

Effectiveness of Weed Management Strategies for Organic Orchards in Central Washington - 2004

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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. Typically, conventional growers have relied on applications of glyphosate and other herbicides to maintain a clean weed strip and limit weed competition with the trees. Alternatives include use of a wood chip mulch or specialized tillage equipment designed or modified to cultivate weeds in between trees. Wood chip mulch can effectively suppress weeds when material is available and cost effective (Neilsen et al., 2003). This study compares the effectiveness and costs of in-row weed control by various treatments.

Objective: Evaluate the effectiveness and costs of various weed management strategies for organic orchards.

Procedures: The study was established in 2004 at the Wenatchee Valley College teaching orchard near East Wenatchee, WA in a block of Gala/M26 apples planted in 1995. Treatment plots were laid out in a Randomized Complete Block (RCB) experimental design consisting of 6 treatments with 5 replications. All treatments are represented in each tree row. Plot size is 35-40'x13' tree rows. Trees are planted on a 3.5'x13' spacing. Grass alleys overseeded with alfalfa were maintained between tree rows. Data collected included weed cover, weed biomass, tractor time for operations, shoot extension, SPAD, and leaf samples for N. Also, soil infiltration rate and penetration resistance were measured to monitor soil quality, and samples were taken for pending organic matter tests.

Weed Control Treatments:

A - Control, no tillage or mulch; weeds mowed

B - Wood chip mulch

C – Cultivator Y 3x tillage

D – Cultivator Z 2x “

E – Cultivator Z 3x “

F – Cultivator Z 4x “

Cultivator Y is a hydraulically driven unit with a vertical axis cultivating head. Several companies make this type of machine. Cultivator Z is a ground-driven rolling cultivator with a spring blade that works in between the trees.

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The research orchard is managed for organic certification; therefore no herbicide was applied to plots. Composted chicken manure was applied to tree rows at typical rates in May. The soil type is a Pogue fine sandy loam with an estimated available water holding capacity of 0.11-.014 in/in in the surface 0-30 cm depth. Fine gravel is present in the 0-15 cm and 15-50 cm depths of the Gala blocks. The soil appears fairly uniform and drains well. Soil measurements (0-15 cm depth) from an adjacent block taken in 2001 included: soil organic matter 1.4-1.8%; bulk density 1.3-1.4 g/cm³; infiltration 0.78-2.62 min/in. (.31-1.03 min/cm).

Observations:

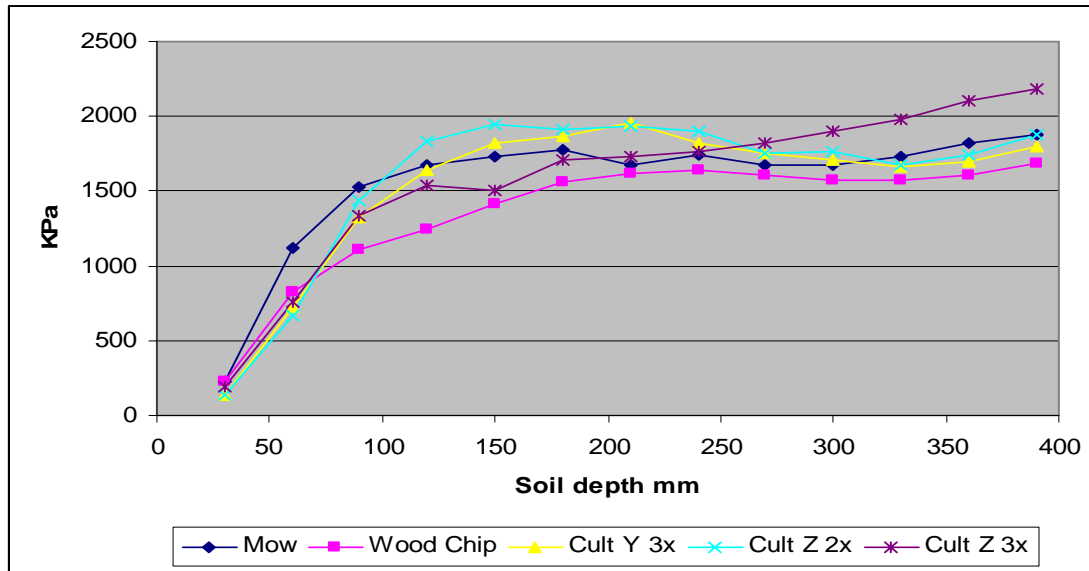
Infiltration and penetrometer resistance were measured this year to help set a baseline for monitoring the soil quality impacts of repeated mechanical tillage compared to untilled or mulched soil. Cultivator Y had significantly slower infiltration than other treatments. **Soil resistance** measurements (KPa) were taken in mid-August using a cone penetrometer with readings from 0-425 mm depth, at 15 mm intervals. Nine measurements were made per plot. There were no differences in soil resistance (KPa) among treatments at the 30 mm depth or below 180 mm soil depth. Differences did show up between 60mm and 150mm. The undisturbed control plots (mowed) showed higher soil resistance (1116 KPa) than all the other treatments at the 60mm depth including the undisturbed wood chip mulch. At 90 and 120 mm, soil resistance in the control plots was again higher than for the wood chip mulch, but similar to the tillage treatments. Data collected to date are inadequate to validate our hypothesis that the wood chip mulch would improve soil physical properties and the tillage would degrade them relative to the control.

Soil Resistance – August 2004

TRT	30 mm	60 mm	90 mm	120 mm	150 mm	180 mm
A Mow	227	1116a	1524a	1672a	1736abc	1773
B Wood Chip	229	830b	1104b	1239b	1413c	1565
C Cultivator Y 3x	141	719b	1326ab	1640a	1818ab	1865
D Cultivator Z 2x	135	664b	1437a	1833a	1941a	1916
E Cultivator Z 3x	197	759b	1336ab	1541a	1504bc	1711
p=	0.0703	0.0144	0.0245	0.0082	0.0307	0.4111

TRT	Soil Resistance (KPa)					
	240 mm	270 mm	300 mm	330 mm	360 mm	390 mm
A Mow	1739	1669	1676	1733	1826	1879
B Wood Chip	1638	1608	1570	1575	1604	1681
C Cultivator Y 3x	1823	1751	1711	1663	1695	1793
D Cultivator Z 2x	1899	1757	1762	1678	1745	1877
E Cultivator Z 3x	1763	1819	1895	1981	2104	2184
p=	0.8827	0.9062	0.7743	0.482	0.2573	0.2416

Soil Resistance (KPa). 2004.



Soil infiltration rate was measured in early August, after Cultivator Y and Cultivator Z (3x) plots had been tilled 3 times. Cultivator Z (2x) plots had been tilled twice. Three measurements per plot were taken. Six inch diameter rings were filled with water to a 1” ponded depth and time of infiltration recorded. Initial and follow-up (T1 and T2) infiltration rates were measured with Time 1 at ambient soil moisture near the end of an irrigation cycle when the soil was drier; and Time 2 following T1 to simulate soil moisture at field capacity. Infiltration in the Cultivator Y (3x) plots was significantly slower than in the other treatments. This difference is not explained by soil resistance, as results were similar to other treatments. Measurements on the wood chip plots were not valid and will be repeated in 2005.

Water Infiltration as measured by single-ring method. August 2004.

TRT	T1 (min/1" water)	T2 (min/1" water)
A Mow	0.696b	3.56b
B Wood Chip	NA	NA
C Cultivator Y 3x	2.328a	8.182a
D Cultivator Z 2x	0.732b	2.138b
E Cultivator Z 3x	1.188b	3.006b
p=	0.0007	0.0047

T1= time at ambient soil moisture; T2=time at field capacity.

Tree Growth

Mechanical tillage in the tree row does prune tree roots but we did not observe any adverse effects on tree growth during this first year of tillage. Shoot extension measured at the end of the growing season and leaf SPAD measured in July were similar for all

treatments. Tillage also disturbs rodent activity but again, we did not find any differences in total gopher mounds in the weed/mulch strips for any treatment.

Tree growth and gopher mounds. 2004

TRT	Shoot Growth (cm)	SPAD 7/8/2004	SPAD 7/23/2004	# Gopher Mounds 11/1/04
A Mow	62.1	38.5	41.2	2
B Wood chip	63.4	39.2	42.6	0.7
C Cultivator Y 3x	67.2	38.2	41.8	2.2
D Cultivator Z 2x	63.7	39.4	42.7	0.4
E Cultivator Z 3x	64.1	39.3	42.2	0.5
F Cultivator Z 4x	62.0	39.9	42.5	0.8
	p= 0.9526	0.5760	0.4202	0.7556

Weed cover

Treatments were ranked (0-5) for weed cover throughout the growing season, with 0= 0% and 5=100% cover. Initial measurements in April, prior to treatment application showed all treatment areas to have similar weed cover. Weed cover was similar for all the cultivation treatments by late season, but significantly less in the wood chip mulch which effectively suppressed weeds throughout the growing season. In the test orchard, annual weeds dominate and there are few perennial species other than dandelion. It will take at least 4 passes to provide adequate weed control. Tillage spurred a major flush of weeds up until mid-August. Depleting the weed seed bank could improve control.

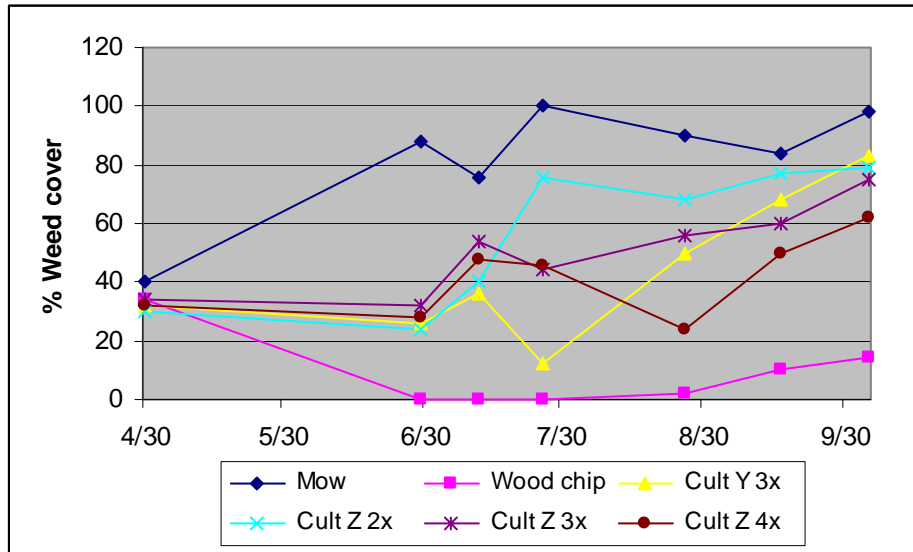
Weed cover rank

TRT	4/30/04	6/29/04	7/12/04	7/26/04	8/26/04	9/16/04	10/5/04
A Mow	2.0	4.40a	3.80a	5.0a	4.50a	4.20a	4.90a
B Wood chip	1.7	0c	0d	0d	0.10e	0.50e	0.70e
C Cultivator Y 3x	1.6	1.30b	1.80c	0.60d	2.50c	3.40b	4.16b
D Cultivator Z 2x	1.5	1.20b	2.00 bc	3.80b	3.40b	3.950a	3.90b
E Cultivator Z 3x	1.7	1.60b	2.70 b	2.20c	2.80bc	3.00bc	3.760b
F Cultivator Z 4x	1.6	1.40b	2.40 bc	2.30c	1.20d	2.50c	3.060c
G Cultivator Z 4x	1.7	1.60b	2.40 bc	1.50c	3.40b	1.70d	2.160d
	p= 0.5284	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Cultivator Z tillage dates: 5/26, 6/12, 7/13, and 8/13

Cultivator Y tillage dates: 5/19, 6/17, 7/13

Percent weed cover in the tree row during the 2004 growing season.



Cultivator Z tillage dates: (5/13), 5/26, 6/12, 7/13, 8/13. The 5/13 tillage was not very effective and we needed to modify equipment, therefore the 5/26 tillage was considered as 1x.
 Cultivator Y tillage dates: 5/19, 6/17, 7/13

Weed Biomass - 2004

Treatment	5/25/04 Biomass (g/m ²)	6/17/04 Biomass (g/m ²)	7/6/04 Biomass (g/m ²)	7/29/04 Biomass (g/m ²)	8/27/04 Biomass (g/m ²)
A Mow	122.7	98.3	65.5	58.56a	59.71b
B Wood chip	0	0	0.5	1.0c	2.00c
C Cultivator Y 3x				19.79bc	74.27ab
D Cultivator Z 2x				84.16a	78.88ab
E Cultivator Z 3x				51.33ab	107.36a
F Cultivator Z 4x					71.49b
p=				0.0017	0.0001

Cultivator Z tillage dates: 5/26, 6/12, 7/13, 8/13.
 Cultivator Y tillage dates: 5/19, 6/17, 7/13

Weed biomass was collected from treatments prior to selected tillage dates. On 5/26, a week following mulch application, biomass was measured in the control and mulched treatments. There would have been little biomass in the Cultivator Z (tilled 5/13 and repeated on 5/26 because of learning how to use equipment effectively – not a good tillage on 5/13 – 1x considered to be 5/26) and Cultivator Y plots (tilled 5/19) were tilled. Based on weed cover data, it is assumed that biomass was similar in all treatment areas prior to treatment application. Control plots were mowed and Cultivator Z plots were tilled after initial biomass collected. Cultivator Z plots were tilled on 5/26 and 6/12 and there was not much biomass to collect from these plots on 6/17. From visual weed cover data there were no significant differences among tilled plots so biomass should also have been similar. Biomass was not collected for tillage plots on 6/17, prior to tillage.

Conclusions

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. For Cultivator Z, the blade that sweeps weeds from between the trunks was less consistent in its weed control than the 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 costs and down time. Since it is front-mounted, it can also be used with another operation such as spraying or mowing, and thus the tractor/operator cost is virtually zero. 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* 38:41- 45.

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