New Findings in Weed Control in Young Apple Orchards

Deborah Breth and Elizabeth Tee
Cornell Cooperative Extension, Lake Ontario Fruit Program
Albion, NY

Weed control is critical to early tree growth and profitability in new apple orchards planted with 1000-2000 trees per acre. Previous research on ground cover management and critical timing of weed control in orchards by Ian Merwin, et.al, (1999) was done in semi-dwarf orchards with 230 trees per acre. This project set out to look at how much impact weed control (or lack thereof) had on new high-density apple plantings and to evaluate herbicide programs. The project was funded by NESARE with a 2-year Partnership grants with 2 growers, Rod Farrow of Lamont Fruit Farm, and Doug Mason of Mason Farms. This report is a summary of the second year results. The first year results were published in the NY Fruit Quarterly, Vol. 20, Number 1.

> **"New high-density orchards depend on good tree growth in the first 2 years to develop the canopy for high crops in years 2-5. Our research shows that poor weed control in the first 2 years can result in less tree growth that is estimated to reduce production in the third year by half and a several year delay in breakeven payment of the initial investment. We estimate this important management practice in new orchards is worth thousands of dollars in long term profitability."**

The objectives of this project were: (1) Identify strengths and weaknesses in herbicide treatments. (2) Evaluate impact of weed control programs on tree growth. (3) Evaluate herbicide treatments for trunk damage. (4) Evaluate changes in soil health.

Materials and Methods

Herbicide treatments were applied with a CO^2 R & D sprayer using 2 L bottles for each treatment and a single Spraying Systems 8004 110° EVS nozzle with 0.28 gallons per minute at 30 psi, at 2 mph. Herbicide strips in rows at Lamont's (planted in 2011) and Mason's (planted in 2010) were 3 ft. wide. Treatments were randomized and replicated, 3 replicates per treatment, in each of 2 sites. Due to label restrictions, the first treatments were applied using mixes that included GoalTender since the label requires application by budswell (Tables 1 and 2). The next treatments were applied at pink bud using Chateau in tank mixes with other herbicides including Prowl H2O or Surflan. The final set of treatments were applied on April 19 at Lamont Fruit Farm and May 2 at Mason's. All residual herbicide treatments were combined with a post-emergent herbicide such as glyphosate or paraquat. This was the second season the same herbicide treatments were applied to the same plots. The treatments are all described in Table 1 and 2 for Lamont and Mason, respectively.

The percent weed cover was evaluated in each plot by taking 3 readings per plot at 2-3 week intervals, and a seasonal average percent weed cover per treatment was calculated. When the plots reached 20-30% weed cover, they were treated again with the prescribed post-emergent herbicide (paraquat, glyphosate, or Rely). The weeds present in the plots for each date of evaluation were identified and recorded. The data was analyzed using ANOVA with mean separation by Tukey HSD using a P value of 0.05.

The number of days the residual treatments were effective before additional post-emergent control was necessary was calculated, and the number of additional post-emergence applications was used for economic analysis.

Tree trunk diameters were measured at 30 cm above the graft union using a caliper, and we calculated the trunk cross-sectional area (TCSA) in cm^2. Based on crop load management research done by Robinson, et al. (2009), we calculated the potential crop production after 1 and 2 years of different herbicide programs and determined the potential difference in profitability with "good weed control" vs. the untreated control plots. The data were incorporated into the "Net Present Value Excel Workbook" constructed by Alison DeMarree, Lake Ontario Fruit Program of Cornell Cooperative Extension, to look at economic impact of weed control in high density orchards. We also examined the trunks of the trees looking for any bark damage visible in Spring of 2013.

Soil samples were collected and tested under the Cornell Soil Health Lab for soil physical, biological, and chemical parameters comparing the first sample taken at the site in spring of 2011 with the samples taken in Oct. 2012 after 2 growing seasons. Because this testing is more adapted to annual crops with regular soil tillage, the purpose was to determine if there was any obvious impact on soil health in apples.

Results

Weed Control

None of the herbicide programs in these plots gave season long control. However, there were differences in the number of post-emergent herbicide applications required depending on the residual herbicide used in the spring (Table 3). The effectiveness of residual herbicides depends on rainfall incorporation. Irrigation definitely reduced the residual herbicide effect, resulting in more post-emergent herbicide applications necessary at Lamont's compared to Mason's.

There were differences in percent weed cover among herbicide programs. The seasonal averages of all evaluations are shown in Table 3. All treatments except for "untreated" and "post-emergence" treatments were held under 30% weed cover for the season. The percent weed cover ratings are shown in Tables 4 and 5.

Prowl or Surflan alone provided about 30-40 days of weed control; the higher rate, the longer control. Without irrigation, 2-3 additional burndown treatments were necessary, but 4 with irrigation. Common ragweed was the first weed species to emerge in these treatments without the inclusion of Chateau or GoalTender. Adding Chateau (12 oz./acre) to Prowl or Surflan extended effective control and broadened the spectrum of weed control for 40-50 days. These treatments needed 2 burndown treatments without irrigation, but 3 with irrigation. Adding Goaltender (3-4 pts) to Prowl or Surflan extended effective control and broadened the spectrum of weed control for 60-70 days and needed 2-3 additional burndown sprays without irrigation, and 3-4 with irrigation. Sinbar treatments resembled Prowl or Surflan plots in residual control and required 3 burndown sprays without irrigation, and 4 with irrigation.

Matrix (registered for use only in trees established for 1 season) at 4 oz./acre provided long term weed control, 60-90 days in 2011, but in 2012, only 40-50 days if alone or mixed with Surflan. When Goaltender was added to Surflan/Matrix, the control window increased to 105 days in Mason's plots which needed only 1-2 post-emergent burndown treatments. Treatments without irrigation using Matrix or a combination usually required 1 burndown application, but in irrigated plots, required 4 added sprays. Alion (registered for use in trees established 3 years) provided 79 days of control in 2011 at Mason's, but only 44 days in 2012. However, in both years, the Alion treatments only required 1 additional burndown treatment. Alion plots were covered with moss and did not have winter annuals germinating for the winter through April resulting in the lowest seasonal percent of weed cover. Diuron + simazine (low rates) was the cheapest treatment at Mason's, lasting over 2 months, and required 2 additional treatments but it is important to watch for resistant weeds.

Tree growth

Table 6 shows a significant reduction in tree growth, potential yield, and economic returns in new apple plantings if left weedy. Trunk cross-sectional area (TCSA) for each treatment is shown for the end of the 2nd season of this project. The average TCSA of untreated plots at Lamont's was 3.8 cm^2 compared to the largest trees in the Prowl + glyphosate treatment of 7.7 cm^2 after 2 seasons of growth; at Mason's, 5.4 cm^2 in untreated plots compared to the largest trees, 10.2 cm^2, found in the Alion plots, followed by 8.6 cm^2 in the Prowl

Table 1. Herbicide treatments, rates and timings (Lamont Fruit Farms 2012, with irrigation)

Pre-emergent Herbicide Treatment	Date applied	Post-emergent Trt	Dates applied
Prowl H2O (4 qts./a)	Apr 18	Gramoxone (2 pts./a) Rely (2.5 qt.)	Apr 18, Jun 20, Jul 19, Aug 21 May 21
Prowl H2O (4 qts./a)	Apr 18	Touchdown IQ (2 qts./a)	Apr 18, Jun 28, Aug 7
Prowl H2O (4 qts./a) plus Chateau WDG (12 oz./a)	Apr 14	Gramoxone (2 pts./a) Rely (2.5 qt.)	Apr 14, Jun 20, Jul 19 May 21
Prowl H2O (4 qts./a) plus Chateau WDG (12 oz./a)	Apr 14	Touchdown IQ (2 qts./a)	Apr 14, May 21, Jul 19, Aug 7
Prowl H2O (4 qts./a) plus GoalTender (3 pt./a)	Mar 21	Gramoxone (2 pts./a) Rely (2.5 qt.)	Mar 21, Jun 28, Aug 7 May 21
Surflan (4 qts./a)	Apr 18	Gramoxone (2 pts./a)	May 25, Jul 13, Aug 17
Surflan (3 qts./a) plus Chateau WDG (12 oz./a)	Apr 14	Gramoxone (2 pts./a) Rely (2.5 qt.)	Apr 14, Jun 28, Aug 7 May 21
Surflan (3 qts./a) plus GoalTender (3 pt./a)	Mar 21	Gramoxone (2 pts./a) Rely (2.5 qt.)	Mar 21, Jun 28, Jul 19, Aug 21 May 21
Surflan (3 qts./a) plus Matrix (4 oz./a)	Apr 18	Gramoxone (2 pts./a)	Apr 18, Jun 6, Jun 28, Jul 19, Aug 7
Surflan (3 qts./a) plus Matrix (4 oz./a) plus GoalTender (3 pt./a)	Mar 21	Gramoxone (2 pts./a)	Mar 21, Jun 6, Jun 20, Jul 19, Aug 21
Sinbar (8 oz./a)	Apr 18	Gramoxone (2 pts./a) Rely (2.5 qt.)	Apr 18, Jun 20, Jul 19, Aug 7 May 21
Post-emergence TRT		Gramoxone (2 pts./a) Rely (2.5 qt.)	Apr 18, Jun 20, Jul 19, Aug 7 May 21
Untreated control	handweeded on Aug. 17		

AMS included with Touchdown IQ and Rely mixtures
All mixes that included Gramoxone, Touchdown IQ, or Rely included NIS (Induce) at .25% v/v

Table 2. Herbicide treatments, rates and timings (Mason Farms 2012, no irrigation)

Pre-emergent Herbicide Trt	Date applied	Post-emergent Trt	Dates applied
Prowl H2O (4 qts./a)	May 2	Gramoxone (2 pts./a)	May 2, Jun 15, Aug 8
Prowl H2O (4 qts./a)	May 2	Touchdown IQ (2 qts./a)	May 2, Jul 5, Aug 8
Prowl H2O (4 qts./a) plus Chateau WDG (12 oz./a)	Apr 14	Gramoxone (2 pts./a)	Apr 14, Jun 15, Aug 8
Prowl H2O (4 qts./a) plus Chateau WDG (12 oz./a)	Apr 14	Touchdown IQ (2 qts./a)	Apr 14, Jun 15, Aug 8
Prowl H2O (4 qts./a) plus GoalTender (3 pt./a)	Mar 22	Gramoxone (2 pts./a)	Mar 22, May 30, Jul 5, Aug 8
Surflan (4 qts./a)	May 2	Gramoxone (2 pts./a)	May 2, Jun 15, Jul 5, Aug 8
Surflan (3 qts./a) plus Chateau WDG (12 oz./a)	Apr 14	Gramoxone (2 pts./a) Rely (2.5 qt.)	Apr 14 May 30, Jul 18
Surflan (3 qts./a) plus GoalTender (3 pt./a)	Mar 22	Gramoxone (2 pts./a)	Mar 22, Jul 5
Surflan (3 qts./a) plus Matrix (4 oz./a)	May 2	Gramoxone (2 pts./a)	May 2, Jun 15, Jul 18
Surflan (3 qts./a) plus Matrix (4 oz./a) plus GoalTender (3 pt./a)	Mar 22	Gramoxone (2 pts./a)	Mar 22, Jul 5
Sinbar (8 oz./a)	May 2	Gramoxone (2 pts./a)	May 2, Jun 15, Jul 18, Aug 8
Matrix (4 oz./a)	May 2	Gramoxone (2 pts./a) Rely (2.5 qt.)	May 2 Jun 15
Alion (5 oz./a)	May 2	Gramoxone (2 pts./a) Rely (2.5 qt.)	May 2 Jun 15
Diuron 4L (1.6 pt./a) plus simazine 4L (1 qt./a)	May 2	Gramoxone (2 pts./a)	May 2, Jul 5, Jul 18
Post-emergence TRT		Gramoxone (2 pts./a) Rely (2.5 qt.)	May 2, Aug 8 Jun 15
Untreated control	hand weeded on Aug 18		

AMS included with Touchdown IQ and Rely mixtures
All mixes that included Gramoxone, Touchdown IQ, or Rely included NIS (Induce) at .25% v/v

plus paraquat plots. Tree size nearly doubled if weeds were kept at bay.

The reduced tree growth we observed from weeds will impact on the following season's capacity to carry fruit and economic returns. We estimated the impact of poor weed control in the first 2 years on yield and returns by assuming crop load was managed to 4 apples per cm^2 of trunk cross-sectional area (TCSA). The estimated potential number of fruit per tree in the third year was nearly double in the best weed control plots compared to the weedy check, 31 vs. 15 at Lamont's, and 41 vs. 22 at Mason's. This would translate to reduced profitability and slower payback of establishment costs when there is poor weed control.

Trunk damage

There was no statistical difference in incidence of trunk damage among treatments at Lamont's but there was trunk damage that appeared as slight flaking of the bark that may have resulted from the Gramoxone burndown treatments applied when the daytime temperatures on Jun 20, 2012, reached 87°F for several hours that day. No apparent trunk damage was recorded at Mason's. The use of glyphosate in 2 treatments at each site did not result in any visible damage when used in the spring and early summer.

Soil health

Soil health data was gathered in four treatments: the untreated check (hand weeded at the end of the growing seasons), Prowl/Chateau + glyphosate, Surflan/Matrix/GoalTender + Paraquat, and Sinbar + Paraquat at each location. A sample report is shown in Figure 1. The only difference in production practices between the 2 farms was the annual application of 2 tons/acre of composted chicken manure to tree rows at Mason's. No heavy mulch treatments were applied, but some herbicide treatments certainly left more weed residue on the surface of the soil.

The soil type at Lamont's is 55% silt, 36% sand, and 9% clay, and the overall soil health quality score started at 68/100 (Medium) in Spring of 2011. The soil at the Mason site is 47% silt, 44% sand, and 9% clay, and started with the overall soil health quality score started at 74/100 (High). In fall of 2012, after 2 seasons, the overall soil health quality score at Lamont's went down to 52-55/100 (Low), while at Masons the score declined to 59-69/100 (Medium). After 2 seasons, there was no difference among treatments tested.

The physical soil health indicators tested included aggregate stability (%, the measure of soil's resistance to falling apart when hit by rain), available water capacity (m/m), surface hardness (psi) and subsurface hardness (psi). At Lamont's, the aggregate stability increased after 2 seasons in all treatments tested. There was no significant change in available water capacity in all treatments tested compared to the baseline test. At Masons, there

Table 3. Duration of residual herbicide effect and number of additional post-emergence treatments necessary.

Treatment	Days After Treatment*	Post-Emergent Applications Needed	Seasonal Avg. % Weed Control
Lamont - irrigated			
Untreated check	-	-	97 a
Prowl + paraquat (P), Rely	33	4	18 de
Surflan + P, Rely	33	4	15 def
Prowl + Chateau + P, Rely	37	3	21 cd
Surflan + Chateau + P, Rely	37	3	17 def
Prowl + GoalTender + P, Rely	61	3	8 f
Surflan + Goal Tender + P, Rely	61	4	11 ef
Prowl + glyphosate (G)*	71	2	14 def
Prowl + Chateau + G	37	3	14 def
Surflan + Matrix + P	49	4	20 de
Surflan + Matrix + Goaltender+ P	77	4	14 def
Sinbar + P, Rely	33	4	17 def
paraquat, Rely - Post	33	4	37 bc
Mason - not irrigated			
Untreated check			86 a
Prowl + paraquat (P)	44	2	19 d
Surflan + P	44	3	18 d
Prowl + Chateau + P	62	2	10 fg
Surflan + Chateau + P, Rely	46	2	7 ghi
Prowl + GoalTender + P	69	3	11 fg
Surflan + Goal Tender + P	69	2	10 fgh
Prowl + glyphosate (G)*	64	2	27 bc
Prowl+ Chateau + G	62	2	17 de
Matrix + P, Rely	44	1	16 de
Surflan + Matrix + P	44	2	17 de
Surflan + Matrix + Goaltender + P	105	1	5 hi
Alion + P, Rely	44	1	4 i
Sinbar + P	44	3	13 ef
diuron 4L + simazine 4L + P	64	2	30 b
paraquat, Rely - Post	44	2	31 b

**Days after treatment is the number of days after residual herbicide treatment when post-emergent herbicide was needed.

Table 4. Weed control from various herbicide treatments during the 2012 season at Lamont Fruit Farms.

	Percent Weed Cover										
Treatment	28-Mar	16-Apr	1-May	15-May	31-May	19-Jun	26-Jun	6-Jul	17-Jul	1-Aug	29-Aug
Prowl+P, R	28.9 cde	49.4 b	9.9 def	48.9 b	0.4 c	18.4 de	0.6 h	4.1 bc	14.1 bc	2.7 d	22.8 bc
Prowl+G	10.6 gh	20.0 de	10.8 def	1.7 e	2.1 c	23.3 cde	39.4 bcd	12.4 bc	12.3 bc	15.6 bcd	11.2 bcde
Prowl+Chateau+P, R	41.1 b	44.4 bc	34.0 bc	52.4 b	0.2 c	21.1 cde	1.0 h	8.0 bc	17.4 bc	3.1 d	8.4 bcde
Prowl+Chateau+G	21.1 bc	43.3 bc	3.1 f	17.6 cde	3.6 c	7.0 e	7.6 efgh	9.8 bc	19.0 bc	15.9 bcd	5.2 cde
Prowl+GoalT+ P, R	13.3 fgh	1.2 f	4.1 ef	21.7 cde	0.5 c	6.7 e	16.8 defgh	0.4 c	1.8 c	22.2 bc	2.2 de
Surflan+P, R	26.7 cde	45.6 bc	5.3 def	41.1 bc	0.3 c	7.2 e	25.6 cdefg	2.2 c	6.3 c	5.1 cd	0.7 e
Surflan+Chateau+P, R	31.1 bcd	30.6 cd	15.2 def	48.3 b	0.2 c	11.7 de	30.6 bcde	1.7 c	4.9 c	14.0 bcd	1.0 de
Surflan+GoalT+P, R	10.0 h	1.9 ef	5.2 def	19.1 cde	0.3 c	12.9 de	28.4 bcdef	5.9 bc	10.8 bc	7.4 cd	14.1 bcde
Surflan+Matrix+P	10.0 h	16.7 def	4.2 def	12.4 de	31.1b	20.2 cde	44.6 bc	14.8 bc	29.4 b	18.4 bcd	15.7 bcde
Surflan+GoalT+Matrix+P	10.6 gh	1.2 f	1.3 f	12.0 de	38.3 b	26.8 bcde	3.1 gh	10.3 bc	28.3 b	5.7 cd	16.2 bcde
Sinbar+P, R	20.6 efg	43.3bc	22.0 bcde	36.7 bcd	1.8 c	11.4 de	2.6 gh	8.1 bc	27.8 b	12.4 bcd	4.8 cde
Post-emergence	86.7 a	90.0 a	22.3bcd	95.0 a	4.7 c	48.3 b	6.4 fgh	9.0 bc	28.9 b	10.2 bcd	2.7 de
Untreated	88.3 a	92.2 a	96.1 a	99.4 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	85.6 a

P = paraquat, G = glyphosate, R = Rely
Numbers followed by the same letters are not statistically different, Tukey HSD, alpha=0.05

Table 5. Weed control from various herbicide treatments during the 2012 season at Mason Fruit Farm.

	Percent Weed Cover									
Treatment	22-Mar	17-Apr	2-May	16-May	30-May	14-Jun	26-Jun	16-Jul	2-Aug	16-Aug
Prowl+P	47 cdef	29 b	42 cd	5 bc	11 cdef	27 bcd	2 e	9 b	13 b	5 de
Prowl+G	73 a	89 a	87 a	1 c	0 g	3 ef	7 de	5 b	5 bc	3 de
Prowl+Chateau+P	61 abcd	0 c	0 f	1 c	14 cdef	12 def	0 e	6 b	11 bc	0 e
Prowl+Chateau+G	51 bcde	1 c	1 f	12 bc	9 defg	36 bcd	33 b	2 b	8 bc	13 cd
Prowl+GoalT+ P	67 abcd	0 c	1 f	4 c	21 cdef	3 ef	3 de	1 b	7 bc	4 de
Surflan+P	37 efg	40 b	62 b	2 c	16 cdef	20 cdef	1 e	2 b	2 c	2 e
Surflan+Chateau+P	29 efg	0 c	0 f	1 c	18 cdef	0 f	2 de	10 b	1 c	7 de
Surflan+GoalT+P	36 efg	0 c	1 f	5 bc	32 b	2 ef	4 de	1 b	5 bc	9 de
Surflan+Matrix+P	48 cde	37 b	28 d	1 c	11 cdefg	21 cde	2 e	12 b	1 c	7 de
Surflan+GoalT+Matrix+P	22 gh	0 c	0 e	0 c	1 fg	8 def	6 de	3 b	2 c	8 de
Sinbar+P	26 fgh	31 b	42 cd	1 c	5 efg	6 ef	3 de	10 b	6 bc	1 e
Matrix+P	46 def	42 b	54 bc	1 c	5 efg	10 def	0 e	0 b	1 c	6 de
Alion+R	6 h	1 c	16 ef	0 c	4 efg	10 def	0 e	0 b	1 c	3 de
Simazine+diuron+P	71 ab	78 a	87 a	0 c	1 fg	4 ef	19 c	10 b	4 bc	30 b
Post-emergence	79 a	76 a	84 a	2 c	14 cde	44 bcd	0 e	0 b	6 bc	0 e
Untreated	70 ab	74 a	92 a	93 a	92 a	97 a	92 a	74 a	88 a	88 a

P = paraquat, G = glyphosate, R = Rely
Numbers followed by the same letters are not statistically different, Tukey HSD, alpha=0.05

was a slight decrease in aggregate stability in untreated check, but a 40% decrease in the herbicide plots after 2 seasons indicating a potential to form a surface crust after a hard rain reducing water infiltration and increasing potential runoff. There was an increase in available water capacity in untreated and Sinbar plots.

The surface and subsurface hardness increased significantly in all treatments tested at Lamont's indicating a hard pan at 9 inch depth. The surface hardness remained the same at Mason's, but the subsurface hardness increased significantly in all treatments tested also indicating a hard pan at 9 inches. This is a common finding when we do any soil penetrometer tests in new orchards due to the limit in plow depth.

The preliminary water infiltration tests conducted in the field at Lamont's on the untreated check and the Surflan/Matrix/Goaltender plots showed more potential water infiltration in untreated plots (7.3 in/hr) due to more roots trails in the soil (before hand pulling weeds), compared to the Surflan/Matrix/Goaltender plots (5.6 in/hr.) The water infiltration tests conducted at Mason's on the untreated check vs. Surflan/Matrix/Goaltender plots showed twice the water infiltration in untreated plots (8.2 in/hr) due to more roots trails in the soil (before hand pulling weeds), compared to the herbicide plot (4.6 in/hr.)

The biological soil health indicators tested were organic matter (%), active carbon (ppm), potentially mineralizable nitrogen (micrograms N/gdw soil/week), and a root health rating (1-9 best). At Lamont's and Mason's, the organic matter decreased slightly in herbicide treatments, compared to the baseline and untreated checks. The active carbon available as an energy source for soil microbes increased from "low" rating in the baseline test to "moderate" level in the untreated plots, and a slight increase in herbicide treatments but still at a "low" level. The active carbon at Mason's increased by 30% in the untreated plots. The potential mineralizable N (an indicator of the soil microbes' ability to convert N into ammonium to be used by plants) decreased significantly in all herbicide treatments tested in both sites after 2 seasons. The overall root health indictor using beans as indicators of pathogens in soil improved slightly after 2 seasons.

At Lamont's, all chemical nutrient indicators were scored as

				Sample ID: j1573
Name of Farmer: Farmer John				
Location: Apple Lane, Appleville, NY				Agent: Deborah Breth 12690 Rt. 31, Albion, NY, 14411
Field Treatment: Treatment 4				Agent's Email: dib1@cornell.edu
Tillaged: 7-9 inch				Given Soil Texture: 0
Crops Grown: Corn/APP/APP				Date Sampled: 10/19/2012
	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	49.9	78	
	Available Water Capacity (m/m)	0.15	43	
	Surface Hardness (psi)	235	23	rooting, water transmission
	Subsurface Hardness (psi)	373	20	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	3.6	54	
	Permanganate Oxidizable Carbon (ppm)	506	29	Soil Biological Activity
	Potentially Mineralizable Nitrogen (mgN/gdwsoil/week)	5.6	19	N Supply Capacity
	Root Health Rating (1-9)	4.3	63	
CHEMICAL	pH (see CNAL Report)	7	100	
	Extractable Phosphorus (see CNAL Report)	1.5	44	
	Extractable Potassium (see CNAL Report)	56.3	72	
	Minor Elements (see CNAL Report)		100	
	OVERALL QUALITY SCORE (OUT OF 100):		53.7	Low
	Soil Textural Class: ==> silt loam			
	SAND (%): 35.9	SILT (%): 53.2		CLAY (%): 10.9

Figure 1. Soil heath testing report form.

"high" except for the extractable phosphorus which decreased by more than 50% compared to the baseline test. If the extractable phosphorus is less than 4.5, there is concern for availability of phosphorus to plants, a value greater than 25 is a concern for runoff. The chemical nutrient indicators at Mason's were all scored in a "high" rating. However, there was an increase in pH from 6.2 to 7.0 after 2 seasons in treatments tested.

Perennial Weeds

After 2 seasons of using the same residual herbicides and post-emergent herbicides, the proportion of perennial species among all weed species identified in the plots was calculated and multiplied times the % weed cover for the reading in mid-August to estimate the percent weed cover by perennial weeds. Of course this is only a snapshot in a whole season of weed development. The untreated weedy check plots had 40-64% of weed cover by perennial weeds, and the greatest number of perennial weed species (Figure 2). In the Lamont site, the most common perennial "weed" in the plots was the Dutch clover planted as the ground cover treatment in the row middles plots followed by narrow leaf plantain, nutsedge, Canada thistle, curly and broadleaf dock, and dandelion. The clover can be stunted by application of glyphosate and paraquat but they do not actually kill the clover. The Mason plot had horsenettle, followed by Dutch clover from ground cover treatments, dandelion, narrow leaf and broadleaf plantain, and broadleaf dock. Horsenettle is a difficult weed to control as it has a very deep root system and will produce seeds for new plants. The plots with no horsenettle were the Prowl plus 2 apps of glyphosate or Prowl plus Chateau plus glyphosate. Likely the glyphosate was doing the work. Surflan/Matrix/GoalTender plus Gramoxone, needed one touchup with Gramoxone. Matrix plus Gramoxone in spring followed by Rely also provided good control of horsenettle. Likely Matrix is providing some residual control.

Discussion

This NESARE Partnership grants has demonstrated the critical need for weed control and the negative impacts if not implemented in new, high-density apple plantings. This project has demonstrated that there is serious reduction in tree growth if weeds are not controlled in the early years. The reduced tree growth translates into the reduced profitability and later payback of investment costs. After 2 years, the potential crop value per acre in the herbicide plots with the greatest tree growth was increased by $2000 over the untreated weedy checks in the super spindle planting at Lamont's and $1300 per acre in the tall spindle planting at Mason's.

The potential economic loss due to poor weed control in the first few years in the Lamont orchard can result in a delay in the breakeven year on investment from year 13 in the best weed control treatment to year 15 in the worst weed control treatment, resulting in a loss of $4454 per acre in Net Present Value in year 15 (Table 7). In the Mason site, if a mature yield of 1000 bushels per acre is used, the breakeven year of investment will be year 22 in the best weed control treatment, but delayed in the worst weed control treatment until year 29. If 1200 bushels per acre is assumed, the breakeven year of investment will occur in year 15 in the best weed control treatment vs. year 19 in the worst weed control treatment, resulting in a loss of $6183 per acre in Net Present Value in year 15.

If production costs in these systems are estimated at $6000 per acre and growers estimate weed control costs at $60/acre, weed management is only 1% of that cost. The cost of herbicides across treatments in this study had a range of $7.50 to $34.00 per acre of apples. Therefore, the choice of herbicide should be made based on problem weeds, and the management system that best suits the farm in scheduling weed control practices, not the cost of herbicides. The cost of the herbicide is insignificant. Weed control is one of the critical components in an orchard development plan that will impact the profitability of new, high-density apple plantings. It is the lack of weed control that will cost growers money!

Acknowledgements

We thank Rod Farrow, Waterport, NY, and Doug Mason, Williamson, NY, for their cooperation on this project. This project

Table 6. Impact of herbicide treatment on tree growth and potential yield.

Treatment	Mean TCSA	# apples / tree	bu/a	$/acre
Lamont (1584 trees/acre, 4 fruit per cm², $7/bu, 88 count/bu)				
Prowl + G	7.7 A	31	553	3874
Surflan/GoalTender + P, R	6.8 AB	27	491	3436
Prowl/Chateau + G	6.7 ABC	27	483	3381
Prowl/Chateau + P, R	6.5 ABCD	26	468	3279
Prowl/GoalTender + P, R	6.3 BCDE	25	454	3180
Prowl + P, R	6.2 BCDEF	25	449	3146
Surflan/Chateau + P, R	6.1 BCDEF	24	436	3055
Surflan + P, R	5.4 CDEF	22	392	2744
Post-emergence TRT	5.3 DEF	21	381	2669
Surflan/Matrix + P	5.2 DEF	21	378	2643
Surflan/Matrix/GoalTender + P	5.2 EF	21	373	2613
Sinbar + P, R	5.0 FG	20	359	2515
Untreated	3.8 G	15	273	1914
Mason (889 trees/acre, 4 fruit per cm², $7/bu, 88 count/bu)				
Alion + P, R	10.2 A	41	412	2887
Prowl + P	8.6 AB	35	349	2440
Surflan/GoalTender + P	7.9 ABC	32	320	2241
Surflan/Matrix + P	7.8 ABC	31	317	2218
simazine/diuron + P	7.8 ABC	31	314	2198
Prowl + G	7.6 BC	30	307	2151
Post-emergence TRT	7.6 BC	30	306	2139
Surflan + P	7.4 BC	30	301	2106
Prowl/GoalTender + P	7.2 BC	29	292	2046
Prowl/Chateau + P	7.0 BC	28	282	1976
Surflan/Chateau + P, R	6.6 BC	26	267	1867
Matrix + P, R	6.5 BC	26	264	1847
Sinbar + P	6.4 BC	26	260	1821
Prowl/Chateau + G	6.4 BC	26	258	1804
Surflan/Matrix/GoalTender + P	6.3 BC	25	254	1781
Untreated	5.4 C	22	220	1537

Table 7. Relative comparison of beak even year and net present value (NPV) for weedy untreated vs. best weed control treatments.

Treatment	Max Yield	Break Even	15 yr NPV	20 yr NPV
Lamont untreated	1210	15	2,366	9,829
Lamont best	1210	13	6,820	14,283
Mason untreated	1000	29	-9,740	-4,940
Mason best	1000	22	-4,550	250
Mason untreated	1200	19	-3,171	4,657
Mason best	1200	15	3,012	10,840

Figure 2. Perennial grasses and broadleaf weeds dominate the weed species 2 seasons after planting the orchard.

was funded by NE Sustainable Agriculture Research and Extension Partnership

Literature cited

Breth, D. and M. Miranda Sazo. 2012. Weed control in young trees and new herbicides for spring 2012. NY Fruit Quarterly 20(1): 17-21.

Robinson, T. 2009. Crop load management of new high density apple orchards. NY Fruit Quarterly 16(2):3-7.

Gugino, B.K., O.J. Idowu, , R.R. Schindelbeck, H.M. van Es, D.W. Wolfe, B.N. Moebius-Clune, J.E. Thies and G.S. Abawi. 2009. Cornell soil health assessment training manual, Edition 2.0, Cornell University, Geneva, NY. http://soilhealth.cals.cornell.edu/extension/manual/manual.pdf

Debbie Breth is a Senior Extension Associate with the Lake Ontario Fruit team who specializes in Integrated Pest Management. **Elizabeth Tee** is the program aide for the Lake Ontario Fruit Program, Cornell Cooperative Extension.