrigation (+ added)	GDD	CHU	pH	NO_3^--N lbs/ac (0-24")	O.M.	SAND	SILT	CLAY
											----------%----------		
2024 WARREN	May 22, 2024	Sept 08, 2024 (peas) Sept 30, 2024 (soybean)	443 mm	379 mm	70 mm	1818	2977	7.8	28	7.6	27	38	35
2024 CARBERRY	June 2, 2024	Sept 22, 2024 (peas) Oct 08, 2024 (soybean)	413 mm	335 mm	85 mm	1335	2161	6.3	60	2.6	75	14	11

Precipitation, Growing Degree Day (GDD), Crop Heat Unit (CHU) and Historical Mean sourced via MAFRD Ag-Weather Program. May 01, 2024 to Sept 30, 2024. Woodlands and Carberry Stations

Figure 1. Aerial image of (a) pea variety block at Carberry field site in 2024, reference strips (b) of wheat, non-nodulating and nodulating soybean isolines at Warren in 2024, (c) shielded and buried data loggers monitoring canopy and soil temperature parameters in season. (d) manual soil sampling at Carberry.

Field Trial Establishment

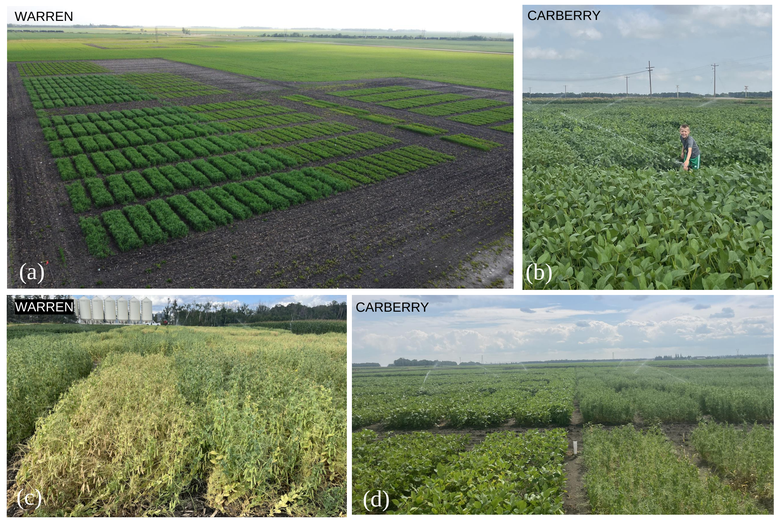

Figure 2. Aerial and ground pictures (a-d) of pea and soybean legacy studies located at Warren and Carberry. Portable K-line irrigation systems and risers with Naan or Rainbird sprinklers (b,d) were positioned within research trials for supplemental irrigation treatments.

Season 1: Soybean and Pea Yields

WARREN FIELD SITE – 2024

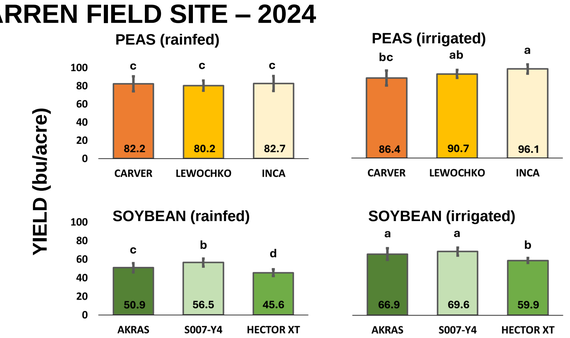

Figure 3. Crop yields (bu/ac) for rainfed and irrigated variety blocks at Warren in 2024. Within location and crop type (rainfed + irrigated combined) varieties with different letters differ according to LSD (0.05) = 5.6 bu/ac, CV = 6.4 for pea.
LSD (0.05) = 4.8 bu/ac, CV = 7.6 for soybean.

CARBERRY FIELD SITE - 2024

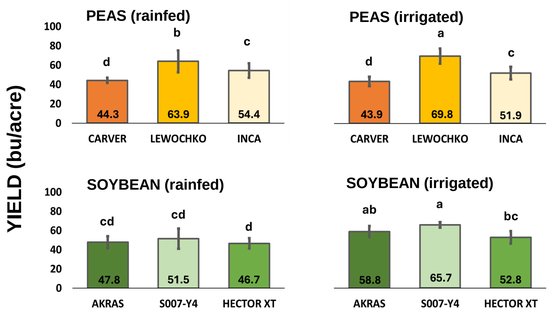

Figure 4. Crop yields (bu/ac) for rainfed and irrigated variety blocks at Carberry in 2024. Within location and crop type (rainfed + irrigated combined) varieties with different letters differ according to LSD (0.05) = 3.8 bu/acre, CV = 6.5 for pea.
LSD (0.05) = 6.6 bu/acre, CV = 11.7 for soybean.

Season 1: Residual Soil Nitrogen (Fall)

TABLE 2. RESIDUAL SOIL NITROGEN VALUES (FALL) ACROSS IRRIGATED AND RAINFED PEA AND SOYBEAN TRIALS - WARREN, MB

	PEA						SOYBEAN					
	RAINFED (lbs N /ac)			IRRIGATED (lbs N /ac)			RAINFED (lbs N /ac)			IRRIGATED (lbs N /ac)		
Soil Sample Depth	NO_3^--N	NH_4^+-N	TOTAL N	NO_3^--N	NH_4^+-N	TOTAL N	NO_3^--N	NH_4^+-N	TOTAL N	NO_3^--N	NH_4^+-N	TOTAL N
0-6"	41	10	52	38	11	49	22	11	33	18	9	28
6-24"	57	38	95	64	37	102	24	28	52	15	33	48
TOTAL (0-24")	98a	48a	146a	103a	48a	150a	46b	39a	85b	34c	42a	75b

Fall soil sampling Warren site Oct 23 and Oct 24, 2024. Composites soil samples (n=3) for each pea or soybean variety. n=9 per crop.
Total depth (0-24") LSD (0.05) for NO_3^--N, NH_4^+-N, and Total N of 10.5, 10.4 and 14.6 lbs/acre, respectively.

TABLE 3. RESIDUAL SOIL NITROGEN VALUES (FALL) ACROSS IRRIGATED AND RAINFED PEA AND SOYBEAN TRIALS - CARBERRY, MB

	PEA						SOYBEAN					
	RAINFED (lbs N /ac)			IRRIGATED (lbs N /ac)			RAINFED (lbs N /ac)			IRRIGATED (lbs N /ac)		
Soil Sample Depth	NO_3^--N	NH_4^+-N	TOTAL N	NO_3^--N	NH_4^+-N	TOTAL N	NO_3^--N	NH_4^+-N	TOTAL N	NO_3^--N	NH_4^+-N	TOTAL N
0-6"	26	9	34	20	9	29	15	6	21	13	8	21
6-24"	15	22	38	13	20	32	7	17	24	10	18	28
TOTAL (0-24")	41a	31a	72a	32b	29a	61b	21c	23a	45c	23c	26a	49c

Fall soil sampling Carberry site at Oct 28, 2024. Composite soil samples (n=3) for each pea or soybean variety. n=9 per crop.
Total depth (0-24") LSD (0.05) for NO_3^--N, NH_4^+-N, and Total N of 7.7, 11.4 and 10.8 lbs/acre, respectively.

Highlights and Future Steps

- 2024 was a relatively wet growing season at both locations, with yields of soybean and pea harvested from rainfed and irrigated systems exceeding long-term provincial average yields of 35.1 bu/acre (soybean) and 45.3 bu/acre (pea), respectively. (Sourced Seed Manitoba)
- Irrigation treatments initiated at both locations during the latter stages of reproductive development encompassing flowering through seed fill. Excess moisture and wind-blasting were early season stressors at the Carberry location.
- At both Warren and Carberry field sites, and encompassing both irrigated and rainfed sub-trials, fall soil test nitrate (NO_3^--N) and total soil N levels (NO_3^--N, NH_4^+-N) were significantly higher in pea plots versus soybean plots **(Table 2; Table 3).**
- Irrigated soybean trials (varieties grouped) at Carberry and Warren yielded 10 bu/acre over adjacent rainfed trials. Similar patterns of over-yielding were not as consistent for the irrigated versus rainfed pea trial contrast.
- In 2025, at both locations, fertilizer replacement value (FRV) treatments will be established in "fertilizer" blocks adjacent to "variety" blocks. Plots will be sown to wheat as a non-legume crop in 2025, followed by canola in 2026.
- In-season monitoring of residual soil nitrogen (NO_3^--N, NH_4^+-N) and tissue sampling will continue at regular intervals into the 2025 growing season.

FUNDING and ACKNOWLEDGEMENT:

Financial support provided by Manitoba Pulse and Soybean Growers (MPSG) and Sustainable Canadian Agricultural Partnership (sCAP) for the current project is greatly appreciated. We would also like to thank AgVise Laboratories for assistance and technical support in processing tissue and soil samples. Thank you to Anastasia Kubinec, Justine Cornelsen, Craig Riddell and Randy Baron for assistance sourcing seed and positioning research trials.