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# Evaluating new breeding material for salinity tolerance in almond rootstocks and exploring novel sources of salinity tolerance in *Prunus*

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**Project No.:** HORT55.Sandhu

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**Project Cooperators and Personnel:**

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Thomas Gradziel, UC Davis;  
Malli Aradhya, USDA-ARS, Davis

Grantee(s) of the Almond Board are REQUIRED to address sections A through G. These should be **submitted in PDF**, using Arial font size 12 for the main text, and be five to seven pages in length.

**A. Summary** (*In laymen's terms – emphasize key findings and recommendations*)

The overarching goal of the proposed study is to develop new vigorous rootstocks, resistant to diseases, insects, and nematodes, as well as tolerant to salinity. The first step is to work with breeders to identify elite hybrids and screen those for salinity tolerance. We are in the process of evaluating 45 such rootstocks from Drs. Aradhya and Gradziel's breeding programs for salinity tolerance. Most of these rootstocks are already evaluated for several other traits in the breeding programs. Identification of the most salt-tolerant rootstocks will result in quick commercialization. The first year of this screening trial will conclude in May 2021. Based on the results of this trial, the salinity tolerance of different breeding lines will be shared with breeders for further evaluation. This comprehensive approach will lead to the development of some elite rootstocks with multiple desirable traits, including salinity-tolerance, in a short period of time.

**B. Objectives** (*300 words max.*)

Objective 1. Evaluate elite rootstocks from breeding populations for salinity tolerance.

Lead Scientist – Devinder Sandhu

We are currently evaluating 45 elite almond rootstocks from breeding populations under control and salinity conditions. After 10 months of salinity treatment (by May 2021), rootstocks will be compared for their salt tolerance, and the most tolerant rootstocks will be identified.

**C. Annual Results and Discussion** (*This is the core function of this report*)

Our previous studies on almond rootstocks provided a detailed analysis of the importance of different component traits in salinity tolerance. However, a coordinated effort is needed to combine multiple component traits into a single rootstock to enhance its salinity tolerance. The best way to tackle this issue will be the screening of elite breeding lines for salinity tolerance in addition to other traits. Using this approach, new rootstocks can be developed that are vigorous, resistant to diseases and insects, and are tolerant to salinity.

Table 1. Evaluation of the hybrid rootstocks developed in breeding programs for their salinity tolerance

S. No.	Name	Parents	Number of trees	Breeding Program
1	UCD 7	Almond x Peach	12	Gradziel, UC Davis
2	UCD 9	Peach x Almond	10	Gradziel, UC Davis
3	UCD 10	Peach x Almond	16	Gradziel, UC Davis
4	UCD 12	Peach x Almond	16	Gradziel, UC Davis
5	UCD 17	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
6	UCD 19	Peach x <i>P. webbii</i>	16	Gradziel, UC Davis
7	UCD 20	Peach x Plum species	16	Gradziel, UC Davis
8	UCD 21	Peach x <i>P. argentea</i>	10	Gradziel, UC Davis
9	UCD 22	Peach x <i>P. scoparia</i>	10	Gradziel, UC Davis
10	UCD 23	Peach x <i>P. tangutica</i>	10	Gradziel, UC Davis
11	UCD 25	Peach interspecies breeding line	14	Gradziel, UC Davis
12	UCD 26	Peach x Almond	10	Gradziel, UC Davis
13	UCD 27	Peach x <i>P. davidiana</i>	9	Gradziel, UC Davis
14	UCD 28	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
15	UCD29	Peach x <i>P. davidiana</i>	15	Gradziel, UC Davis
16	UCD 31	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
17	UCD 32	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
18	UCD 33	Peach x <i>P. davidiana</i>	15	Gradziel, UC Davis
19	UCD 34	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
20	UCD 35	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
21	UCD 37	Peach x <i>P. davidiana</i>	10	Gradziel, UC Davis
22	UCD 38	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
23	UCD 40	Plum x Plum	15	Gradziel, UC Davis
24	UCD 44	Complex interspecies hybrid	10	Gradziel, UC Davis
25	UCD 45	Complex plum interspecies hybrid	7	Gradziel, UC Davis
26	UCD 46	Peach x <i>P. davidiana</i>	16	Gradziel, UC Davis
27	197-198	Peach x <i>P. davidiana</i>	4	Aradhya, USDA-ARS
28	197-207	<i>P. persica</i> x <i>P. kansuensis</i>	12	Aradhya, USDA-ARS
29	197-209	<i>P. persica</i> x <i>P. kuramica</i>	12	Aradhya, USDA-ARS
30	DK3	<i>P. dulcis</i> x <i>P. kansuensis</i>	12	Aradhya, USDA-ARS
31	DM1	<i>P. dulcis</i> x <i>P. mira</i> (bulk)	12	Aradhya, USDA-ARS
32	DV3-7	<i>P. dulcis</i> x <i>P. davidiana</i>	12	Aradhya, USDA-ARS
33	Krymsk 86	Commercial variety - Check	12	Aradhya, USDA-ARS
34	Nemaguard	Commercial variety - Check	6	Aradhya, USDA-ARS
35	P-4-10	<i>P. nemared</i> x <i>P. fenzliana</i>	9	Aradhya, USDA-ARS
36	PB2-8	<i>P. persica</i> x <i>P. bucharica</i>	12	Aradhya, USDA-ARS
37	PM2-12	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
38	PM2-14	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
39	PM2-43	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
40	PM2-45	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
41	PM2-48	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
42	PM2-51	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
43	PM2-54	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
44	PM2-6	<i>P. persica</i> x <i>P. mira</i>	12	Aradhya, USDA-ARS
45	PV2-2	<i>P. persica</i> x <i>P. davidiana</i>	12	Aradhya, USDA-ARS

Our current project involves collaboration with breeders to identify elite hybrids (based on vigor and biotic stress resistance) and screen those for salinity tolerance. Several elite lines have been developed by Dr. Tom Gradziel (UC Davis) and Dr. Malli Aradhya (USDA-ARS, Davis, CA) in their breeding programs. We have received 45 rootstocks from these breeding programs and initiated salinity evaluation trials on those (Table 1 and Figure 1).



Figure 1. Physical layout of the experiment.

The trunk diameter was taken before the initiation of the salinity treatment (Figure 2). The salinity tolerance evaluation will continue until May 2021 and then the second trunk diameter reading will be taken. Leaf samples will be taken in April 2021 to determine tissue ion composition.

The change in trunk diameter will be correlated to their Na and Cl tissue accumulation to establish salinity tolerance of each genotype.

From the results of 2020-21 trials, the top 10 hybrids will be selected. These selected hybrids, along with additional dozen new hybrids from Drs. Gradziel's and Aradhya's breeding programs will be evaluated in 2021-22. Relation of salinity-tolerance data with other traits such as vigor, disease and nematode resistance will help in selecting hybrids with multiple superior traits that can be commercialized in a short-time span.

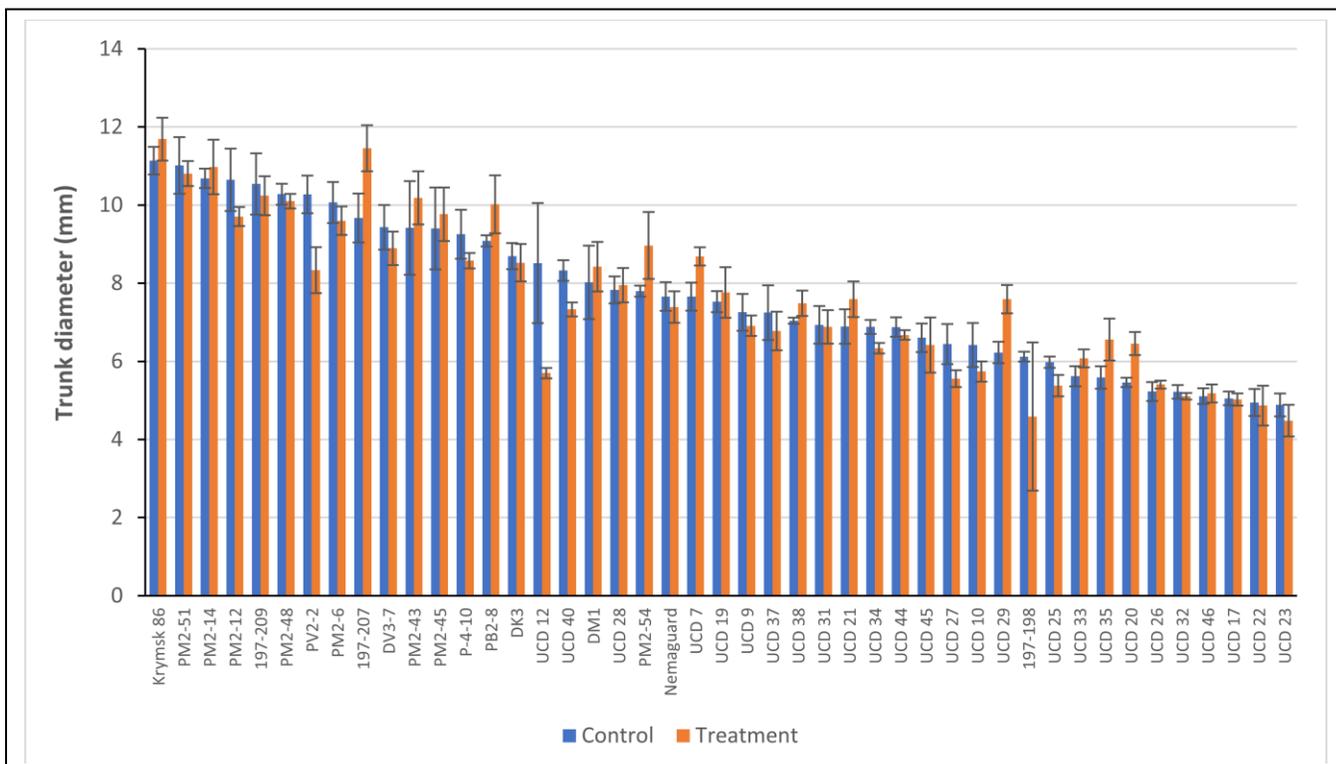


Figure 2. Trunk diameter of different rootstocks for control and treatment taken at the initiation of the experiment. Error bars represent standard error.

#### D. Outreach Activities

1. Dr. Devinder Sandhu presented at the 2020 ASA-CSSA-SSSA International Annual Meeting, November 9-13, Virtual. Title of presentation: Genetic dissection of the salt tolerance mechanisms in almond rootstocks. Participants: 70. Researchers, Students, Extension workers, Growers.
2. Dr. Sandhu was a keynote speaker and panelist at the International Salinity Webinar: Resilient Agriculture in Saline Environments under Changing Climate organized by ICAR-Central Soil Salinity Research Institute, India and International Center for Biosaline Agriculture, Dubai. Nov. 3, 2020. Title of presentation: Genetic characterization of the salt tolerance mechanisms in forage and nut crops. Participants: 200. Researchers, Students, Extension workers.
3. Dr. Sandhu gave a virtual guest lecture on the mechanisms of salinity tolerance in plants in Sustainable Crop Production course at New Mexico State University. Oct. 29, 2020. Title of presentation: Understanding the landscape of salt tolerance mechanisms in crop plants. Participants: 35. Students.

## E. Materials and Methods (500 word max.):

The hybrid rootstocks developed by Drs. Aradhya and Gradziel were transplanted in 3-gallon pots using loamy sand soil:sand (1:1) mix. The experiment was set up in field in three replications (three plants per replication) in a randomized block design. Our previous experiments showed that Na and Cl both play important roles in ion toxicity in almonds. So, for our treatment, we used mixed ion composition to represent a range of natural water compositions, with Na as the main cation and Cl as the main anion. Control treatment constituted of basic ½-strength Hoagland's nutrient solution containing essential macro- and micronutrients. After transplanting into 3-gallon pots, plants were allowed to acclimatize for four weeks. As almonds are sensitive to salinity, a moderate salinity level was to screen genotypes. At high-salinity levels, other mechanisms such as osmotic shock play a dominating role that will likely dilute the effect of genes involved in salinity tolerance. The electrical conductivity (EC) of the salinity treatment is set at EC = 4.5 dS m<sup>-1</sup>, as this is the upper limit of salinity levels that would likely be used for almond irrigation at the farmers' field. Pots are being watered with an automated drip system to maintain a target leaching fraction of 0.2.

Tissue samples will be dried, digested in a Milestone Ethos EZ microwave digestion system, and analyzed with a Perkin Elmer Optima ICP OES to determine the concentration of major and minor elements, except chloride, which will be determined using a Labconco chloridometer. At the end of the experiment, we will take soil samples and analyze water extracts for EC.

Statistical analysis will be performed with the SAS software package.

The project is going smoothly. We do not expect any change to the timeline or the scope of the work.

## F. Publications that emerged from this work

1. This is the first year of this project. There are no peer-reviewed publications from this work yet.

Publications from the previous ABC project-

- a. Sandhu D, Kaundal A, Acharya BR, Forest T, Pudussery MV, Liu X, Ferreira JF, Suarez DL. 2020. Linking diverse salinity responses of 14 almond rootstocks with physiological, biochemical, and genetic determinants. *Scientific Reports* 10, 21087. DOI: 10.1038/s41598-020-78036-4
- b. Kaundal A, Sandhu D, Duenas M, Ferreira JFS. 2019. Expression of the *high-affinity K<sup>+</sup> transporter 1 (PpHKT1)* gene from almond rootstock 'Nemaguard' improved salt tolerance of transgenic Arabidopsis. *PLOS ONE* 14 (3): e0214473. DOI: 10.1371/journal.pone.0214473

2. Other publications (e.g. outreach materials)

Publications from the previous ABC project-

- a. Sandhu D and Acharya BA. 2019. Mechanistic insight into the salt tolerance of almonds. *Progressive Crop Consultant* 4 (5): 44-49.

3. Please provide copies of publications  
Attached.