Understanding the Variability in Salt Uptake and Accumulation Among Different Almond Cultivars and the Effect of Salt Uptake on the Growth and Physiology of Almonds

Project No.: **15-HORT25-Brar**

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Note:

This report is for work performed during the 2015-2016 crop year with results achieved by Dr. Brar prior to his departure from UCCE and new employment with the University of Florida.

Objectives:

The counties of Fresno and Madera account for more than 30% of all bearing acreage under almonds in California (County Ag. Commissioner Crop Reports, 2013). The area under almonds has been increasing for the past several years. Along with that trend, we have seen many newer orchards being planted in marginal soils with issues like soil and groundwater salinity among others. Reports about salinity effects in almonds have been coming lately from the central valley region in general and from the western parts of valley in particular. Interestingly, some variability has been observed among different cultivars with regard to being affected by sodium and chloride toxicity.

Year 1 objectives:

1. To understand the effects of long-term exposure to soil and water salinity on the almond yield, tree growth and nut quality.

Interpretive Summary:

The studies were initiated at the UC Westside Field Station Almond block. This report covers the efforts done during the first year by getting the soil, leaf and wood tissues tested to make a baseline for designing the irrigation treatments in the second year. During the first year, the proposal was to assess the status of current growth and physiological parameters of the trees pertaining to salt stress as they have been subjected to high salinity water for the last several years.

During this period, measurements of physiological parameters like tree water status, leaf and wood tissue salt content, were recorded. Based on the sampling and surveying results from the first year, different treatments were to be planned to compare high EC well water with lower EC irrigation district water over the next two years.

Materials and Methods:

During 2015 (first year), the selection of trees was made randomly and extensive tissue sampling was done from the trees during the season.

1. The almond block has 36 rows of trees with 19 trees in each row (see **Figure 1**, layout).
2. Since the field is very uniform in regard to soil properties, the sampling study was designed as a completely randomized design.
3. Six trees of each variety, Nonpareil and Carmel, were selected across the block and tagged. All trees in this block are on Nemaguard rootstock.
4. The trees were irrigated with available well water (EC ~1.7) throughout the season.
5. The following measurements were taken periodically from the selected trees and the soil around them:
    a. Plant water status with the pressure bomb: measured for 5 weeks during the months of July and August to access the water status of the trees of two varieties, Nonpareil and Carmel. This helped in making an assessment whether the trees were stressed for water or not.
    b. Leaf tissue analysis: Taken in July
    c. Wood tissue collected from stem above the graft union and the rootstock portion below the graft union: In August
    d. The trees were visually rated for salt stress symptoms and also whether they exhibited low chlorophyll content or not.
    e. Soil samples were taken from three locations within the block at three different depths.

Results and Discussion:

The soil test results of the block are provided in **Table 1**. The block has been receiving irrigation with well water that has an EC value of about 1.7 dS/m. The samples were taken at three sites across the whole block and at three different depths: 0 to 18 inches; 18 to 36 inches; and 36 to 48 inches. The sodium content of the soil was relatively higher than the normal acceptable range of 8.0 meq/l at all depths across all sample sites. As the depth of the samples increased, the sodium content also increased. The similar trend was observed with chloride

content. Chloride concentration of up to 4 meq/l is considered permissible in regard to almond cultivation. However, the average chloride content of the sampled soil at three sites in this block was higher than 4 at all locations and depths. The chloride content increased in relation to increased sample depth. Electrical conductivity (in dS/m) was on an average 1.77 dS/m in 0-18", 2.19 dS/m in 18-36" and 2.21 dS/m in 36-48" samples depth. All these values are higher than the general site characteristic recommendations for cultivation of almonds. The soil pH values were also observed to be in the higher range , an average of 7.73 in 0-18", 7.87 in 18-36" and 7.77 dS/m in 36-48" samples depth. The exchangeable sodium percentage (ESP) was also high. The normal range for ESP is considered between 0.1 to 5.0%. However, in these soil samples all averages for different sites and depths were greater than 6.

While the soil characteristics show that the soil of this block has high salt content, high EC and high pH values, the leaf tissues of the two varieties Nonpareil and Carmel did not show any high values of Na and Cl in them (**Table 2**). The leaves were sampled from 6 trees of each of these varieties across the block and all trees had less than 0.01 % Na and less than 0.1% of Cl.

Wood tissues from the trunk above the graft union and from the rootstock below the graft union were also taken in August and the nutrient content including salts were tested (**Table 3**). The trunk tissue from both varieties showed very low values on both Na and Cl content and the rootstock tissue from the Carmel on Nemaguard trees also showed a chloride content of less than 0.01. However, the rootstock tissue from Nonpareil on Nemaguard trees showed higher Na content (ranging from 0.02 to 0.04%) than any other trees. As noted above, all trees in the experimental block are on Nemaguard rootstock.

The midday stem water potential of the experimental trees was also taken for 5 consecutive weeks during the months of July and August (**Table 4**). The data were taken on same trees twice every week: before starting the irrigation and within 24 hours after the irrigation stopped. All values were depicted in bars. The irrigation was applied on the basis of evapotranspiration based scheduling and all SWP values were normal for an almond tree. There were no signs of water stress on the trees.

Conclusion:

The soil and tissue characteristics of experimental almond block present an interesting picture and should be considered ideal to form the basis of the proposed salinity study. The block has been watered with well-water having EC close to 1.7 dS/m which is considered higher than the threshold limit for salt

sensitivity of almonds. However, the trees of both the varieties did not show any signs of salt stress. It has been observed in the field that the almonds trees to such conditions start showing symptoms of salt stress under long term exposure. Therefore, the proposed irrigation treatments of high EC well water and low EC surface water will be helpful in determining the threshold levels of these varieties to salt stress over time.

Research Effort Recent Publications:

None.

References Cited:

None.

Table 1: Soil characteristics of Westside Field Station Almond Block, 2015

Na (meq/l)			
Site	0-18"	18-36"	36-48"
1	12.3	15.3	14.5
2	12.9	10.2	13.2
3	7	12.8	11.2
Avg	**10.73**	**12.77**	**12.97**
Cl (meq/l)			
1	5	6.9	8
2	6	4.7	7.8
3	2.5	5.6	4.6
Avg	**4.50**	**5.73**	**6.80**
EC (dS/m)			
1	2	2.6	2.45
2	2.22	1.85	2.46
3	1.09	2.11	1.73
Avg	**1.77**	**2.19**	**2.21**
pH			
1	7.7	7.9	7.7
2	7.8	7.8	7.8
3	7.7	7.9	7.8
Avg	**7.73**	**7.87**	**7.77**
ESP (%)			
1	6.5	6.4	7
2	6.1	5.4	5.9
3	5.5	6.6	6.7
Avg	**6.03**	**6.13**	**6.53**

Table 2: Leaf tissue characteristics of Westside Field Station Almond Block, 2015

Leaves	**Na**		**Cl**	
Tree	NP	Carmel	NP	Carmel
1	0.01	0.01	<0.1	<0.1
2	<0.01	<0.01	0.1	<0.1
3	0.01	0.01	<0.1	<0.1
4	0.01	0.01	<0.1	<0.1
5	<0.01	<0.01	<0.1	0.1
6	0.02	0.01	0.1	0.1

Table 3: Trunk and rootstock tissue characteristics of Westside Field Station Almond Block, 2015

Trunk	**Na**		**Cl**	
Tree	NP	Carmel	NP	Carmel
1	<0.01	<0.01	<0.1	<0.1
2	<0.01	<0.01	<0.1	<0.1
3	<0.01	<0.01	<0.1	<0.1
4	<0.01	<0.01	<0.1	<0.1
5	<0.01	<0.01	<0.1	<0.1
6	<0.01	<0.01	<0.1	<0.1
Rootstock	**Na**		**Cl**	
Tree	NP	Carmel	NP	Carmel
1	0.04	0.05	<0.1	<0.1
2	0.02	0.02	<0.1	<0.1
3	0.04	0.02	<0.1	<0.1
4	0.02	0.05	<0.1	<0.1
5	0.03	0.04	<0.1	<0.1
6	0.04	0.03	<0.1	<0.1
Average	**0.03**	**0.04**		

Table 4: Midday Stem Water Potential (SWP) data from Westside Station Almond block, 2015

Before Irrigation (Start Time - 1:00 p.m.; Date - 07/08/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	16, 14, 14.5	Carmel	12.5, 13.5, 13
2	13, 13.5, 13	Carmel	12, 13, 11
3	12, 13, 12	Carmel	13, 12.5, 12
4	11.5, 14, 15	Carmel	13, 14.5, 15
5	13, 14, 14	Carmel	14, 12.5, 15
6	14, 16, 17	Carmel	13.5, 13.5, 11

After Irrigation (Start Time - 1:00 p.m.; Date - 07/10/15)			
Tree	**Nonpareil (bars)**	**Variety**	**Carmel (-bars)**
1	11, 10, 11	Carmel	9, 9, 8.5
2	9.5, 9, 10	Carmel	8.5, 10, 11
3	9, 9.5, 9.5	Carmel	9.5, 9, 8.5
4	8, 9, 9	Carmel	9, 9, 8.5
5	11, 12, 11	Carmel	9, 12, 9
6	10.5, 11, 9.5	Carmel	8.5, 9.5, 11

Before Irrigation (Start Time - 1:00 p.m.; Date - 07/15/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	17, 17.5, 17	Carmel	15.5, 19, 13.5
2	13.5, 16, 14	Carmel	14, 14, 14
3	13.5, 14, 14	Carmel	13, 14.5, 13
4	14, 14, 13.5	Carmel	13.5, 14, 14
5	14, 14.5, 15.5	Carmel	13, 18.5, 13.5
6	16.5, 15.5, 18	Carmel	13.5, 15.5, 15

After Irrigation (Start Time - 1:00 p.m.; Date - 07/17/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	15, 14, 15.5	Carmel	12.5, 11.5, 14.5
2	14, 14, 15.5	Carmel	15, 13, 12
3	15, 15, 14.5	Carmel	13.5, 14, 14
4	15, 13, 15.5	Carmel	12, 13.5, 14.5
5	13, 16, 15.5	Carmel	13.5, 14.5, 13
6	16, 16.5, 12	Carmel	11, 12.5, 14

Before Irrigation (Start Time - 1:00 p.m.; Date - 07/22/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	14, 15.5, 14	Carmel	10.5, 11.5, 12.5
2	13, 14, 13	Carmel	11.5, 14, 11.5
3	14.5, 12.5, 11.5	Carmel	13, 13, 12,
4	12, 14, 12	Carmel	11, 12.5, 13
5	15, 13.5, 14.4	Carmel	13.5, 14, 13
6	16, 14.5, 16	Carmel	13.5, 14, 14

After Irrigation (Start Time - 1:00 p.m.; Date - 07/24/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	14, 15, 12.5	Carmel	10.5, 11, 11
2	13.5, 12.5, 13	Carmel	11.5, 11, 11
3	13.5, 12, 12.5	Carmel	11.5, 12.5, 10.5
4	13, 13, 12.5	Carmel	11.5, 12, 11
5	13.5, 14, 14.5	Carmel	11, 12, 11
6	15, 13.5, 15.5	Carmel	10.5, 12, 12

Before Irrigation (Start Time - 2:45 p.m.; Date - 08/12/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	13, 14.5, 13	Carmel	11, 10.5, 10
2	11, 11.5, 11.5	Carmel	11, 10.5, 11.5
3	10.5, 10.5, 11	Carmel	10.5, 10, 11.5
4	10.5, 11.5, 11	Carmel	10.5, 10.5, 10
5	10, 11.5, 12.5	Carmel	10.5, 10.5, 11
6	13, 13.5, 14	Carmel	10, 11, 12

After Irrigation (Start Time - 2:45 p.m.; Date - 08/14/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	13, 12, 12.5	Carmel	11.5, 10, 11
2	12, 11, 10.5	Carmel	11, 10, 10
3	11, 12, 10	Carmel	10, 11, 11
4	10.5, 10, 11	Carmel	11.5, 11.5, 10
5	10.5, 13, 12	Carmel	10, 10.5, 9.5
6	12, 12.5, 11.5	Carmel	10, 10.5, 9

Before Irrigation (Start Time - 1:00 p.m.; Date - 08/19/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	14.5, 12.5, 13	Carmel	11, 12.5, 10
2	12, 12.5, 13	Carmel	13, 11.5, 12
3	13.5, 13, 12	Carmel	11.5, 11.5, 11
4	11, 13, 13.5	Carmel	12, 11, 11.5
5	16, 14, 13	Carmel	11, 12, 13
6	13.5, 14, 15.5	Carmel	11.5, 12, 11.5

After Irrigation (Start Time - 1:00 p.m.; Date - 08/21/15)			
Tree	**Nonpareil (-bars)**	**Variety**	**Carmel (-bars)**
1	12, 11.5, 12.5	Carmel	9.5, 11, 10.5
2	12.5, 14, 12	Carmel	10, 12, 11.5
3	11, 11.5, 13	Carmel	10.5, 11, 11
4	11, 12.5, 10.5	Carmel	11.5, 10.5, 12
5	11, 11.5, 11	Carmel	15, 17.5, 16
6	14, 15.5, 13.5	Carmel	10, 11, 10.5

Rows >>>>> (Total Number of rows=36; Marked 1-36 here); Number of trees in each row=19 (Marked A-S here)

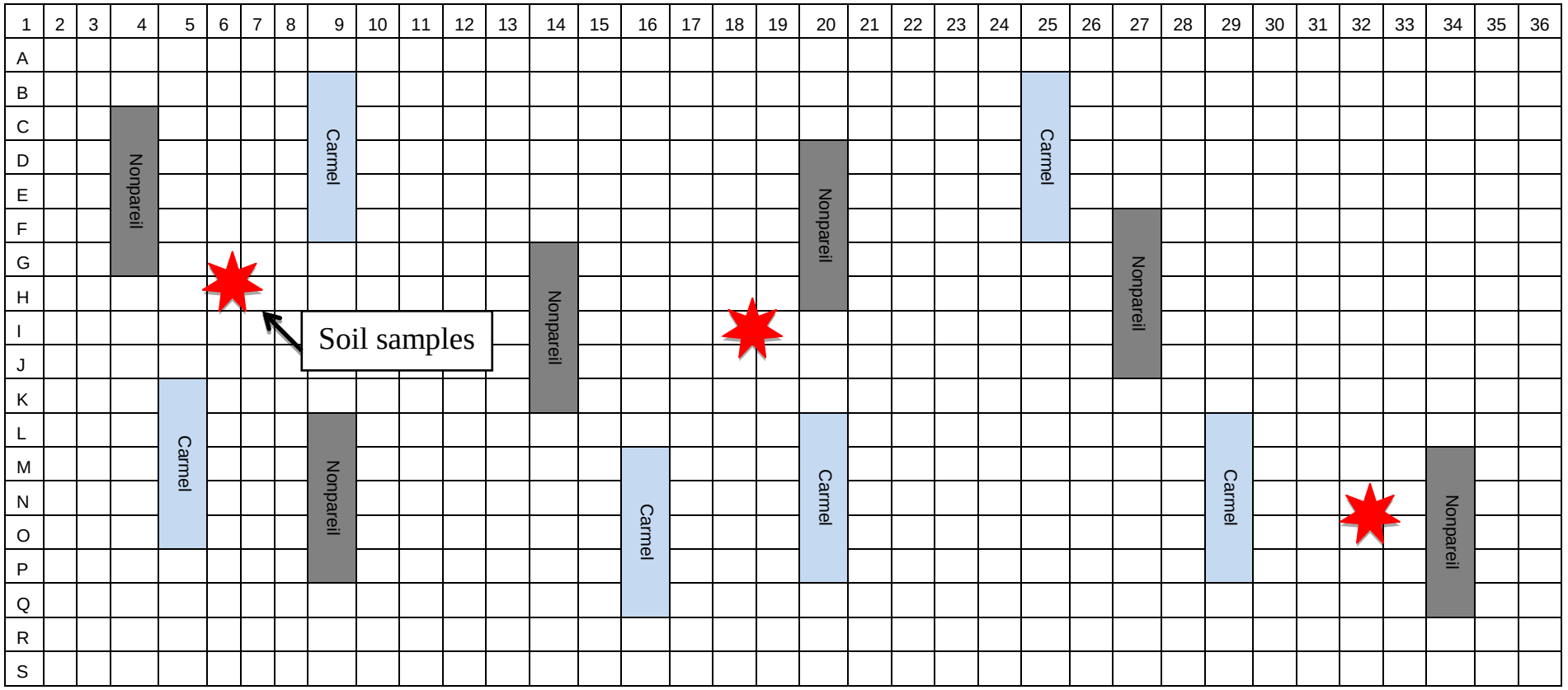

Figure 1: Layout plan for the sampling study for first year. Six trees of each variety across the block were selected. Bars represent location of trees to be sampled. Red stars represent soil sampling location.