BC FoodWeb

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RESEARCH SUMMARY

Production Type
- Berries

Practice Benefit(s)
- Improved nutrient management
- Reduced water use
- Improved soil health

Research Location
- Abbotsford, B.C.

Cover crop, irrigation, and fertilization strategies for improved nitrogen management in raspberry production

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KEY TAKEAWAYS

- Of the practices tested, **growing a perennial grass cover crop in alleyways improved crop nitrogen (N) use** the most (indicated by less nitrate leaching) and did not not reduce raspberry yield.
- **Using only poultry manure to supply N wasted a lot more N than N fertilizer** (indicated by very high nitrate leaching).
- **Evapotranspiration (ET)-scheduled irrigation used 50% less water compared to fixed-duration irrigation** and reduced nitrate leaching during the growing season with no negative impacts to crop performance.
- Higher N application rates (50 and 100 kg N/ha compared to 0 kg N/ha) did not always lead to higher fruit yield.
- In this study, nitrate leaching under raspberry fields was high regardless of the management practices tested. **We discovered that the irrigation water, which is sourced from groundwater, contained a lot of N.** This N from irrigation was not accounted for and was added to the fields in addition to the N fertilizer and manure applied.
- High nitrate leaching indicates that the crop isn't using all the applied N, suggesting lost time and money on fertilization and a risk of contaminating the Abbotsford-Sumas aquifer.
- **Using multiple beneficial management practices (BMPs) is likely more effective at improving N use in raspberry production, saving water, and reducing N pollution, while maintaining crop productivity and yield, than any practice alone.**

Figure 1. Saanich raspberries at harvest. Photo by Shawn Kuchta.

Key Terms:
- *Nitrate leaching: when nitrate (a form of nitrogen that plants can use) moves down through the soil, below the reach of crop roots, and is no longer usable by the crop.*
- *Evapotranspiration (ET)-scheduled irrigation: adjusts the amount and timing of irrigation based on plant needs, rather than following a fixed daily schedule.*

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HOW CAN THIS RESEARCH BE USED?

Raspberry producers can consider:

- Developing a nutrient management plan so that all N inputs are used efficiently (including the N in irrigation water). Where feasible, mineral N fertilizer or composted manure are encouraged over the use of raw poultry manure.
- Switching from fixed-duration irrigation to irrigating according to plant demand (ET-scheduled irrigation).
- Growing a perennial grass cover crop in alleys.

WHY WAS THIS RESEARCH DONE?

We tested and compared management practices that can help reduce nitrate leaching in red raspberry production in the Lower Fraser Valley of British Columbia (B.C.).

The Lower Fraser Valley sits on top of the Abbotsford-Sumas aquifer, a groundwater resource that supplies drinking water to over 100,000 people in B.C. and Washington. High nitrate levels in the aquifer have been partly linked to the use of poultry manure in raspberry production. These high nitrate levels may be indicating that the N applied to raspberry fields above the aquifer is not completely used by the crop before it moves below the root zone. From a producer's perspective, this may mean that more time and money is spent on N fertilization than necessary.

Figure 2. 64 samplers were installed under raspberry rows and alleys to catch water leaving the root zone. Photo by Shawn Kuchta.

We compared typical producer practices to practices that have the potential to improve crop N use:

- N application rate (0 vs. 50 vs. 100 kg N/ha)
- N source (mineral fertilizer vs. raw poultry broiler manure)
- Alley management (clean cultivated (no cover crop) vs. perennial grass vs. annual barley)
- Irrigation (conventional fixed-duration vs. ET-scheduled)

Based on the characteristics of our field, we determined that typical producer practice would include: 100 kg N/ha surface broadcast on the row as a split application, clean cultivation of alleys, and fixed-duration drip irrigation.

WHAT WAS THE OUTCOME?

Alleyway cover cropping reduced nitrate leaching the most

Growing a perennial grass cover crop in the alley reduced nitrate leaching more than any other practice tested (Table 1). Cover crops are well known to improve overall soil health. As they grow, they can help take up any leftover N in the ground that the main crop doesn't use. Some producers are concerned that cover crops might compete with raspberries. However, we found that the perennial cover crop did not negatively affect raspberry yield, and either had no negative effect or led to some improvements in crop vigor and crop N content.

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Additionally, other studies have suggested that perennial alley cover crops may act as hosts for soil-borne pests. However, we found that the perennial cover crop did not have any effect on root-lesion nematode populations (a common pest for raspberry in this region). **We also tested an annual barley cover crop, which did not have a notable impact on nitrate leaching, raspberry crop performance, or leachate water quality.**

Figure 3. Left: A clean cultivated alley. **Middle:** Annual fall-seeded barley cover crop. **Right:** Perennial grass cover crop. Photos by Shawn Kuchta.

High nitrate leaching regardless of N application rate

Regardless of whether 0, 50, or 100 kg N/ha was applied, nitrate leaching was high (Table 1) because of the region's inherently high soil fertility and a large amount of N provided through irrigation water. **Even when no N fertilizer or manure was applied, fixed-duration irrigation added 61 kg N/ha to the field and ET-scheduled irrigation added 28 kg N/ha to the field.**

Because of the N provided through irrigation water, reducing N application rates alone is likely not enough to improve crop N use. **A combination of practices, which includes alleyway cover crops and/or ET-scheduled irrigation, is likely needed to see a bigger impact. Additionally, producers can take advantage of the N in irrigation water by accounting for it in their nutrient management planning.**

N fertilizer application rate only affected yield and crop vigor (the growth and health of the crop, measured by primocane and floricane length and diameter in this study) in the first two years of crop establishment: higher N rates led to longer and wider primocanes in the first year (2009), and higher fruit yield in 2010 (first year of berry production). But no significant impacts were seen in the following two years. Across all management practices, the population of root-lesion nematodes was found to be at high enough levels to cause economic damage to the crops. The prevalence of nematodes may have made it difficult for raspberries to access and use the full amount of N applied and may be part of the reason why we didn't see consistent yield and crop vigor improvements.

Poultry broiler manure led to the highest nitrate leaching

Using raw (un-composted) poultry manure instead of mineral N fertilizer increased annual nitrate leaching from the row by 148%. Additionally, even though manure was only applied in the row, nitrate leaching from the alley was also significantly higher (65% higher). Using manure was the only management practice that led to nitrate levels in the leachate to exceed Canada's safe drinking water level. Raw poultry manure has historically been used because it's readily available and lower cost. However, it is difficult to predict how much manure N will become plant-available after application due to variability in manure nutrient content and environmental conditions.

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We applied manure based on the assumption that 33% of the manure total N would be plant-available in the first year. However, the high nitrate leaching suggests that more N was available than expected. **Because of these variations in manure and N inputs, we recommend that producers develop a nutrient management plan. And, where feasible, mineral N fertilizer or composted manure (where the N is more stable and released more gradually) is encouraged over the use of raw manure.**

Table 1. Effect of N, alley, and irrigation management practices on nitrate leaching from the row and alley over the growing season, rainy season (October to April), and full year (averaged over four years). Management included N fertilizer applied at 100 kg N/ha, clean cultivated alleys, and fixed-duration irrigation unless otherwise stated by the 'Practice'.

Practice	**Nitrate leaching from the row (kg N/ha)**			**Nitrate leaching from the alley (kg N/ha)**		
	Growing season	Rainy season	Total	Growing season	Rainy season	Total
0 kg N/ha (fertilizer)	51	39	90	10	39	50
50 kg N/ha (fertilizer)	57	40	97	8	38	47
100 kg N/ha (fertilizer)	46	47	93	9	41	51
100 kg N/ha (manure)	98	133	231	19	65	84
Perennial grass alley	51	42	92	1	4	5
Annual barley alley	60	45	105	11	38	48
ET-scheduled irrigation	14	70	84	13	53	66
ET-scheduled irrigation and 50 kg N/ha (fertigation)	20	32	52	6	29	34

ET-scheduled irrigation cut water use in half compared to fixed-duration irrigation

ET-scheduled irrigation reduced water use by 50% compared to fixed-duration irrigation, with no negative effects on raspberry yield, crop vigor, or plant N content. Over the 4-year study, the total irrigation applied per year with fixed-duration irrigation ranged from 285-367 mm and 152-158 mm with ET-scheduled irrigation. During droughts, ET-scheduled irrigation may help producers maintain yield and crop health with less water.

ET-scheduled irrigation also reduced nitrate leaching (to less than 25 kg N/ha) during the growing season (Table 1). This is because ET-scheduled irrigation applied less N-containing water and there was less water to move nitrate down the soil. **However, in the shoulder season, nitrate leaching returned to high levels (Table 1)**. N that wasn't used by the crop accumulated in the soil during the growing season and was quickly leached by high rainfall in the fall/winter. This highlights that each practice alone is not enough to improve crop N use – and that a combination of practices is needed.

WHAT'S NEXT?

Barriers to adopting these practices include cost and lack of needed information. For example, our four-year study found that growing perennial grass cover crops in the alleys had no negative effects on raspberry yield, however, longer studies are needed to confirm that crop performance won't be affected in the long term. Similarly, to get a full understanding of ET-scheduled irrigation, raspberry tolerance to a lower volume but more frequent watering needs to be studied. While the effect of root-lesion nematodes on raspberry productivity is well-researched, their specific effect on a raspberry plant's ability to absorb and use N is not yet known. Research in this area could lead to improved fertilization guidelines based on expected impacts of nematodes to crop N use.

HOW WAS THE RESEARCH DONE?

This research took place from 2009-2013 at the Clearbrook Substation of Agriculture and Agri-Food Canada, located over the Abbotsford-Sumas aquifer, south of Abbotsford, B.C. The field was not cropped or fertilized in the four years prior to this research. All management practices were replicated four times. We planted roots of 'Saanich' raspberry in late April 2008, creating a 1.2 m wide raspberry row, which was kept weed free using herbicides, and a 1.8 m wide alley.

For research plots receiving fertilizer, urea was hand broadcasted in split applications in early and late spring each year. To apply 100 kg plant-available N/ha from manure, we measured the manure's total N and assumed 33% would be available in the first year. The wood shavings–bedded poultry broiler manure application rates ranged from 10.4 to 16 cubic yards/acre each year.

We applied Terralink Horticulture's 'Evergrow post-harvest blueberry blend' (0-20-20 NPK) annually in all plots to provide phosphorus, potassium, and micronutrients. Irrigation was used from mid-June to late September/early October. Fixed-duration irrigation consisted of irrigation every second day for 4 h to supply 5.6 mm of water on a field scale and was increased to 6 h to supply 8.4 mm of water during peak periods. For ET-scheduled irrigation, irrigation would turn on automatically every day based on water used or lost by the crop in the previous day.

We hand seeded the perennial grass cover crop (blend of 'Keystone 2' perennial ryegrass and 'Bridgeport II' chewings fescue) at a rate of 44.4 kg/ha in September 2008. We hand seeded the barley cover crop (Terralink's 'Common Barley') at a rate of 174 kg/ha in 2008 and reseeded each September at a rate of 348 kg/ha. For plots with clean cultivated alleys, the alleys were tilled to 25-cm depth four times per year.

All other production, maintenance, and pest management practices were the same for each research plot and were carried out according to Provincial recommendations at the time.

Figure 4. An evapotranspiration gage measuring the amount of water used and released by a crop over a day. Photo by Shawn Kuchta.

ABOUT THIS BRIEF

This brief is based on the following scientific journal articles:

- Kuchta, S., Neilsen, D., Forge, T., Zebarth, B. J., & Nichol, C. (2020). Nitrogen, irrigation, and alley management effects on nitrate leaching from raspberry. Vadose Zone, 19(1). https://doi.org/10.1002/vzj2.20054
- Kuchta, S. Neilsen, D. Zebarth, B. J., Forge, T., & Nichol. C. (2021). Nitrogen, irrigation, and alley management effects raspberry crop response and soil nitrogen and root-lesion nematode dynamics. Soil Science Society of America, 85(4), 1139-1156. https://doi.org/10.1002/saj2.20190

Want to learn more?

- For any questions regarding this research, contact Shawn Kuchta at shawn.kuchta@agr.gc.ca
- Funding may be available to help producers develop a nutrient management plan. Learn more at: https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/programs/beneficial-management-practices
- Producers can access daily crop evapotranspiration information in their region at: https://farmwest.com/

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