

GOVERNMENT

IMPROVING TEMPERATURE, MOISTURE AND INFILTRATION IN FINE PARTICLE SOILS THROUGH DEEP ROOTED COVER CROPS

In recent years, many producers have experienced extreme weather events (excess rainfall and/or drought conditions) in their own farming operations and are now recognizing that climate variability is going to be a big challenge for them in the years to come. Cover crops have been suggested as a solution to improve soil physical properties by increasing soil organic matter, thereby increasing both soil water holding and drainage capacity (Basche et al. 2016; Chen et al. 2014). Cover crop acreage has been on the rise in Alberta over the past 15 years. Although producers are continuously finding innovative ways to match cover cropping practices to management goals (building soil health, weed suppression, erosion control, managing problem soils, etc), one of the main areas of concern is the lack of research on the role of spring seeded cover crops on soil physical properties and moisture regimes, and whether they can maintain or improve soil water storage. Some producers have been reluctant to sow cover crops as they are concerned that they may deplete soil water reserves for the main crop.

Most cover crops studies have been conducted in the US Midwest and Southwestern Ontario, where producers benefit from longer growing seasons and cover crops have been investigated predominantly as a fall-seeded crop (Applegate et al. 2017; Irmak et al. 2018). The extent to which cover crops improve the soil organic matter has been largely linked to the quality and the quantity of below-ground biomass produced (Bowman et al. 2000). In Alberta, as with most of the Canadian Prairies, the climate is characterized by a short growing season, which often leads to insufficient biomass production for fall-seeded cover crops. Therefore, there is a need to establish strong research on the benefits of spring-seeded cover crops.

Mixtures of cool (C3) and warm (C4) season cover crops are gaining more interest and have been suggested to maximize biomass production under both cool and warm conditions. In Alberta, species selection is of critical importance, and particularly for warm season crops, as there are fewer options. The North Peace Applied Research Association (North Star, AB) has been growing a variety of cool and warm season cover crops since 2012, and has listed corn, proso millet, german millet, and japanese millet as excellent warm season choices for grasses for mixtures. Deep-rooted cover crops, such as oilseed radish, chicory, sunflower, and sweet clover have also been suggested to improve soil permeability and infiltration, and particularly in finer textured soils. Most of the research on deep-rooted cover crops has been conducted on brassicas, where seeding rates vary considerably across studies (1 to 5 Kg/ha). Therefore, there is also a need to assess which brassica seeding rates are best suited for mixtures. The proposed study will be conducted on unirrigated land.

KEY POINTS:

- **More infiltration was found in plots whose treatments had greater plant root diversity than in plots where treatments were only composed of plant taproot systems such as radishes, turnips, and brassicas**
- **It is possible that cumulative infiltration may be greater over specific areas, likely areas where radish, turnips and brassicas established in the ground. This may be overlooked as there are more species with fibrous roots that outnumber radish, turnip and brassicas in stand number and thus also outnumber them in root diversity over larger areas**

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Soils at the research farm fall predominantly under the Nampa series, which is classified as a Solodic Grey Luvisol, with clay loam in the Ap horizon, and heavy clay in the B and C horizons. Drainage is classified as imperfect. Soil samples were taken using a 2cm diameter core. A total of 6 samples per plot and mixed according to depth. Thus, samples taken at 0-15 and 15-30cm were separated for fertility analysis prior to cover crop seeding. Table 2 compiles all dates when soil sampling and infiltration were conducted.

Infiltration under both methods was also performed prior cover crop seeding. Since double ring and mini-disk infiltration are exhaustive process. One plot per treatment was randomly selected across the trial and used for cumulative infiltration measurements. Water volume change was recorded based on specific amounts of time. In the case of the mini-disk infiltrometer readings were performed every 15 minutes, whereas double-ring infiltrometer readings were performed every 30 minutes. The goal was to obtain enough data points to plot a curve generally established as the Philip's two term equation, as follows:

$$i(t) = [S(t)]^{1/2} + At$$

where $i(t)$ is cumulative infiltration, S is sorptivity, t is time of infiltration and A is the parameter.

HYDRAULIC CONDUCTIVITY

Saturated

Hydraulic conductivity refers to the rate at which water moves through soil and can be an important indicator of soil structure. Compaction and soil type are both factors that can impact hydraulic conductivity.

Saturated hydraulic conductivity was measured with a large set of rings that are hammered into the ground and filled with a layer of water, a double ring infiltrometer.



The bridge holding the measuring rod with float

Inner ring filled with a layer of water

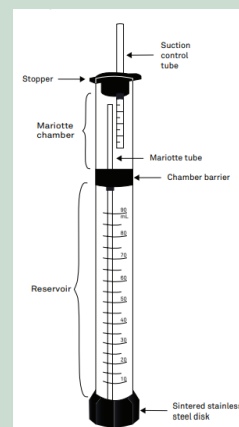
Outer ring filled with a layer of water. This layer was equal to the inner ring at the start of the test

Rates for this method are measured in height over time. Data is recorded from the start when the water is added until the rate becomes consistent, the number at this plateau gives the infiltration rate of a saturated soil.

Unsaturated

Unsaturated hydraulic conductivity measurements were taken using a mini disk infiltrometer. The mini disk infiltrometer is a glass cylinder with a special permeable base. When set on soil and adjusted properly volume can be read from markings on the cylinder and with a time

measurement this gives a rate of volume over time. The goal with this style of measurement is to measure the time it takes for a specific volume of water to infiltrate unsaturated soil.



Soil infiltration measurements are preliminary and do not provide any effect made by the treatments themselves. It is expected that in following seasons, soil analysis and infiltration conducted can be used to compute and further analyze differences among treatments

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SATURATED

Average cumulative infiltration in double-ring procedure

Treatment	mL mi ⁻¹	
Fallow	0.34	AB
Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch	0.23	CDE
Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch	0.37	A
Daikon radish, forage brassica and forage turnip seeded at the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch.	0.25	BCDE
Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, spring triticale, red proso millet, and berseem clover	0.33	ABC
Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, spring triticale, red proso millet, and berseem clover	0.29	ABCDE
Daikon radish, forage brassica and forage turnip seeded at the recommended rate, field pea, sunflower, spring triticale, red proso millet, and berseem clover	0.28	ABCDE
Daikon radish, forage brassica and forage turnip seeded thrice the recommended with oat Japanese millet, sweet clover, chicory, field pea and sunflower	0.32	ABCD
Daikon radish, forage brassica and forage turnip seeded twice the recommended with oat Japanese millet, sweet clover, chicory, field pea and sunflower	0.22	DE
Daikon radish, forage brassica and forage turnip with oat Japanese millet, sweet clover, chicory, field pea and sunflower	0.36	AB
Daikon radish, forage brassica and forage turnip thrice seeding rate.	0.21	E
Daikon radish, forage brassica and forage turnip twice seeding rate	0.32	ABC
Daikon radish, forage brassica and forage turnip at recommended seeding rate	0.21	E
Standard error	1.50	

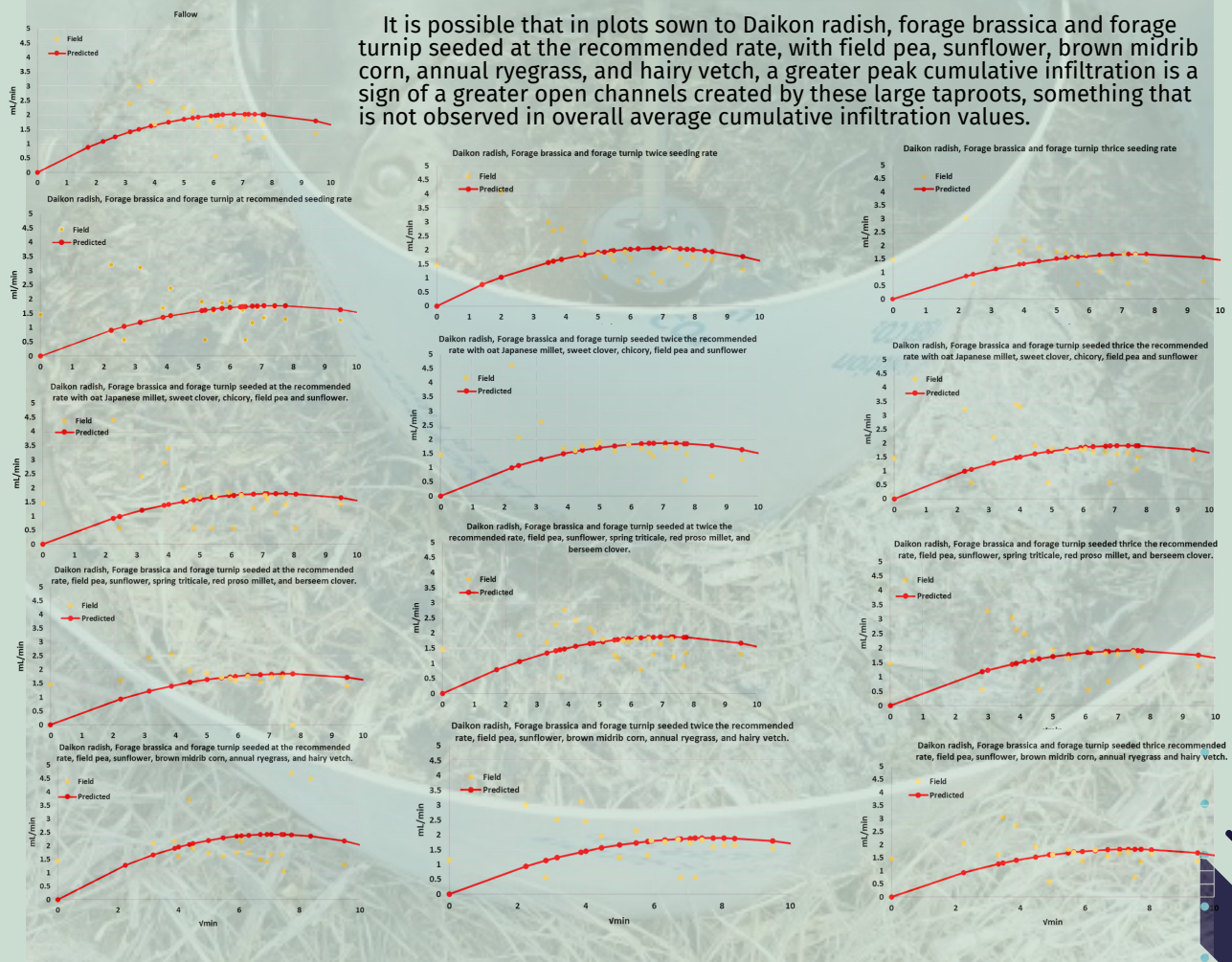
Analysis of variance performed on the data set obtained from that infiltration varied by treatment ($P=0.0091$). As such, more cumulative infiltration (measured as ml per minute) was found where plots were sown to Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch compared to those plots sown to Daikon radish, forage brassica and forage turnip at recommended seeding rate and thrice the recommended seeding rate. This means that more water was percolating through the soil in plots whose treatments had greater plant root diversity than in plots where treatments were only composed of plant taproot systems such as radishes, turnips, and brassicas. Cumulative infiltration as that found in the former treatment was also found in plots that were either fallow and also sown to a) Daikon radish, forage brassica and forage turnip twice seeding rate, b) Daikon radish, forage brassica and forage turnip with oat Japanese millet, sweet clover, chicory, field pea and sunflower c) Daikon radish, forage brassica and forage turnip seeded thrice the recommended with oat Japanese millet, sweet clover, chicory, field pea and sunflower, d) Daikon radish, forage brassica and forage turnip seeded at the recommended rate, field pea, sunflower, spring triticale, red proso millet, and berseem clover e) Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, spring triticale, red proso millet, and berseem clover and f) Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, spring triticale, red proso millet, and berseem clover.

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Nonlinear regressions established from the Philip's two term equation showed that all of them follow a dome shape pattern. All curves are very similar to each other and simply show a general predicted pattern in which water infiltration would develop at each treatment. Their peak predicted cumulative infiltration (red line) was observed at 56 minutes after the beginning of the experiment. Most peak cumulative infiltration values follow the same trend as that found in average cumulative values, meaning, smaller peak cumulative infiltrations correspond to small average cumulative infiltrations. Peak cumulative infiltration in plots sown to Daikon radish, forage brassica and forage turnip seeded at the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch, was the greatest in comparison to those found in other curves, yet its average cumulative infiltration is lower than that found in plots sown to Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch. Taproots in radish, turnip and brassica sown at the recommended rate in comparison to those sown at greater seeding rates may have bigger roots.

It is possible that in plots sown to Daikon radish, forage brassica and forage turnip seeded at the recommended rate, with field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch, a greater peak cumulative infiltration is a sign of a greater open channels created by these large taproots, something that is not observed in overall average cumulative infiltration values.



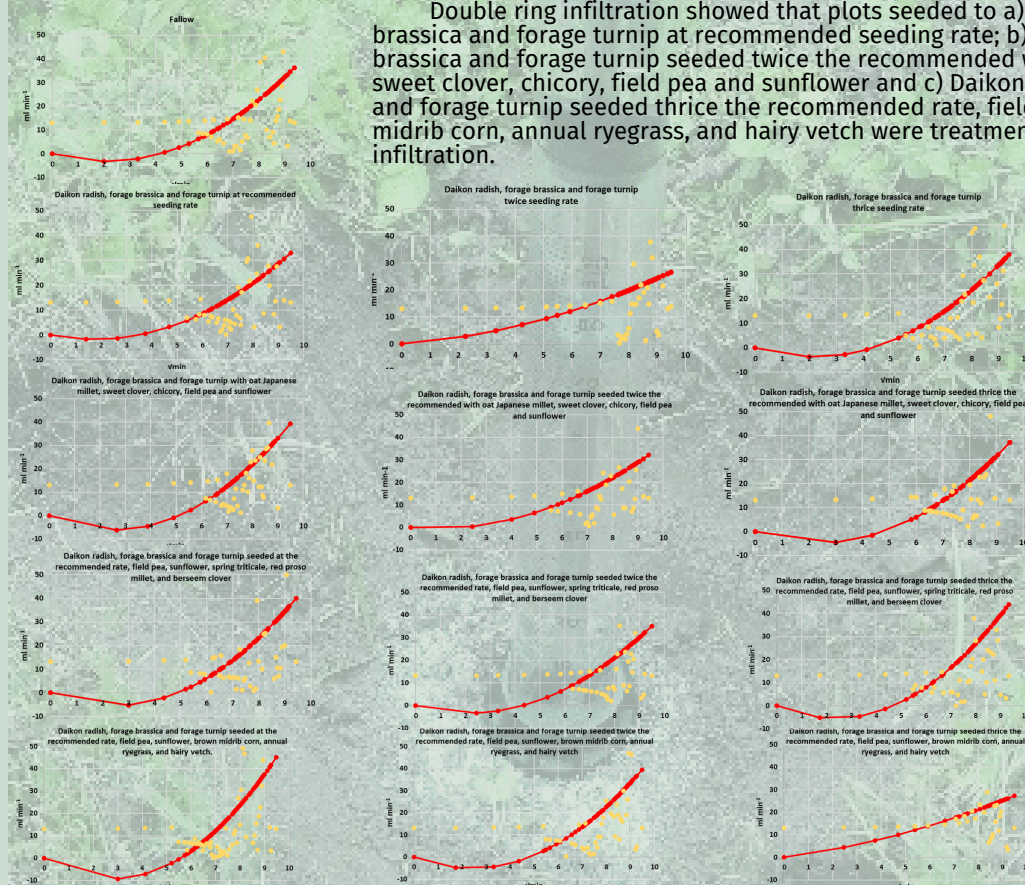
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Mini disk infiltration shows no difference among treatments ($P=0.9728$). Infiltration measurements with a mini disk in comparison to a double ring infiltration are certainly different. It is possible that less surface area covered through a mini disk is less sensitive to changes in soil subsurface flow in contrast to the surface area covered by the double ring device.

However, curves obtained through mini disk measurements show that cumulative infiltration increased sooner in four treatments. As such, plots sown to a) Daikon radish, forage brassica and forage turnip at recommended seeding rate; b) Daikon radish, forage brassica and forage turnip twice seeding rate; c) Daikon radish, forage brassica and forage turnip seeded twice the recommended with oat, Japanese millet, sweet clover, chicory, field pea and sunflower; and d) Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch, showed that it took less than ten minutes for cumulative infiltration to increase.

Double ring infiltration showed that plots seeded to a) Daikon radish, forage brassica and forage turnip at recommended seeding rate; b) Daikon radish, forage brassica and forage turnip seeded twice the recommended with oat, Japanese millet, sweet clover, chicory, field pea and sunflower and c) Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch were treatments with low average infiltration.



It is possible that cumulative infiltration may be greater over specific areas, likely areas were radish, turnips and brassicas established in the ground. This may be overlooked as there are more species with fibrous roots that outnumber radish, turnip and brassicas in stand number and thus also outnumber them in root diversity over larger areas.

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Table 4. Parameters obtained through two infiltration methods: minidisk and double ring infiltrometers to plot Phillip (1957) equation of infiltration. A and S values were predicted using Gauss-Newton non-linear analysis. All P values in double ring and mini disk infiltration curves were <0.0001.

Treatment	Minidisk				Double ring			
	Parameters (standard error)							
	A		S		A		S	
Daikon radish, forage brassica and forage turnip at recommended seeding rate	0.58	(0.3)	-2.05	(2.4)	-0.03	(8.5x10-4)	0.48	(8.x10-3)
Daikon radish, forage brassica and forage turnip twice seeding rate	0.21	(0.4)	0.75	(3.7)	-0.04	(1.5x10-3)	0.60	(0.1)
Daikon radish, forage brassica and forage turnip thrice seeding rate.	0.80	(0.4)	-3.50	(3.1)	-0.03	(8.0x10-4)	0.45	(7.7x10-3)
Daikon radish, forage brassica and forage turnip with oat Japanese millet, sweet clover, chicory, field pea and sunflower	0.94	(0.4)	-4.85	(2.9)	-0.03	(1.0x10-3)	0.50	(9.9x10-3)
Daikon radish, forage brassica and forage turnip seeded twice the recommended with oat Japanese millet, sweet clover, chicory, field pea and sunflower	0.46	(0.5)	-0.95	(3.8)	-0.04	(1.0x10-3)	0.53	(9.6x10-3)
Daikon radish, forage brassica and forage turnip seeded thrice the recommended with oat Japanese millet, sweet clover, chicory, field pea and sunflower	0.83	(0.5)	-3.99	(4.3)	-0.03	(9.4x10-4)	0.52	(9.0x10-3)
Daikon radish, forage brassica and forage turnip seeded at the recommended rate, field pea, sunflower, spring triticales, red proso millet, and berseem clover	0.93	(0.4)	-4.57	(3.4)	-0.03	(8.0x10-4)	0.49	(8.0x10-3)
Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, spring triticales, red proso millet, and berseem clover	0.71	(0.5)	-3.10	(4.0)	-0.04	(1.0x10-3)	0.52	(9.2x10-3)
Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, spring triticales, red proso millet, and berseem clover	1.01	(0.5)	-4.72	(4.4)	-0.03	(9.0x10-4)	0.51	(8.4x10-3)
Daikon radish, forage brassica and forage turnip seeded at the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch	1.20	(0.4)	-6.72	(3.4)	-0.05	(1.4x10-3)	0.68	(0.1)
Daikon radish, forage brassica and forage turnip seeded twice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch	0.89	(0.4)	-4.31	(3.6)	-0.03	(8.5x10-4)	0.49	(8.0x10-3)
Daikon radish, forage brassica and forage turnip seeded thrice the recommended rate, field pea, sunflower, brown midrib corn, annual ryegrass, and hairy vetch	0.15	(0.4)	1.41	(3.6)	-0.03	(7.6x10-4)	0.49	(7.3x10-3)
Fallow	0.74	(0.4)	-3.13	(3.2)	-0.04	(1.0x10-3)	0.57	(9.6x10-3)