The Use of Biofumigant Mustards to Manage Verticillium Wilt of Potato in Manitoba 2019-2022

Principal investigators: Zachary Frederick and Haider Abbas

MHPEC technician: Andrea Hamilton, Jane Giesbrecht

Manitoba Agriculture Technician: Faryal Yousef

CMCDC staff: Garth Christison, Shelly Rowland, Beverly Mitchell and Alan Manns

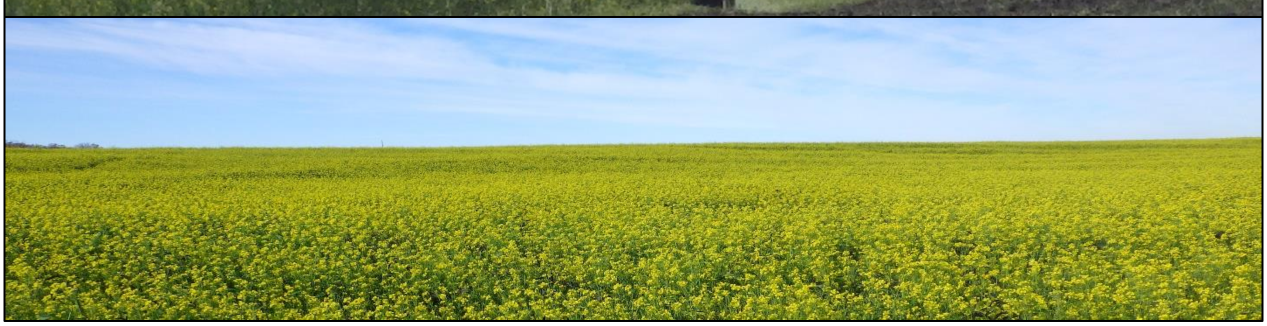
Students: Madison Bowley, Whitley McDonald, Jessica Kalyniuk, Olivia Gessner and Nicole Buurma

Funding sources:

Objective 1: [Haider Abbas] Funds provided by the Canadian Agricultural Partnership (CAP) for crop diversification at CMCDC

Objective 2: [Zachary Frederick] This work was supported by a Manitoba Strategic Initiative (project #1000219435) and the Canadian Agricultural Partnership Ag Action Manitoba Program (projects #1000210208, 1000239308) Funds also provided by MHPEC members: Simplot Canada II, McCain Foods, and the Keystone Potato Producers Association.

The investigators wish to thank our grower cooperators for providing their time and land to evaluate the process of biofumigation. We also want to acknowledge High Performance Seeds for providing the 'Caliente Rojo" mustard seed and M21 for providing the "AAC Brown 18" and male sterile hybrid seed for small plot research.



-This is a summary document with major conclusions. Full report with all detail available on mbpotatoresearch.ca-

Abstract

Biofumigation describes the elimination or suppression of soilborne pests, pathogens and weeds by gases emitted from buried biomass from members of the Brassicaceae family (e.g., brown mustard, oriental mustard, radish, etc.). Biomass is pulverized and incorporated into moist soil to combine with oxygen and ultimately convert glucosinolates into degradation products such as isothiocyanates. The process has been developed and experimentally validated as a control measure of Verticillium wilt of potato in the United States and Europe. However, the methods of growing the mustard crop and the effectiveness of the process to reduce Verticillium wilt in Manitoba have yet to be validated regionally with all cultivars of mustards. The overarching goal of this study was to explore a way to economically manage Verticillium wilt of potato in Manitoba using a mustard crop as a biofumigant green manure to kill *Verticillium* propagules in soil and/or suppress the disease. More specifically, experiments were conducted to determine agronomic inputs to maximize biomass of mustard cultivars 'AC Volcan', 'Caliente Rojo', 'Cutlass', 'AAC Brown 18', and a male sterile hybrid. Additional studies examined field-scale mustard biofumigation to verify *Verticillium* CFU/g soil before and after biofumigating, as well as mustard biomass at the time of biofumigation. These experiments demonstrate that these mustards can be grown to sufficient biomass levels to theoretically achieve biofumigation, and that the practice is a viable disease management strategy. The conclusions of this project will scientifically reinforce growers' efforts to reduce Verticillium wilt with evidence to support choices to effectively and economically manage the disease for their entire operations. These experiments also provide use extension results and a blueprint for

Objectives and Deliverables

1. Evaluate whether mustard biofumigation with "Caliente Rojo" and "AAC Brown 18" reduces *Verticillium dahliae* soil CFU and/or Verticillium wilt of potato (subsequent potato rotation after mustard)
    a. Deliverables
        i. Implement and validate the applicability of a real-time *Verticillium dahliae* quantification tool for soil testing
        ii. List approximate number of acres planted, and practices used to grow the crop
        iii. Individual grower will have comparison of numbers of Verticillium propagules at three timings: 1) before mustard biofumigation 2) one-month post-biofumigation and 3) post-potato production.
        iv. Calculate cost of biofumigant use for the reduction in *Verticillium* CFU/g or Verticillium wilt (e.g. cost-benefit analysis)

Conclusions

1. Deliverables
   i. Implement and validate the applicability of a real-time *Verticillium dahliae* quantification tool for soil testing
      a. Completed in 2019. PSI is running qPCR markers developed by) for *V. dahliae* every year of study by Pest Surveillance Initiative Inc.
   ii. List approximate number of acres planted, and practices used to grow the crop
      a. Completed every year. Since 2019, 100 acres of biofumigant mustard are planted across the province and new recommendations are developed annually. These numbers have risen to 200-500 acres in 2021 and 2022. (see supplementary file on recommendations for current best practices, mustard recommendations are published on mbpotatresearch.ca)
   iii. Individual grower will have comparison of numbers of Verticillium propagules at three timings: 1) before mustard biofumigation 2) one-month post-biofumigation and 3) post-potato production.
      a. Completed in 2022 – more fields could be added for additional analysis with other mustards targeting other pathogens or wind erosion control
      - Refining mustard biofumigation technique for Verticillium wilt yield variability management. Data supports using Caliente Rojo (High Performance Seeds) to manage Vertcillium wilt on the field scale, working better method to measure cost effectiveness of the model because of the spatial variability associated with Verticillium wilt. Weakness in the method is that the Caliente mustard requires irrigation to get lots of biomass in Manitoba. Working with new mustard cultivars from Mustard 21 to see if a dryland mustard suitable for growers without dedicated irrigation. This requires verification that the glucosinolate profile in any other mustard compares to Caliente to ensure the efficacy of the method is preserved with other mustards.
   iv. Calculate cost of use for reduction in Verticillium CFU/g or Verticillium wilt
      - A soil test of 40 CFU/g (common in Carberry) is estimated to lose the grower $11.30 per acre, 100 CFU/g is estimated to lose the grower $79.10 per acre, and a soil test of 300 microsclerotia is estimated to lose the grower $305.10 per acre.
      - An estimate for the cost of the mustard is $200-250 per acre, making mustard biofumigation theoretically profitable with sufficient levels of Verticillium in the soil

Additional Results:

Field #	Year	Seeding Dates	Seeding Rate lbs	Total NPKS	Upfront	Fertigation	Total Irrigation inches
MB-10	2022	10-Jun	6.00	140-0-0-30	120-0-0-25	2.26 gal/ac 15-0-0-20 5.44 gal/ac 28-0-0-0	7.2 total for both crops
MB-10	2022	28-Jul	6.00	120-0-0-25	120-0-0-25	-	-
MB-11	2021	Aug 14-19	3-3.5 15" row spacing	130-0-0-25	70-0-0-15	-	3.05
MB-12	2021	06-Aug	-	150-0-0-40	135-0-0-40	15-0-0-0	-
MB-13	2021	18-May	7.99	180-30-30-45	120-30-30-30	3 apps 20-0-0-5 ea.	~25" total for both crops
MB-13	2021	15-Jul	7.01	80-0-0-25	80-0-0-25	-	-
MB-14	2021	06-Jun	-	95-0-0-19		-	0
MB-15	2021	Aug 14-19	3-3.5 15" row spacing	130-0-0-25	70-0-0-15	-	3.05
MB-16	2021	Aug 14-20	3-3.5 15" row spacing	130-0-0-26	70-0-0-15	-	3.05
MB-18	2021	17-May	8.00	180-30-30-45	120-30-30-30	3 apps 20-0-0-5 ea.	~25" total for both crops
MB-18	2021	19-Jul	7.22	80-0-0-25	80-0-0-25		

Table 1: Mustard commercial collaborator fertility and irrigation data. Generally, the mustard crops benefitted from a more advanced fertility program, at least 7 inches of irrigation (depending on rain, most of the irrigation required to germinate seed), and a seed treatment and/or follow up insecticide programs in years where flea beetle pressure was high.

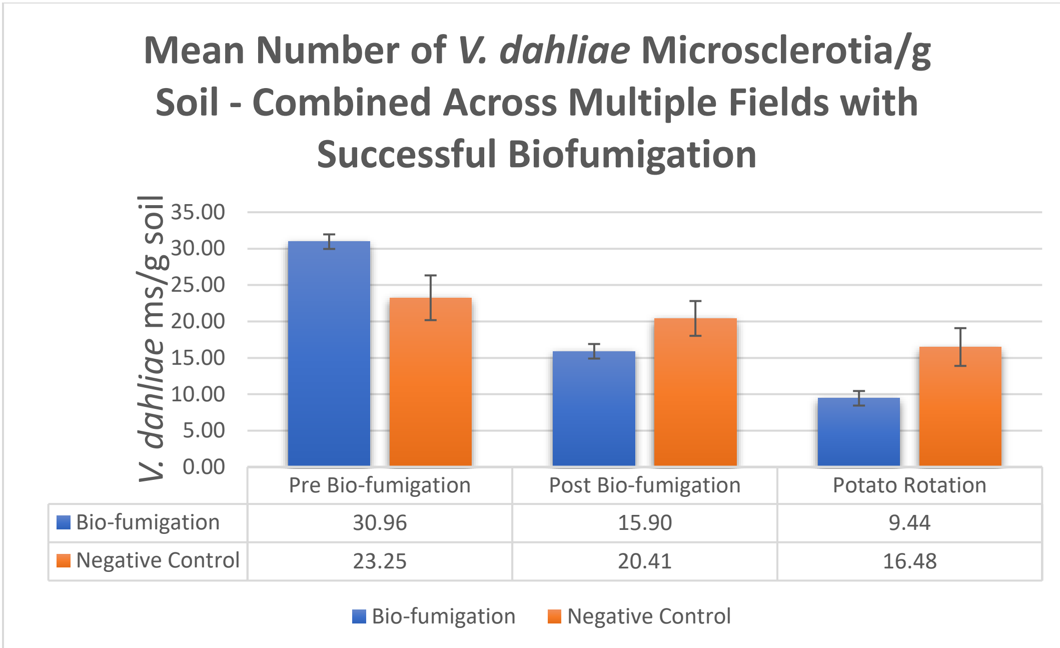


Fig. 1 The number of *V. dahliae* microsclerotia per gram of field soil (y-axis) observed within replicated strips (four per treatment) for four fields MB-7, 8, 10, and 16. These fields were chosen because the mustard achieved sufficient biomass and there were more than five *V. dahliae* microsclerotia per gram of soil to observe a treatment effect. Given the standard error whiskers overlap for both treatments pre-biofumigation, both sets of plots started with approximately the same amount of microsclerotia per gram of soil. Post biofumigation, it appears that biofumigated plots generally had fewer microsclerotia per gram of soil than the non-biofumigated, negative controls. In the following spring, after the potato crop was planted, it appears that both sets of plots had fewer microsclerotia per gram of soil. It is important to note that, in this particular case, only the negative controls consistently had a number of microsclerotia were over the 10 threshold to cause disease in a potato. While fall tillage and spring planting disrupts soil and moves it around, which changes the number of microsclerotia observed in the soil, this one field does support the idea that mustard treatment could reduce the number of microsclerotia in the soil.