Hawaii Agriculture Research Center

Vegetable Report 3
October 2001

INDEX WORDS: molasses, papaya, vegetables, nematodes

MOLASSES SOIL AMENDMENT FOR CROP IMPROVEMENT AND NEMATODE MANAGEMENT

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Summary

Molasses was applied to soil through sprinkler irrigation system or by overhead boom sprayer. In a papaya plantation on Maui where high and damaging populations of reniform nematodes had caused a reduction in fruit yield and quality, the molasses applications lowered nematode soil populations and resulted in marked improvement in the tree growth and harvestable fruit. When applied to Chinese cabbage, there was a decrease in the numbers of *Heterodera* nematode cysts following harvest. Preplant applications of molasses to onions improved plant color and onion yield although no difference in soil nematode populations or in cyst number was observed. Molasses soil amendments supply carbohydrates and alter the C/N ratio. This affects the soil microbial ecology, usually resulting in lowered populations of plant parasitic nematodes as well as having other favorable effects on plant growth. The specific mechanisms involved are not well understood and vary with the crop, soil conditions, and nematode species present.

Introduction

The benefits of amending soil with molasses were recognized many years ago in the sugarcane industry. It was added to soil as a fertilizer from time to time when the price happened to be low and served to increase sugarcane yields, particularly in low potassium areas (Anon. 1939, Story 1939). It soon became apparent that molasses was providing greater benefits to the crop in addition to nutrition. During the process of decomposition, molasses appeared to reduce damage to roots caused by root parasites (Anon. 1939, Story 1939). Vawdrey and Stirling (1997) observed a reduction in severity of root galling in tomato when molasses was added without urea. Molasses applied to field plots in relatively high rates achieved a degree of root-knot control comparable with that of the chemical nematicide fenamiphos. Researchers have also shown that high concentrations of urea fertilizer, commonly used for pineapple and sugarcane, reduced populations of plant parasitic nematodes (Huebner *et al*. 1983, Rodriguez-Kabana 1986). But urea alone resulted in an imbalance of the C/N ratio, increased soil nitrates and ammonia nitrogen and, consequently, was phytotoxic to plants (Rodriguez-Kabana 1980, Muller and Gooch 1982). Additional available carbon had to be provided along with the urea to permit soil microorganisms to metabolize excess nitrogen and avoid phytotoxic effects (Rodriguez-

Kabana, 1986). The addition of a carbon source, such as molasses or hemicellulose, along with the urea eliminated the phytotoxicity and reduced the nematode numbers even more than urea alone (Rodriguez-Kabana and King, 1980). Soil populations of some microorganisms and of microbial enzymatic activity were also increased by the soil amendments. Under sterile conditions, molasses was not toxic to nematodes so the suppressant effect was probably due to antagonism by microorganisms, to changes in oxygen concentration due to microbial metabolism of molasses, or to the release of toxic compounds from decomposing molasses. Organic amendments such as molasses do not pose a threat to the environment that chemical pesticides do since they are readily decomposed in soil to CO_2 and harmless organic products.

The papaya trial was carried out at the Maui Tropical Plantation. This site was chosen because of the very severe nematode problems occurring there at the time. Trees were stunted and dying. The leaf canopy was off color and very sparse. Reniform nematode, *Rotylenchulus reniformis*, counts were very high and the trees had ceased to produce marketable fruit. There were very few or no fruits per tree and what fruits were produced were undersized with an off flavor and began to deteriorate immediately after picking. This plantation sells its own produce in its fresh produce market and had lost all its usual customers for papaya. Trials for the control of nematodes on Chinese cabbage and onion were installed on the farm of Neil Nakamura in Kula, Maui. The fields had previously been planted to Chinese cabbage and had damaging numbers of cyst nematodes, *Heterdera schachtii*. Having been fallow for a few weeks, the preplant nematode counts were relatively low. The cyst nematode can be very damaging and is difficult to eliminate from infected fields. As their name indicates, they produce resistant cysts containing from 200 to 600 eggs that can remain viable in soil for up to five years and are resistant to drying.

Materials and Methods

Papaya was planted in rows and irrigated by sprinklers along one drip line for the length of each row. The sprinklers each watered an area about 4 ft in diameter. Molasses was injected from a tank into each treated drip line at a dilution of 1:20 (3 gal molasses per 55 gal water). Alternate rows of trees were used as sample plots. Molasses was applied to the treated plots once a week for 12 weeks. Treated and untreated plots also received adequate irrigation water.

Molasses was applied to the Chinese cabbage field by overhead boom sprayer preplant and worked into the soil. Cabbage was then planted without further nematode control measures in April, 2000. The onion trial was installed in an adjacent field and molasses applied preplant by overhead boom sprayer. Onions were planted in April, 2000.

Results

Counts of reniform nematodes were taken in the papaya trial area on September 11, 1999 before the start of the project. The results are shown in Table 1. Counts of over 100 per 50 cc soil sample are considered damaging to papaya. As seen on the table, many of the samples had counts in the thousands. Results of the molasses treatment on nematode counts are shown in Table 2. Samples were taken on February 24, after the last treatment was applied. Two things are readily apparent; counts of reniform nematodes decreased, but were not reduced to very low numbers. Secondly, there was no apparent difference in treated and untreated rows. It was concluded that the molasses moved through the soil farther than had been expected and reached the roots of the trees in the untreated rows. The rows were roughly six feet apart and the sprinkler irrigation reached part was into the interrow space. Roots extend outward from papaya trees into the interrow space for several feet. In this respect the test was not adequately designed for statistical analysis, but did show a difference before and after treatment application.

The molasses trial was installed in half of a papaya field. The other half was not treated or measured at the start of the project. Because the results of the trial showed no difference in nematode counts between treated and untreated rows, it was decided to sample and compare the treated and untreated halves of the field. Table 3 shows the counts taken on April 3, 2000, and there was a significant difference between the counts in the two areas. Since pretreatment counts were not taken, we could not compare before and after treatment, but this gives some indication that molasses may be altering the soil nematode populations. There was also a visible difference in tree height and bearing between the two field areas. The effect of the molasses on the papaya trees and yield was remarkable. Trees regained their green color and leaves began to grow again. The trees also began to produce marketable fruits that had good shelf life and good taste.

Preplant cyst nematode counts in the cabbage and onion trial areas were relatively low. Numbers per 50 cc soil sample ranged from 0 to 33. The cabbage harvest took place in July, 2000. There was no significant difference in total weight of yield between treatments. Nematode counts were taken again after harvest. The counts of live worms in both treated and untreated areas had risen significantly during the crop cycle as shown in Table 4. However, there was a difference between treated and untreated areas in the number of nematode cysts in the soil with lower numbers in the treated area. There was little if any effect of the molasses on the treated crop itself, but the initial populations of cyst nematodes will be lower in the treated areas for the next crop to be planted.

Ten weeks after planting there was an obvious color difference in the onion plants between the treated and untreated areas. The harvest took place on June 22, 2000. The total harvest weight of onions was 117 lb in the treated area and 115.3 lb in the untreated area. Twenty onions were sampled at random from each area and weighed individually. The 20 molasses-treated onions ranged in weight from 0.5 to 1.25 lb and totaled 12 lb. From the untreated area they ranged from 0.25 to 0.75 lb and totaled 8 lb. Unlike the Chinese cabbage trial, there were very few *Heterodera* worms in the soil samples after harvest and no significant difference in cyst number between treated and untreated plots (see Table 5).

Conclusions

The effect of molasses applications on papaya trees was probably due to other factors besides nematode control, but it is unknown at this time what the factors were. There may be a change in nutritional balance of the soil, in soil structure and in the soil microbial populations. Molasses provides a carbon source which alters the C/N ratio in soil and this affects the soil microbiota which in turn effects the available nutrients. In any case, yields of a non-bearing papaya plantation were regained. Maui Tropical Plantation is open to the public as a tourist attraction so, in addition to recovering marketable yields, the change in appearance of the fields was also important. This plantation uses no pesticides. Had nematicides been in use, they would have controlled the nematodes, but at a cost and may not have produced the effect that molasses did. The use of molasses would allow a papaya plantation to continue farming without nematicide applications. There is a cost involved in molasses application also but the current price of molasses, the by-product of raw sugar production, is very low at this time. The overall costs of ongoing molasses applications to papaya have not yet been worked out in detail, but indications are that it will prove to be cost effective.

The applications of molasses in Chinese cabbage had no measurable effect on the current crop but, postharvest soil populations of *Heterodera* cysts were lowered. If molasses applications are continued in future crops, they will have a lasting effect in maintaining cyst nematodes below damaging levels. In the onion crop there was no significant effect on *Heterodera* levels, but plant color and onion yields were enhanced. This was probably due to changes in nutrient levels or to alterations in the soil microflora favorable to plant growth. The lack of increase in nematode numbers or cyst formation in untreated plots indicates that onions, or at least this onion cultivar, were relatively resistant to cyst nematodes.

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Table 1. Pretreatment Counts of *Rotylenchulus reniformis* in Papaya Soil

	Sample Molasses	*Nemas per 50 cc Soil*	*Sample Check*	*Nemas per 50 cc soil*
One-year trees	1A	170	3A	1236
	1B	524	3B	2340
	1C	1072	3C	568
	1D	256	3D	676
	1E	30	3E	1536
	1F	118	3F	3852
New trees	2A	246	4A	106
	2B	186	4B	74
	2C	316	4C	484
	2D	174	4D	47
	2E	216	4E	248
	2F	236	4F	934

Table 2. Post-treatment of *Rotylenchulus reniformis* in Papaya Soil

	Sample Molasses	*Nemas per 50 cc Soil*	*Sample Check*	*Nemas per 50 cc Soil*
One-year trees	1A	44	3A	31
	1B	75	3B	33
	1C	54	3C	18
	1D	56	3D	407
	1E	150	3E	273
	1F	43	3F	130
New trees	2A	33	4A	75
	2B	11	4B	40
	2C	4	4C	4
	2D	90	4D	134
	2E	103	4E	92
	2F	61	4F	129

Table 3. Counts of *Rotylenchulus reniformis* in Molasses-Treated and -Untreated Papaya Fields

Nematodes per 50 cc Soil Sample			
Treated Area		Untreated Area	
1.	14	1.	177
2.	65	2.	125
3.	59	3.	596
4.	37	4.	164
5.	19	5.	1528
6.	43	6.	97

Table 4. Postharvest Counts of *Heterodera schachtii* on Chinese Cabbage

Sample Treated	*Nemas per 50 cc Soil*	*Cysts per 150 cc Soil*
1.	132	55
2.	510	47
3.	784	74
4.	2	50
5.	12	49
6.	7	95
Untreated		
7.	133	297
8.	0	150
9.	20	159
10.	11	218
11.	80	143
12.	20	100

Table 5. Postharvest Counts of *Heterodera schachtii* on Onions.

Sample Treated	*Nemas per 50 cc Soil*	*Cysts per 200 cc Soil*
1.	0	142
2.	2	102
3.	0	104
Untreated		
4.	4	133
5.	1	81
6.	1	91