Rotationally Grazing Hogs for Orchard Floor Management in Organic Apple Orchards

L. Nunn[1], C. G. Embree[1], D. Hebb[1], and S. D. Bishop[1] D. Nichols[2]
[1]Atlantic Food and Horticulture Research Centre
Agriculture and Agri-Food Canada, 32 Main St.
Kentville, Nova Scotia B4N 1J5
Canada

Nova Scotia Fruit Growers Assoc.
Kentville, Nova Scotia
B4N 1J5
Canada

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Abstract

The effectiveness of hogs in controlling weed competition and removing drop apples from organic orchards was evaluated. Two densities of hogs (46.45 m^2/pig and 24.4 m^2/pig) were pastured in an organic apple orchard for 2 days during June (bloom) and October (post-harvest), 2005, to determine their effectiveness in removing orchard floor vegetation and drop apples as compared to an un-mowed control plot. The impact on vegetation was assessed by comparing vegetation sample weights from the control plot with each treatment plot immediately following both grazing periods and in August. To determine the risks associated with grazing hogs in the orchard, leaves, fruit, soil and manure were analyzed for total coliforms and *Escherichia coli* immediately following the spring grazing period and again in October, following harvest. For all vegetation assessments, a significant difference occurred between the control (June = 1231.73 kg/ha; August = 2058.02 kg/ha; October = 2083.89 kg/ha) and treatment plots (46.45 m^2/pig treatment: June = 584.75 kg/ha; August = 1215.26 kg/ha; October = 1633.34 kg/ha and 24.40 m^2/pig treatment: June = 443.09 kg/ha; August = 1502.41 kg/ha; October = 741.63 kg/ha). However, inconsistencies were observed between the two hog densities and grazing periods, with significant differences occurring between the treatments during the fall period ($P < 0.001$), but not during the bloom period ($P = 0.368$) or at mid-season ($P = 0.143$). Differences were also seen between high and low traffic areas, but there was no interaction between the traffic areas and the two hog densities. *Escherichia coli* was not detected in any samples from the control plot or on leaves or apples in either of the treatment plots. Pre-harvest, the control plot leaf samples had higher total coliform counts than leaves taken from either treatment plot. The control plot apple samples had fewer total coliforms than the low swine density (46.45 m^2/pig) plots, but more than the high swine density (24.4 m^2/pig) plots. Soil *E. coli* and total coliform numbers in the treatment plots increased over the season compared with the control. The hogs left less than 4% of drop apples compared to the control plot, with a 0.07 kg/ha difference between the low and high pig densities.

INTRODUCTION

The organic food industry in Canada is increasing at approximately 15% to 20% per year (Connell and Morton, 2003). In the Maritime Provinces, apples lead the organic retail market for locally-grown produce, comprising 24.8% of total sales (Connell and Morton, 2003). Recent discussions with organic and transitional apple growers in the Annapolis Valley, Nova Scotia, revealed their top 3 research concerns were weed, apple maggot (*Rhagoletis pomonella*) and apple scab (*Venturia inaequalis*) management.

In conventional, integrated pest management (IPM) and integrated fruit production (IFP) systems, problems such as weeds, apple maggot and scab are generally managed using synthetic pesticides, while pest management options available to organic apple producers are limited to mechanical, biological and cultural means (Braun, 2002). Due to limited pest management options, substantial crop damage can occur in organic apple production systems. Orchard floor management plays an important role in helping to reduce certain insect levels (Hardman et al., 2004).

Weeds compete with apple trees for moisture and nutrients (Solymar, 1999). In an attempt to reduce competition in organic systems, orchard floor vegetation is controlled through mechanical means such as mowing, mulching and flame-weeding (Gut and Weibel, 2005). However, each of these methods has drawbacks. Mowing within the tree row does not provide the same weed control as an herbicide strip and is not practical from about mid-August, so the resulting tall grass and weed growth make harvesting drops difficult and time consuming. Mulching can provide good weed control within the tree row, but it may be necessary to use mouse guards or move mulch away from the base of trees in the fall to prevent winter rodent infestations, thus increasing orchard management costs (CHC, 2003). Flame-weeding is often only partially effective in controlling perennial weeds, uses a lot of energy and presents some risk of damage to the trunk and low-hanging branches (Gut and Wiebel, 2005).

In cases where an orchard has an established apple maggot population, one of the only effective management tools available to organic producers is to manually pick up drop apples twice weekly. Fruit should then immediately be removed from the orchard and processed, deeply buried or placed in cold storage to disrupt the insect's life cycle (Braun, 2002). However, this is a very labour intensive process and it is difficult to find and collect every apple when vegetation under the trees is not effectively controlled.

Outdoor hog finishing systems have been used in Europe and the United States for several years, and in Sweden it is mandatory to keep organic hogs at pasture from May to September (Gustafson and Stern, 2003). This trend toward pasturing supports the utilization of hogs in organic orchard floor management. Orchardists could potentially integrate hogs into their farm operations or collaborate with an organic livestock producer to supply pasture-adjusted hogs for short periods. While there is a concern over *E. coli* contamination (Riordan et al., 2001) when grazing livestock in an orchard, a well-managed system that prevents grazing between bloom and harvest should have little, if any, risk. In a certified organic orchard, there is a need for effective orchard floor vegetation management, and hogs may provide a means of controlling both weeds and, to a lesser degree, apple maggot in this setting.

The objectives of this study were to determine if grazing hogs at bloom and after harvest can be used as an effective method of organic orchard floor management.

MATERIALS AND METHODS

Site and Grazing

The one-year experiment was conducted at Morristown, Nova Scotia, Canada (45°03'00N-64°46'00W). The orchard was planted in N-S direction and tree spacing was 4.9 m x 6.1 m. Plots were 464.5 m^2 (15.2 m x 30.5 m) and included 6 'McIntosh' and 9 'Golden Russet' trees. Plots were enclosed using 2 strands of electric fencing. Treatments included an unmowed control and 2 densities of hogs; low [10 pigs (46.45 m^2/pig)] and high [19 pigs (24.4 m^2/pig)]. Densities and spacing were selected based on 2 observational trials, conducted in the fall of 2004 (C.G.E. unpublished data). Grazing was conducted during bloom in June 2005 and following harvest in October 2005. Hogs were moved to new plots after 2 days of grazing. Treatments were repeated in triplicate.

Hog Management

Conventional hogs weighing approximately 45 kg were fed certified organic hog grower for 1 month prior to entering the orchard. They were supplemented with hay to prepare them for grass consumption. Prior to the trial, pigs were housed in a barn that provided free access to an exterior area enclosed with electric fencing for approximately 3 weeks to acclimatize them to plot conditions. White pigs (Duroc crosses) and coloured pigs (Durocs) were used for the pre-bloom and post-harvest grazing trials (Fig. 1), respectively. Initially, the intention was to use Durocs for both grazing periods; however, there were none available for June, so Duroc crosses were used instead. Hogs were given nose rings to discourage rooting, thus minimizing potential damage to tree roots and the orchard floor. Organic hog grower was provided in troughs placed in the center of each plot to supplement the pigs' diet in the orchard, and huts bedded with hay were available to the pigs for shelter and sleeping areas during the study. The same pigs were used for each replicated treatment during each grazing period.

Data Collection

To determine the effects of grazing density and differences in grazing patterns within each plot, orchard floor vegetation was measured in the week following both grazing periods (June and October) and at mid-season (August). Areas around the feeding troughs were designated as heavily-grazed or high-traffic zones (Fig. 2), while areas further away from the troughs were designated as lightly-grazed or low traffic zones. A 0.3 m^2 metal frame was tossed randomly in 6 locations in each plot (3 locations each for high-traffic and low-traffic areas), for a total sampling area of 1.8 m^2 within each treatment and control plot. Observational data including preferred weed species and areas of defecation were also collected. In order to evaluate the potential risks associated with grazing hogs in the orchard, apple leaves, soil and manure were collected immediately following the spring grazing period in June. Just prior to harvest in September, leaves, soil, manure and apples were collected. Fifty leaves were randomly collected from each plot on each sampling date, while 50 apples per plot were randomly collected in September. Soil samples were taken at depth of 0 to 15 cm, using a soil probe. Five to six soil samples were collected from each grazing area within each treatment plot. The same number of soil cores was also collected from each plot using a grid pattern over the whole area to obtain a representative sample. Finally, soil samples were also collected in the manuring area in each treatment plot. Surface manure samples were collected by randomly searching for dung within each treatment plot and scooping up 5 to 6 samples using a plastic bag. Samples from all three replicates were pooled at each sampling date and evaluated for the presence of total coliforms (TC) and *E. coli*.

Soil, leaf and fruit samples were homogenized and made into a 1/100 dilution of the sample using a 90 ml water blank. A serial dilution series was then made from the 1/100 dilution using 99 ml water blanks. Aliquots of the various dilutions were filtered through a 47 mm filter using standard techniques. The filter was then transferred to a 50 mm Petri plate containing an absorbent pad saturated with m-ColiBlue24 Broth, incubated at 35°C ±0.5°C for 24 hours and then examined for the presence of bacterial colonies. The m-ColiBlue24 membrane filtration method (Hach Company) is an enzyme substrate-based colorimetric method approved by the United States Environmental Protection Agency (USEPA Method No. 10029; USEPA, 2003) for determining the numbers of total coliforms and *E. coli* in drinking water.

Following the post-grazing period, any remaining drop apples were collected from each treatment plot, weighed and compared to the control plots to determine the amount consumed by the pigs.

Data were analyzed using GenStat 8th Edition (GenStat, 2005). Orchard floor vegetation data were analyzed using an ANOVA with 3 grazing densities [none (0 pigs), low (46.45 m^2/pig) and high (24.4 m^2/pig)] and two levels of traffic (low and high). Drop apple data were compared using mean and standard deviations. Total coliform and *E. coli* raw data are presented on a per sample basis. Unless noted otherwise, only results significant at $P \leq 0.05$ are discussed.

RESULTS AND DISCUSSION

Bloom Time (June) Grazing and *E. coli* Assessment

Grazing hogs during bloom reduced orchard floor vegetation in the 24.4 m^2/hog (443.09 kg/ha) and 46.45 m^2/hog (584.75 kg/ha) plots as compared with the control

(1231.73 kg/ha), but no difference was observed between the 2 treatment densities (Table 1). There was a difference between the high and low traffic areas; however no interaction was observed between the pig density and traffic area effects at bloom (Table 1). *Escherichia coli* and total coliforms were higher in the manure samples from the lower swine density treatment (2,070,000 *E. coli*/g and 2,180,000 TC/g) than the higher density treatment (19,000 *E. coli*/g and 58,000 TC/g) (Tables 2 and 3). Total coliform counts were slightly lower on leaf samples in the control plots (2 TC/g), compared with 3 TC/g for both hog densities (Table 3). No *E. coli* were detected in soil samples taken from low traffic areas from either pig density (Table 2). Coliform bacteria were found in all soil samples from both pig densities, but did not seem to be consistently higher in either treatment (Table 3).

Mid-season (August) Sampling and *E.coli* Assessment

When orchard floor re-growth was compared mid-season, the 46.45 m^2/hog (1215.26 kg/ha) and 24.4 m^2/hog (1502.41 kg/ha) density plots again had less vegetation than the control (2058.02 kg/ha), and a difference also remained between the high (46.45 m^2/hog = 708.02 kg/ha, 24.4 m^2/hog = 1135.06 kg/ha) and low (46.45 m^2/hog = 1722.50 kg/ha, 24.4 m^2/hog = 1869.75 kg/ha) traffic areas. Again, there was no interaction between the traffic area and hog density (Table 1). *Escherichia coli* levels remained the same for the soil samples from the high traffic areas (1 *E. coli*/g) (Table 2). No detectable *E. coli* were recovered from any plot on apple or leaf samples, or from soil samples collected randomly or in low traffic areas (Table 2). As with the spring manure samples, *E. coli* levels remained higher in the 46.45 m^2/hog treatment (15 *E. coli*/g) than in the 24.4 m^2/hog (8 *E. coli*/g) (Table 2). Total coliforms remained lower in soil samples taken from the control plot (54 TC/g), compared with both the 46.45 m^2/hog (86 TC/g) and 24.4 m^2/hog (92 TC/g) (Table 3). Total coliforms on leaf samples from the control plot were higher (39 TC/g) than those collected from either treatment plot (46.45 m^2/hog = 26 TC/g, 24.4 m^2/hog = 30 TC/g), while coliform counts from apple samples were lower in the control (127 TC/g) than in the 46.45 m^2/hog treatment (152 TC/g) and higher in the control than in the 24.4 m^2/hog treatment (83 TC/g) (Table 3).

Post-harvest (October) Grazing

As with the bloom trial, there was a reduction in herbaceous orchard floor cover in the grazing treatments (1633.34 kg/ha in the 46.45 m^2/hog plot and 741.63 kg/ha in the 24.40 m^2/hog plot), compared with the control (2083.89 kg/ha) plot (Table 1). Again, there was a difference between the high and low traffic areas, but no interaction between the traffic area and hog density. However, unlike the bloom trial, there was a difference between the 2 grazing treatments, with vegetation growth in the 46.45 m^2/hog plots (1633.34 kg/ha) 45% greater than that in the 24.4 m^2/hog plots (741.63 kg/ha) (Table 1). Less than 4% of drop apples were left in both the 46.45 m^2/hog (1.94 kg/ha) and 24.4 m^2/hog (2.01 kg/ha) plots, compared with the control (53.35 kg/ha) (Table 4).

Qualitative Hog Observations

Nose rings seemed to affect feed consumption for the first few days after ringing, but the hogs soon adapted. The white pigs used in the spring trial experienced sunburn. Hogs seemed to prefer dandelions to grass and other weed species present. Even with the nose rings, there was slight rooting in wetter areas; however, the rooting was not enough to cause damage to trees or the orchard floor. Upon first entering a new area, the hogs did not seem to have a preferred defecation area, but by the second day, especially in the higher density treatments, they had established a manure area. All vegetation around the feeding troughs was eliminated by heavy pig traffic (Fig. 2). It was also observed that the pigs seemed to prefer Golden Russet to McIntosh apples, as there were no Golden Russet apples remaining in any treatment plots; however, this is known to be a less productive cultivar than McIntosh.

CONCLUSIONS

Hogs appeared to effectively control weed and grass growth in the orchard, with both densities of hogs performing equally. They also performed well when cleaning up drop apples. At the same time, very few *E. coli* were found in soil samples taken from the treatment plots immediately after the bloom grazing period. Even fewer *E. coli* were found in the same plots in September, just before harvest. No *E. coli* were detected on leaf or apple samples in either treatment plot. There is good potential for the use of hogs as a method of orchard floor vegetation control in organic orchard systems; however, more work is needed to determine if grazing times can be altered to improve disease, rodent and insect control.

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Tables

Table 1. Analysis of herbaceous cover of orchard floor following hog grazing for two stocking densities (46.45 m^2/hog and 24.40 m^2/hog).

	Assessment Period					
	Bloom Mean (kg/ha)		Mid-season Mean (kg/ha)		Post-harvest Mean (kg/ha)	
	Control					
	1231.73		2058.02		2083.89	
	46.45 m^2/hog density					
High traffic	37.90		708.02		1076.63	
Low traffic	1131.60		1722.50		2190.04	
Mean	584.75		1215.26		1633.34	
	24.40 m^2/hog density					
High traffic	10.62		1135.06		483.15	
Low traffic	875.56		1869.75		1000.11	
Mean	443.09		1502.41		741.63	
Grand Mean	753.19		1578.00		1486.29	
	SEM	P	SEM	P	SEM	P
Control vs. Treatments	110.1	<.001	136.4	<.001	143.5	<.001
46.45 vs. 24.40 m^2/hog *	110.1	NS	136.4	NS	143.5	<.001
High vs. low traffic area	110.1	<.001	136.4	<.001	143.5	<.001
Density X traffic area	155.7	NS	192.9	NS	203.0	NS

*Comparison of grazing effects between hog densities.

Table 2. *Escherichia coli* per gram of sample collected for soil, manure, apples and leaves immediately after June (Bloom) grazing and prior to harvest in September (Preharvest).

	Control (*E.coli*/g)		46.45 m^2/hog (*E.coli*/g)		24.40 m^2/hog (*E.coli*/g)	
Sample Type	Bloom	Preharvest	Bloom	Preharvest	Bloom	Preharvest
Soil – high traffic	n/a*	n/a	1***	1	2	2
Soil – low traffic	n/a	n/a	nd	nd	nd	nd
Soil – random	nd**	nd	12	nd	nd	nd
Soil – conc. manure	n/a	n/a	2	n/a	6	n/a
Apples	n/a	nd	n/a	nd	n/a	nd
Manure	n/a	n/a	2070000	15	19000	8
Leaves	nd	nd	nd	nd	nd	nd

*n/a = no sample
**nd = not detected
***Each sample value is a single measurement of a pooled sample of the three replicate plots.

Table 3. Total Coliforms (TC) per gram of sample collected for soil, manure, apples and leaves immediately after June (Bloom) grazing and prior to harvest in September (preharvest).

	Control (TC/g)		46.45 m^2/hog (TC/g)		24.40 m^2/hog (TC/g)	
Sample	Bloom	Preharvest	Bloom	Preharvest	Bloom	Preharvest
Soil – high traffic	n/a*	n/a	108**	64	319	89
Soil – low traffic	n/a	n/a	88	65	48	74
Soil – random	36	54	58	86	69	92
Soil – conc. manure	n/a	n/a	33	n/a	79	n/a
Apples	n/a	127	n/a	152	n/a	83
Manure	n/a	n/a	2180000	95	58000	64
Leaves	2	39	3	26	3	30

*n/a = no sample
**Each sample value is a single measurement of a pooled sample of the three replicate plots.

Table 4. Mean (kg/ha) drop apples remaining in orchard after fall grazing period.

Density	Mean (kg/ha)	Standard Deviation (kg/ha)
Control (n=3)	53.35	15.35
10 pigs (n=3)	1.94	0.65
19 pigs (n=3)	2.01	0.54

Figures

Fig. 1. A Duroc hog feeding on apple drops during the post-harvest grazing period in a 15.2 m x 30.5 m plot.

Fig. 2. A representative high traffic area in the center of the 15.2 m x 30.5 m plot around the feeder and water source during the bloom period. Note the un-grazed area outside the plot fence.