Nitrogen considerations for whole orchard recycling

by

Holtz, B.[1], Browne, G.[2], Doll, D.[3], Lampinen, B.[4], Gaudin, A.[4], Culumber, M.[5], Yaghmour, M.[6], Gordon, P.[7], and Jahanzad, E.[4]

University of California Cooperative Extension, San Joaquin[1]*, Merced*[3]*, Fresno*[5]*, Kern*[6]*, and Madera*[7] *Counties, USA*

[2]*USDA-ARS, University of California, Davis, USA*

[4]*Plant Science, University of California, Davis, USA*

University of California
Agriculture and Natural Resources

Can we return this organic matter to our orchard soils without negatively effecting the next orchard that will be planted?

Can whole orchards be incorporated into the soil when they are removed and not burned in the field or in a co-generation plant?

- When we remove an orchard we grind up 25-30 years worth of photosynthesis and carbon and nutrient accumulation and haul it away. 25-30 years of organic matter is lost from our system, estimated at 60 tons per acre for almond.


The Iron Wolf

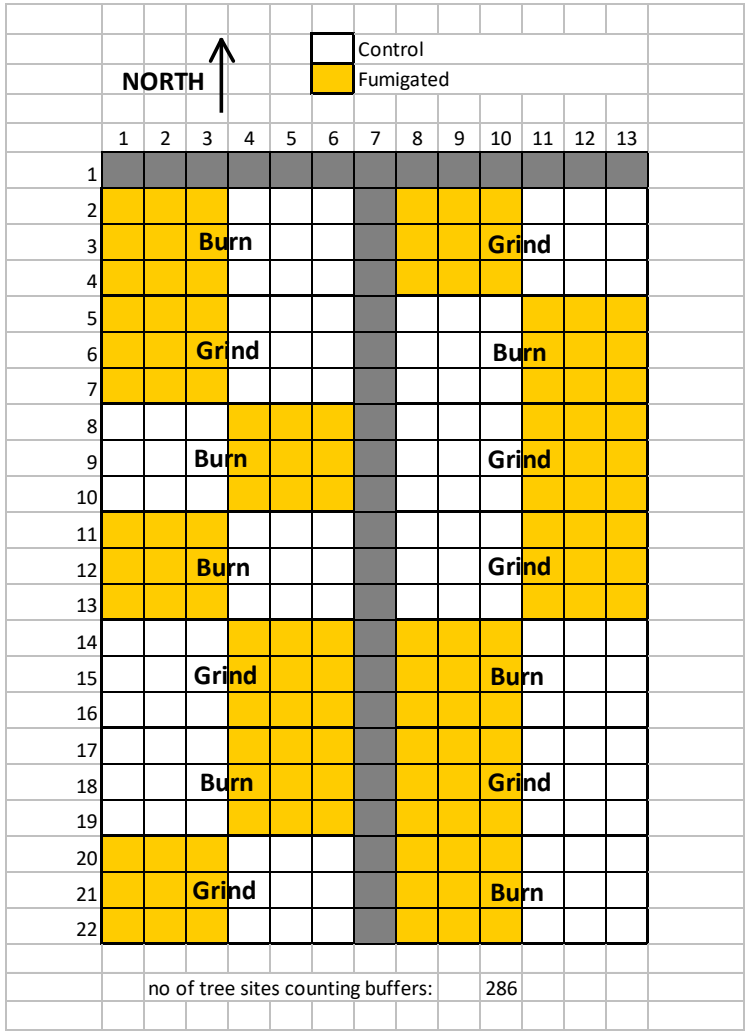
http://ucanr.edu/?blogpost=16603&blogasset=74534

The Iron Wolf
a 100,000 lb (45,000 kg) rototiller


The Iron Wolf

Two Treatments:
Orchard Grinding with Iron Wolf
Pushing and Burning Trees

In a natural forest system– Tree nutrients come from either decomposing logs or ashes from forest fires.


NORTH
Control
Fumigated
1 2 3 4 5 6 7 8 9 10 11 12 13
1
2
3 Burn Grind
4
5
6 Grind Burn
7
8
9 Burn Grind
10
11
12 Burn Grind
13
14
15 Grind Burn
16
17
18 Burn Grind
19
20
21 Grind Burn
22
no of tree sites counting buffers: 286

2009 First leaf trees growing in grinding plot

2010 Second leaf trees

No difference in tree circumference

The Grinding did not stunt the second generation orchard

2011 Third leaf trees growing in grinding plot

2012 Fourth leaf trees growing in grinding plot

Soil Analysis

	2010		2011		2012	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	4.06 a	4.40 b	2.93 a	3.82 b	4.27 a	3.17 b
Na (ppm)	19.43 a	28.14 b	13.00 a	11.33 b	11.67 a	12.67 a
Mn (ppm)	11.83 a	8.86 b	12.78 a	9.19 b	29.82 a	15.82 b
Fe (ppm)	32.47 a	26.59 b	27.78 a	22.82 b	62.48 a	36.17 b
Mg (ppm)	0.76 a	1.52 b	1.34 a	1.66 a	2.05 a	1.46 b
B (mg/L)	0.08 a	0.07 a	0.08 a	0.08 a	0.08 a	0.05 b
NO_3-N (ppm)	3.90 a	14.34 b	8.99 a	11.60 a	19.97 a	10.80 b
NH_4-N (ppm)	1.03 a	1.06 a	2.68 a	2.28 a	1.09 a	1.06 a
pH	7.41	7.36	6.96 a	7.15 b	6.78 a	7.12 b
EC (dS/m)	0.33 a	0.64 b	0.53	0.64	0.82 a	0.59 b
CEC(meq/100g)	7.40 a	8.47 b	8.04	7.88	5.34	5.32
OM %	1.22 a	1.38 b	1.24	1.20	1.50 a	1.18 b
C (total) %	0.73 a	0.81 a	0.79 a	0.73 a	0.81 a	0.63 b
C-Org-LOI	0.71 a	0.80 b	0.72	0.70	0.87 a	0.68 b
Cu (ppm)	6.94 a	6.99 a	7.94 a	7.54 a	8.87 a	7.92 b

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Soil Analysis

	2013		2014		2015	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	3.78 a	3.25 b	7.55 a	5.45 b	4.02 a	1.36 b
Na (ppm)	2.74 a	1.90 b	3.41 a	2.34 b	2.32 a	1.21 b
Mn (ppm)	26.35 a	5.71 b	14.46 a	10.65 b	7.31 a	4.67 b
Fe (ppm)	32.56 a	20.38 b	38.58 a	29.30 b	24.29 a	17.21 b
Mg (ppm)	2.15 a	1.20 b	3.61 a	2.57 b	2.01 a	0.68 b
B (mg/L)	0.06	0.07	0.07 a	0.10 b	0.05 a	0.07 b
NO_3-N (ppm)	20.11	12.27	26.53 a	18.89 b	20.64 a	5.23 b
NH_4-N (ppm)	0.37	0.33	1.59 a	1.36 b	0.89 a	0.65 b
K (mg/L)	94.50	84.88	28.50 a	13.60 b	19.76 a	16.97 b
pH	7.39 a	7.53 b	6.95	7.06	7.27 a	7.60 b
EC (dS/m)	0.91 a	0.68 b	1.54 a	1.08 b	0.90 a	0.38 b
CEC(meq/100g)	9.54	10.16	7.78	8.30	5.16	5.14
OM %	1.55 a	1.06 b	1.21 a	0.93 b	1.37 a	1.08 b
C (total) %	0.87 a	0.51 b	0.71 a	0.54 b	0.66 a	0.50 b
C-Org-LOI	0.87 a	0.61 b	0.70 a	0.54 b	0.79 a	0.62 b
Cu (ppm)	8.26 a	7.11 b	8.03	7.73	7.51 a	7.03 b

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Soil Analysis

	2016		2017		2018	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	5.53 a	2.66 b	3.02	3.05		
Na (ppm)	1.50 a	1.20 b	0.89 a	0.72 b		
Mn (ppm)	10.86 a	7.66 b	9.03 a	6.79 b		
Fe (ppm)	30.25 a	23.15 b	33.23 a	28.01 b		
Mg (ppm)	2.60 a	1.29 b	1.46	1.43		
B (mg/L)	<0.05	<0.05	0.30	0.31		
NO_3-N (ppm)	13.87 a	10.50 b	11.93	12.66		
NH_4-N (ppm)	1.15 a	0.98 b	1.39	1.31		
K (mg/L)	54.78 a	11.33 b	11.06	11.68		
pH	7.20 a	7.37 b	6.94	7.02		
EC (dS/m)	1.21 a	0.56 b	0.57	0.58		
CEC(meq/100g)	8.35	9.25	8.23	7.78		
OM %	1.41 a	1.10 b	1.52 a	1.07 b		
C (total) %	0.82 a	0.55 b	0.79 a	0.55 b		
C-Org-LOI	0.82 a	0.64 b	0.88 a	0.62 b		
Cu (ppm)	8.43	8.20	9.25	9.25		

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Leaf Analysis

	Nitrogen %		Phosphorus %		Potassium %		Magnesium %		Manganese ppm		Iron ppm		Sodium ppm	
	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn
2010	2.40 a	2.33 b	0.11 a	0.10 b	1.76 a	1.44 b	0.98 a	1.03 b	23.63 a	17.44 b	102.5	104.3	340.5 a	455.5 b
2011	2.58	2.58	0.14	0.14	1.92 a	1.67 b	0.66 a	0.71 b	25.70	24.91	91.34	93.75	19.38 a	54.00 b
2012	2.46	2.44	0.13	0.13	1.14 a	1.02 b	0.87	0.90	20.13	19.13	84.84	83.95	24.88 a	49.50 b
2013	2.57 a	2.49 b	0.112 a	0.106 b	0.94 a	0.73 b	1.04 a	1.12 b	27.83 a	23.25 b	113.59 a	102.79 b	634.6 a	957.5 b
2014	2.40 a	2.33 b	0.11 a	0.10 b	1.76 a	1.44 b	0.98 a	1.03 b	23.63 a	17.44 b	102.5	104.0	340.5 a	455.5 b
2015	2.42	2.39	0.12	0.11	1.66 a	1.43 b	0.97	1.01	23.96 a	17.88 b	142.5	148.22	243.8 a	358.22 b
2016	2.77	2.75	0.14	0.14	1.35 a	1.16b	0.93	0.97	24.46 a	21.58 b	97.09 a	88.20 b	207.1 a	335.38 b
2017	2.57 a	2.50 b	0.12	0.12	1.28	1.20	1.09	1.09	29.23 a	27.11 b	199.50 a	225.63 b	353.50	392.88

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Trunk Diameter

Butte Variety (cm)

Year	Grind	Burn	P value
2009	4.87	4.96	P= 0.19
2010	14.56	15.22	P=0.07
2011	22.39	22.72	P=0.38
2012	30.53	30.23	P=0.18
2013	38.52	37.73	P=0.09
2014	46.50 a	45.24 b	P=0.01
2015	55.71 a	53.79 b	P=0.01
2016	63.15 a	60.58 b	P=0.007
2017			

Butte Variety, Kernel pounds/acre

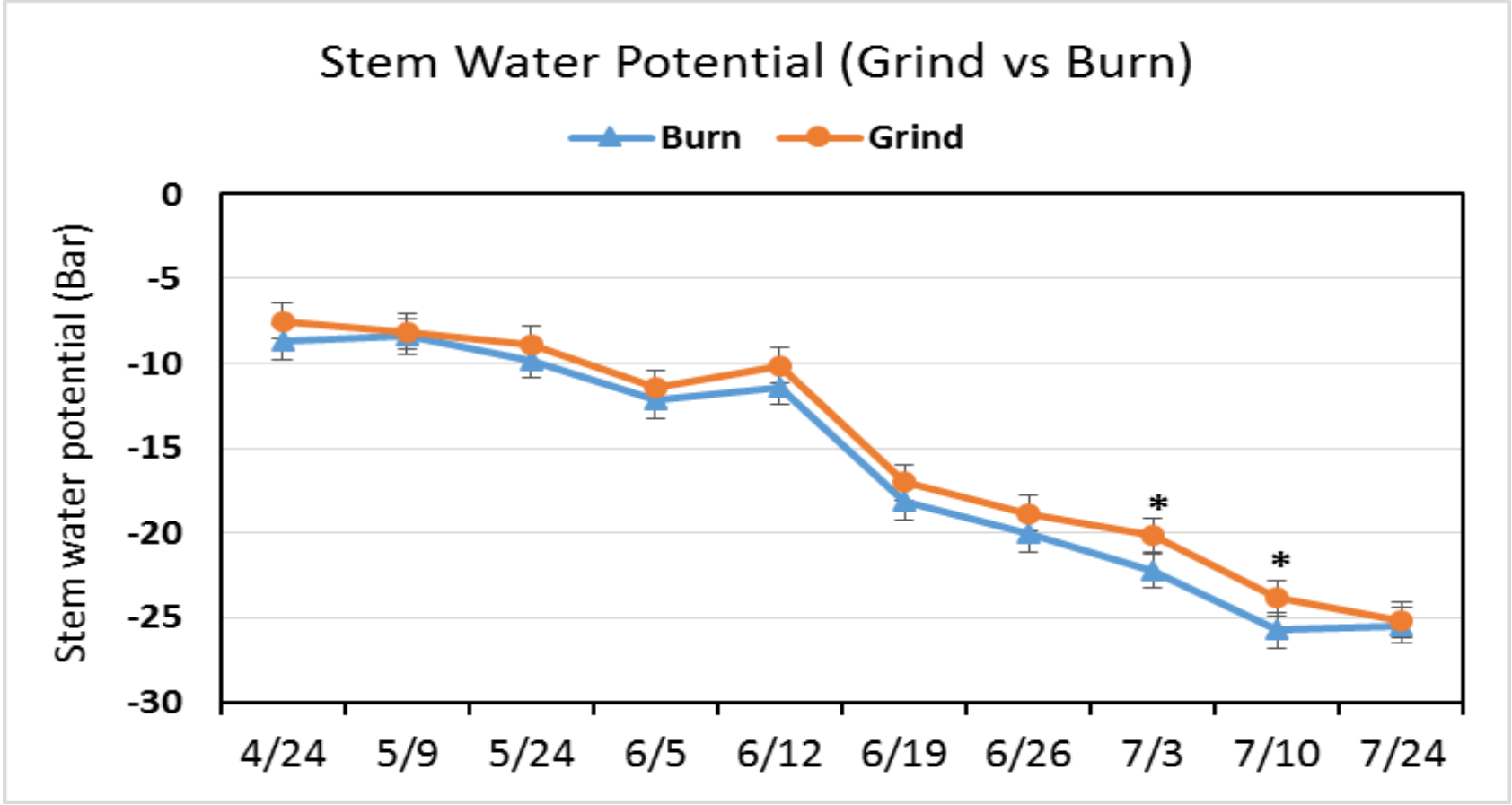
Year	Grind	Burn	Difference
2011	687.40 lbs/ac	687.37 lbs/ac	0.03 lbs/ac (P= 0.49)
2012	1,472.40 lbs/ac	1,379.42 lbs/ac	92.98 lbs/ac (P=0.19)
2013	1909.64 lbs/ac	1667.91 lbs/ac	241.73 lbs/ac (P=0.05)
2014	2272.11 lbs/ac	1767.25 lbs/ac	504.86 lbs/ac (P=0.12)
2015	1,072.90 lbs/ac	877.54 lbs/ac	195.36 lbs/ac (P=0.11)
2016	1,341.97 lbs/ac	1,206.96 lbs/ac	135.01 lbs/ac (P=0.14)
2017	1956.01 lbs/ac	1539.17 lbs/ac	416.84 lbs/ac (P=0.07)
Total	**10,712.43 lbs/ac**	**9,125.62 lbs/ac**	**1,586.81 lbs/ac**

Nonpareil Variety, Kernel pounds/acre

Year	Grind	Burn	Difference
2014	2,147.02 lbs/ac	1,957.97 lbs/ac	189.05 lbs/ac (P=0.02)
2016	2,821.86 lbs/ac	2,386.02 lbs/ac	435.84 lbs/ac (P=0.03)
2017	2,246.66 lbs/ac	1,871.86 lbs/ac	374.80 lbs/ac (P=0.01)
Total	**7,215.54 lbs/ac**	**6,966.98 lbs/ac**	**999.69 lbs/ac**

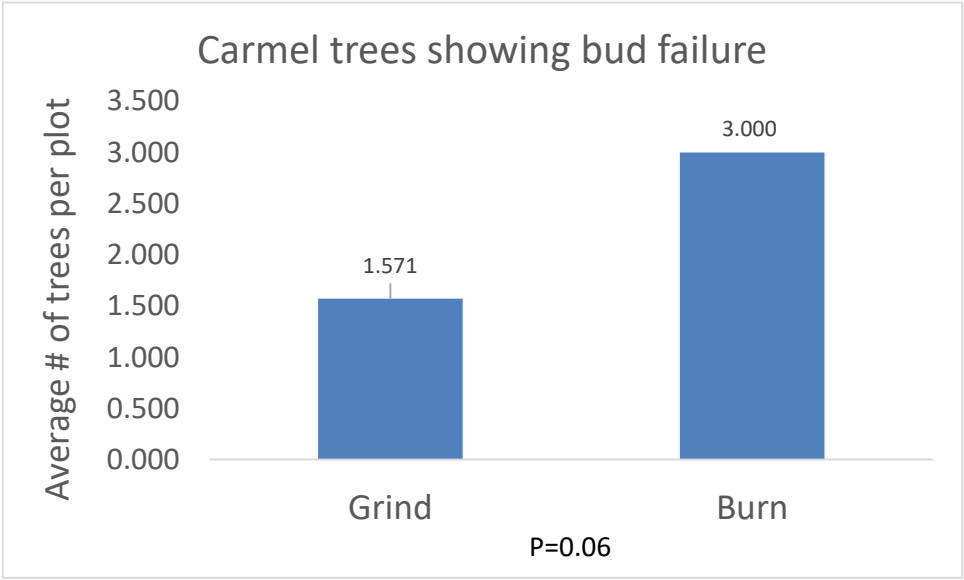
% photosynthetically Active radiation (PAR) light interception

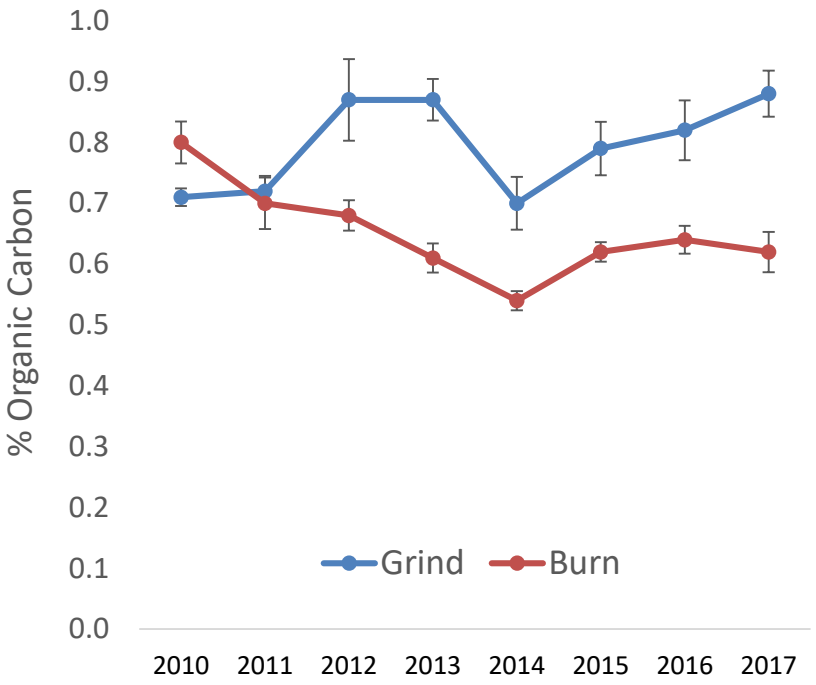
Date	Variety	Treatment	PAR(%)	Yield (kernel lbs/ac)	Yield per unit PAR intercepted
10/16/17	Butte	Grind	56.8 a	2025 a	35.1 a
		Burn	54.3 a	1590 a	29.1 a
10/16/16	Nonpareil	Grind	66.0 a	2268 a	34.3 a
		Burn	61.4 a	1868 a	30.7 a

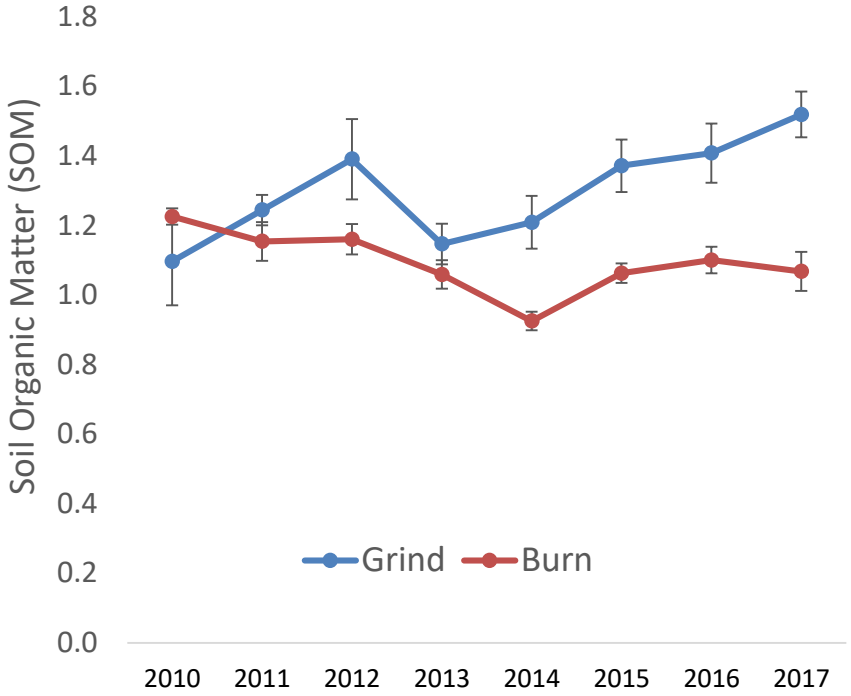

Stem Water Potential (Grind vs Burn)
Burn
Grind
Stem water potential (Bar)
0
-5
-10
-15
-20
-25
-30
4/24
5/9
5/24
6/5
6/12
6/19
6/26
7/3
7/10
7/24
*
*

Carmel trees were rated for bud failure symptoms

Trees growing in the grind plots had less bud failure




% Organic Carbon
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Grind
Burn
2010
2011
2012
2013
2014
2015
2016
2017


Soil Organic Matter (SOM)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Grind
Burn
2010
2011
2012
2013
2014
2015
2016
2017

Whole Orchard Recycling has:

- Increased soil organic matter
- Increased soil organic carbon
- Increased soil nutrients
- Increase soil microbial diversity
- Increased orchard productivity

Closure of more biomass plants reduces options

By Christine Souza

The closure or threatened closure of more California biomass power plants leaves farmers with fewer options for disposing of tree prunings or of trees uprooted during planned orchard removals.

"The last few projects that we've done,

AgAlert®

THE WEEKLY NEWSPAPER FOR CALIFORNIA AGRICULTURE

A few growers have used manure spreaders to spread wood chips back on the soil surface

G & F Ag Services orchard removal typically involves 5 machines and costs ~$600 acre

Wood chips are spread uniformly over entire field surface

G & F Ag Services in Ripon has purchased two Kuhn & Knight Spreaders and modified them for spreading wood chips.

Keeping the chips and having them spread back onto your orchard floor will cost and additional $400 acre.

After spreading the woodchips growers can proceed with typical land preparation practices for the next orchard: ripping, disking, fumigation….

When 64 tons of wood chips are returned to the soil per acre:

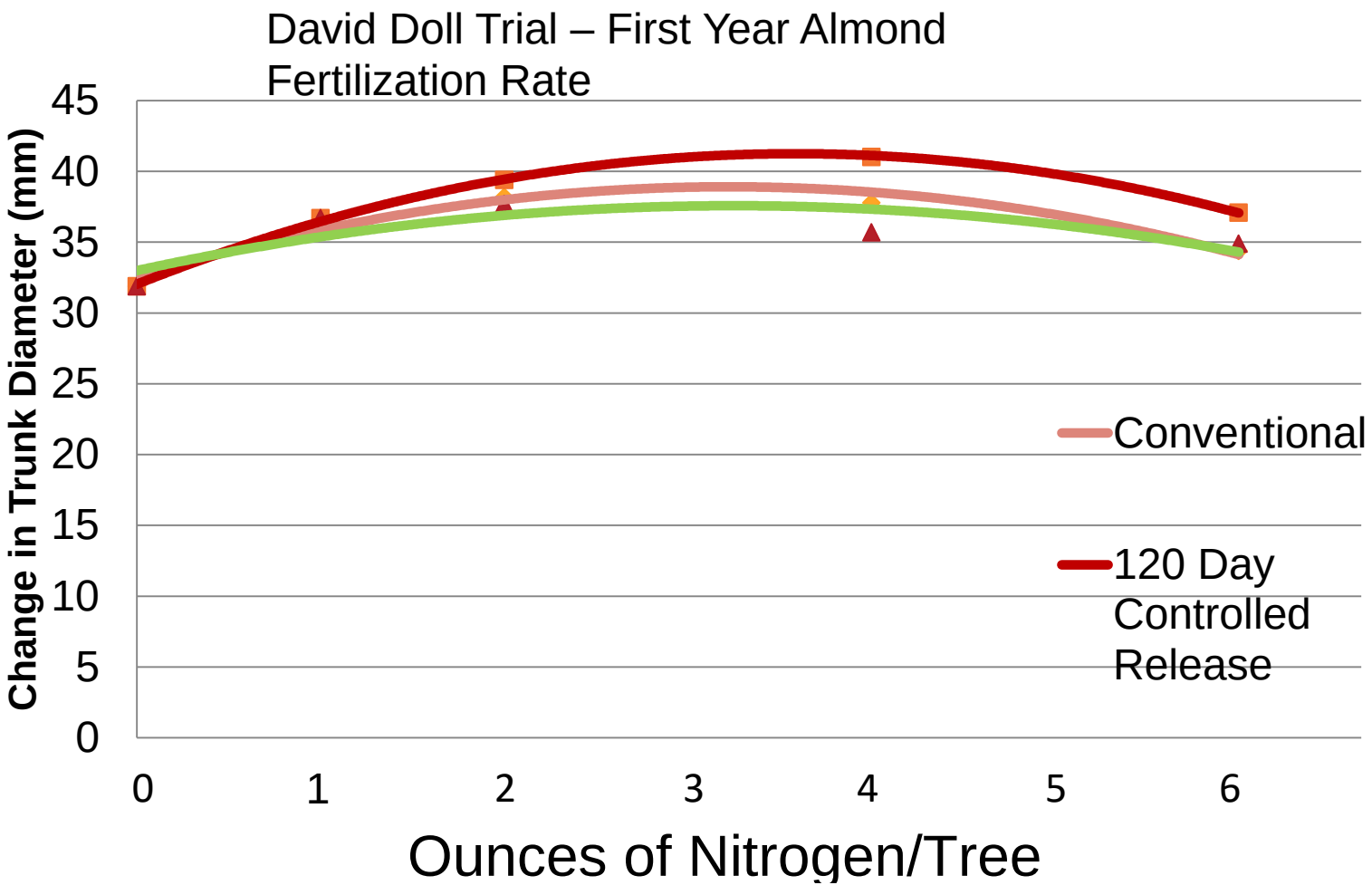
N= 0.31 %, 396 lbs/ac
K= 0.20 %, 256 lbs/ac
Ca= 0.60 %, 768 lbs/ac
C= 50 %, 64,000 lbs/ac

The nutrients will be released gradually and naturally

Tallerico Orchard in Manteca

In the portion of the orchard where the wood chip piles were—there was total weed control.

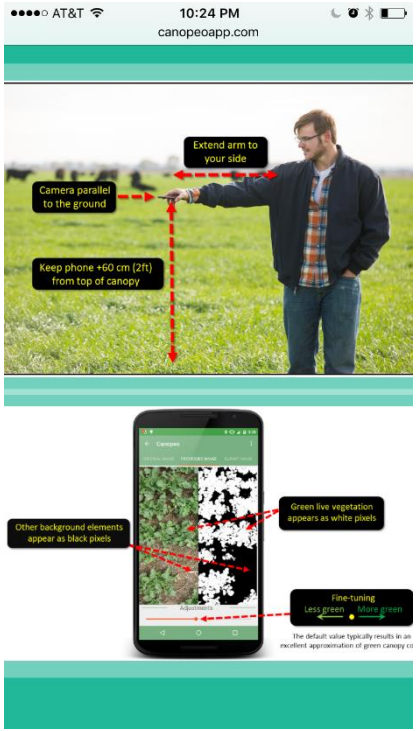
We doubled our nitrogen applications through fertigation in order to keep the tree growth up.

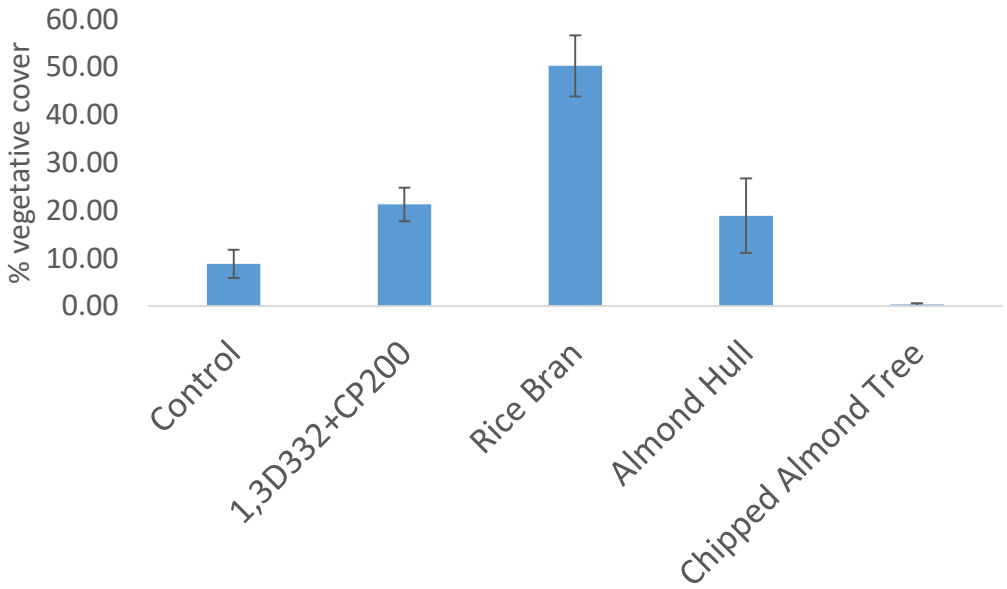

David Doll Trial – First Year Almond
Fertilization Rate
Change in Trunk Diameter (mm)
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
Ounces of Nitrogen/Tree
Conventional
120 Day Controlled Release

University of California
Agriculture and Natural Resources

85 tons per acre rate—Kearney REC

Measurements taken between the centermost two trees in each plot, from edge of the south side of plot facing to north, parallel to the surface at about 56” above the ground.



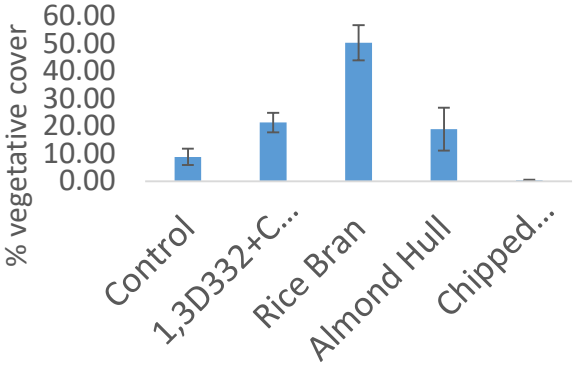


The % coverage of green vegetation was estimated with the Canopeo app: http://agriapps.ie/sub/canopea/

Estimated % Cover in Microplots

Wood Chips 0.4 % ± 0.3 %

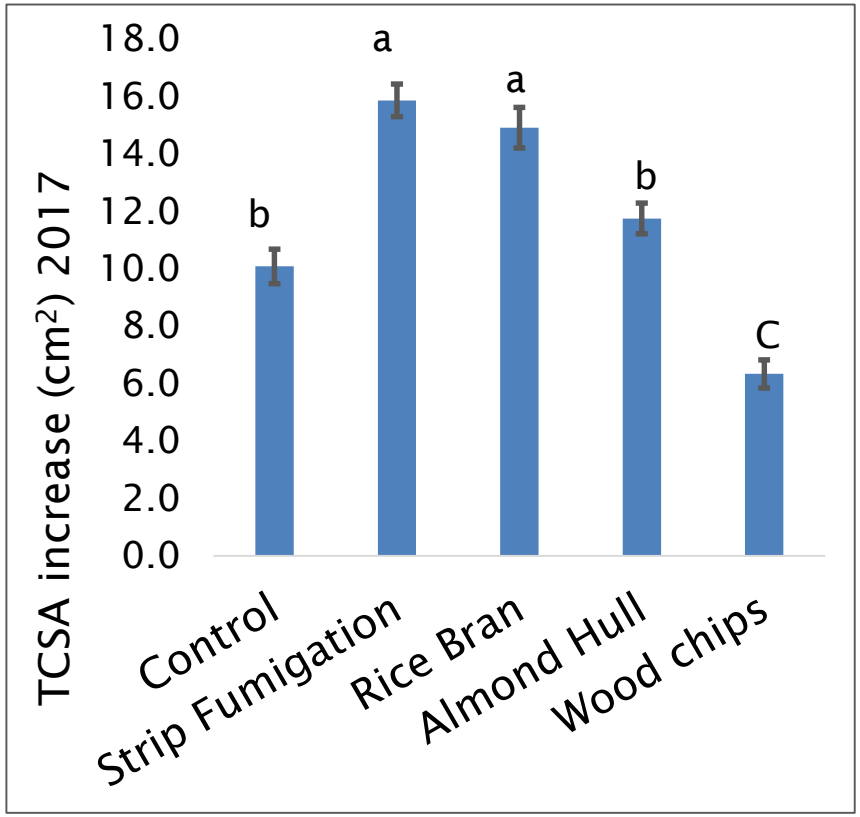
Control 8 % ± 3 %

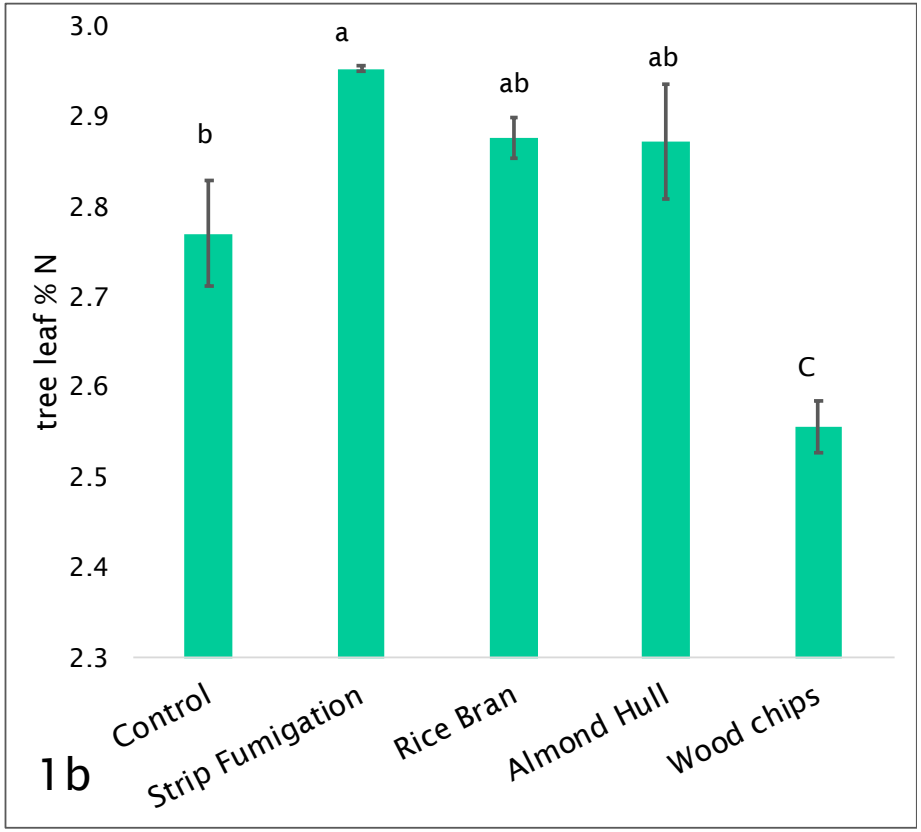


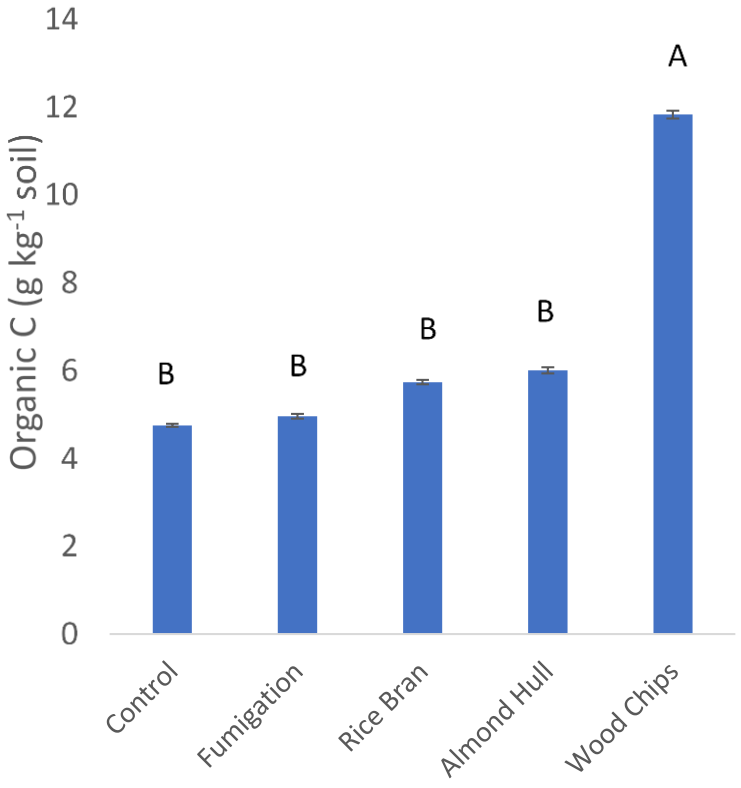
1,3D332+CP200 21% ± 4%

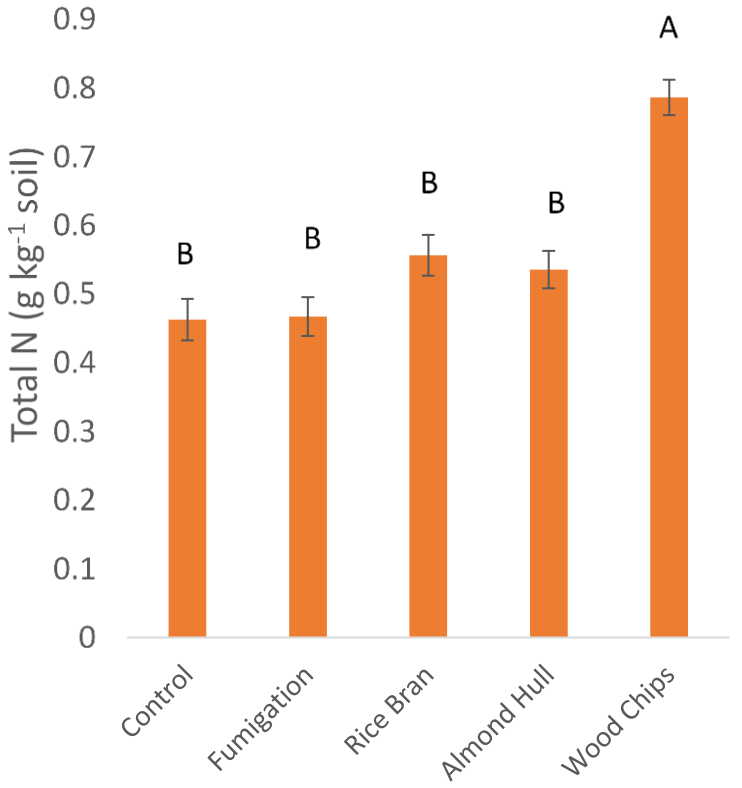
Rice Bran 50 % ± 6 %

Almond Hull 19 % ± 8 %


TCSA increase (cm²) 2017
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
b
a
a
b
C
Control
Strip Fumigation
Rice Bran
Almond Hull
Wood chips


tree leaf % N
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
b
a
ab
ab
C
Control
Strip Fumigation
Rice Bran
Almond Hull
Wood chips
1b


Organic C (g kg-1 soil)
14
12
10
8
6
4
2
0
B
B
B
B
A
Control
Fumigation
Rice Bran
Almond Hull
Wood Chips


Total N (g kg-1 soil)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
B
B
B
B
A
Control
Fumigation
Rice Bran
Almond Hull
Wood Chips

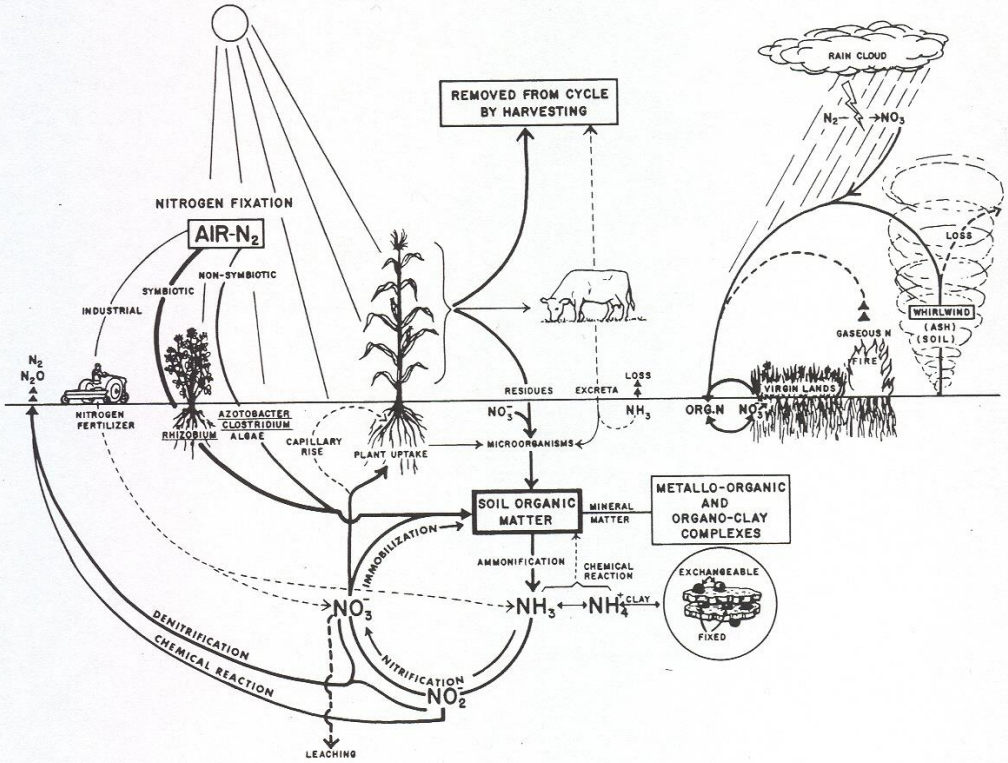


Figure 8.1. Nitrogen cycle in soil. (From Stevenson, 1982.)

This Duratech grinder is mobile and spreads the wood chips evenly as it grinds.

Efficiencies are improved every year that whole orchard recycling is performed.

Will Whole Orchard Recycling:

- Increase water holding capacity?
- Bind pesticides and fertilizers?
- Increase Nitrogen efficiency?
- Increase/decrease Green House Gas production?
- Provide carbon credits to farmers?

Thank You!