Evaluation of a Bio-Pesticide for Control of Soil-borne Diseases and Pests

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Summary: This project, undertaken with the assistance of the Ontario Farm Innovation Program (OFIP), examined the effectiveness of the bio-pesticide, MustGrow, to control soil-borne plant pathogenic nematodes and diseases. MustGrow is produced by MPT Mustard Products and Technologies of Saskatchewan and is derived from mustard seed meal. The product produces allylisothiocyanate (AITC) when exposed to water after incorporation in soil and this has nematicidal and fungicidal activity. It has more favourable environmental and worker safety characteristics than the currently used chemical soil fumigants in the marketplace. As such, the use of MustGrow may offer an alternative to the practice of chemical soil fumigation for disease and pest control. Results will be of general interest to growers of high value commodities such as tobacco, ginseng, strawberries, orchard and nursery crops and certain specialty crops where fumigants are currently employed for the control of soil-borne diseases or nematodes and where alternatives to this practice are being sought. In the absence of effective soil fumigation, it is reasonable to expect yield declines of 20-25% or greater for many of these commodities.

In this project a field trial was conducted using flue-cured tobacco as the host species. The trial examined the effects of several rates of MustGrow on crop growth and populations of soil-borne pathogenic nematodes and soil fungi and compared their effectiveness to plants grown without any treatment or with the commercial standard treatment of soil fumigation with Chloropicrin 100.

Figure 1. MustGrow application. The product is a dry granule which was incorporated down the length of the row with a roto-tiller. The highest rate used in the trial, 2240 kg/ha, is shown in the image to the right.

Figure 2. Planting into MustGrow-treated rows. Planting was done 22 days after incorporation of the product into the soil.

During most of the 2014 season, plants grown in plots treated with MustGrow showed heights intermediate between that of the non-treated control (poorest) and the Chloropicrin 100 fumigation treatment (best). Most other measurements of plant growth and development were not significantly affected by the treatments. The percentage of plants showing flower development on August 1, however, were significantly increased by fumigation with Chloropicrin 100 and by the use of MustGrow at the highest tested rate, 2240 kg/ha, compared to the lower rates of MustGrow (i.e. 980 and 1610 kg/ha) and the non-treated control.

Although the plots assigned to the various treatments showed similar numbers of Root-Lesion Nematode at the start of the trial (May 13), treatment with MustGrow at the highest rate or with Chloropicrin 100 fumigant had significantly lower numbers than the other treatments by July 24. In spite of these late-season effects on nematodes shown by the high rate of MustGrow, dry weight yields were significantly greater for the Chloropicrin 100 fumigation treatment in the first three of four harvests and for the trial as a whole.

The effect of these treatments on selected soil fungi was also studied. At the start of the trial on May 13, populations of soil fungi were equal across the trial site; this was true for potential pathogens such as Fusarium and Pythium and also for saprophytic fungi (i.e. Mortierella and Komada selected fungi which are normally present in soil and break down dead organic matter). Seventy-one days after the application of treatments (i.e. on July 24), the untreated and the fumigated plots tended to have lower numbers of all the fungi under testing while the addition of MustGrow to the soil at the three tested rates tended to increase all the fungi examined. It is possible that these fungi were able to use the MustGrow as a food source to increase their numbers by this time. This was also generally true by the end of the trial in late September. As such, there was no clear indication that the use of MustGrow would be of value in attempting to control soil-borne fungal plant pathogens.

Outcomes: In this field trial, plots treated with MustGrow at three different rates had plants which were intermediate in growth compared to a non-treated control (poorest growth) and the Chloropicrin 100 fumigation treatment (greatest growth) on 5 assessment dates from June 26 to July 24. Other measurements of plant development (i.e. topping height, leaf number and the measurements of eighth and tip leaves) did not show significant treatment effects.

Results of interest for the control of pathogenic nematodes was the finding that MustGrow at either of the two highest rates used led to significantly lower numbers of Root-Lesion Nematodes in soil in late July compared to the lowest rate of MustGrow or the non-fumigated and Chloropicrin 100 fumigated treatments. When yield was determined, however, the Chloropicrin 100 fumigation treatment had significantly greater plant dry weight yields on the first three of four harvests and for the season overall. It may be that activation of the MustGrow treatment in the soil was not rapid enough to lead to the early season growth enhancement seen with the Chloropicrin 100 soil fumigant, presumably through the ability of Chloropicrin 100 to provide immediate soil-borne pest control at the time of application. This early season growth enhancement seems essential to achieve high yields in the face of significant nematode and disease pressure.

There was no indication that MustGrow at any rate lowered numbers of potential soil-borne fungal plant pathogens; instead the addition of this material to soil tended to increase populations of several different fungi.

Detailed results are found in tables 1-5.

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Table 1. Ex 30-6. MustGrow 2014. Effect of treatments on plant heights during the season and bud development.

	Plant height (cm) by date								Bud %
Treatment	**June 12**	**June 19**	**June 26**	**July 3**	**July 10**	**July 16**	**July 24**	**Aug 1**	**Aug 1**
1 Non-treated	12.5 a	15.0 b	17.6 c	22.8 c	38.7 c	54.8 c	78.5 c	111.1 b	67 b
2 Fumigated	12.5 a	16.2 a	22.5 a	34.0 a	56.9 a	77.1 a	104.0 a	-	95 a
3 MustGrow 980 kg/ha	13.1 a	15.4 a	18.2 b	24.6 b	42.1 b	59.4 b	83.6 b	117.9 a	73 b
4 MustGrow 1610 kg/ha	13.3 a	15.2 b	18.4 b	24.4 b	41.3 b	58.2 b	81.5 b	114.9 a	72 b
5 MustGrow 2240 kg/ha	13.4 a	15.8 a	19.2 b	24.4 b	41.3 b	57.7 b	82.0 b	115.2 a	80 a
P=[1]	0.020	0.008	0.000	0.000	0.000	0.000	0.000	0.003	0.011

[1]= The probability associated with the F-statistic for treatment effects being significant. Numbers within a column shaded in yellow followed by the same letter are not significantly different based on the Tukey's b HSD test.

Table 2. Ex. 30-6. MustGrow 2014. Effect of treatments on topping height, leaf number at topping and the size of eighth and tip leaves.

			Eighth Leaf Measurements			Tip Leaf Measurements		
Treatment	**Topping height (cm)**	**Leaf number at topping**	**Length (cm)**	**Width (cm)**	**Area (cm^2)**	**Length (cm)**	**Width (cm)**	**Area (cm^2)**
1 Non-treated	111	19	61.4	32.8	1364	53.6	20.3	737
2 Fumigated	111	19	64.0	34.2	1482	55.9	21.6	819
3 MustGrow 980 kg/ha	112	20	63.6	32.0	1379	53.9	20.1	736
4 MustGrow 1610 kg/ha	112	20	62.0	32.2	1357	54.8	20.9	779
5 MustGrow 2240 kg/ha	112	20	65.0	33.4	1469	54.9	21.6	808
P=[1]	0.974	0.386	0.186	0.323	0.323	0.581	0.279	0.314

[1]= The probability associated with the F-statistic for treatment effects being significant.

Table 3. Ex 30-6. MustGrow 2014. Nematode counts through the 2014 season.				
	Nematode counts by sampling time[2]			
	Root Lesion Nematode		**Stunt Nematode**	
Treatment	**Early**	**Late**	**Early**	**Late**
1 Non-treated	140	115 a	175	160
2 Fumigated	170	75 a	165	0
3 MustGrow 980 kg/ha	145	65 a	110	135
4 MustGrow 1610 kg/ha	100	30 b	135	115
5 MustGrow 2240 kg/ha	100	35 b	145	90
P=[1]	0.423	0.013	0.443	0.059

[1]= The probability associated with the F-statistic for treatment effects being significant. Numbers within a column shaded in yellow followed by the same letter are not significantly different based on the Tukey's b HSD test.
[2]= Early counts are from May 13; late counts are from July 24.

Table 4. Ex. 30-6. MustGrow 2014. Effect of treatments on the dry weight yield per plant.					
	Dry weight yield (g)/ plant by priming number				
Treatment	**P1**	**P2**	**P3**	**P4**	**Total**
1 Non-treated	39.8 b	60.0 b	73.0 b	123.2	296.0 b
2 Fumigated	53.3 a	84.4 a	87.3 a	122.1	347.1 a
3 MustGrow 980 kg/ha	38.7 b	66.2 b	72.3 b	114.7	292.0 b
4 MustGrow 1610 kg/ha	38.6 b	61.1 b	76.7 b	136.3	312.7 b
5 MustGrow 2240 kg/ha	38.5 b	58.7 b	72.8 b	134.3	304.3 b
P=[1]	0.001	0.002	0.016	0.214	0.030

[1]= The probability associated with the F-statistic for treatment effects being significant. Numbers within a column shaded in yellow followed by the same letter are not significantly different based on the Tukey's b HSD test.

Table 5. Ex 30-6. MustGrow 2014. Effect of treatments on populations of selected soil fungi during the season.

	Colony forming units of various soil fungi/g dry weight soil by month									
	May									
Treatment	**Fusarium**			**Komada[2]**			**Pythium**	**Mortierella**		
1 Non-treated	3166			6528			54	1220		
2 Fumigated	1465			6103			40	522		
3 MustGrow 980 kg/ha	1493			7623			11	1062		
4 MustGrow 1610 kg/ha	1575			7197			78	581		
5 MustGrow 2240 kg/ha	1651			6135			13	808		
P=[1]	0.305			0.583			0.158	0.072		
	July									
		Test			Test				Test	
Treatment		Tukey	FLSD		Tukey	FLSD			Tukey	FLSD
1 Non-treated	1246	a	c	8786	a	bc	10	846	b	b
2 Fumigated	1636	a	bc	6763	b	c	0	935	b	b
3 MustGrow 980 kg/ha	3138	a	abc	13202	a	a	50	4111	a	a
4 MustGrow 1610 kg/ha	3401	a	ab	11493	a	ab	64	3352	a	a
5 MustGrow 2240 kg/ha	3878	a	a	11995	a	ab	14	3005	a	a
P=[1]	0.037			0.005			0.136	0.000		
	September									
		Test			Test					
Treatment		Tukey	FLSD		Tukey	FLSD				
1 Non-treated	2075	a	c	10653	a	b	10	690		
2 Fumigated	1811	a	c	6382	b	c	0	40		
3 MustGrow 980 kg/ha	2449	a	bc	15183	a	a	0	1096		
4 MustGrow 1610 kg/ha	4072	a	ab	10546	a	b	29	857		
5 MustGrow 2240 kg/ha	4383	a	a	13823	a	ab	38	1320		
P=[1]	0.025			0.001			0.652	0.078		

1= the probability associated with the F-statistic for treatment effects being significant. Numbers within a column shaded in yellow followed by the same letter are not significantly different using Tukey's b HSD test (P>0.05) or Fisher's LSD test.

2=counts of non-Fusarium colonies which arose on Komada's Fusarium selective medium.

3=although the F-statistic shows significance, the Tukey's b HSD test could not discriminate differences among the treatment mean values. Fisher's LSD test results are shown for purposes of comparison.