http://www.acpistachios.org/Industry/research

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

2010

Progress Report for the California Pistachio Commission

December 31, 2010

Author Listing

Blake Sanden, Irrigation and Agronomy Advisor, UCCE Kern County; Louise Ferguson, UCCE Pomology Specialist, Kearney Ag. Center; Craig Kallsen, Subtropical Crops and Pistachio Advisor, UCCE Kern County

Cooperators

Houchin Farmining/Buttonwillow Warehouse, Larry Antongiovanni

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 and 12.5 inches for 2009, with irrigations scheduled by soil moisture tension using Watermark Blocks combined with Goldhamer Kc values.

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 five years, however, there is no significant difference in the rootstock circumference of any treatments; showing no benefit from any deep tillage. As of 7/30/09 soil salinity to 60 inches averaged 3.4 dS/m and 7.8 pH. Leaf tissue nutrient concentrations have been essentially the same for **Auger** and **Backhoe** treatments since the end of 2006. As of 7/15/10 soil salinity to 60 inches averaged 1.5 dS/m and 7.8 pH. July tissue nutrient concentrations were virtually the same for **Auger** and **Backhoe** treatments at 2.48% N, 0.15% P and 1.80% K. Ironically, considering the Westside location of the orchard, boron is low for both treatments @ 105 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/applied acre 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.

Fig. 1. Trial boundaries and plot layout for ripping trial.

Results and Discussion

A total of one pre-irrigation and three in-season irrigations (18 inches total as irrigations were applied just down the tree row) were sufficient to supply trees with adequate moisture in this heavy black clay in 2006. At the end of the first season the rootstock circumference for the most intensive tillage treatments averaged 1.87 inches; a significant 18% advantage over the auger and chisel only treatments. For the same treatments tree height (Kerman scion or UCB 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 since the end of 2007 there has been no significant difference in trunk circumference or tree height for any tillage treatment (Figure 2).

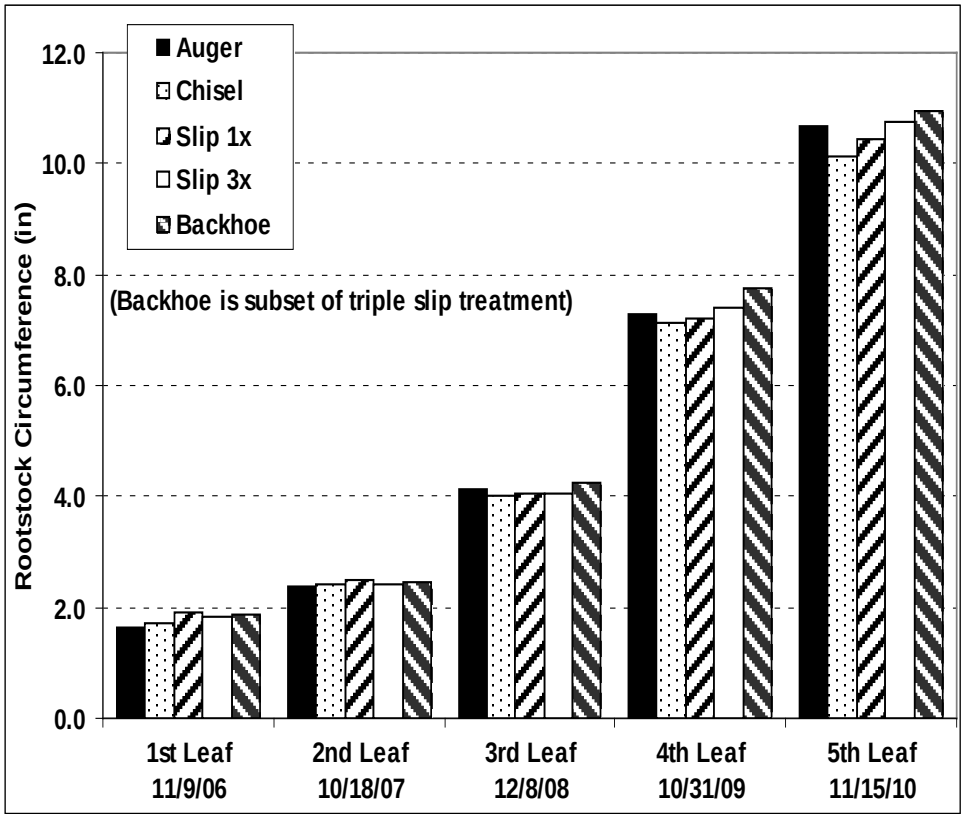

Fig. 2. Rootstock circumference and tree height for all treatments and years.

Applied irrigation was estimated at 8 inches for flood in 2006 and measured at 4.5, 5.2, 12.5 and 18.0 inches for drip irrigation for 2007, '08, '09 and '10 seasons respectively. The grower liked to irrigate in 48 hour sets on this extremely fine Buttonwillow 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 only 5 irrigations for the whole season in 2008 and 12 irrigations for 2009. The grower ran more 24 hour sets in 2010 to reduce transient water logging.

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 and zinc being marginally low. Tissue nutrient concentrations on 7/15/10 were still the same for the **Auger** and **Backhoe** treatments at 2.48% N, 0.15% P and 1.80% K. Boron is low for both treatments @ 105 ppm. (Table 1).

At the end of 2006 composite soil salinity to 60 inches averaged 2.3 dS/m and 7.6 pH. As of 7/30/09, average soil salinity (ECe) increased to 3.35 dS/m and pH increased to 7.8 (Table 2) even though it had dropped to 7.4 as of October 2008. This is surprising in light of the 15 t/applied acre sulfur application banded down the tree row prior to planting, which did result in a large release of free calcium through 2008. Incorporation of the sulfur to a two foot depth was excellent and we expected to see pH continue to fall, but it is not entirely surprising to see this result as there is a large buffering capacity from precipitated lime in this soil. Thus, after an initial increase in salinity from the additional calcium and a subsequent

improvement in leaching the soluble sodium down to a 3 foot depth has continued to decline to less than 50% of original levels. As of 7/15/10 soil salinity to 60 inches averaged 1.5 dS/m and 7.8 pH.

Table 1. 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
2009	**Date Sampled: 7/30/09; Grower/Location/Project: Houchin Ripping**												
Auger	2.73	0.18	2.30		154			46	0.18	8	30	65	7.3
Backhoe	2.44	0.15	1.93		153			49	0.16	9	18	57	6.9
2010	**Date Sampled: summer 2010; Grower/Location/Project: Houchin Ripping**												
Auger	2.44	0.15	1.84		110			134	0.15	27	36	56	14.7
Backhoe	2.51	0.14	1.75		100			144	0.18	31	21	50	18.9

Table 2. Soil analyses for composite samples from Auger and Backhoe treatments as of 7/21/10

Auger **Date Sampled: 7/21/10**

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"	58	7.5	1.44	3.24	7.20	1.23	6.65	2.06	0.23	2.8	<0.1
15-30	66	7.8	1.29	4.28	4.94	1.02	7.38	1.65	0.28	2.3	<0.1
30-45	58	8.0	2.13	6.30	7.61	1.81	13.68	2.12	0.45	1.5	<0.1
45-60	48	8.0	2.23	10.19	4.45	1.50	17.58	2.38	0.55	1.9	<0.1

Soil Fertility summer 2010 -- Auger Treatment

Depth (inches)	NO3-N (ppm)	Olsen-P (ppm)	AA-K (ppm)	Zn (DTPA)	Mn (DTPA)	Cu (DTPA)	Fe (DTPA)
0-15"	10.57	39.1	361	1.8	5.5	1.3	11.7
15-30	11.07	5.8	198	0.4	1.0	1.2	6.5
30-45	12.52	3.9	89	0.1	0.4	0.8	1.5
45-60	11.42	2.3	98	0.2	0.7	0.4	3.7

Backhoe **Date Sampled: 7/21/10**

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"	56	7.7	0.86	2.67	3.70	0.75	3.98	1.10	0.19	1.7	<0.1
15-30	58	7.8	0.91	3.38	3.54	0.77	4.96	1.06	0.21	2.0	<0.1
30-45	57	8.0	1.26	4.83	4.11	1.07	7.78	1.61	0.31	1.8	<0.1
45-60	58	7.9	2.12	5.89	7.54	2.47	13.18	1.80	0.38	1.8	<0.1

Soil Fertility summer 2010 -- Backhoe Treatment

Depth (inches)	NO3-N (ppm)	Olsen-P (ppm)	AA-K (ppm)	Zn (DTPA)	Mn (DTPA)	Cu (DTPA)	Fe (DTPA)
0-15"	10.72	15.2	221	1.7	2.4	1.3	4.1
15-30	6.22	3.9	183	0.3	1.8	0.8	4.4
30-45	6.27	2.8	148	0.2	1.5	0.7	2.5
45-60	6.57	2.0	144	0.2	1.9	0.6	3.1

Conclusions and Practical Application

After five years, tree development is virtually the same for all treatments with rootstock circumference at 10.6 inches and tree height at 13 feet as of 11/15/10; 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 significantly lowering sodicity through displacement by calcium and leaching, slightly lowering pH slightly 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

I am grateful to Clay Houchin of Houchin Farming/Buttonwillow Warehouse for his cooperation in allowing this trial to go forward. I also wish to thank Larry and Beau Antongiovanni of Bella Vista Farm Management for their timely management and interaction over the season.

Literature Cited

Begg, E.L., G.L. Huntington, and W.E. Wildman. 1998. *Walnut Production Manual,* Evaluation and Modification of Soils. University of California Division of Agriculture and Natural Resources. Publication 3373. Chapter 6. Pp. 51.

Edstrom, J., S.Cutter. 2004. Nickels soil lab projects Deep tillage slip plow affects on almonds. 2004 Conference Proceedings, CA Almond Board. Pp.75-76