EVALUATION OF BRASSICA WINTER CROPS AND METAM SODIUM FOR NEMATODE CONTROL IN EGGPLANT

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Introduction

Many plants produce compounds called allelochemicals that directly or indirectly impact their biological environment. Glucosinolates (GSLs) are allelochemicals that occur throughout the agronomically important Brassicaceae (Cruciferae) family. There is sufficient evidence to suggest that glucosinolates contained in Brassicaceae tissues produce a variety of allelochemicals that are effective pesticides. Glucosinolate degradation products such as isothiocyanates (ITC's) have broad-spectrum biocidal activity, including insecticidal, nematicidal, fungicidal, antibiotic and phytotoxic effects. For example, methylisothiocyanate (MITC) is used as a soil fumigant and is the active pesticidal agent produced from the degradation of synthetic dithiocarbamates (e.g., metam sodium) and diazines (e.g., dazomet). Because isothiocyanates have pesticidal activities and are dominant products formed from glucosinolates in soil, the use of Brassica species and other glucosinolate-producing species to control soilborne plant pests could be a valuable component of a methyl bromide alternatives program.

In this test we investigated the effects of three winter crops, two Brassica crops (turnip and rutabaga) and rye, by themselves or in combinbation with metam sodium and/or methyl bromide on subsequent plasticulture pepper.

Materials and Methods

The study was located at the Blackshank Farm, CPES, Tifton, GA. The area had a history of soybeans, tobacco, and assorted vegetables. The area was prepared using all current University of Georgia Extension Service recommendations. The plot design was a split plot design with winter crops and fumigants as main treatments and biomass incorporation or removal as sub-treatments (Table 1). Plots were arranged in randomized complete blocks consisting of single bed plots replicated five times. Each main plot was 50 feet long and 6 feet wide with 10 ft alleys. Plastic bed plots were 23 ft long and 30" wide with 3 ft spacing between split-plots.

Turnip (cv. Purple Top White Globe), rutabaga (cv. American Purple Top) and rye (cv. Elbon) were planted on October 15, 2003 with a Stanhay planter. Winter crops were grown until February 17, 2004. On February 17, 2004, the winter cover crops were cut with a Flail mower. Biomass, both above and belowground, was removed from designated sub-plots and all plots were rototilled twice. Planting beds were shaped (twice), pathogen/pest sachets buried (fungi/bacteria near tape, weeds nearer shoulder), methyl bromide (67-33) injected at 300 lbs/A, and beds covered with 1 mil black polyethylene with drip tape in the center of the bed approximately 1 in. deep. Metam sodium was drip-applied at 37.5 gal/A on February 23 over a 6 h irrigation period.

Eggplant seedlings, cv. Santana, were produced in nutrient tray system to the 4-leaf stage. A single plant was transplanted using a mechanical type transplanter, which cuts holes in the plastic just ahead of the planters in the center of the plastic bed adjacent to the drip tape on March 24, 2004. Plant spacing was 12 in. Phytotoxicity due to herbicide application on the plastic prior to planting required re-planting of eggplant on March 29, 2004.

As per the recommendation of the University Of Georgia Extension service, all plots received 500 lbs of fertilizer prior to winter crop planting and 700 lbs. of fertilizer (10-10-10) prior to plastic laying. Additional fertilizer on eggplant was added in the form of liquid fertilizer (4-0-8 at 6 lbs N/day) injected through the irrigation tubing bi-weekly during the growing season. All eggplant plots were sprayed on a 4 to 7 day interval with Bravo (2 pts/A on 15 April) for control of foliar diseases, and Spintor (8 oz./A on 1 April) alternating with Avaunt (3 oz./A on 15 April), Asana XL (9 oz./A on 14 May) and Lannate (1pt/A on 28 May) for insect control.

Stand counts were made to record live plants on 27 April and plant vigor ratings were done on 27 April and 7 May. Plant vigor was rated on a 1 to 10 scale, 10 representing live and healthy plants and 1 representing dead plants. Fresh plant (root and shoot) weights were recorded on 25 May (at flowering stage).

Twelve cores of soil, 2.5-cm-diam × 25-cm-deep, were collected from the center of each plot before planting winter crops (15 October, 2003), at harvest of winter crops (15 February), and at planting (24 March) and after harvest (4 July) of eggplant. Nematodes were extracted from a 150-cm^3 soil sub-sample using a centrifugal sugar flotation technique, except at planting when they were extracted in Baermann pans (to capture only active nematodes). On 25 May (at flowering stage) an early root gall evaluation was done on three plants per plot using a 0 to 10 scale, whereby, 0 = no galls, 1 = very few small galls, 2 = numerous small galls, 3 = numerous small galls of which some are grown together, 4 = numerous small and some big galls, 5 = 25 % of roots severely galled, 6 = 50 % of roots severely galled, 7 =75 % of roots severely galled, 8 = no healthy roots but plant is still green, 9 = roots rotting and plant dying, 10 = plant and roots dead. Again following final harvest on 27 June ten plants per plot were evaluated for root galls using that same scale.

All eggplant fruits were hand-harvested from the 15-ft center area of each bed (15 plants per plot). Each harvest was separated into marketable and cull fruits, counted, and weighed. There were a total of four harvests, on 7, 10, and 15 and 20 June.

All data collected was analyzed with an analysis of variance (P = 0.05) and means were separated using Duncan's Multiple range test.

Summary

Root-knot nematode soil populations did not change during winter and similar populations were observed for all winter crops (Table 2). However, root galls were observed with turnip and especially rutabaga (Table 3). All winter crops, especially both Brassica crops, produced high amounts of biomass. Stubby root nematode populations increased over winter, with rutabaga and rye having higher build up than turnip (Table 2).

Following fumigation with methyl bromide and/or metam sodium, at planting of eggplant, populations of plant-parasitic nematodes were always low and slightly higher

in the control than in the methyl bromide-treated beds (Table 4). Free-living nematodes were more affected by fumigants and were higher in untreated > metam sodium > methyl bromide-treated beds. Stubby root and fungivorous nematodes were slightly higher following rye**.** Biomass incorporation or removal did not affect plant-parasitic nematodes, but higher levels of free-living nematodes were found when biomass was incorporated (Table 4).

By harvest of eggplant, populations of root-knot nematodes had increased tremendously, which is often the case with eggplant, and were not different with regard to winter crop (Table 5). Free-living, and more specifically bacterivorous, nematodes were more numerous following rye. Root-knot nematode populations were greater in the control > metam sodium > methyl bromide-treated beds (Table 5). Stubby root nematodes, however, were more numerous in methyl bromide-treated beds. Free-living, and more specifically bacterivorous, nematodes were higher following metam sodium than untreated or methyl bromide-treated beds. Biomass incorporation or removal did not affect plant-parasitic nematodes, but higher levels of free-living nematodes were found when biomass was incorporated (Table 5).

Eggplant growth, in terms of plant vigor and plant weight at mid season, was somewhat better following rye than following rutabaga and turnip (Table 6). Fumigated plots showed somewhat better growth than untreated plots and shoot weight following methyl bromide was greater as compared to metam sodium and especially untreated beds. Biomass incorporation had no effect on eggplant growth.

Root-knot gall indices were low at mid season, and did show some effect of fumigation at this stage (Table 6). By harvest gall indices increased and were greater following turnip and rutabaga as compared to rye. Untreated plots had greater GI than fumigated plots and biomass had no effect.

Eggplant yield was not affected by previous winter crop or biomass incorporation or removal, but greater yields (~ 20%) were recorded following fumigation with methyl bromide (Tables 7, 8).

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Table 1. Treatment table

Winter Crop	Fumigant (on eggplant)
Turnip	None
Rutabaga	None
Rye	None
Turnip	Metam sodium (37.5 G/A)
Rutabaga	Metam sodium (37.5 G/A)
Rye	Metam sodium (37.5 G/A)
Rye	Methyl bromide (300 lbs/A)

* All plots were split in two following the winter crop, with one half having all biomass (shoot and root) incorporated, the other half having all biomass removed.

Table 2. Soil populations of plant-parasitic, free-living nematodes and soil fungi at planting and harvest of Brassica crops, fall 2003-spring 2004, Black Shank Farm Tifton, GA.

Time / Cover crop	Plant-parasitic nematodes			Free-living nematodes			
	per 150 cc soil						
	Root-knot	Stubby	Total	B'vores	F'vores	O'vores	Total
At planting of cover							
Turnip	44	3	49	921	55	250	1249
Rutabaga	21	3	63	1014	28	206	1248
Rye	21	2	34	1026	28	195	1249
At harvest of cover							
Turnip	16	40 b	56 b	1105	101	220	1233
Rutabaga	40	104 a	144 a	1018	136	209	1248
Rye	31	73 a	103 a	956	119	143	1249

Root-knot nematode (*Meloidogyne* spp.); Stubby root nematode (Trichodoridae); Free-living nematodes = non-parasitic nematodes; B'vores = bacterial-feeding, F'vores = fungal-feeding, O'vores = predatory and omnivorous nematodes.
Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference; NS = not significant.

Table 3. Biomass productivity and root-knot nematode infection of Brassica's, March 2003, Blackshank Farm, Tifton, GA.

Cover crop	Fresh Biomass (lbs/acre)(x1000)			Root-knot nematode
	Shoot	Root	Total	Gall index (0-10)
Turnip Purple Top White Globe	26.98 a	21.15	48.13	0.9 b
Rutabaga	21.63 a	20.24	41.87	2.6 a
Rye	13.23 b	-	-	0.0 c

Table 4. Populations of plant-parasitic and free-living nematodes at planting of eggplant, as affected by winter cover crops, pre-plant fumigants, and incorporation/removal of winter crop biomass, spring 2004, Black Shank Farm Tifton,GA

Factor effects	Plant-parasitic nematodes / 150 cc soil			Free-living nematodes / 150 cc soil			
	Root-knot	Stubby	Total	B'vores	F'vores	O'vores	Total
WINTER CROP							
Turnip	0.9	0.9 b	1.8	2924	166 b	34	3124
Rutabaga	0.3	0.9 b	1.2	2204	178 b	17	2398
Rye	0.0	3.4 a	3.4	3084	321 a	18	3423
Fpr	NS	0.05	NS	NS	0.06	NS	NS
FUMIGANT							
Metam sodium	0	1.5	1.5 ab	2017 ab	133 b	4 b	2154 ab
Methyl bromide	0	0.0	0.0 b	1123 b	34 b	1 b	1157 b
Control	0.8	2.1	2.9 a	3458 a	310 a	42 a	3810 a
Fpr	NS	NS	0.04	0.03	<0.01	<0.01	<0.01
BIOMASS							
Incorporated	0.0	1.9	1.9	3628 a	281 a	20	3929 a
Removed	0.8	1.7	2.5	1847 b	162 b	26	2035 b
Fpr	NS	NS	NS	0.03	0.04	NS	0.02
INTERACTIONS *Fpr* (all)	NS	NS	NS	NS	NS	NS	NS

Nematode samples were collected on April 30; Root-knot nematode (*Meloidogyne* spp.); Stubby root nematode (Trichodoridae); Free-living nematodes = non-parasitic nematodes; B'vores = bacterial-feeding, F'vores = fungal-feeding, O'vores = predatory and omnivorous nematodes. Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference; NS = not significant.

Fumigant effects averaged over all plots (n=56); Winter crop and biomass effects averaged for all plots excluding Rye + MBr (n=48)

Table 5. Populations of plant-parasitic and free-living nematodes at harvest of eggplant, as affected by winter cover crops, pre-plant fumigants, and incorporation/removal of winter crop biomass, spring 2004, Black Shank Farm Tifton, GA.

Factor effects	Plant-parasitic nematodes / 150 cc soil			Free-living nematodes / 150 cc soil			
	Root-knot	Stubby	Total	B'vores	F'vores	O'vores	Total
WINTER CROP							
Turnip	2598	38	2636	1011 b	51	86	1149 b
Rutabaga	2767	45	2812	1063 b	106	115	1284 b
Rye	3093	33	3126	1700 a	171	121	1992 a
Fpr	NS	NS	NS	0.02	NS	NS	0.01
FUMIGANT							
Metam sodium	1648 b	46 ab	1694 b	1538 a	154	111	1803 a
Methyl bromide	384 c	66 a	450 c	675 b	191	69	935 b
Control	3991 a	30 b	4021 a	978 b	65	104	1147 b
Fpr	<0.01	0.02	<0.01	<0.01	NS	NS	<0.01
BIOMASS							
Incorporated	3163	33	3196	1698 a	155 a	105	1959 a
Removed	2475	44	2520	818 b	64 b	110	991 b
Fpr	NS	NS	NS	0.03	0.09	NS	<0.01
INTERACTION *Fpr*							
Winter crop*Fumigant	NS	0.06	NS	NS	NS	NS	NS
Winter crop*Biomass	NS	0.06	NS	NS	NS	NS	NS
Fumigant*Biomass	NS	NS	NS	0.05	NS	NS	NS
Winter crop*Fumigant*Biomass	NS	NS	NS	NS	NS	NS	NS

Nematode samples were collected on July 4; Root-knot nematode (*Meloidogyne* spp.); Stubby root nematode (Trichodoridae); Free-living nematodes = non-parasitic nematodes; B'vores = bacterial-feeding, F'vores = fungal-feeding, O'vores = predatory and omnivorous nematodes. Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference; NS = not significant. Fumigant effects averaged over all plots (n=56); Winter crop and biomass effects averaged for all plots excluding Rye + MBr (n=48)

Table 6. Plant vigor and root-gall indices of eggplant as affected by winter cover crops, pre-plant fumigants, and incorporation/removal of winter crop biomass, spring 2004, Black Shank Farm Tifton, GA.

	Plant stand	Plant vigor [a]		Shoot weight	Root weight	Root gall index [b]	
	At 4 w	At 4 w	At 6 w	At 8 w	At 8 w	At 8 w	At 12 w
WINTER CROP							
Turnip	23	7.9	8.8	6.325 b	90.0 b	0.4	2.5 a
Rutabaga	23	7.9	8.9	6.769 ab	95.5 ab	0.4	2.7 a
Rye	23	8.3	9.4	7.456 a	111.3 a	0.3	1.8 b
Fpr	NS	NS	0.09	0.01	0.03	NS	0.01
FUMIGANT							
Metam sodium	23	8.3	9.3	7.167 b	100.4	0.2 b	1.6 b
Methyl bromide	23	8.3	9.4	8.263 a	109.3	0.1 b	0.7 c
Control	23	7.8	8.8	6.533 b	97.5	0.6 a	3.0 a
Fpr	NS	0.11	NS	0.02	NS	<0.01	<0.01
BIOMASS							
Incorporated	23	8.0	9.0	6.967	103.2	0.3	2.3
Removed	23	8.0	9.0	6.733	94.7	0.4	2.4
Fpr	NS	NS	NS	NS	NS	NS	NS
INTERACTION *Fpr*							
Winter crop*Fumigant	NS	NS	NS	NS	NS	0.09	0.05
Winter crop*Biomass	NS	0.07	NS	NS	NS	NS	NS
Fumigant*Biomass	NS	0.02	0.05	0.01	NS	NS	NS
Winter crop*Fumigant*Biomass	0.04	NS	NS	NS	NS	0.04	NS

[a] Vigor was done a 1-10 scale with 10= live and healthy plants and 1=dead plants; [b] Root Gall Index 0-10 scale whereby, 0 = no galls, 1 = very few small galls, 2 = numerous small galls, 3 = numerous small galls of which some are grown together, 4 = numerous small and some big galls, 5 = 25 % of roots severely galled, 6 = 50 % of roots severely galled, 7 =75 % of roots severely galled, 8 = no healthy roots but plant is still green, 9 = roots rotting and plant dying, 10 = plant and roots dead; Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference; NS = not significant.

Table 7. Effect of winter cover crops, pre-plant fumigants and incorporation/removal of winter crop biomass on fruit yield number of eggplant, spring 2004, Black Shank Farm Tifton, GA.

Fumigant	Number of marketable fruits*					Number of culls
	Yield 1	Yield 2	Yield 3	Yield 4	Total	Total
WINTER CROP						
Turnip	14	20	31	37	103	5
Rutabaga	13	22	33	40	107	6
Rye	14	23	34	37	110	7
Fpr	NS	NS	NS	NS	NS	NS
FUMIGANT						
Metam sodium	14	24 b	33	38 ab	110 b	7
Methyl bromide	12	33 a	36	45 a	126 a	7
Control	13	20 b	32	38 b	103 b	6
Fpr	NS	<0.01	NS	0.16	0.01	NS
BIOMASS						
Incorporated	13	22	33	38	106	7
Removed	15	22	32	38	107	6
Fpr	NS	NS	NS	NS	NS	NS
INTERACTION *Fpr*						
Winter crop*Fumigant	NS	NS	NS	NS	NS	NS
Winter crop*Biomass	NS	0.09	NS	NS	NS	NS
Fumigant*Biomass	NS	NS	0.05	NS	NS	NS
Winter crop*Fumigant*Biomass	NS	0.02	NS	NS	NS	0.02

* per 15 ft bed length; Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference; NS = not significant.

Table 8. Effect of winter cover crops, pre-plant fumigants and incorporation/removal of winter crop biomass on fruit yield weight of eggplant spring 2004, Black Shank Farm Tifton, GA

Fumigant	Weight of marketable fruits (lbs)*					Weight of culls
	Yield 1	Yield 2	Yield 3	Yield 4	Total	Total
WINTER CROP						
Turnip	20.6	16.2	26.7	29.1	92.6	4.2
Rutabaga	19.7	18.0	29.3	29.8	96.8	4.6
Rye	21.2	19.2	30.4	28.0	98.8	5.7
Fpr	NS	NS	NS	NS	NS	NS
FUMIGANT						
Metam sodium	21.1 a	19.0 b	29.2 ab	29.3	98.6 b	5.1
Methyl bromide	17.5 b	28.2 a	32.7 a	33.5	111.9 a	4.6
Control	20.0 ab	16.6 b	28.4 b	28.6	93.5 b	4.5
Fpr	0.09	<0.01		NS	0.03	NS
BIOMASS						
Incorporated	19.9	18.4	28.7	29.0	96.1	5.3
Removed	21.1	17.2	28.9	28.9	96.1	4.3
Fpr	NS	NS	NS	NS	NS	NS
INTERACTION *Fpr*						
Winter crop*Fumigant	NS	NS	NS	NS	NS	NS
Winter crop*Biomass	NS	NS	NS	NS	NS	0.08
Fumigant*Biomass	NS	NS	0.09	NS	NS	NS
Winter crop*Fumigant*Biomass	NS	0.02	NS	NS	NS	0.10

* per 15 ft bed length; Data are means of five replications. Means in the same column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test. No letters indicate non-significant difference; NS = not significant.