

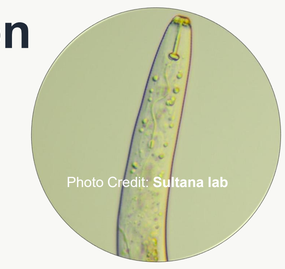
Mixture of Cover Crops to Manage Plant-Parasitic Nematodes in Ontario Carrot Production

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ABSTRACT

Plant-parasitic nematodes (PPNs) are a persistent and economically significant threat to carrot (*Daucus carota L.*) production in Ontario (ON), and their management is challenging after regulating chemical nematicides. Cover crops are an alternative biological approach, but what happens when a nitrogen-hungry carrot is paired with a cover-crop rotation and mixture is unknown. This study validated that cover crops may suppress PPNs, particularly when mixed (legume–grass), under carrot field condition sustaining yield; where implementation of nitrogen fertilizer is a common practice among carrot growers.

INTRODUCTION

Ontario's vegetable industry rich in farmgate value over $815 million, where 15% yield loss marked due to PPNs. Restrictions on chemical nematicides are limiting the management options for growers; thereby biologically based integrated pest-management (IPM) tools is in demand. Cover crops are a promising lever, but how functionally contrasting interact with nitrogen fertilization to shape soil nematode communities and crop yield in Ontario carrot systems remains incompletely characterized. This study compared Alfalfa (legume), Sorghum (non-legume), and their mixture to understand covers effect within two nitrogen regimes, finding best recommendation controlling PPNs towards ON carrot production.

OBJECTIVES

- Plant-parasitic nematodes (PPNs) abundance under contrasting nitrogen regimes using different cover crops.
- Soil nematode community composition and functional-group structure using covers.

MATERIALS & METHODS

Study design:

- Split-plot field experiment at Jordan Station, Ontario (43.16° N, 79.36° W).
- Three cover-crops treatments (Alfalfa, Sorghum-Sudangrass, Alfalfa + Sorghum Mixture) and a control; within 2 nitrogen regimes (0 and 120 kg N ha^{-1}) and 4 replications.
- Sampling at 2 growth stages: cover crop and carrot harvest.
- Total 48 soil samples (Fig. 1).

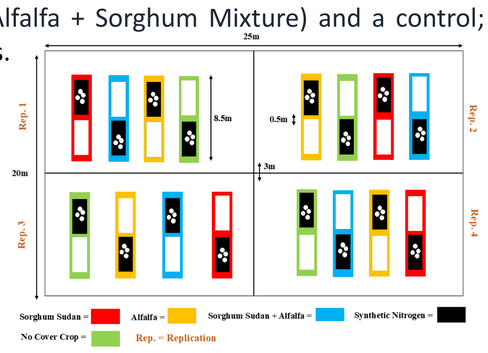


Fig.1 Split-plot layout (25 m × 20 m).

Analytical workflow:

- Nematode extraction (100 g soil; modified sucrose flotation)
- DNA extraction; 18S rRNA amplification (NF1/18Sr2b primers)
- Illumina MiSeq paired-end sequencing
- nf-core/ampliseq Nextflow pipeline (R); NemaTaxa database;
- Feeding-group, faunal-index, and ANOVA analyses

RESULTS & DISCUSSION

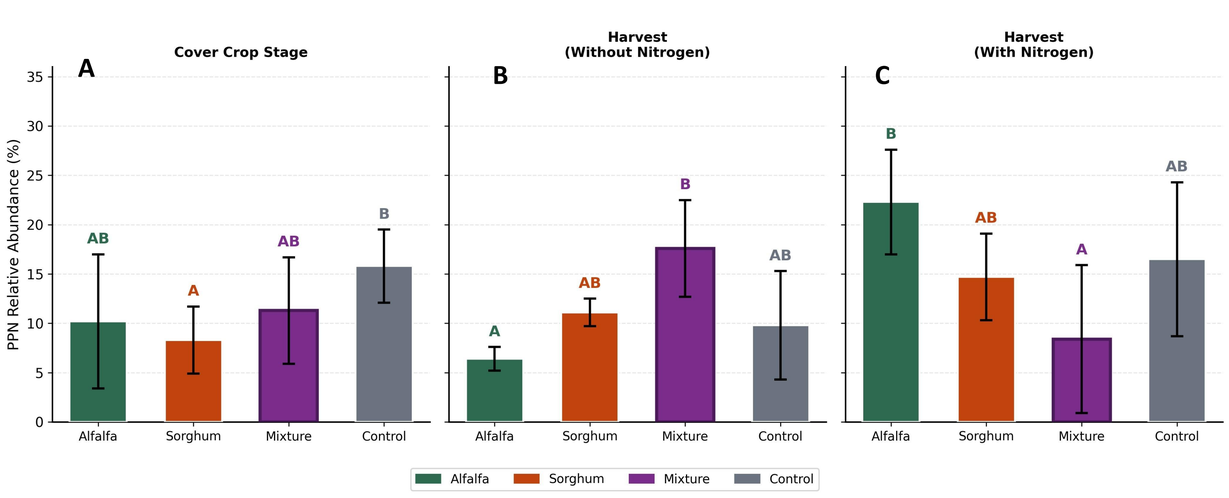


Fig.2 Relative abundance of PPNs across cover-crop treatments within two nitrogen regimes. Bars show mean ± SE.

- At the cover crop stage (Fig.2-A): Sorghum-Sudangrass showed numerically lowest PPN abundance (8.2%,) compared to Control (highest, 15.7%).
- At harvest, without nitrogen (Fig.2-B): Alfalfa suppressed PPN most effectively at 6.4% significantly lower than Mixture (17.7%).
- At harvest, with nitrogen (Fig.2-C): Only the Mixture maintained the lowest PPN abundance (8.4%). Opposite to no-nitrogen, Alfalfa shows the highest PPN abundance (22.3%, +238%).

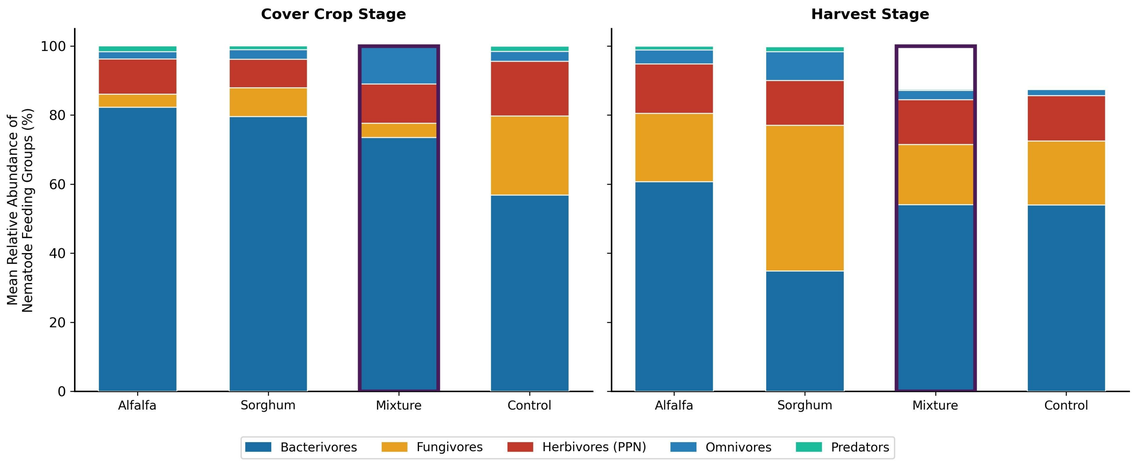


Fig.3 Mean relative abundance of five nematode feeding groups across cover crop treatments at both stages.

- Bacterivores dominated all treatments (60.8% overall) at both sampling points.
- Herbivores (PPNs) remained a consistent important component across all treatments
- Fungivores increased proportionally from cover crop stage to harvest, most notably in Sorghum plots.
- Omnivores and predators comprised small but consistent fractions across the dataset (Fig. 3).

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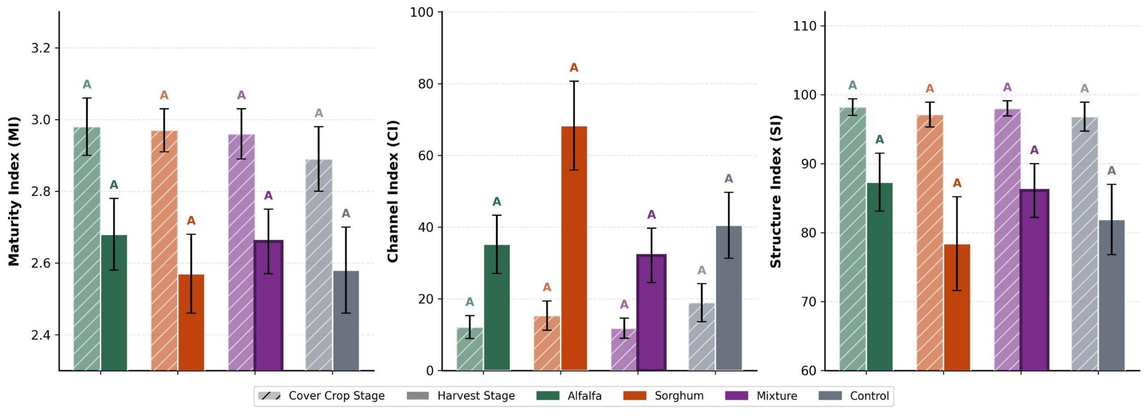


Fig.4 Nematode-based faunal indices: Maturity Index (MI), Channel Index (CI), and Structure Index (SI) across cover-crop treatments at the two sampling stages. Bars show mean ± SE.

- All three indices showed significant seasonal restructuring from cover crop stage to harvest ($p < 0.001$): Maturity Index (MI) declined, Channel Index (CI) increased, and Structure Index (SI) shifted consistent; meaning a shift towards more opportunistic, enrichment-indicator nematode taxa.
- No significant cover-crop treatment effect was detected on any community-level index. (Fig. 4).

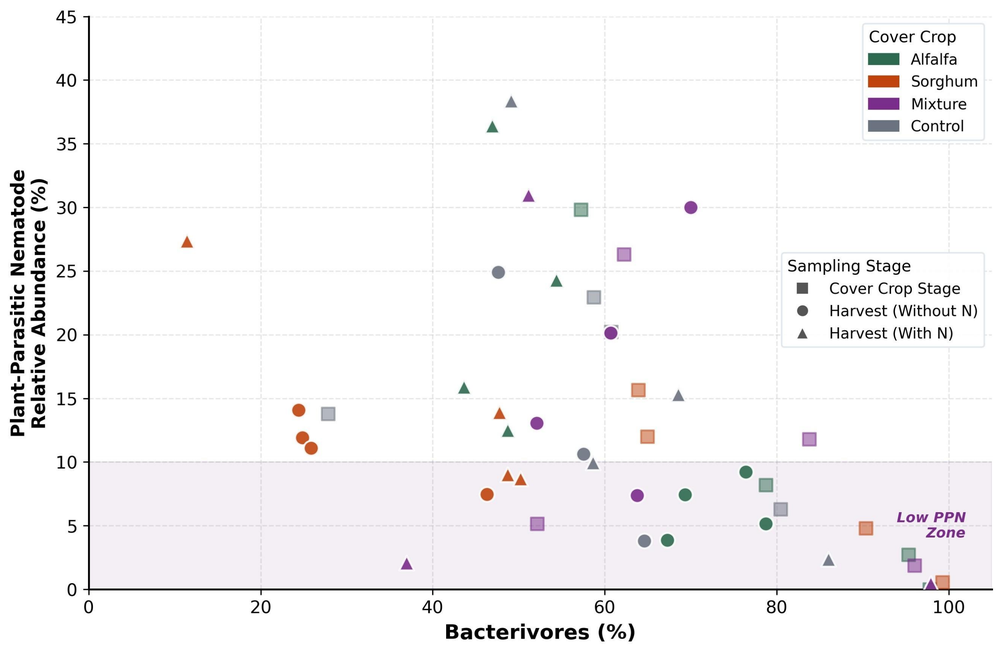


Fig.5 Individual-sample relationship between bacterivore and PPN relative abundance across all treatments, sampling stages, and nitrogen regimes.

- The shaded "Low PPN Zone" (< 10%) is dominated by covers at harvest, particularly in the high-bacterivore range (> 80% bacterivore relative abundance). (Fig.5)
- Samples with high PPN (> 20%) cluster at intermediate bacterivore levels (40–70%) and correspond mostly to nitrogen-treated plots (Fig.5).

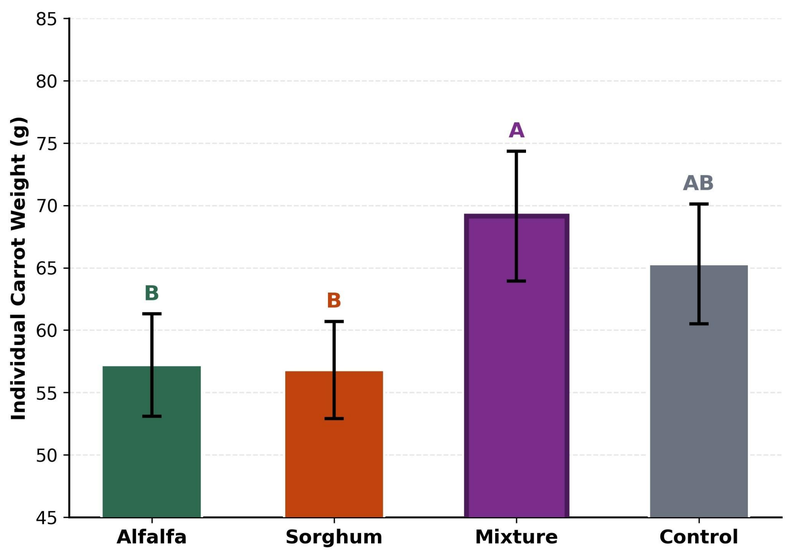


Fig.6 Mean individual carrot weight at harvest by cover-crop treatment.

- The Mixture of covers produced the highest individual carrot weight (69.15 g), significantly higher than Alfalfa (57.0 g) or Sorghum (56.6 g) alone. The Control (65.1 g) was intermediate.
- This result demonstrates that the Mixture's PPN suppression under nitrogen (Fig. 2) is accompanied by a measurable yield benefit (Fig. 6).

TAKE HOME MESSAGE

- **Alfalfa** alone suppressed PPNs best **without nitrogen** implemented plots (Fig.2-B).
- Addition of nitrogen fertilizer, which is a common practice among Ontario carrot growers, reversed Alfalfa's suppression, PPN increased by 238% (Fig.2-B).
- **Only Mixture of covers** maintained the **lowest PPN** under nitrogen implementation (Fig.2-C), providing **better soil health** (Fig.3 and 4) maintaining **carrot yield** the highest (Fig.6).
- Use of covers improve soil health by increasing soil nematodes activities in soil (Fig.5).
- Using mixture of legume (Alfalfa) and non-legume (Sorghum) covers on nitrogen derived carrot production could be a powerful recommendation for Ontario growers considering PPN management and boosting soil health.

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