Effectiveness of Weed Control Strategies for Organic Orchards in Central Washington

Year 2 Report, April 2006

David Granatstein[1], Elizabeth Kirby[1], Michel Brockington[1], Gene Hogue[2], Kent Mullinix[3]

Keywords: wood chip mulch, mechanical weed control, organic orchard, apple, soil quality

Abstract: Non-chemical control of orchard weed strips under the tree row presents a major challenge to growers and can be a barrier to adoption of organic or low input weed management. To limit weed competition with young trees, growers need alternatives to chemical herbicides to maintain a clean weed strip. Mechanical weed control has been the standard practice in organic orchards, often with high cost and potential degradation of soil quality. Organic standards dictate the need to maintain or improve soil quality. Alternative mulches can control weeds and improve tree growth and yield, and have been shown to improve soil quality. For example, wood chip mulch can effectively suppress weeds when material is available and cost effective (Neilsen et al., 2003). We compared the efficacy and soil quality effects of in-row weed control using two mechanical tillage implements, a wood chip mulch, and a mowed control in an 8-year old block of Gala/M26 apple in organic transition. In addition, fruit yield efficiency, size, and crop value were assessed in year 2 of the study. In both years, cultivation implement and frequency affected weed control. Wood chips controlled weeds well, and increased fruit size and gross crop value, but the mulch needed replenishing by the end of year 2.

Objective: Evaluate the effectiveness of weed management strategies including cultivation method and frequency on weed control, fruit production, and soil quality in an organic apple orchard.

Procedures: A trial investigating mulching and cultivation was initiated in April 2004 in an 8-yr old block of Gala/M26 apple in transition to organic certification at the Wenatchee Valley College teaching orchard near East Wenatchee, WA. Treatments included control (with mowing to keep weeds down), wood chip mulch (applied 6" thick, see Fig. 1), Cultivator Y (3 times per growing season), and Cultivator Z at three different frequencies (see Treatments, below). Cultivator Y (Weed Badger) is a hydraulically driven unit with a vertical axis cultivating head. Cultivator Z (Wonder Weeder) is a ground-driven rolling cultivator with a spring blade that works in between the trees (Fig.2). The experimental design was a randomized complete block with 5 replicates. Plot size was 35-40'x13' tree rows, with trees on a 3.5'x13' spacing. In Year 2, Cultivator Y treatment was tilled once only, in early August. Also, Cultivator Z (3x) was given 2 different timings in Year 2: there was a 3x treatment tilled on 4/18/05, 6/3/05, and 7/8/05, and a Cultivator Z 3x Late (delayed) treatment tilled on 6/3/05, 7/8/05, and 8/10/05. Data collected in both years included weed percent cover, weed cover and biomass, and soil infiltration rate and penetration. In 2004, tractor time for operations, shoot extension,

[1] Center for Sustaining Agriculture and Natural Resources, Washington State University, Wenatchee, WA
[2] Agriculture Canada, Summerland, British Columbia
[3] Washington State University and Wenatchee Valley College Tree Fruit Program

SPAD, and leaf nutrient concentration were measured. Weed biomass and percent cover by species, and fruit weight, cost, and yield were measured in 2005. Additionally, soil samples from both years will be tested for organic matter.

Weed Control Treatments

A- Control; no tillage or mulch, weeds mowed occasionally
B- Wood chip mulch
C- Cultivator Y tillage
D- Cultivator Z 2x tillage
E- Cultivator Z 3x tillage
F- Cultivator Z 4x tillage

The research orchard is in transition to organic certification, and these plots were managed according to the NOP organic standards. Composted chicken manure was applied to tree rows at typical rates each May for the duration of the study. The soil type is a Pogue fine sandy loam, with an estimated available water holding capacity of 0.11-0.14 in/in in the surface 0-30 cm depth. Fine gravel is present in the 15-50 cm depth of the Gala block.

Results and Conclusions:

Weed Control. In year 2, increasing tillage frequency led to reduced weed pressure (Fig. 3), although weed cover did appear to increase in year 2 (nearly 100%) over year 1 (80%), suggesting an increase in the weed seed bank. In both years, weed cover varied widely, but Cultivator Z had the most success in reducing weeds overall, was faster, and therefore a more cost-efficient device. In year 2, percent cover data showed the delayed timing of Cutivator Z 3x Late yielded significantly lower weeds overall, suggesting that timing of tillage is an important factor and may affect weed species diversity (Figure 3). Weed data by species showed annual grasses predominated in the plots, and tillage did appear to stimulate these, particularly the warm-season grasses green foxtail (*Setaria viridis*) and large crabgrass (*Digitaria sanguinalis*). Wood chip mulch provided good weed control for two seasons with no additional management, but weeds began to increase in this treatment toward the end of the year 2 growing season, suggesting the wood chips were beginning to break down (Fig. 4). Weed biomass was measured in August 2004 after the last tillage (Figure 5), and in spring 2005 and 2006 prior to the first tillage (Fig. 6). While increasing tillage frequency reduced percent weed cover in 2004, this same pattern did not occur with weed biomass. Spring weed biomass measurements reflect the previous year treatment effects on cool season weeds, and biomass did not decrease with increasing tillage frequency.

Fruit Production. Tillage with either cultivator had no negative effect on tree shoot growth, leaf SPAD or leaf nutrient levels in year 1, and no negative effect on yield efficiency, fruit weight, or size in year 2. Wood chip mulch did provide a modest benefit to the trees, as fruit weight (g/apple) in 2005, and box size were significantly better for this treatment (Table 1). This led to significantly higher gross crop value in the wood chip plots than in any of the tillage plots. Fruit yield and trunk cross sectional area were highest in the wood chip plots, but not statistically significant.

Soil Quality. In year 1, leaf P levels were significantly higher (p=0.002) for the wood chip treatment although all treatment levels were considered to be sufficient. Wood chips may increase organic matter (results still pending) but we observed root, fungal hyphae, and organic matter development at the surface where the wood chips were breaking down. The wood chip layer was renewed in spring 2006. In the first year, water infiltration was significantly slower with Cultivator Y compared to the control. The control treatment (untilled) had higher infiltration at low tension in year 2, suggesting more macropores (Table 2). In year 2, there was no consistent effect of any treatment on soil resistance (Fig. 6), with the control treatment having the least resistance and the wood chips the most. This was opposite 2004 when wood chips showed the least resistance.

Refer to on-line report for cost comparisons and detailed results from Year 1: Effectiveness of Weed Management Strategies for Organic Orchards in Central Washington - 2004.

Cost Effectiveness. Cultivator Z proved to be an effective mechanical device. It is much faster to operate than other mechanical weeders (e.g. 440 ft/min for Cultivator Z vs. 20 ft/min for Cultivator Y) and weed control results are comparable to Cultivator Y. The Cultivator Z blade that sweeps weeds from between the trunks was less consistent in its weed control than its rolling spiders on each side of the tree row. The spiders were able to work in heavy weed pressure (e.g. weeds 10-12' tall) but did a better job if weeds were smaller. Cultivator Y is a more effective cultivator in grass sod. Cultivator Z is similar in cost to other mechanical cultivators (about $5,000). However, it is a very simple machine with no internal hydraulics and thus should have lower maintenance and repair costs. Since it is front-mounted, it can also be used in conjunction with spraying or mowing, and thus the tractor/operator cost is negligible. The machine manufacturer noted that he is able to cultivate 40 acres of orchard in about 8-10 hr of operation, which is supported by the ground speed measured in this trial. The cost of applying wood chip mulch was also calculated from this trial, and is estimated to be $924/ac for this setting, using a tractor-pulled mulch spreader that was loaded with a tractor front-end loader. It took about 6 hr/ac to actually apply mulch to the row (6" depth on 5' weed strip), 12.4 hr/ac to load the spreader, and 12.4 hr/ac to drive from the mulch stockpile to the orchard block. The mulch was delivered free to the orchard by tree removal services in the area.

References:

Neilsen, G.H., E.J. Hogue, T. Forge, and D. Neilsen. 2003. Mulches and biosolids affect vigor, yield and leaf nutrition of fertigated high density apple. *HortScience* 38(1):41-45.

Figure 1. Wood chip mulch in tree row.

Figure 2. Tillage with Cultivator Z.

Figure 3. Weed cover response to tillage frequency of Cultivator Z.

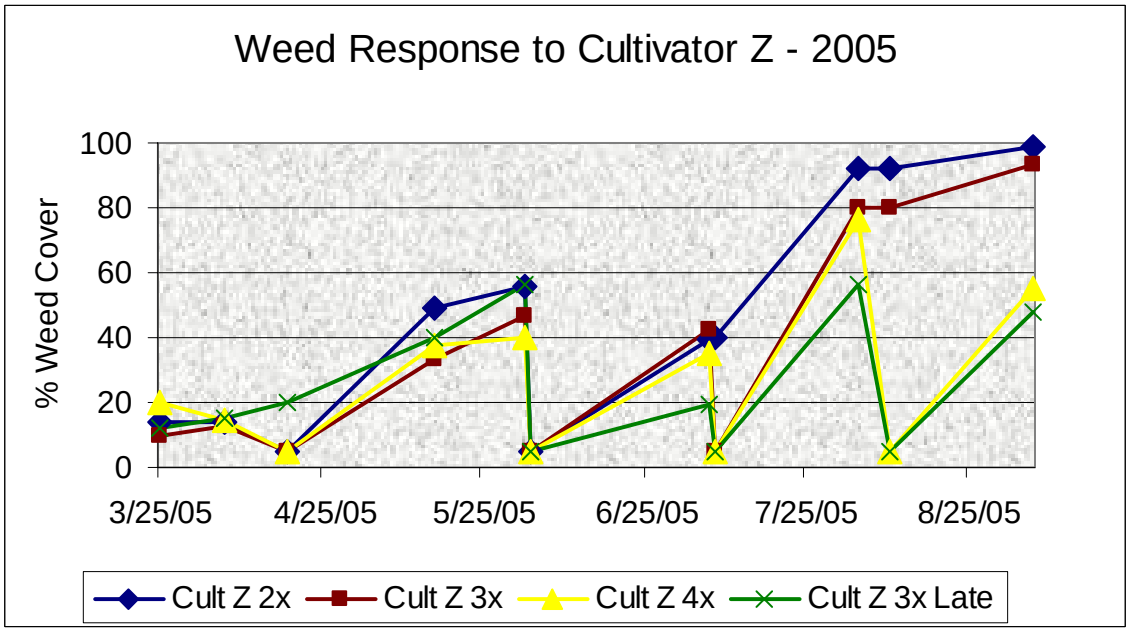

Figure 4. Weed percent cover for years 1 and 2. Arrows represent approximate tillage dates.

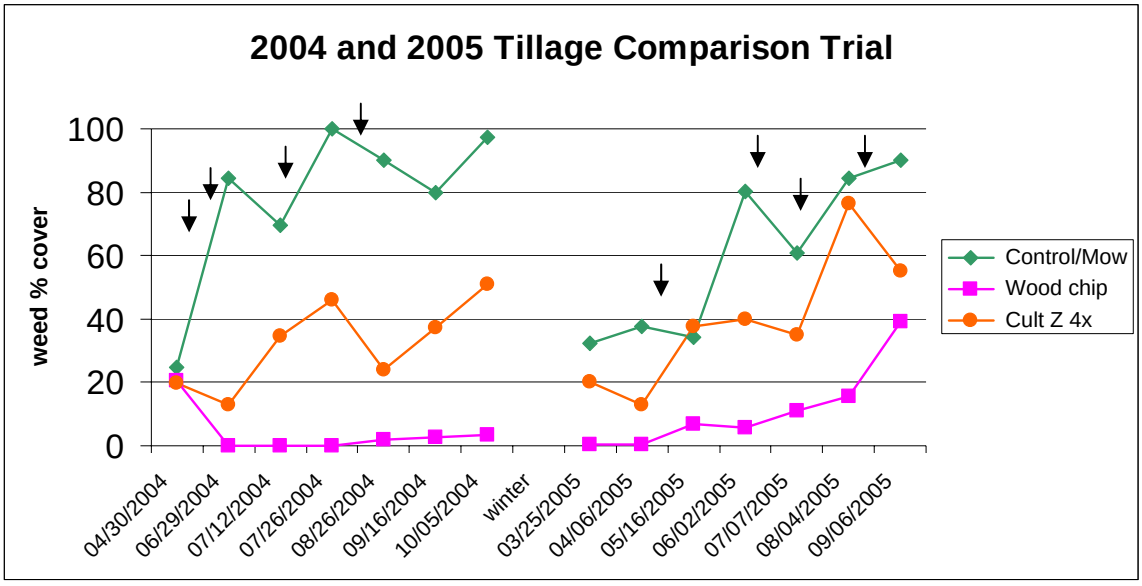

Figure 5. Weed biomass measured in August 2004 after last tillage.

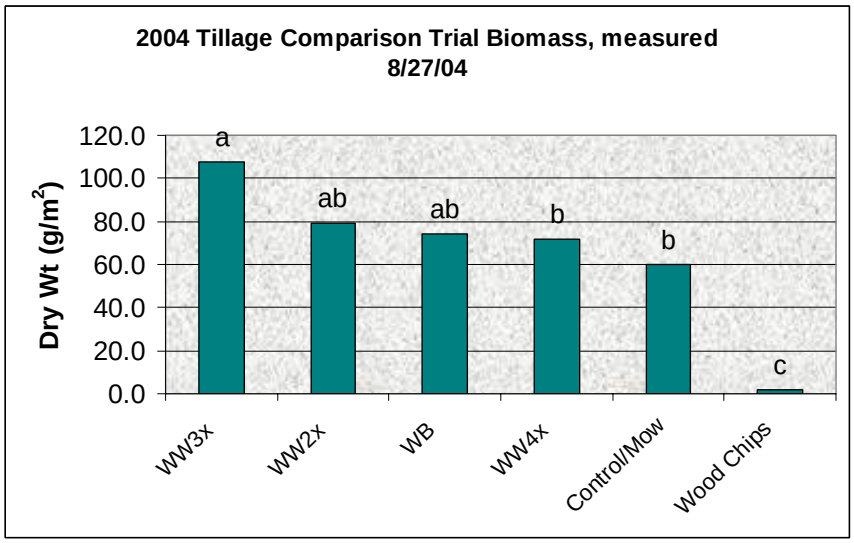

Figure 6. Spring weed biomass prior to tillage.

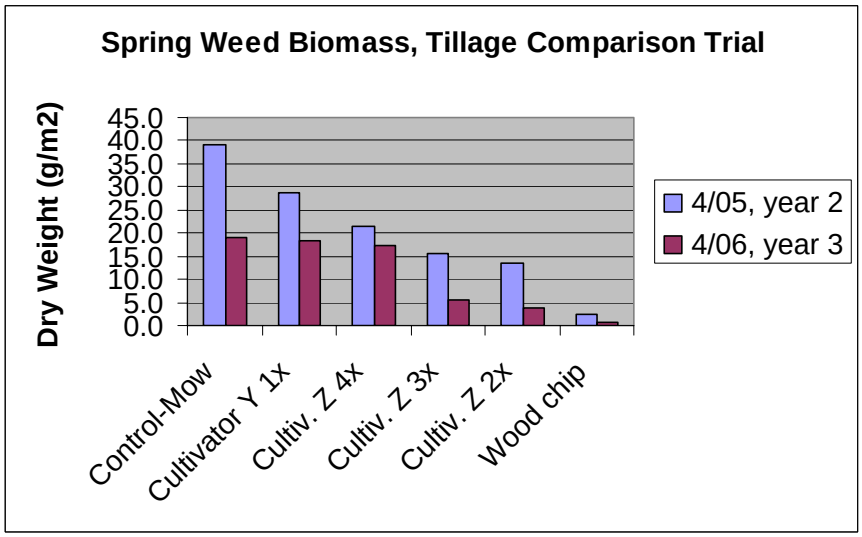

Figure 7. Soil resistance, September 2005, Year 2.

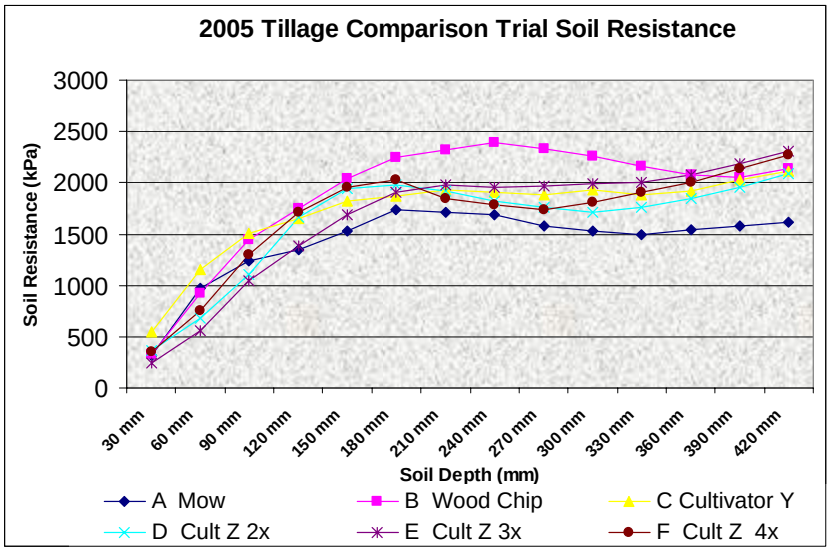

Table 1. 2005 Apple tree and fruit performance (Year 2).

Treatment	Fruit Yield (kg/tree)	Fruit wt (g/apple)	% Fruit at box size 80	Gross Crop Value/5 trees*	TCSA (cm^2)	Yield eff. (kg fruit /cm^2 TCSA)
Wood chip	22.4	206.9 a	15.5 a	$108 a	43.8	0.51
Mow	20.4	197.0 b	6.5 b	$93ab	41.2	0.50
Cult Y 1x	20.0	195.8 b	7.5 b	$91 b	42.6	0.47
Cult Z 2x	19.3	196.8 b	6.0 b	$88 b	40.0	0.48
Cult Z 4x	18.7	194.9 b	6.5 b	$85 b	38.6	0.48
Cult Z 3x	17.6	189.5 b	7.0 b	$79 b	37.7	0.47
p=	**0.150**	**0.037**	**0.014**	**0.017**	**0.574**	**0.941**

*Note: Fruit was field-sorted and culled during harvest.
TCSA = trunk cross sectional area

Table 2. 2004 & 2005 soil water infiltration.

	2004*		2005*	
	R1 (cm/min)	R2 (cm/min)	$T_{0.5}$ (ml/min)	T_2 (ml/min)
Treatment				
A Control (mow)	3.7 b	0.7 b	2.3 a	1.0
B Wood chip	n.a.	n.a.	0.9 b	0.7
C Cultivator Y	1.1 a	0.3 a	1.3 b	1.0
D Cultivator Z 2x	3.5 b	1.2 b	1.0 b	0.7
E Cultivator Z 3x	2.1 b	0.9 b	1.3 b	1.0
F Cultivator Z 4x	n.a.	n.a.	1.1 b	1.0
p=	**0.0007**	**0.0047**	**0.0088**	**0.1400**

*A single ring infiltrometer was used for 2004, with two consecutive runs separated by 5 minutes. A mini-disk tension infiltrometer was used, with two consecutive runs at 2cm tension and 0.5cm tension.