

# Effectiveness of Weed Control Strategies for Organic Orchards in Central Washington

Year 3 Report, January 2007

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**Keywords:** wood chip mulch, mechanical weed control, organic orchard, apple, soil quality, gross fruit value, box size

**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. Growers require alternatives to chemical herbicides to limit competition with weeds and 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, organic mulches can effectively suppress weeds when material is available and cost effective (Neilsen et al., 2003). Two mechanical tillage implements, a wood chip mulch, and a mowed control were tested for weed control efficacy and soil quality effects for three years in an organic block of Gala/M26. Weed percent cover and biomass were measured in all years. Fruit yield and crop value were assessed in Year 2 and 3 of the study. Wood chip mulch provided good weed control for the first two growing seasons, although it needed re-application of a 6-inch layer by Year 3. Tillage had no negative effect on tree shoot growth, leaf SPAD or leaf P levels in Year 1 (2004), and did not negatively affect fruit yield in either Year 2 or 3. However, trunk growth and canopy volume were significantly reduced with tillage by Year 3. Wood chip mulch improved fruit size in Year 2 and 3, increasing gross receipts to offset the cost of a single wood chip application. Wood chips also increased TCSA and canopy volume by Year 3. There was no consistent effect of any treatment on soil quality measured, although the control (untilled) did have higher infiltration at low tension, suggesting more soil macropores.

**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:** Refer to on-line reports for detailed Year 1 and Year 2 information: [Effectiveness of Weed Management Strategies for Organic Orchards in Central Washington - 2004](#). [Effectiveness of Weed Management Strategies for Organic Orchards in Central Washington - 2005](#) This trial was initiated in April 2004 in an 8-yr old block of Gala/M26 in transition to organic certification at the Wenatchee Valley College teaching orchard near East Wenatchee, WA, with organic certification granted in 2006 (Year 3). Treatments included a mowed control, wood chip mulch (applied 6" thick, see Fig. 1), Cultivator Y (3 times per growing season), and Cultivator Z at three different frequencies (2 tillage times, 3 times, or 4 times). Cultivator Y (Weed Badger) is a hydraulically driven unit with a vertical axis cultivating head. Cultivator Z (Wonder

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Weeder) is a ground-driven rolling cultivator with a spring blade that works in between the trees (Figure 2). Experimental design was a randomized complete block with 5 replicates. Plot size was 9-13 trees with 5 sample trees in the center (trees trellised on a 3.5'x13' spacing). In Year 3, the trial was simplified to only maintain the mowed control, wood chip mulch, and Cultivator Z 3x tillage, with 5 replications. The tilled treatment was a 3x treatment in past years, but tilled 2 times in 2006 on 6/5/06 and 8/5/06, while the control treatment was mowed monthly. Measurements of the three treatments included weed biomass and percent cover by species, trunk cross-sectional area (TCSA), tree canopy volume, fruit yield and size, soil infiltration,. In Year 3, soil organic matter (loss-on-ignition method) and soil active carbon (aerobic incubation) were measured. The plots were managed according to the NOP organic standards, with mint compost applied at a rate of 6 tons/ac in Year 3, and composted chicken manure applied at typical rates each May for Years 1 and 2. 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 0-12 inch depth. Small gravel often occurs below a depth of 6 inches in this soil.

### **Results and Conclusions:**

**Weed Control.** Overall, tillage may have stimulated compensatory weed growth in Year 1, as biomass measures were higher with increasing tillage frequency, but this effect was reduced by Years 2 and 3 (Figures 4 & 5). Total weed percent cover and total weed biomass were lower in Year 3 than Year 2, suggesting an overall reduction in weed seed bank. Between the two tillage implements, Cultivator Z had the most success in reducing weeds overall, was faster, and therefore a more cost-efficient device. Tillage frequency data showed that by Year 3, weed biomass was significantly lower in the 2x and 3x tillage with Cultivator Z than Cultivator Y or control (Figure 4). Thus, we simplified the experiment in Year 3 to only the 3x tillage treatment (tilled 2 times in 2006 season), wood chip mulch, and control treatments. Wood chip mulch provided the most weed control overall in all three years, although it needed re-application of a 6-inch layer in April of Year 3 (Figures 3, 4, & 5). These results are contrary to another trial with younger trees and less shade, in which the wood chips broke down much more quickly and provided less weed control (Granatstein 2007). Weed data by species in Years 2 and 3 showed annual grasses predominating in the plots. Tilling 2 and 3 times significantly reduced the percent cover of cheatgrass (*Bromus tectorum*) measured the next April and June. Bluegrass was lowest in the tilled plots. By August in both years, cheatgrass cover was reduced to 0-5 % cover, and warm season grasses dominated, particularly green foxtail (*Setaria viridis*) and large crabgrass (*Digitaria sanguinalis*).

**Tree Growth and Fruit Production.** Tillage had no negative effect on tree shoot growth, leaf SPAD or leaf nutrient levels in Year 1 (2004), and no significant negative effect on fruit yield or tree canopy volume in Years 2 or 3. However, tree trunk growth with tillage was significantly reduced by Year 3 over the control (Table 1). Any loss of root anchoring due to tillage was not noticed, as the trees are on a trellised system. In a related trial, tilled trees (second leaf) exhibited significantly increased leaning. Over year and treatment, TCSA and canopy volume were greater in the wood chips than the control, and control greater than tillage (Table 1). Fruit yield was not statistically different among treatments in either year. However, the wood chip mulch improved fruit size in Year 2

and 3 over the control and tilled treatments. When gross receipts were calculated (sum of fruit yield per size class x price per size class), the increased value in wood chips more than offset the cost of one wood chip application. This cost would depend upon the availability of wood chips in a given area. Wood chips can thus provide weed control, improved tree performance, and water conservation (as illustrated in previous experiments), all of which have economic benefits to offset the mulching cost.

**Soil Quality.** In Year 1, leaf P levels were significantly higher ( $p=0.002$ ) for the wood chip mulch than any other treatment, although all treatment levels were sufficient. Tilled plots had higher soil organic matter levels than wood chips as measured in Year 3 (Table 5). This may be due to the greater incorporation of compost in the tilled plots, while in the mulch treatment, soil was sampled below the wood chips. In the actual mulch layer, root, fungal hyphae, and organic matter development within the wood chip layer was observed. Soil active carbon measured fall of 2006 did not show significant differences (Figure 6). Control plots had the fastest water infiltration in Years 2 and 3, suggesting more macropores due to plant root development (Table 4). Penetrometer data in Year 2 showed the trend of greater resistance in the wood chip plots, though the increase was not significant (Figure 7).

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; thus it 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 situation, with chips delivered free to the orchard and spread 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. Flame weeding, not included in this study, has been reported by growers to cover 4-5 acres/hr, using 10 gal propane/hr, and requiring 4 passes per season, at an estimated cost of \$70/acre (2006).

**References:**

Granatstein, D., K. Mullinix, M.Wiman, and E. Kirby. 2007. Progress report: Organic Cropping Research for the Northwest, Integrated Multiple Mulch Trial. In Progress.

Neilsen, G.H., E.J. Hogue, et al. 2003. Mulches and biosolids affect vigor, yield, and leaf nutrition of fertigated high density apple. HortScience 38:41-45.

Table 1. Apple fruit yield, size, value and tree growth of 2005 & 2006.

Treatment	2005			2006				
	Fruit yield kg/tree	Fruit Size 80-88 %	Gross Fruit Value* \$/acre	Fruit Yield kg/tree	Fruit Size 80-88 %	Gross Fruit Value* \$/acre	TCSA increase cm <sup>2</sup>	Canopy volume cu. ft./5 trees
Wood chip	22.4	15.5 a	14,354	14.7	39.0	11,032	3.7 a	1531 a
Control mow	20.4	6.6 b	12,003	14.3	33.5	9,748	3.0 b	1286 ab
Cultivator Z 3x	17.6	7.0 b	9,556	13.3	22.0	10,162	2.3 c	1059 b
<b>p=</b>	<b>0.150</b>	<b>0.014</b>		<b>0.805</b>	<b>0.076</b>		<b>0.001</b>	<b>0.008</b>

\*Based on Gala WAXF #1 price, 9/1-10/30, reg. storage, domestic, conventional. Fruit field sorted.

Table 2. Total % Weed Cover. Years 2 (2005) & 3 (2006).

Treatment	April Yr2	Jun Yr2	Aug Yr2	April Yr3	Jun Yr3	Aug Yr 3
Cultivator Z 2x	8.8 b	55.8 ab	92.0 a	2.5 c	27.5 c	78.6 ab
Cultivator Z 3x	10.0 b	46.4 b	79.8 ab	4.0 c	31.3 bc	68.1 bc
Cultivator Z 4x	12.8 b	39.8 b	76.5 b	9.5 bc	49.0 a	72.3 abc
Control mow	37.8 a	80.4 a	84.5 ab	21.0 a	45.3 ab	89.1 a
Wood chip	0.3 b	5.7 c	15.6 d	0.8 c	2.7 d	24.2 d
<b>p=</b>	<b>0.0014</b>	<b>0.0039</b>	<b>0.0000</b>	<b>0.0011</b>	<b>&lt; 0.0001</b>	<b>&lt; 0.0001</b>

Table 3. Percent Cover of Predominant Weed Species over Years 2 & 3.

	Cheat grass ( <i>Bromus tectorum</i> )	Green Foxtail ( <i>Setaria viridis</i> )	Bluegrass ( <i>Poa annua</i> )	Large Crabgrass ( <i>Digitaria sanguinalis</i> )	Alfalfa ( <i>Medicago sativa</i> ) + Clover ( <i>Trifolium</i> spp.)
<b>Control-Mow:</b>					
Year 2 - March 05	20.9	0.0	2.7	0.0	7.9
Year 2 - Aug 05	0.0	7.0	5.5	56.4	12.3
Year 3- Apr 06	8.8	0.0	3.0	0.0	10.8
Year 3 - Jun 06	14.2	6.8	10.7	0.0	15.7
Year 3 - Aug 06	0.0	49.7	28.0	0.0	15.5
<b>Cultivator Z cultivation:</b>					
Year 2 - March 05	11.3	0.0	0.0	0.0	0.0
Year 2 - Aug 05	0.7	29.5	0.0	55.1	1.1
Year 3 - Apr 06	0.9	0.0	0.4	0.0	0.0
Year 3 - Jun 06	6.0	10.7	3.0	0.0	5.7
Year 3 - Aug 06	63.0	0.0	0.0	0.0	0.0
<b>Wood Chip Mulch:</b>					
Year 2 - March 05	0.4	0.0	0.0	0.0	0.0
Year 2 - August 05	0.3	6.1	3.7	8.1	3.3
Year 3 - Apr 06	0.7	0.0	0.0	0.0	0.2
Year 3 - Jun 06	1.5	0.0	3.4	0.0	0.0
Year 3 - Aug 06	0.0	0.0	0.0	0.0	0.0

Table 4. 2004, 2005, and 2006 soil water infiltration.

Treatment	2004*		2005*		2006	
	R1 (cm/min)	R2 (cm/min)	T0.5 (ml/min)	T2 (ml/min)	T0.5 (ml/min)	T2 (ml/min)
<b>Control mow</b>	3.7 b	0.7 b	2.3 a	1.0	7.0a	3.3a
<b>Wood chip</b>	n.a.	n.a.	0.9 b	0.7	2.4b	1.0b
<b>Cultivator Y</b>	1.1 a	0.3 a	1.3 b	1.0	n.a.	n.a.
<b>Cultivator Z 2x</b>	3.5 b	1.2 b	1.0 b	0.7	n.a.	n.a.
<b>Cultivator Z 3x</b>	2.1 b	0.9 b	1.3 b	1.0	2.7b	1.2b
<b>Cultivator Z 4x</b>	n.a.	n.a.	1.1 b	1.0	n.a.	n.a.
<b>p=</b>	<b>0.0007</b>	<b>0.0047</b>	<b>0.0088</b>	<b>0.1400</b>	<b>0.0052</b>	<b>0.0083</b>

\*A single ring infiltrometer was used for 2004, with two consecutive runs separated by 5 minutes. A mini-disk tension infiltrometer was used in 05 & 06, with two consecutive runs at 2cm tension and 0.5cm tension.

Table 5. 2006 % organic matter (loss-on-ignition method).

Treatment	% OM
Wood chips	2.65 b
Control	2.96 ab
Wonder Weeder	3.49 a
<b>p=</b>	<b>0.0318</b>

Figure 1. Wood chip mulch in tree row.



Figure 2. Tillage with Cultivator Z.



Figure 3. Overall weed percent cover for Years 2 and 3. Note: tillage estimated to reduce weeds to 5 % weed cover, as the tillage does leave some weeds uncontrolled (see Figure 2, above).

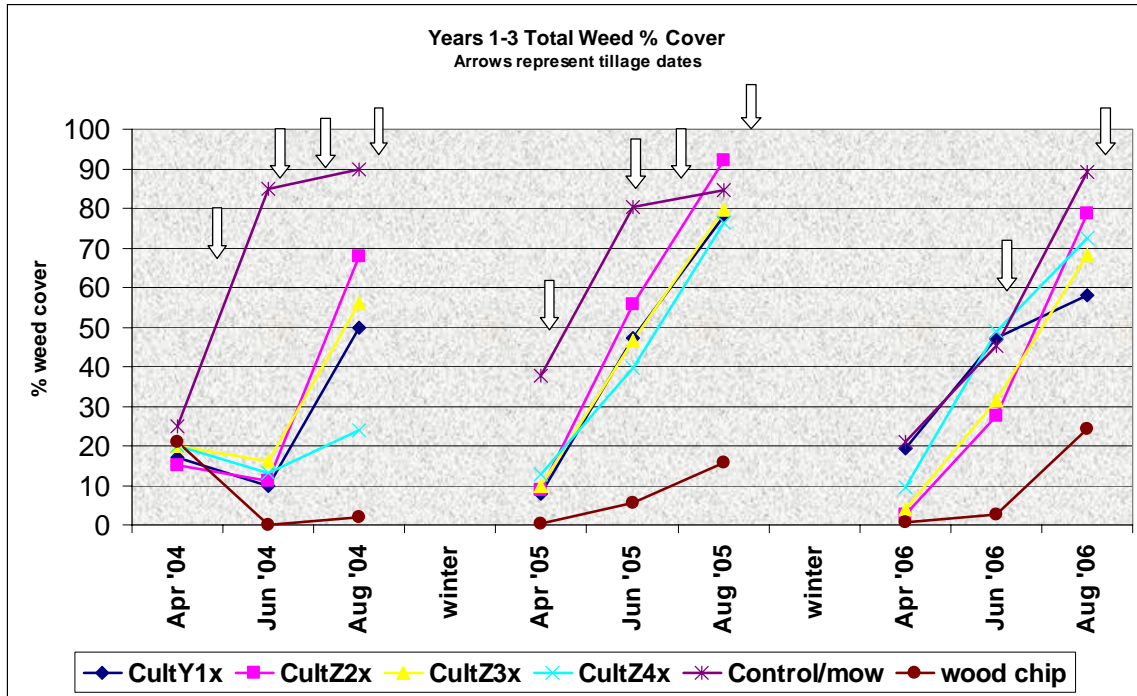


Figure 4. Weed biomass data by treatment. Sampled prior to Year 3 treatments; reflects Year 1 and 2 treatments.

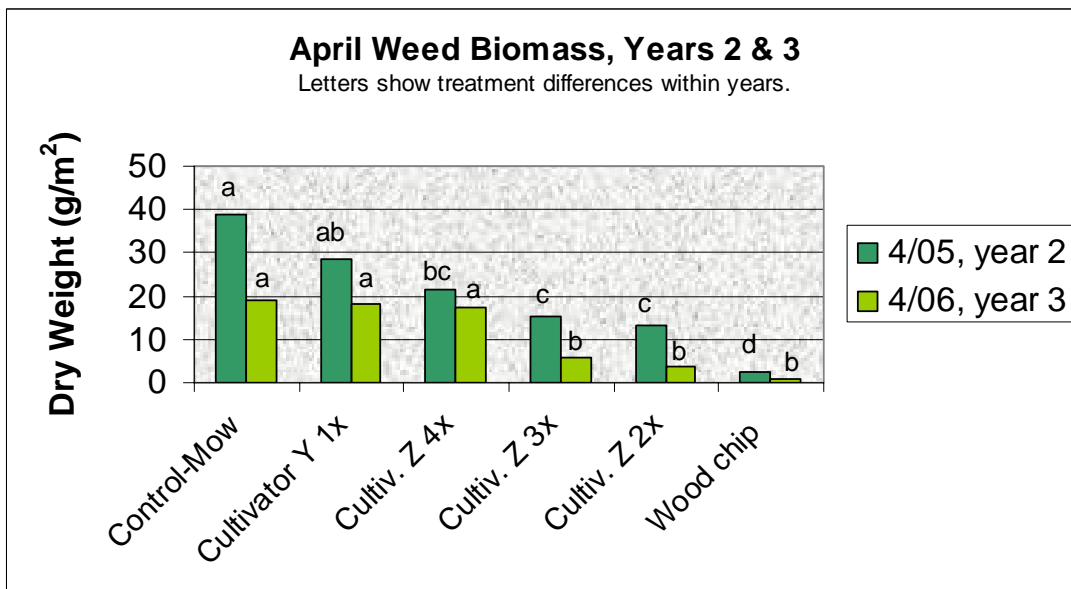


Figure 5. Weed biomass data by treatment. Reflects Year 1 treatments, sampled 8/27/04.

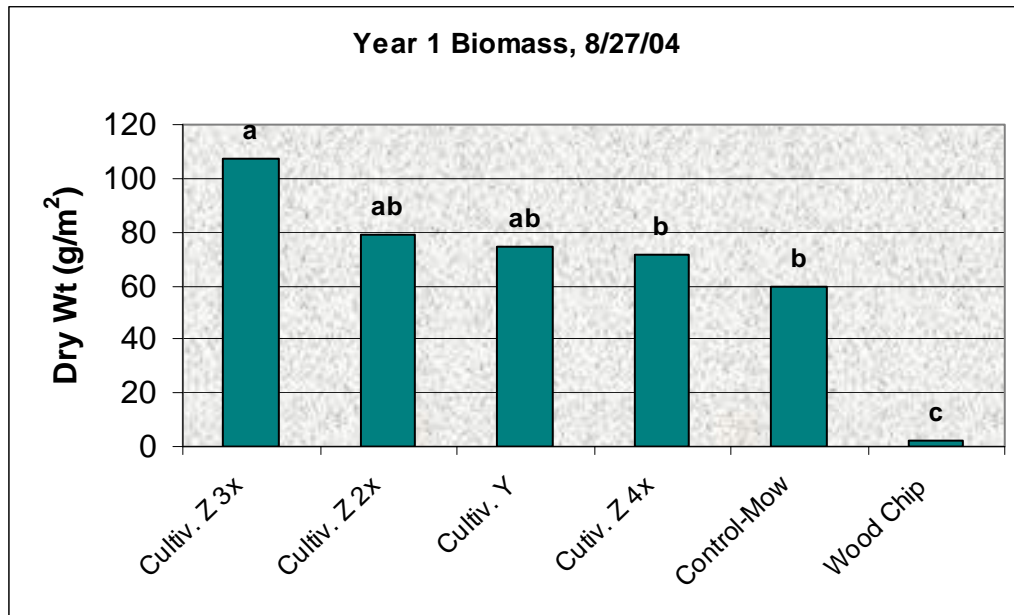


Figure 6. 2006 Soil Active Carbon measured September 9, 2006.

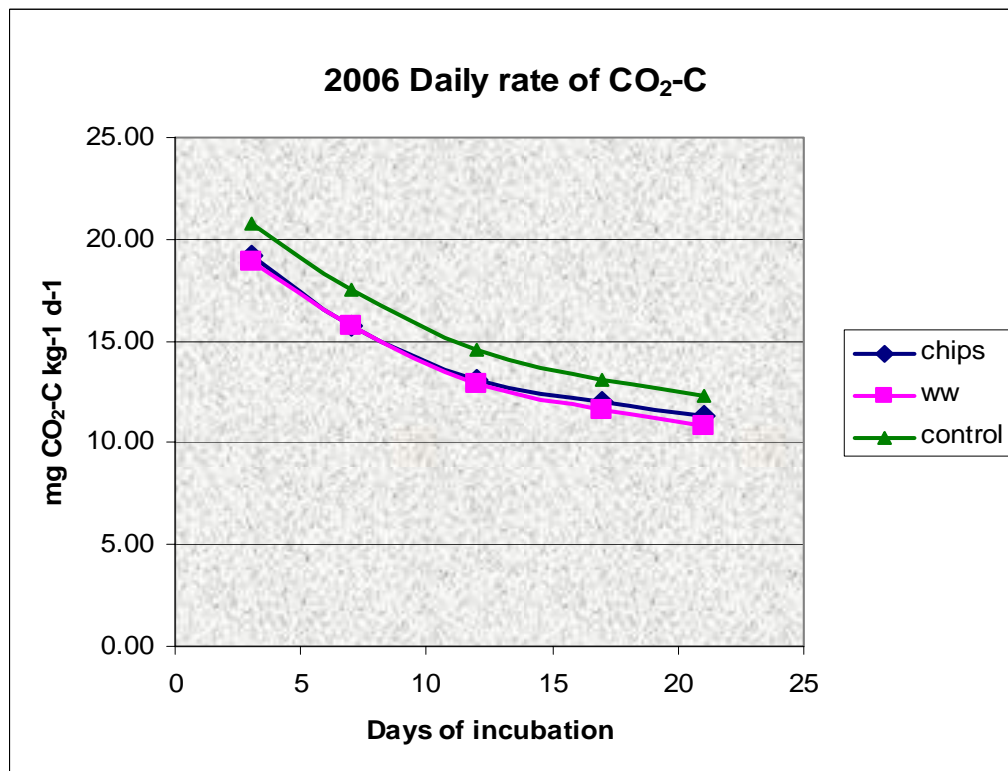


Figure 7. Year 2 soil resistance.

