Effect of Pre-plant Tillage on Pistachio Development Under Drip Irrigation

2008

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Summary

No published data on the benefit of preplant tillage exists for pistachios in California. Common wisdom for more than 60 years has been that a "good" orchard development should have some kind of ripping/deep tillage to a depth of 3 to 6 feet prior to planting. For many soils with hardpans and other layered structures this "just makes good sense" when considering the mechanics of root development and water penetration. Some older research was indeed carried out under flood irrigation (reported in Begg, et al., 1998) and found that tree size and yield in walnuts under flood irrigation increased in proportion to the amount of mixing in the top 4 feet of rootzone – with the least benefit given by ripping, slip-plowing next and deep moldboard plowing giving the greatest benefit.

In 1997 a new trial was installed in Arbuckle comparing cross-ripping to six feet on a four to six foot spacing to no pre-plant tillage in almonds in using microsprinkler irrigation (Edstrom and Cutter, 2004). Even though this soil has a pronounced hardpan and should benefit from slip plowing, as of the 2007 harvest there has been no real yield difference between treatments. The major difference between this and earlier trials is the microirrigation. The high frequency, uniform application of water on a more precise irrigation schedule appears to compensate for the soil moisture advantage that deep tillage provided under flood irrigation.

QUESTION: Are we really gaining any benefit from the $150 to $400/acre that is often spent for deep tillage prior to planting pistachios if we are going to use drip irrigation?

A deep tillage trial was established in Western Kern County in December 2005 comparing five different pre-plant tillage treatments ranging from no deep tillage and only using the standard one foot diameter by three foot deep 3-point post hole auger used to bore planting holes to backhoeing a three foot wide by seven foot deep trench down the tree row prior to planting.

UCB rootstocks were planted March 2006 to a 17 x 20 foot spacing and flood irrigated the first year due to lack of grower capital. The single hose drip system with six, 1 gph emitters/tree was installed January 2007 and irrigated with 4.5 inches of water during the 2007 season. Applied water for 2008 was 5.2 inches, with irrigations scheduled by soil moisture tension using Watermark Blocks.

At the end of the 2007 season soil salinity to 60 inches averaged 3.1 dS/m and 7.6 pH. A 1.5 ton/ac sulfur application concentrated into a 2 foot wide band successfully decreased average soil pH from about 8.0 prior to planting down to 6.8 to 7.3 to a 15 inch depth after two years. The deep tillage treatments gave an 18% increase in tree circumference at the end of the first year (2006) over the **Auger only** at planting.

After three years, however, tree development is virtually the same for all treatments with rootstock circumference at 4.1 inches and tree height at 8.1 feet as of 12/8/08; showing no benefit from any deep tillage. Leaf tissue nutrient concentrations have been essentially the same for **Auger** and **Backhoe** treatments since the end of 2006. As of 8/26/08 average tissue nutrient concentrations were all in the sufficient to optimum range with the exception of boron being less than 200 ppm.

Procedures

This deep tillage trial was established in western Kern County in December 2005 just inside the boundary of the ancient Buena Vista Lakebed where black Buttonwillow Clay is the dominant surface soil type. The ground has been farmed in cotton and wheat rotations for about 30 years. Soil salinity throughout the project area runs 1.5 to 5 dS/m and averages about 3.1 dS/m in the testplot area. Irrigation is supplied by a mix of canal and marginally saline well water. The soil in the area of the test plot is typical of the whole project area: Buttonwillow clay (0-2 feet) overlaying a Garces/Lethent clay loam (2-4 to 6 feet) with a weak caliche layer about 6 to 10 inches thick around the 3 foot depth. A Kimberlina coarse to fine sandy loam underlays the entire area at a depth of 5 to 7 feet. Tree rows were laid out and bagged with tillage treatments imposed directly over the row. A two-foot band of sulfur was applied over the treatments @ 15 ton/ac and incorporated to a depth of about two feet. UCB rootstock was planted March 2006 to an 17 x 20 foot spacing and flood irrigated the first year as the grower was unable to capitalize the drip system until December 2006. Standard tillage for the whole project was a slip plow down the tree row with a 15 inch shoe penetrating 42 to 50 inches. A 1.5 ton/ac rate of fine soil sulfur was applied in a 2 foot wide band over the slip trench (equivalent to 15 ton/applied acre) and incorporated to a depth of 20 to 24 inches with a modified furrowing shovel mounted to a 36 inch chisel shank to reduce alkalinity in the tree row. Drip tubing with 4, 1gph emitters was installed January 2007.

Treatments:

1) Auger only: no deep tillage. Row marked with furrowing shovel, sulfur applied as above and incorporated with second pass of same shovel. Standard 3 point hitch auger to be used at planting same as all other treatments.

2) Cotton chisels: standard gang of seven, 36 inch chisels, one pass down the tree row to a depth of 30 inches.

3) Slip plow (Control): single slip plow 42 to 50 inch depth as used on rest of project.

4) Triple slip: slip plow treatment down tree row (as above) with an additional pass 6 foot on either side. A final fourth pass was repeated down the center (tree row) pass to achieve a 60 inch penetration and further fracture the profile. This treatment is meant to be similar from the benefit gained by "straddle ripping" after slip plowing.

5) Backhoe to 7 feet: *(installed as a subplot in the Triple Slip treatment)* a 3 x 51 foot trench to 7 feet was excavated along the space that will be occupied by trees 4, 5 and 6 (counting from the West). This subplot provides for replicated observations on trees receiving the maximum amount of deep tillage possible.

Data Collection and Analysis: (Note: this project is designed to require a minimum amount of monitoring and data collection on a yearly basis to keep down costs and time commitments; assuming no observed differences in tree growth.)

Applied irrigation water: 2 small flowmeters were installed at the riser outlet of the Auger and Triple Slip treatments in the third block to insure equal amounts of applied water. Total water applied will be checked mid-season and after irrigation ceases.

Soil moisture monitoring: The grower elected to install a Hanson AM400 logger connected to Watermark sensors placed in the same rows as the above water meters at the 24 and 48 inch depths with a third sensor installed 3 foot deep and 3 feet away from the drip hose and adjacent to the sixth tree to the east of the farm drive.

Soil and water salinity: For the **Auger only** and **Backhoe treatments,** one soil sample will be composited from all replications for the 0-15, 15-30, 30-45 and 45-60 inch depths will be taken mid-season and analyzed for EC, pH, Ca, Mg, Na, Cl, HCO3, B, NO3-N, PO4-P, K, Zn, Mn, Cu, and Fe. The irrigation water will be analyzed for the same salts at the same time.

Plant data (years 1-6): Trunk circumference will be measured at the end of the season on trees 1 through 10 from the west in all plots. Mid-season leaf tissue Ca, Mg, Na, Cl, B, N, P, and K will be determined for a single composite sample of the **Auger only** and the **Backhoe** treatments**.** This assumes that there will be no treatment differences in tree circumference and visual appearance. If differences appear then replicated tissue samples should be taken, which will significantly increase costs.

Plant data (years 7-10): Replicated yield and quality, in addition to the above.

shoot) averaged 94.9 cm; an 11% increase for deep tillage. These differences were not obvious to the eye as you walked through the trial area and are very small in terms of overall biomass. But by the end of 2007 and 2008 seasons there was no difference in circumference or tree height for any tillage treatment (Figure 2).

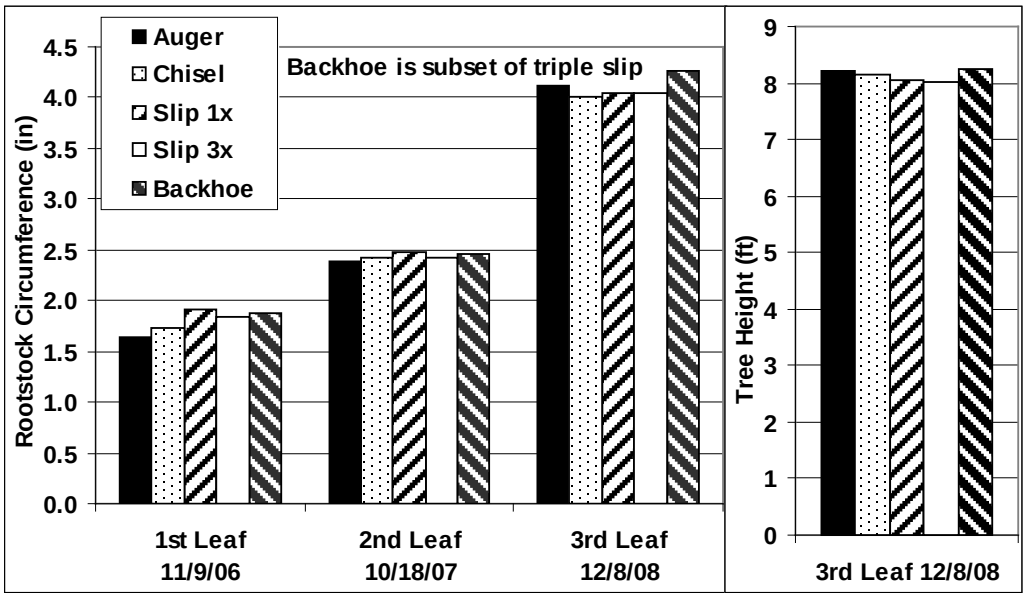

Fig. 2. Rootstock circumference and tree height for all treatments and years.

Applied irrigation was estimated at 8 inches for 2006, measured 4.5 inches for 2007 season, and 5.2 inches for 2008. The grower liked to irrigate in 48 hour sets on this extremely fine Button-willow clay in order to push salts away from the tree and sub water out to 3 to 4 feet. As the grower tended to schedule his irrigations by soil water tension estimates from the Watermark sensors and in this very high water holding capacity soil this would result in very long intervals between irrigations – with one 5 irrigations for the whole season (Figure 3).

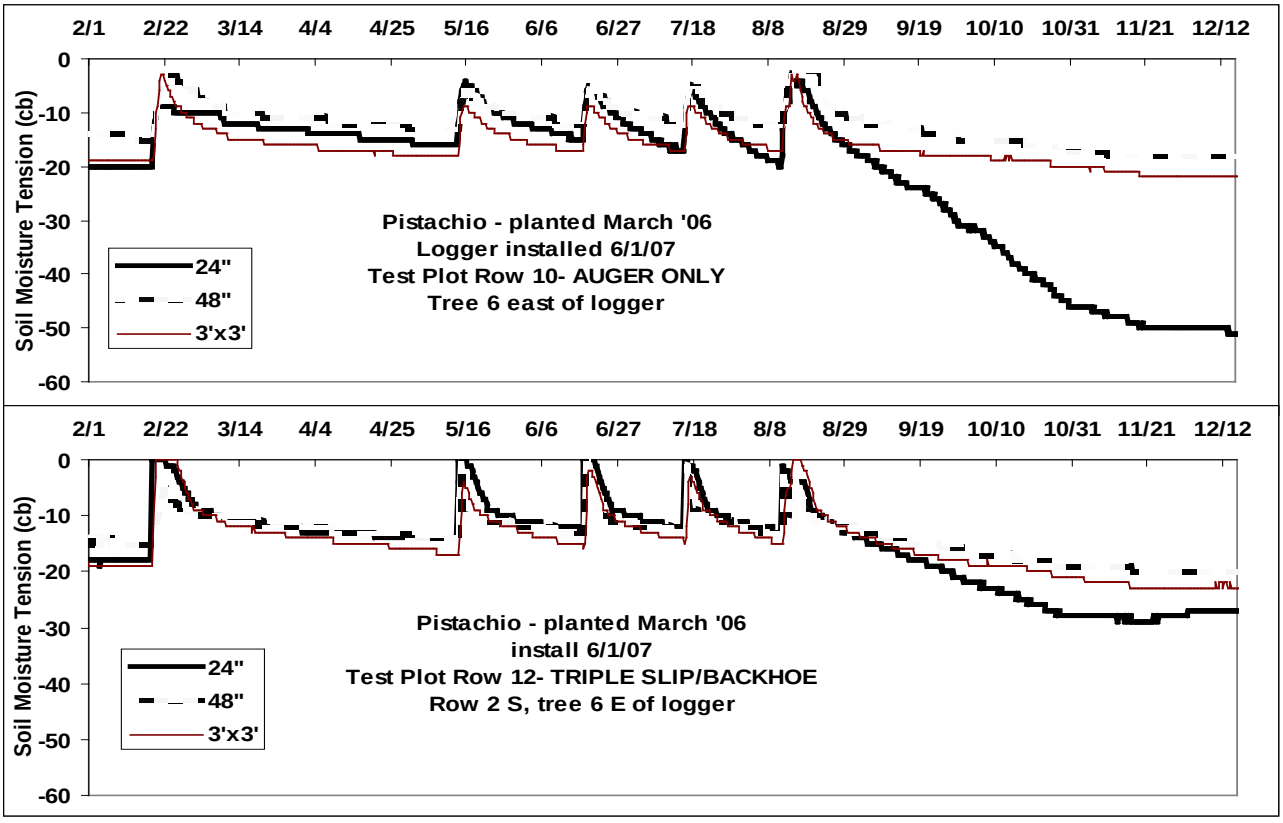

Fig. 3. Soil moisture tensions near trees in AUGER and TRIPLE SLIP/BACKHOE treatments are virtually identical.

At the end of 2006 composite soil salinity to 60 inches averaged 2.3 dS/m and 7.6 pH. As of 10/19/08, average soil salinity (ECe) had increased to 3.15 dS/m and the pH dropped to 7.4 (Table 1). The soluble calcium more than doubled down to a 3 foot depth over 2006 due to the continued acidification of the fine-grained soil sulfur and was by and large the reason for an increase in soil EC. There appears to be no major difference in soil salts/nutrients between the Auger and Backhoe treatments except that a higher nitrate and potassium concentration was measured in the Auger treatment. If this aberration persists when results from the 2008 soil sampling become available then we will do replicated soil sampling on the top 15 inches.

Table 1. Soil analyses for composite samples from Auger and Backhoe treatments as of 10/19/07

Auger **Date Sampled: 10/19/07**

Depth (inches)	**SP** %	**pH**	EC dS/m	SAR	Ca meq/l	Mg meq/l	Na meq/l	Cl meq/l	B ppm	HCO3 meq/l	CO3 meq/l
0-15"	50	7.3	5.2	4.8	32.6	5.6	21.0	9.6	0.6	3.4	<0.1
15-30	55	7.4	3.6	4.6	22.3	4.1	16.8	3.4	0.4	2.9	<0.1
30-45	54	7.8	1.8	7.7	4.1	1.2	12.6	1.2	0.5	2.9	<0.1
45-60	46	7.9	1.8	10.2	2.9	1.2	14.6	1.4	0.6	3.3	<0.1

Soil Fertility 10/19/07 -- Auger Treatment

Depth (inches)	NO3-N (ppm)	Olsen-P (ppm)	AA-K (ppm)	Zn (Total)	Mn (Total)	Cu (Total)	Fe (Total)
0-15"	132.3	15.7	353	66	202	19	24800
15-30	48.1	6.9	236	60	181	20	25400
30-45	11.9	4.0	170	53	204	17	22000
45-60	8.3	2.3	147	53	340	15	21600

Backhoe **Date Sampled: 10/19/07**

Depth (inches)	**SP** %	**pH**	EC dS/m	SAR	Ca meq/l	Mg meq/l	Na meq/l	Cl meq/l	B ppm	HCO3 meq/l	CO3 meq/l
0-15"	52	6.8	4.0	2.8	30.7	7.50	12.4	4.8	0.40	4.3	<0.1
15-30	54	7.4	3.3	3.4	23.7	5.40	12.8	1.9	0.30	2.6	<0.1
30-45	53	7.5	2.7	5.2	12.9	3.40	14.9	1.7	0.40	3.0	<0.1
45-60	47	7.6	2.7	5.8	11.6	3.60	16.0	1.8	0.50	2.6	<0.1

Soil Fertility 10/19/07 -- Backhoe Treatment

Depth (inches)	NO3-N (ppm)	Olsen-P (ppm)	AA-K (ppm)	Zn (Total)	Mn (Total)	Cu (Total)	Fe (Total)
0-15"	35.9	19.8	214	59	274	18	24100
15-30	17.6	5.1	203	61	237	20	24700
30-45	12.8	4.2	204	60	258	18	24400
45-60	11.6	3.6	177	57	251	17	23300

Leaf tissue nutrient concentrations have been essentially the same for **Auger** and **Backhoe** treatments since the end of 2006. As of 8/26/08 average tissue nutrient concentrations were all in the sufficient to optimum range with the exception of boron being less than 200 ppm (Table 2).

Table 2. Leaf tissue analyses for Auger and Backhoe treatments for all years.

Treatment	N %	P %	K %	S ppm	B ppm	Ca %	Mg %	Na ppm	Cl %	Zn ppm	Mn ppm	Fe ppm	Cu ppm
2006	**Date Sampled: 11/9/06; Grower/Location/Project: Houchin Ripping**												
Auger	2.42	0.22	2.03	1610	91	1.78	0.22		0.18	19	28	97	7.4
Backhoe	2.43	0.21	1.89	1610	102	1.54	0.22		0.18	14	24	106	6.8
2007	**Date Sampled: 10/19/07; Grower/Location/Project: Houchin Ripping**												
Auger	1.97	0.14	2.04	1490	182	3.02	0.38	128	0.21	10	26	99	6.1
Backhoe	1.88	0.14	2.09	1410	164	2.75	0.33	146	0.21	8	18	142	6.8
2008	**Date Sampled: 8/26/08; Grower/Location/Project: Houchin Ripping**												
Auger	2.43	0.14	2.31		172			95	0.15	9	23	59	5.5
Backhoe	2.37	0.15	2.27		160			97	0.16	6	17	61	7.0

Conclusions and Practical Application

After three years, however, tree development is virtually the same for all treatments with rootstock circumference at 4.1 inches and tree height at 8.1 feet as of 12/8/08; showing no benefit from any deep tillage. A few trees show marginal growth, but this has no correlation with any tillage treatment and is likely a function of variable tree genetics combined with isolated "hotspots". The 1.5 t/ac sulfur that was laid down in a two foot wide band (15 t/applied ac) and incorporated to a depth of 24 inches was successful in lowering pH and sodicity and increasing available calcium, phosphate and potassium.

Typical deep tillage costs run $150 to $400/acre depending on the soil and intensity/depth of modification. This will only increase as diesel costs continue to climb. A $300/ac investment over a 30 year orchard life @ 5% interest is eventually worth $1,297/ac. That's $300,000 cash for a 1,000 acre development with an eventual investment cost of $1.3 million. Of course, at $2/lb for splits this is only 862 lbs/ac of pistachios, basically 50 lb/ac/yr for 20 years to pay for the tillage. We all pay for insurance, and preplant deep tillage may fall into that category. No one thinks they'll die tomorrow, but once you're "planted" it's too late to buy life insurance!

Acknowledgements

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