TOO MUCH WATER OR TOO LITTLE: CLIMATE RESILIENT VEGETABLE FARMING

FARM ADAPTATION INNOVATOR PROGRAM | RESEARCH SUMMARY | JUNE 2019 - JANUARY 2023

Geographic Applicability

- Research locations: Delta, BC; Duncan, BC; Nelson, BC
- Applicability: South Coast, Vancouver Island, Kootenay

Commodity Relevance

- Annual vegetable
- Other annual production systems

Practical benefits

- Management of spring soil moisture depending on overwinter cover type
- Management of residual plant available nitrogen depending on overwinter cover type
- Information about the interaction between drainage systems and fertility amendments
- Inform nutrient amendment strategy to optimize yield and low soil residual nitrogen levels

Project lead

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Research Team

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Project Overview

The climate patterns that farmers have learned to manage are starting to break down globally. In British Columbia (BC), shifting precipitation patterns are becoming increasingly unpredictable and volatile. Wetter spring and fall shoulder seasons are impeding farmers' ability to prepare and harvest their fields while warmer drier summers challenge their ability to provide their crops with sufficient water during the production season. We designed this project to identify practices that would improve organic vegetable farmers' capacity to adapt to these changing conditions of too much or too little water. Over a three-year period, we evaluated the field performance of a suite of novel soil management practices relative to, and in combination with, existing practices, on soil-water dynamics in a coordinated set of studies that includes controlled replicated experiments, and on-farm regional trials. Specifically, our project objectives were to:

- Objective 1: Quantify the effects of overwinter cover on soil physicochemical properties
- Objective 2: Evaluate the interaction between overwinter cover and three nutrient amendment strategies on plant available nitrogen, volumetric water content and crop yield
- Objective 3: Investigate the interactions between amendment application timing and tile drainage spacing on their effects on soil moisture and salinity and crop yield

A combination of experimental and regional trials allowed for the comparison of management strategies under realistic conditions which is critical in evaluating their performance. Field trials were conducted on 15 organic-practicing farms in BC to evaluate overwinter cover options, amendment application rates and timing and tile drainage across a variety of climates and soil types. These trials are referred to as experimental and regional to describe differences in on-farm replication and controlled conditions. Three experimental (mother) sites hosted trials with on-farm treatment replication where fertility amendments, irrigation type, and crop type were controlled. Regional (daughter) sites hosted non-replicated trials with a subset of treatments where management decisions during the growing season were at the discretion of the individual farms. Both the experimental and regional trials began in October 2019. Data collection was completed in May 2021 in the regional trial and remained ongoing at two of the experimental trials through the end of the project, January 2023. Throughout this project, we engaged with participating farmers to ensure that our results were shared, discussed, and contextualized for their conditions as much as possible. Results were shared through annual project reports, presentations, podcasts, field days and videos.

KEY PROJECT OUTCOMES

- The use of plastic silage over the winter conserved soil nitrate and provided a significantly greater source of plant available nitrogen in the spring relative to cover crops or bare fields.
- We observed no increase in soil salinity after two winters of silage tarp use.
- Silage tarps showed meaningful impacts on field soil water, keeping fields drier during the winter rains than uncovered fields and then wetter as the production season started in the spring.
- We observed no interaction effect on plant available nitrogen (PAN) between silage tarp use and various amendment treatments. Amendment treatments had minimal impacts on crop yields.
- Tile drains at 15 ft spacing significantly reduced spring soil moisture and electrical conductivity compared to 30 ft spacing but had no interaction effect with compost either fall or spring applied.
- There were no significant differences in crop yields due to fall or spring applied compost.

KEY FINDINGS

Our results show that overwinter soil cover, drainage tile and nutrient amendment strategies strongly influence the ecological and potentially the economic outcomes of organic mixed vegetable farms. Our findings show some consistencies between our two replicated mother farm experiments and 12 daughter farms located across three distinct agricultural regions in Southern BC. This study showed that tarps significantly influenced spring soil nitrate (NO3--N), electrical conductivity (EC), and soil volumetric water content (VWC) relative to cover crops or fallow ground. Trends observed at University of British Columbia (UBC) and Green Fire Farm (GRF) mother farm experiments held true in the regional experiment despite differences in climates and soil types. NO3--N was elevated under tarps in every region (Figure 2). EC did not increase between the first and second year of study in the tarp treatment, indicating that salts were not building up in the soil with the use of over winter tarps.

No differences in yield between overwinter cover types were observed in this study; however, an analysis of the impact of tarps on labour requirements for ground preparation and weed management may reveal a more complex picture. Tarps show potential to be a valuable tool for small-scale organic growers in circumstances when adequate winter protection cannot be provided by cover crops. Based on conversations with growers involved in this study and beyond, tarps are valued by growers for their ability to reduce tillage in organic vegetable systems. This is an important strategic advantage to traditional cover cropping in a changing climate.

Figure 1. *Image of a field with a silage tarp and rye cover crop.*

The results from the nutrient amendment experiment at UBC and GRF Farms were less clear with few differences observed between the high compost (HC), low compost (LC), and compost + fertilizer treatments (C+F) and no differences at the Delta site experiment for compost timing were observed. It was expected that PAN would decrease with decreasing compost application throughout the growing season. However, no clear trend was observed over the course of the

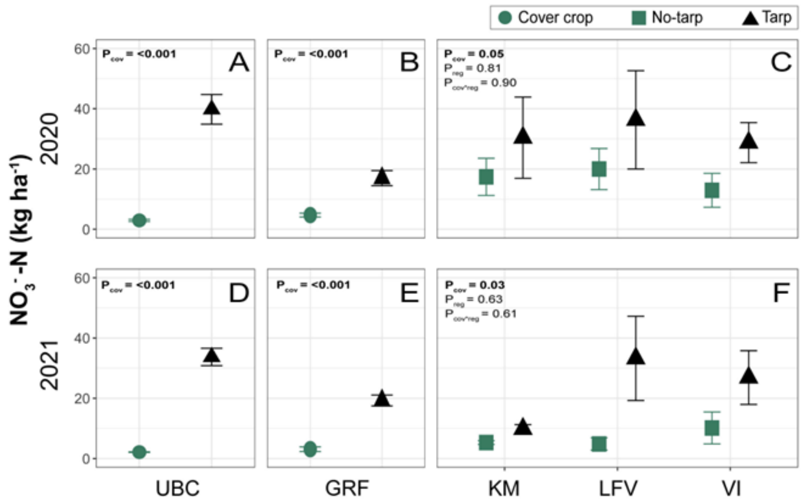

Figure 2. *Soil nitrate (NO3--N; kg ha-1) means ± one standard error measured at the time of tarp removal to a depth of 0-15 cm. Results are shown for the experimental trial at the University of British Columbia Farm (UBC; n=16; A, D) and Green Fire Farm (GRF; n=16, B, E) and the regional study with sites in the Kootenay Mountain (KM; n=4, C, F), Lower Fraser Valley (LFV; n=4, C, F), and Vancouver Island (VI; n=6, C, F) by overwinter cover type (cover crop, tarp, no-tarp). P-values determined by linear mixed-effect models show the significance of cover type (cov) treatment and/or region (reg) and their interactions. Significant findings (P<0.05) are shown in bold.*

growing season between PAN and nutrient amendment strategy. These results highlight the difficulty of estimating Nitrogen (N) dynamics in organic systems. A more accurate calculation of amendment treatment application rate relative to additional sources of N may reveal a clearer relationship between compost application in PAN. The data collected in 2021 when a N-fixing legume crop was grown illustrates how additional N can have a modulating effect on PAN. Interestingly, while there was no statistically significant effect of interaction of overwinter cover type and nutrient amendment type on PAN, another trend was observed under high N conditions. In 2021 at UBC Farm, when PAN was relatively high throughout the growing season, the initial relative difference between tarp and cover crop PAN levels remained throughout the season. The longevity of this relationship was apparent in the measure of post-harvest PAN. Post-harvest PAN was concerningly high and represented a significant risk of leaching. Residual N also represents a significant economic value to the growers, reiterating the need for effective overwinter cover that preserves this resource for the following growing season and protects it from loss to the detriment to the surrounding environment. No consistent impact to EC by nutrient amendment strategy was observed. Few conclusive findings can be drawn from the spring VWC data collected at the regional sites in this experiment. Continuous measurement of VWC at sites with differing soil texture and soil organic matter (SOM) may show interesting effects of nutrient amendment strategies. Relative crop yield was not reliably impacted by nutrient amendment strategy. This information can be contextualized by differences in economic cost of amendment strategies; however, the lack of differences could be due to abundant PAN across strategies.

Given no differences were observed between a high (15% mineralization) and low (30% mineralization) compost application or fall and spring applications producers should consider their applications rates more carefully. This result suggest that growers may be able to opt for a more conservative compost application rate without experiencing a reduction in yield. However, this finding would be strengthened if application rates were calculated using an agronomic model that accounted for N mineralization from cover crops, SOM, and biological N fixation. While no significant interactions were observed between nutrient amendment strategies with farm and year, trends indicate the impact of overwinter cover had impacts on NO3--N that lasted into growing season when NO3--N levels remained high.

In South Coastal BC, cover crops must be established in late summer to achieve adequate root development to scavenge residual N, however, harvest of many vegetable crops persists late into the fall. Asynchrony between cover crop planting date and timing of vegetable harvest is exacerbated by predictions of the climate change. With predicted increases in the fall and spring precipitation, it will become more difficult for famers to move fields in and out of production. The benefits of cover cropping must be weighed against the soil degrading practices of improperly timed tillage relative to soil moisture, and the potential loss of income if crops are terminated early to accommodate cover crop establishment. This project observed that the use of tarps changed both NO3--N and VWC dynamics relative to cover crops. Tarps preserved residual NO3--N potentially impacting the amendment strategy following an overwinter tarp. Growers may be able to reduce spring N applications following overwinter tarping having potentially positive economic impacts. However, grower accessible PAN testing would improve the confidence of growers to rely on such information. Further study is required to provide adequate quantification of these tarps on spring NO3--N before producer action can be expected.

On a course textured soil in South Coastal BC, silage tarps reduced overwinter VWC relative to cover crops until mid-March when VWC under the tarps measured higher than the cover crops. This finding indicates that there is likely a window in the early spring when tarps should be removed if the management goal is to minimize soil moisture. This finding is particularly important for systems that require spring tillage or for systems on course textured soils that may want to preserve soil water into the late spring. While the timing for this switch in VWC between overwinter cover types was observed to be mid-March at UBC Farm, this management important window of shifting soil moisture will likely vary with soil type and climate.

At the Delta site, drainage tile improved moisture conditions in the spring. On the initial spring sampling date (April 7th, 2020), VWC was significantly lower for 15-ft tile spacing than the 30-ft (Figure 3) at the 15 cm depth. At the 30 cm depth the differences were not as pronounced. There were no significant differences among amendment treatments, or any difference observed one week later. While this suggests there are clear benefits for improving the flexibility of the timing of spring field preparation if may also influence soil salinity. On the initial spring sampling date at the Delta site, we observed significantly different EC between 15- and 30-ft tile drainage spacing, but not between amendment treatments. One week later, EC dropped and was unaffected by tile drainage spacing or amendment application.

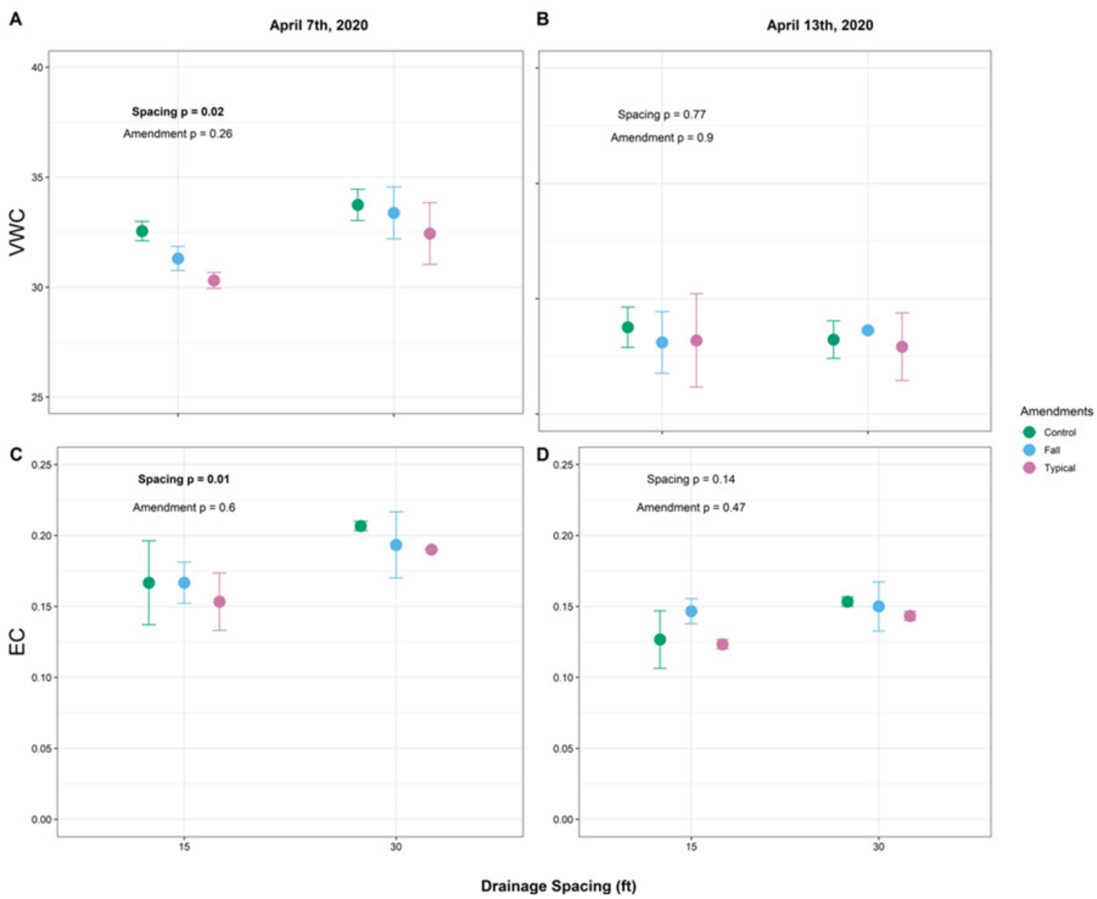

Figure 3. *Average volumetric water content (VWC) for each tile drainage spacing treatment at the Delta site on April 7th, 2020 (A) and April 13th, 2020 (F) and average soil electrical conductivity (EC) on April 7th, 2020 (C) and April 13th, 2020 (D). The coloured points represent three amendment application treatments (green-control, blue-fall compost application, and pink-typical (spring) compost application. Significant differences ($p > 0.05$) are indicated in bold for tile drainage spacing. No significant differences between amendment treatments, at either level of tile drainage spacing. Error bars show ± standard error (SE) of the mean.*

RESEARCH METHODS

A mother-daughter field trial was conducted on 15 organic-practicing farms in BC to evaluate overwinter cover options, amendment application rates and timing and tile drainage across a variety of climates and soil types. These trials are referred to as experimental and regional to describe differences in on-farm replication and controlled conditions. Three experimental (mother) sites hosted trials with on-farm treatment replication where fertility amendments, irrigation type, and crop type were controlled. Regional (daughter) sites hosted non-replicated trials with a subset of treatments where management decisions during the growing season were at the discretion of the individual farms. Both the experimental and regional trials began in October 2019. Data collection was completed in May 2021 in the regional trial and remained ongoing at two of the experimental trials through the end of the project, January 2023.

The regional trial was conducted on 12 organic-practicing farms in three key agricultural regions in BC: the LFV, Vancouver Island (VI), and the Kootenay Mountains (KM). Each farm hosted one trial plot containing two equal-sized subplots to which one of two randomly assigned treatments were applied, (1) tarp and (2) no-tarp. Treatments were applied on the regional farms in September-November of 2019 and September-December of 2020. Tarps were removed in the spring in April of 2020 and March-May of 2021. For the first experimental study, nutrient amendment treatments were applied at the plot level. At UBC and GRF overwinter treatments were applied at the subplot level in October of 2019 and 2020 when tarps were installed and cover crops seeded. Overwinter treatments were removed in the April or May of 2020 and 2021 when the tarps were removed, and cover crops mowed and tilled. Soil samples were collected at the time of tarp removal and on the experimental farm, at three additional points during the growing season. Soils were analyzed for plant available nitrogen, electrical conductivity, and volumetric water content. Yield was measured at the time of cash crop maturation.At both farm sites, the following three nutrient amendment strategies and one control were evaluated:

- High Compost (HC): compost applied to meet crop N removal assuming a N mineralization rate of 15% of total N in the first growing season after application (Gale et al., 2006).
- Low Compost (LC): compost applied to meet crop N removal assuming a N mineralization rate of 30% of total N in the first growing season after application.
- Compost + Fertilizer (C+F): compost applied to meet crop P demand plus feather meal fertilizer to meet crop N removal.
- Control (CON): No nutrient application of any kind.

The second experimental study was established to investigate the interaction between amendment application timing (either fall or spring) and tile drainage. Plots were established in the fall of 2019 in Delta, BC. A 2-factor randomized complete block design (n=3) was established to compare two levels of tile drainage spacing and three levels of amendment application. Tile drainage treatments included a 15- and 30-ft tile spacing, and amendment application treatments included a fall compost application (municipal compost), a spring compost application (chicken manure compost), and control (no compost application). Fall compost application occurred on October 1st, 2019 and spring compost application occurred on April 27, 2020, by manure spreader according to the rates defined in Table 1. The area of each treatment plot was 100 m2. The field at the Delta site, as part of its vegetable rotation, had been planted with field peas during the 2019 growing season. Silage corn was planted in the spring of 2020. A cover crop mixture (tillage radish, sunflower, and vetch) was also planted during the over-winter period. The silage corn crop was harvested from 3 m x 3 m subplots within the center of each plot to determine crop biomass. Biomass sampling was completed just prior to the harvesting of silage corn, in October 2020.

Season / Year	Compost Moisture Content	Compost Applied (dry weight Mg/ha)	Plant Available N Applied (kg/ha)	Total N Applied (kg/ha)
Fall 2019	0.41	15.49	61	281
Spring 2020	0.51	10.37	106	270

Table 1. *Compost amendment and plant-available nitrogen (N) application rates for fall 2019 and spring 2020 in kg or Mg compost per hectare and kg plant-available N per hectare.*

ACKNOWLEDGEMENTS

We thank all the farmers who participated in this project despite the challenges of a global pandemic. We acknowledge that the farms in this project were located on the shared, traditional, ancestral, and unceded territories of a number of Indigenous peoples.

This work was made possible by many students including Morgan Hamilton, Hannah Friesen, Amanda Dickson-Otty, Inbar Avrahami Saraf, Yiming Zhang and Jordy Kersy.

The work was led and executed primarily by Dr. Kira Borden and Raelani Kesler.

Tim Carter, from UBC Farm, Dr. DeLisa Lewis, from Green Fire Farm and Rachael Roussin, Kootenay & Boundary Farm Advisors (KBFA) were instrumental in developing and executing the project.

Funding for this project has been provided in part by the Natural Sciences and Engineering Research Council of Canada, the University of British Columbia Work Learn Program and in part by the Governments of Canada and British Columbia through the Canadian Agricultural Partnership, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

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Delivered by: Investment Agriculture Foundation

Funding provided by: Canadian Agricultural Partnership; NSERC CRSNG; British Columbia; Canada