SHORT COMMUNICATION

GREEN MANURE CROPS: AGRONOMIC CHARACTERISTICS AND EFFECT ON NEMATODES

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Abstract

Green manure crops can improve soil health and, if chosen correctly, reduce pest and disease problems. Nineteen different cover crops were planted into nematode-infested soil in early summer 2004. These crops were grown for three months, whereafter they were destructively sampled. A similar procedure was performed with nine cover crops planted in winter 2005.

Results indicated that, of the summer crops, babala, buckwheat, cowpeas, forage sorghum, Rhodes grass and velvet beans had a significantly greater per cent soil cover than sugarcane. Similarly, babala, cowpeas, Rhodes grass and velvet beans had a significantly higher aboveground biomass than sugarcane. Babala, cowpeas and tomatoes were associated with increases in *Meloidogyne javanica*. Ten crops significantly decreased the numbers of *Pratylenchus zeae.*

All of the winter crops showed greater per cent soil cover than sugarcane, and six crops exhibited greater aboveground biomass. Most of the crops were associated with decreases in *Pratylenchus zeae* and some crops, such as giant English rape, grazing vetch, lucerne, lupins and red clover, were associated with increases in *M. javanica.*

Taking into account the agronomic and nematode status, velvet beans, Rhodes grass and buckwheat would be most favourable for summer planting and oats (black), serradella and wheat for winter.

Keywords: green manure crops, plant parasitic nematodes, free living nematodes, sugarcane

Introduction

Plant parasitic nematodes cause extensive damage each year to sugarcane crops grown in South Africa, especially in sandy soils. They decrease cane yield and can reduce the number of consecutive ratoon crops (Cadet and Spaull, 2003). Green manure crops can be incorporated into the sugarcane production system to break the continuous cane monoculture and relieve the effects of the sugarcane yield decline syndrome (Garside, 1997), and can also affect nematode dynamics (Pankhurst *et al*, 1999; Berry and Wiseman, 2003). With a worldwide trend towards biological farming methods and integrated pest management, it is worthwhile to consider alternative methods of nematode control.

This study was undertaken to determine the effects of different cover crops on nematode populations in the soil, as well as to assess the performance of a number of crops in different seasons.

Materials and Methods

Two trials were planted, one in October 2004, and the other in May 2005. In both trials, 25 L pots were filled with nematode-infested, sandy soil containing *Pratylenchus zeae, Helicotylenchus dihystera, Meloidogyne javanica, Xiphinema elongatum, Paratrichodorus* sp*, Criconemella* sp*, Scutellonema* sp. and various free-living nematodes.

The pots were randomly stratified, according to crop height, and placed in the rain shelter. This allowed them access to sunlight, with water supplied via drip irrigation and hand watering. The crops were fertilised every second week. After three months of growth, all the crops were harvested. Root and shoot biomass (dry and wet mass respectively), percentage cover and height measurements from five random stalks were recorded, and soil and roots were collected for nematode counts.

In October 2004, five seedlings of each cultivar were planted. Seeds were donated by Agricol Seeds. Where seedlings died off, they were replaced to maintain plant density at five seedlings per pot. Nineteen green manure crops were planted, with three replicates per crop (Table 1). Tomato (susceptible to *Meloidogyne* species), sugarcane (N12), and a bare fallow were used as controls. In January 2005, the trial was harvested.

The winter trial followed a similar format. However seeds were not pre-germinated but sown directly into the pots. Plant density was maintained at five plants per pot. In May 2005, nine winter green manure crops were planted, with four replicates per crop (Table 2). The same controls were used. In September 2005, the trial was harvested.

The agronomic data was analysed by ANOVA and Student t-test (JMP Software, SAS Institute). Nematode data was transformed to $\log_{10}(x+1)$ to remove the inherent variability before analyses. Data was analysed by the non-parametric test of Kruskal and Wallis (JMP Software, SAS Institute).

Results and Discussion

Crop performance

From these trials, crops not suitable for growing in summer included canola, giant English rape, Jap radish and turnips. All of these crops, although provided with sufficient moisture and nutrients, grew poorly and did not survive. In the winter trial, however, only cool-season crops were planted, and all grew well.

Of interest are the differences in growth of the same crops in two seasons. Six crops were common to both trials. Of these, the most marked differences in growth were for lucerne and lupins, which increased their root weight, aboveground biomass, % cover and height by 10-20x, 3x, 5x and 13x respectively.

Green manure crops can be used for various purposes. These include producing a large amount of biomass to return sufficient organic matter to the soil; producing a large and deep root system for alleviating the effects of compaction; and providing good ground cover to alleviate weed problems.

Table 1. Agronomic characteristics of the green manure crops grown in summer (1A) and winter (1B) compared with the continuous production of sugarcane. Values with different letters are significantly different to each other.

Crop	Scientific name	Root weight (g)		Biomass (t/ha)		Cover (%)		Height (mm)	
(1A)									
Babala	*Pennisetum glaucum*	18.7*	a	72*	a	85*	ab	1100*	a
Buckwheat	*Fagopyrum esculentum*	1.1	cd	11	fg	62*	c	493*	de
Cabbage	*Brassica* sp.	0.6	cd	4	fg	32	efg	126*	h
Cowpeas	*Vigna unguiculata*	4.4	cd	56*	ab	99*	a	427*	ef
Forage sorghum	*Hordeum vulgare*	12.7*	ab	30	cde	67*	bc	1078*	a
Hairy vetch	*Vicia villosa*	0.2	cd	1	fg	25	fg	455*	def
Jap millet	*Echinochloa crusgalli* var. *frumentacea*	1.7	cd	7	fg	60	cd	480*	def
Lucerne	*Medicago sativa*	1.4	cd	2	fg	16*	g	243*	gh
Lupin	*Lupinus* sp	0.8	d	4	fg	16*	g	369*	fg
Oats – black	*Avena strigosa*	1.4	cd	5	fg	30	efg	780	b
Oats – white	*Avena sativa*	0.9	cd	4	fg	25	fg	371*	efg
Rhodes grass	*Chloris gayana*	7.6	bc	42*	bc	99*	a	724	bc
Serradella	*Ornithopus sativus*	1.6	cd	3	g	43	de	171*	h
Sugarcane	**N12**	**2.6**	**cd**	**14**	**efg**	**41**	**def**	**840**	**b**
Tomato	*Lycopersicon esculentum#*	3.4	cd	20	def	58	cd	412*	efg
Velvet beans	*Mucuna deeringiana*	3.4	cd	35*	cd	95*	a	605*	cd
		P=0.0004		P<0.0001		P<0.0001		P<0.0001	
(1B)									
Giant English rape	*Brassica napus*	2.7	b	7	d	31*	d	191*	f
Grazing vetch	*Vicia villosa* x *dasycarpa*	9.8	b	11*	c	59*	c	436*	bc
Lucerne	*Medicago sativa*	27.9*	a	6	d	79*	b	316*	e
Lupin	*Lupinus* sp	8.8	b	13*	c	65*	bc	480*	b
Oats - black	*Avena strigosa*	35.6*	a	19*	b	73*	bc	391*	cd
Red clover	*Trifolium pratense*	7.7	b	8	d	82*	ab	181*	f
Serradella	*Ornithopus sativus*	8.0	b	19*	b	97*	a	302*	e
Sugarcane	**N12**	**9.3**	**b**	**7**	**d**	**13**	**e**	**544**	**a**
Tomato	*Lycopersicon esculentum#*	5.2	b	26*	a	75*	bc	388*	cd
Wheat	*Triticum aestivum*	27.9*	a	12*	c	64*	bc	355*	de
		P<0.0001		P<0.0001		P<0.0001		P<0.0001	

#Variety Heinz 1370 IMP
*P<0.05, significantly different to sugarcane

In summer, babala and forage sorghum produced significantly larger root biomass than that of the other crops (Table 1A). Babala, cowpeas, Rhodes grass and velvet beans all produced significantly more aboveground biomass than sugarcane. These same crops, together with forage sorghum and buckwheat, produced a ground cover of more than 60%, making them good options where physical weed suppression is needed. Conversely, lucerne and lupin, with their lower biomass, covered only 16% of the soil surface. Babala and forage sorghum produced the tallest crops, averaging 1.1 m in three months, particularly when compared with sugarcane, which yielded only 0.8 m over the same period.

In winter, oats, lucerne and wheat produced the highest amount of root biomass. Six crops produced significantly more aboveground biomass (Table 1B), and all of the crops covered the soil better than sugarcane.

Table 2. Number of nematodes for each treatment in soil and roots after three months of growth in summer (2A) and winter (2B). Data were transformed to $\log_{10}(x+1)$. However, actual values are shown here for ease of reading. Values with different letters are significantly different to each other.

Crop	Soil						Roots			
	Helicotylenchus		*Xiphinema*		*Paratrichodorus*		*Pratylenchus*		*Meloidogyne*	
(2A)										
Babala	63	abc	40	a	47	cdef	9025	abc	11669	bc
Buckwheat	477	ab	17	a	650	a	180*	de	307	bc
Cabbage	117	ab	53	a	223	abcd	0*	fg	0	c
Cowpeas	147	ab	20	a	35*	e	12*	fg	10727	ab
Fallow	193	ab	27	a	73	abcd	0*	fg	0	c
Forage sorghum	47	bc	33	a	450	a	15660	a	7	c
Hairy vetch	50	bc	20	a	125	abcd	35*	efg	47	bc
Jap millet	223	abc	113	a	187	abcd	7335	ab	117	c
Lucerne	77	abc	80	a	360	ab	47*	ef	231	bc
Lupin	80	abc	112	a	110	abcd	838*	d	503	c
Oats - black	23	c	93	a	20	bcdef	365	cd	28	c
Oats - white	53	bc	33	a	70	abcd	1192	abcd	271	bc
Rhodes grass	60	abc	83	a	20*	def	826	bcd	33	bc
Serradella	68	abc	40	a	48	abcdf	0*	g	1868	bc
Sugarcane	**110**	**abc**	**20**	**a**	**153**	**abc**	**8237**	**abc**	**105**	**bc**
Tomato	440	ab	60	a	17*	def	0*	fg	135847*	a
Velvet beans	440	a	10	a	53	abcdef	129*	fg	23	c
	P=0.39		P=0.92		P=0.014		P<0.0001		P=0.011	
(2B)										
Fallow	10	bc	2	a	17*	cd	0*	f	18	b
Giant English rape	127	abc	0	a	57	abc	20*	def	8204	ab
Grazing vetch	240	abc	17	a	502	a	187	abc	53223	a
Lucerne	2*	c	5	a	227	ab	308	abcd	13085	a
Lupin	55	abc	7	a	67	abc	82*	cdef	29464	ab
Oats - black	47	bc	2	a	27*	d	230*	cdef	1132	ab
Red clover	37	abc	0	a	265	a	12*	ef	20219	a
Serradella	67	abc	0	a	35*	bcd	86*	bcde	701	ab
Sugarcane	**162**	**ab**	**25**	**a**	**337**	**a**	**1148**	**a**	**622**	**ab**
Tomato	287	a	22	a	265	a	89*	cdef	9462	ab
Wheat	45	abc	7	a	310	a	708	ab	929	ab
	P=0.23		P=0.80		P=0.0006		P=0.0011		P=0.51	

Number of nematodes in soil = number per 250 ml soil
Number of nematodes in roots = number per gram dry weight roots x total dry weight of roots
*P<0.05, significantly different to sugarcane

Nematode effect

Growing green manure crops in the sugarcane production system is an effective way of improving the environment for the cane plant, provided the selected crops do not, at the same time, encourage plant pathogenic nematode populations. From these trials, for the summer crops, there were no significant changes in the number of *Helicotylenchus* and *Xiphinema* (in the soil), *Meloidogyne* (in the roots) and free-living (non plant pathogenic) nematodes (Table 2A). Three crops significantly decreased numbers of *Paratrichodorus.* Ten crops significantly decreased the numbers of *Pratylenchus* in the roots. Interestingly, Rhodes grass, alleged to be resistant to *Meloidogyne*, allowed multiplication in the roots. York (1990) found that susceptibility to *Meloidogyne* species differed according to the strain of Rhodes grass used.

Winter crops showed the same trend, with three nematode genera (*Helicotylenchus, Xiphinema* and *Meloidogyne*) and free-living nematodes not altered significantly when compared with the sugarcane monoculture. Three and seven crops significantly reduced the numbers of *Paratrichodorus* and *Pratylenchus* respectively.

It should be noted that, although there were no statistical significant differences between treatments for *Meloidogyne*, there is still cause for concern for some crops, since this nematode species is known to result in substantial yield loss (Cadet and Spaull, 2003). Crops such as babala, cowpeas, giant English rape, grazing vetch, lucerne, lupins and red clover could in some instances result in substantial increases of this nematode.

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