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Kern Pistachio Notes

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What's the Story on the 2020 – 2021 Fall and Winter Chilling for Pistachio?

About this time of the year a number of growers are wondering how effective our fall and winter chilling period was. I have had several queries this year. One query came from the writer for a grower magazine and came in the form of the following three questions (*in italics*). I will answer here.

How did chill accumulation stack up this year? How does it compare to the previous year's accumulation?

As some of you know, I am not a big fan of the models we use to estimate the effectiveness of the previous fall-winter chilling period, although I feel they do have a place in achieving a general 'feel' for the adequacy of the chilling period at a given location. For the San Joaquin Valley of Kern County, I look at the following three models: Model 1) hourly air temperature accumulations less than 45 °F from Nov. 1 to Feb. 28; Model 2) the dynamic model (i.e. accumulated chilling portions) from Nov. 1 – Feb 28 and Model 3) hourly temperature accumulations above 65 °F from Nov. 15 to Feb. 15. For good chilling, we want Model 1 and Model 2 to be high, and Model 3 to be low. If the first model is above 1100 and the second is above 64 and the third is under 80, I would feel confident that during the previous fall and winter we had had a "high" chilling season. In Kern County, especially in the last decade, we seldom have had very high-chilling seasons and we have had to settle for one of our "normal" chilling seasons. Typically, in a normal chilling season, Model 1 and Model 2 accumulations are 10% to 15% below the threshold values I mentioned above and Model 3 accumulations 30% above. A normal Kern County chilling season is nothing to fear, after all, it is normal for us. To some extent our industry in Kern County is adapted to borderline deficient chilling, and normal is good enough and means our trees can produce good crops. However, if all three of these models are really far out on the low side of high chilling, then I think some dedicated worrying is in order.

More important to me than the models are how the trees are actually blooming. As we get closer to bloom, and bloom is delayed this year likely due to the cool March temperatures, I let the trees try and tell me how adequate the chill was. How the trees bloom can say a lot about how effective our fall and winter chilling really was. Each year, the first trees I get to look at are the early blooming cultivars and experimental selections that are present in some growers' orchards and our test trials. What I look for is how even the bloom is between the north and south side of the trees and how good the bloom synchronization is between the male pollinizer and its respective female cultivar. If the male pollinizer is synchronized with its female cultivar, and the more even the bloom is between the north and south sides of the tree, whether male or female, the better I feel that adequate fall and winter chilling was achieved. Since our industry in the southern San Joaquin Valley has grown up with borderline chilling, a very "high" chilling years may not always be a "good" chilling year. Back in the 1980s and early 2000s high chill years occurred frequently. During these years, the male pollinizer 'Peters' often bloomed much earlier than 'Kerman' causing concerns of possible poor pollination. In 2014 and 2015, when chilling was very poor, 'Peters' bloomed much later than' Kerman', again raising concerns of poor pollination.

‘Peters’ was selected, most likely, as the pollinizer for ‘Kerman’ as a result of our borderline chilling, which keeps it synchronous with ‘Kerman’.

So what are the trees saying this year? In visiting our trials around Kern County on March 30, both in low and high elevation locations all below 575’, the early blooming trees are telling me that our fall and winter chilling season was adequate. Bloom development on the north side of the tree versus the south side was close enough and the respective male and female cultivars are showing adequate bloom synchrony. Definitely, it is not a “high” chill year, because, at least in the locations I looked at, I see that ‘Peters’ is a little behind ‘Kerman’, ‘Randy’ is even or a little behind ‘Golden Hills’ and ‘Lost Hills’ and ‘Tejon’ is a tad behind ‘Gumdrop’. The good news is that in these early stages of bloom, at least, the respective male and female cultivars were blooming close together enough, suggesting that we have had another of our normal, and potentially successful, borderline-deficient chilling seasons in the San Joaquin Valley of Kern County.

What implications do this year's hours have for growers through the rest of the season?

If the chill is really inadequate, that pretty much ruins the season as we found out in 2014 and 2015. Achieving adequate chill is the first step toward having some nuts to harvest in the fall and based on early bloom observations in the field, this year as discussed above, we achieved this last fall and winter. Adequate chilling, at least, means that we have the capacity to produce good nut yields this year. So the first hurdle has been passed. Obviously, having great chill does not guarantee a great harvest. The industry is well aware, and which some work I did a few years ago in trying to correlate air temperature accumulations with yield also supports, is that your best indicator of how good this year’s harvest will be depends on how good last year’s harvest was. Pistachio is a very alternate bearing crop. If last year’s crop was good, the odds are this year’s crop will be less so and vice versa.

Even if the chill was great and last year was an “off” year in an orchard’s alternate bearing cycle, the grower still needs to do all of the things necessary, such as proper fertilization, irrigation, insect and disease control, and the host of other things necessary to achieve a great yield. There are still weather events that can come into play later in the season, such as heavy rains during harvest. There is a long growing season ahead of us.

Getting back to that work I did a few years ago in correlating air temperature with yield, one negative correlation arising out of that study was that the greater the hourly accumulation of temperatures greater than 80 °F during the bloom period, the lower the yield. This has been noted in other crops such as stone fruits. High temperatures during bloom, shortens the bloom window, but can hurt pollination. I note that during this the week of March 29 we have been accumulating, and are predicted to accumulate, a higher number of hours greater than 80 degrees than is normal. Today (March 31) in Bakersfield, the high is something like 88 °F. Fortunately, cooler, but not too cool, temperatures are forecasted for the week of April 5.

Do you have any recommendations for growers after reviewing this year's chill data?

At last a question with a short answer. The answer is no, but I can safely say that for the orchards I visited in late March “so far, so good!”

Why the UCBI Pistachio Rootstock is Salinity Tolerant

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In the late 1990s Sanden, Grattan and I did a series of experiments demonstrating the relative salinity tolerance of the primary California pistachio rootstocks. We did a single greenhouse experiment with budded non-bearing trees using growth rate as a parameter and two field trials, one using a five-year-old established orchard and a second in which we established a new orchard under saline conditions. In both filed trials yield and quality were the indicators of salinity tolerance. Collectively these trials demonstrated that, based on growth and yield, the single species rootstock, *Pistacia atlantica,* Atlantica, by growth was the most saline tolerant rootstock and that *P. integerrima*, PGI, was the most saline sensitive rootstock. The hybrids of these two species*; P. atlantica X P. integerrima*, UCBI and the reciprocal cross, *P integerrima* x *P. atlantica,* PG II, based on growth and yield, were intermediate in salinity tolerance.

The Atlantica and PGII seedling rootstocks subsequently demonstrated erratic susceptibility to the soil borne fungus, *Verticillium dahliae,* Verticillium, and were dropped from commercial production. Currently, of the four seeding rootstocks tested, the single species, PGI, and the hybrid, UCBI hybrid have emerged as the two major industry rootstocks, both available as seedling rootstocks and the latter UCBI rootstock now available as a clonally propagated rootstock. The PGII hybrid, also a commercially important rootstock now available as the clonally propagated Platinum® is not included in the following discussion as it was dropped from the second, longer term, field trial. The results discussed here will are for seedling UCBI and PGI rootstocks.

The collective field results of the two field trials demonstrated 'Kerman' pistachio scions on both UCBI and PGI rootstocks tolerated a root zone ECe of 5-6 dS/m. Above that, for every 1 dS/m increase in ECe trees on a UCBI seedling rootstock had a yield decline of 1.4%. Trees on PGI rootstocks had a yield decline of 3.2% (Sanden et al. 2014)

The nursery trial using budded non-bearing UCBI and PGI seedling rootstocks demonstrated there was a difference in how the rootstocks absorbed, translocated and stored sodium, Na^+, and chloride, Cl^- (Ferguson et al. 2004). This is demonstrated in Figures 1 and 2 below. Figure 1 demonstrates that, as soil EC_e rises, the UCBI rootstock, and (blue bar), clearly takes up less Na^+ than the Atlantica rootstock (green bar) or Integerrima (brown bar) and transports a far smaller proportion to the scion leaves than the other two rootstocks. Similarly, as shown in Figure 2 the UCBI rootstock takes up less Cl^- than the other two rootstocks. Collectively this data suggests the UCBI hybrid rootstock takes up less Na^+ and Cl^- and sequesters both in the rootstock. This suggests a difference in dealing with these ions in uptake at the root level, and in transport at the trunk level.

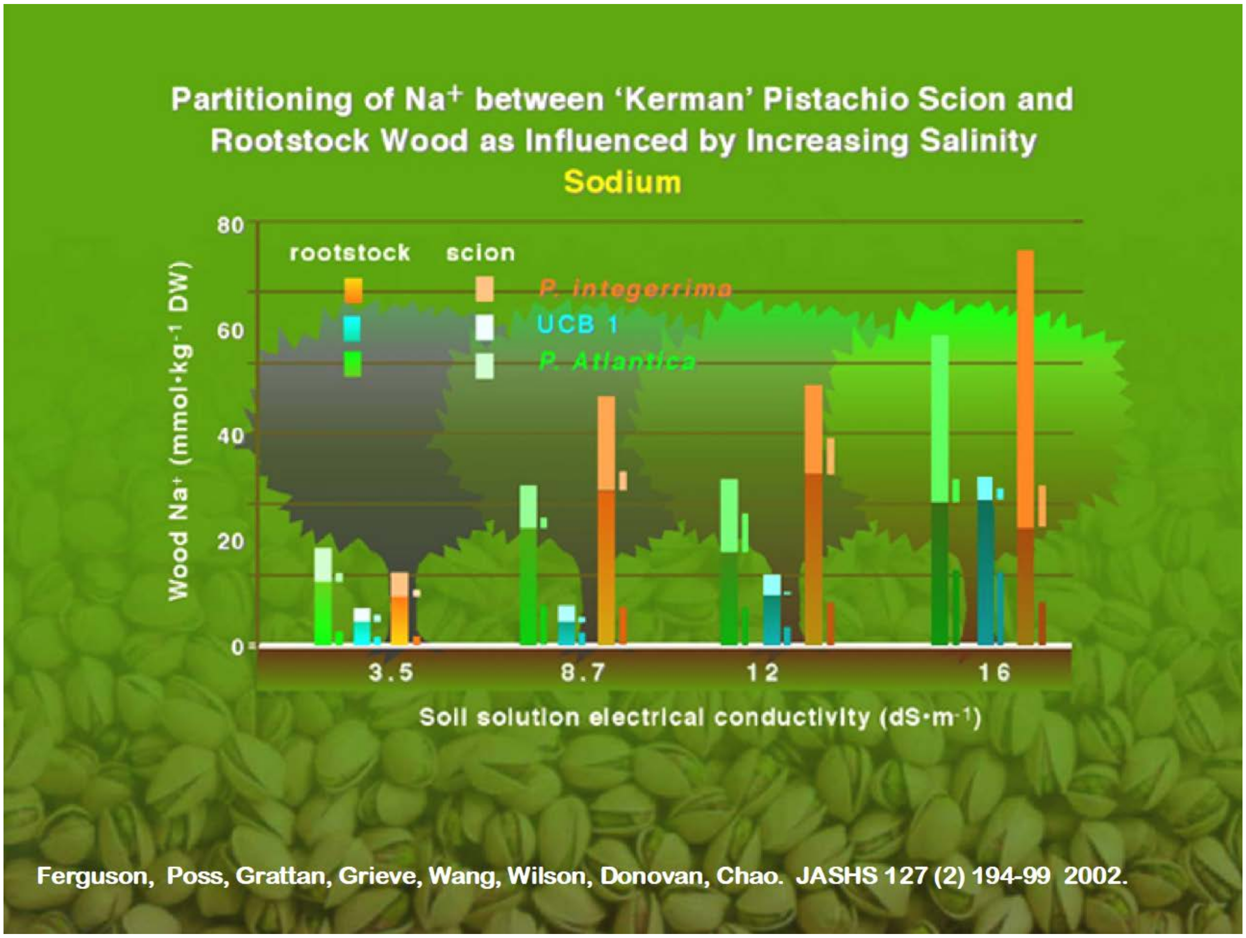

Figure 1. As soil EC_e rises the UCBI rootstock, (blue bar), clearly takes up less Na^+ than the Atlantica rootstock (green bar) or Integerrima (brown bar) and transports a far smaller proportion to the scion leaves than the other two rootstocks. This suggests exclusion at the root level and a sequestering mechanism within the rootstock.

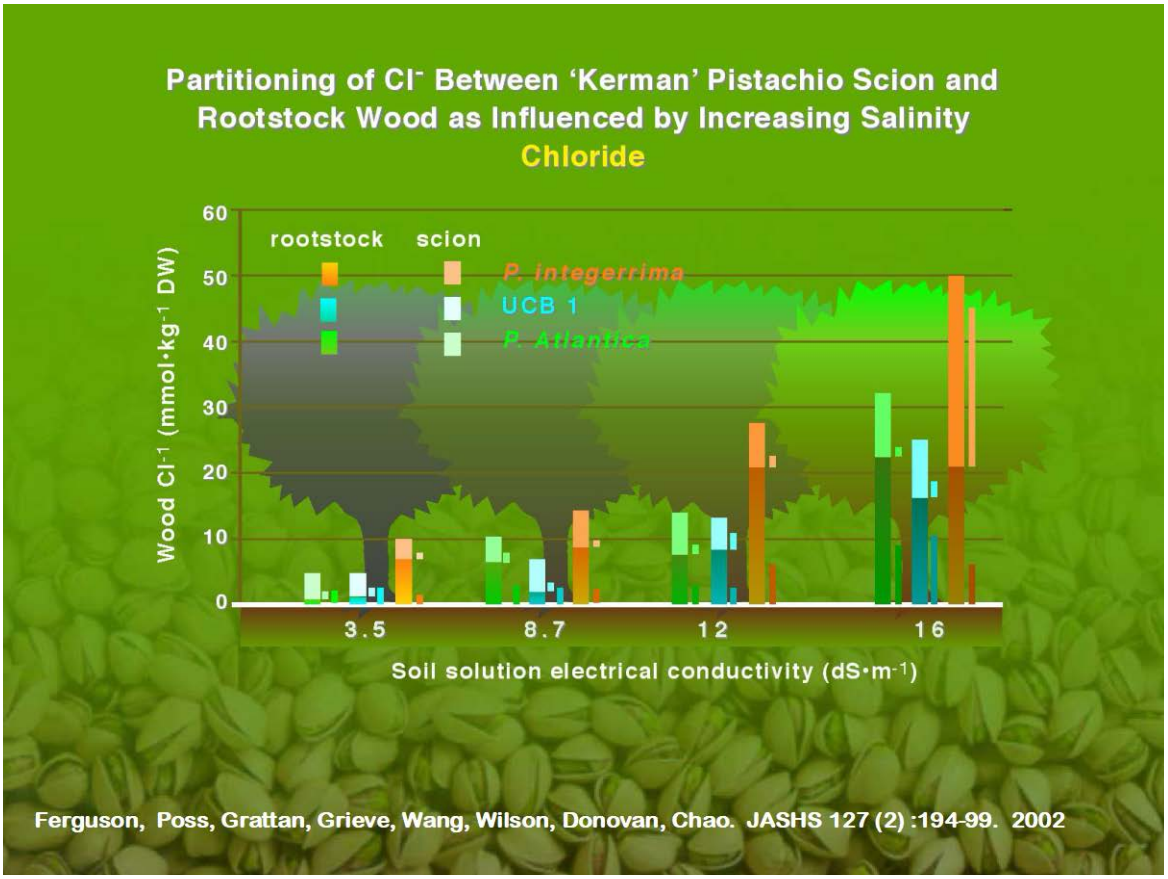

Figure 2. As soil EC_e rises the UCBI rootstock, (blue bar), clearly takes up less Cl^- than the Atlantica rootstock (green bar) or Integerrima (brown bar). As with Na^+, this pattern again suggests exclusion of Cl^- at the root level and a sequestering mechanism within the rootstock.

It was these findings that precipitated the 2012-2021 investigations of Drakakaki and Godfrey discussed below.

Drakakaki demonstrated the UCBI rootstock was excluding Na^+ and Cl^- at the root level, and sequestering Na^+ in the vacuoles (Zhang et al. in press 2021). They found a correlation between vacuolar sequestration of Na^+ in the root cortex and suberization of the exodermis and endodermis which decreased Na^+ uptake. Both parameters increased with increasing salinity stress.

Godfrey et al. (2019, in press 2021) demonstrated the UCBI rootstock was intercepting Na^+ in the transport stream and storing it in the xylem parenchyma and recirculating Cl^- in the phloem.

Collectively, the results of Godfrey and Zhang confirm and explain the earlier findings of Ferguson and Sanden demonstrating that the higher salt tolerance of the UCBI hybrid seedling root versus the seedling PGI rootstock. The UCBI seedling rootstock is more salinity tolerant because it excludes Na^+ and Cl^- at the root level, stores Na^+ in the vacuoles of the root's cortex, retrieves Na^+ from the xylem stream, storing it in the xylem parenchyma and recirculates Cl^- in the rootstock trunk phloem. What is interesting is that none of these mechanisms are present in the UCBI parents even though the seedling rootstocks Drakakaki and Godfrey used were almost certainly from the original UCBI parents. These results were produced with seedling rootstocks. However, there is no physiological reason to think these mechanisms of salinity tolerance would be different in clonally propagated rootstocks.

Currently, Dr. Pat J. Brown is investigating the genetics of salinity tolerance in UCBI and has located two quantitative trait loci (QTLs), or locations in the UCB-1 genome, one on a P. atlantica chromosome and one on a P. integerrima chromosome, that control the amount of sodium and chloride in leaves of ungrafted UCBI seedling rootstocks. The implication is that some UCBI seedlings may be more salinity tolerant than others. The original UCBI clonal selection carries the "good" (salinity tolerant) allele, a form of the gene on the chromosome, at both these QTL, locations, and thus may be a good choice for saline sites.

So, how does this information impact pistachio growers now, in the short term? Except for determining the relative salinity tolerance of the current commercially available rootstocks our trials did not change what growers have been doing for decades. Salinity cannot be eliminated; it can only be managed. Below are the principle management strategies, as presented by Mae Culumber, Fresno County Farm Advisor, at multiple Advances in Pistachio Production Short Courses Statewide Pistachio Days.

In saline situations:

- use a UCBI rootstock
- maintain the soil Ece below 4.5 dS/m
- sample your soil and irrigation water
    - preplant
    - before and after the growing season
- address sodicity first and salinity second
    - apply gypsum before winter rains or leaching
- leach during the dormant period
    - when Et is lowest
    - when ECe is highest
    - and before the spring root flush

However, in the mid and long term the results discussed above are of great significance and impact. In the midterm the phenotypic and physiological biomarkers identified by Godfrey and Drakakaki can be used to identify seedling rootstocks for clonal propagation. Field studies by Dr. Patrick J. Brown, geneticist in the Department of Plant Sciences at UC Davis are now ongoing to determine whether the salinity tolerance QTL detected in ungrafted rootstocks translates into yield differences in mature orchards, and molecular work is underway to try to connect the genetic and physiological observations in these different studies. In the long term, understanding the molecular mechanisms behind these differences in rootstock performance can be used to further improve the salinity tolerance of pistachio rootstocks.

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