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Kern Pistachio Notes

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Can a Table of Weather Variables from an Experimental Trial (2014-2022) Teach Us Anything about the Adaptation of Pistachio to the climate of the San Joaquin Valley of California?

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There appears to be general agreement that the nut yield of pistachio was disappointing to many growers in California in 2022. Based on the yields achieved during the 2021 season, and the number of the buds that appeared to be on the trees going into the winter of 2021-22, the pistachio industry was expecting higher yields than what were harvested in the fall of 2022. So what happened? I wrote about some of the reasons put forward for these poorer than expected yields in this newsletter in the October 2022 edition (https://cekern.ucanr.edu/newsletters/Pistachio_Notes_Newsletter95062.pdf). The purpose of this article is to dig deeper into what happened this year in relation to previous years in one of the trials we have been monitoring closely since 2014.

Fair Warning! The detailed discussion of the data in this article could be considered overly involved, tedious, and possibly confusing to many. Those wishing to make a long story shorter are advised that they may want to skip down to the "Summary of Observations and Tentative Conclusions" at the end of this article.

First, it might be useful to discuss the adaptation of pistachio to the San Joaquin Valley (SJV) of California.

The Adaption of Pistachio and the San Joaquin valley of California

Pistacia vera is the genus and species of the tree that we grow to produce pistachio nuts. Kerman, for example, is a selection of *P. vera.* Pistachio originated in central Asia, probably in the countries we currently call Iran, Afghanistan, Turkmenistan and in some neighboring countries. This area of origin is much higher in elevation than the SJV. In Asia, pistachio grows in hilly and mountainous regions at elevations greater than 4000 ft. above sea level. Compare this with the 200 – 650 ft. elevations where pistachio is grown in the SJV. Higher elevations, of course, are associated with colder temperatures – much colder with significant elevation gain. As the degree of winter dormancy increases, pistachio trees grown from seed can survive temperatures to 10 °F and colder. In the Central Valley of California, we have compromised pistachio's adaptation to extremely cold climates somewhat by grafting it to other species of *Pistacia,* which are not as cold tolerant, or to hybrids with other species of *Pistacia*, that have the advantage under SJV conditions of conferring greater disease resistance. Therefore, we have traded some cold tolerance for disease resistance. These other *Pistacia* species used as rootstocks include *P. integerrima* and *P. atlantica* and hybrids of the two. However, extreme cold in mid-winter is not a particular problem with pistachio's adaptation to the San Joaquin Valley so the trade-off for disease resistance was a good one.

Tree species, such as pistachio, move through several stages of metabolic activity through the year, especially from fall through spring. As daylight decreases and temperatures begin to cool in the fall in California, the trees begin to enter a state we call "endodormancy", realizing, of course, that a tree is never truly dormant. Usually, by the end of December the trees are about as dormant as they are going to get.

Winter chilling: Some trees such as cherry and pistachio have a useful adaptation that prevents them from flowering and leafing out too early. Plants like these have a poorly understood physiological mechanism that allows them to monitor and "clock" the amount of cold to which they have been exposed that prevents them from producing frost sensitive tissue, such as flowers and leaves, during the winter. We call the minimum exposure to cold that prevents early flower and leaf bud push and promotes adequate bloom their "chilling requirement". Trees are considered to be in endodormancy until the chilling requirement is met. If the chilling requirement is not met, the growth of flower and leaf buds in the spring, as the land warms back up, can be delayed and erratic. If the tree is not exposed to enough cold, it acts as if it is still winter and will be hesitant to leaf out and bloom.

Pistachio trees remain in this dormant state until they begin to emerge from endodormancy sometime in late February or early March in the northern hemisphere. Once the chilling requirement has been met, a certain amount of heat is required to awake from endodormancy and push new leaves and blooms. The period when the tree is awakening from endodormancy in the spring is called "ecodormancy". How fast the ecodormancy temperature requirement is achieved is a function of temperature. Once the amount of heat required to truly "wake up" the tree is met, the ecodormancy stage ends and the tree is ready to flower and push vegetative buds. In general, the greater the winter chilling, the more evenly and earlier the endodormancy period is completed. The earlier the endodormancy periods ends, the earlier the trees can start clocking the heat required to meet the ecodormancy requirement. The faster the ecodormancy requirement is met, the faster bloom is initiated. Thus a rapid and uniform bloom is dependent on plenty of chilling, and warm, but not too hot, temperatures during ecodormancy and during the period from initial swelling of the flower buds through the bloom period.

Unfortunately, for accurate bloom predictions, the interrelationship of weather variables such as air temperature and plant bud temperature as affected by absorption of direct radiation from the sun are complex. So, too, is the physiological state of the tree related to the abruptness of the onset of cooler and warmer conditions in the fall and spring, respectively. Consequently, we currently, do not have the tools to determine the adequacy of the amount of chilling a pistachio tree accrues to predict, with confidence. However, we do have some "models" that are used that provide some rough "relative" values that suggest whether bloom was inadequate, borderline, adequate, or superior. The trees themselves can provide visual signs as to the adequacy of the chilling. Symptoms of insufficient chill include the following:

-delayed bloom
-asynchronous bloom between the female and its usual male pollenizer
-abnormal development of male and/or female flower parts
-high variability of bloom stages (early, mid, full, and late) among inflorescences across the tree canopy
-leafless gaps in new spring branch growth
- the northeast and lower tree canopy flower and leaf-out before the upper canopy and southwest side

Originally, when pistachio orchards were first planted in the SJV in the 1960s through the 1980s, the fall and winter was characterized by long periods of thick fog. This thick fog provided fall, winter and spring temperatures more similar to those of the climate in their area of origin in central Asia. The SJV sort of "tricked" the trees into thinking they were in Central Asia. Unfortunately, in the years since, the SJV has warmed considerably during the winters and has become drier. Pistachio in the SJV has lost a lot of its fog blanket. In addition, the SJV has another characteristic that interferes with satisfying the chilling requirement. The SJV exists at the bottom of a deep "bowl" of mountains with the Coastal Ranges on the west, the Sierras on the east, and the Tehachapais on the south. These mountains often block and prevent wind from mixing layers of air deep in the bowl. In winter, a warm inversion layer is created from 300 to 1000 feet above the valley floor. This temperature inversion is the result of radiation absorbed by the ground during the day being reradiated and absorbed by the lower atmosphere. With temperature inversion, temperatures measured upward from the ground increase with altitude, unlike in Central Asia where increases in altitude mean cooler temperatures. It is not a coincidence, that frost sensitive citrus, in the SJV has been planted up in the foothills where the winter inversion layer typically forms. While these warm inversions are great for preventing frost damage in citrus, they are not beneficial in meeting the chilling requirement necessary for breaking endodormancy in pistachio. In general, pistachio orchards planted above about 650 feet above sea level in the SJV, often do not receive sufficient chilling for a rapid and uniform bloom.

While the pistachio industry in California in the past has focused on winter chilling as a primary variable governing and limiting bloom and yield, it is apparent that other temperature-related variables measured at other times of the year may play an equally important role in achieving good bloom, pollenization and eventual yield of nuts. The objective of this article, is to explore the role that temperature, as measured both during the fall, winter and spring, may play in explaining what growers have been observing during bloom and, eventually, at harvest.

As a newsletter, "Kern Pistachio Notes" has been written as more of a personal "blog" than a typical newsletter. Therefore, for the purpose of this newsletter on this topic, I am going to put my serious "blogger" hat on. I am wearing the blogger hat because much of the ensuing article is based on my opinions developed over years of field observations, on the limited scientific literature available and not on rigorous randomized and replicated scientific experiments, which, generally, do not exist. I think of the information provided in this article as a possible guide for future research. The main purpose of this article is to familiarize the audience with weather variables that appear to be important in the adaptation of pistachio to the San Joaquin Valley and how these variables may interact to affect early tree growth and bloom. These variables appear in headings in the tables (Tables 1 – 3) and I hope are self-explanatory. Further details on how they were calculated appear in Table 4. Many of these variables are commonly used to estimate or track winter chilling or heat accumulation by pistachio growers.

In this article, my objective will be to explain, on a year-by-year basis, differences in the uniformity or variability in tree growth and flowering observed during the bloom period at the Jasmine Trial located near the intersection of Garces Highway (State Highway 155) and Grapefruit Rd. in Kern County. A further objective will be to determine if these bloom differences are reflected in the nut harvest. In this trial, hourly air temperatures were measured at a height of 4 feet above the ground in a radiation-shielded station located equidistant between two trees within a tree row. Temperature measurement began in March of 2014 and continued through 2022.

Observations on the course of the bloom development in this trial each year were made at closely spaced intervals during the bloom period. Observations related to tree growth and flowering during the bloom period included the following:

- Variability in bloom uniformity between the north and south side of the tree canopy
- Variability in bloom uniformity across the entire canopy of the tree, including unusual variability within the north and/or south portions of the canopy when differences in side of the tree were present.
- Length of the bloom period (from initial observable inflorescence bud swell to full bloom) in days.

Note that bloom variability, often, is associated with the production of non-viable flower buds and inflorescences that fail to open, open and later dry up and blow away, or that produce few nuts. Bloom uniformity has two components. There is the uniformity of the bloom of the flowers within a single inflorescence (later to become the rachis) and differences in the uniformity of all the inflorescences in the tree canopy. At any given time during the bloom period, some inflorescence buds will not have pushed while others on the same tree are at full bloom. The observations made for the purposes of this article refer to bloom uniformity of flowering based on a holistic estimate of all of the inflorescences on the tree. For example, if a majority if the flowers on the tree are at full bloom, that is when full bloom occurs even if a noteworthy number have not yet bloomed or have finished blooming. If it was difficult to determine which bloom stage predominates for example "early bloom" or "mid-bloom" or "full bloom" that would be an indication of high bloom variability.

The Effect of Fall and Winter Chilling on bloom at the Jasmine Trial

The amount of bloom variability and duration by year compared to the modeled chilling variables is presented for the Jasmine Trial from 2015 through 2022 in Table 1. Values of particular interest are highlighted in yellow.

Table 1. Chilling related variables, bloom timing and variability, bloom duration and yield of Kerman at the Jasmine Trial in Kern County. The superscript numbers in the Table headings indicate that that particular variable is further explained in Table 4 below.

A	B	C	D	E	F	G	H	I	J
Harvest year	Chill year	Tree age, years	Tree bloom variability between sides of tree canopy[4]	Bloom variability, across tree[5]	Days in bloom period[6]	Chill portions[1]	Chill hours <45 °F[2]	Winter Warm hours > 65 °F[3]	Yield of Kerman lbs/acre[8]
2014		4							0
2015	2014-15	5	No bloom	No bloom	No bloom	56	549	175	0
2016	2015-16	6	Low	Low	16	64	1031	104	915
2017	2016-17	7	Low	Low	17	60	835	106	3293
2018	2017-18	8	High	High	19	57	886	209	1137
2019	2018-19	9	Low	Low	15	66	820	87	3473
2020	2019-20	10	Low	Low	22	62	934	113	3109
2021	2020-21	11	Low	High	13	64	1092	141	4081
2022	2021-22	12	Low	High	10	71	970	126	102
Average					**16**	**63**	**890**	**133**	**1790**

As discussed above, the objective of Table 1 was to gather the visual characteristics of the uniformity and length of the bloom period (Columns D,E and F) together with the modeled chill-related variables (Columns G, H, I) and with yield (J). The actual arithmetic and calendar calculation of the variables that appear in Tables 1- 3 are explained in detail in Table 4 below. Values of the variables in Columns D, E and F that appear abnormal are marked in yellow in Table 1. Note that where Chill Portions (Col. G) were below 60, Tree bloom variability between the north and south side of the tree was either "high" in 2018 or there was no bloom in 2015 (Column D). In 2015, the orchard was in sixth leaf, and normally, yields of upwards of 1000 lbs./acre of nut yield would have been expected. Note that Chill Portions (Col. G) were only 56. It has been my observation over the years, that when there is a big difference in the appearance of bloom between the north and south sides of the tree canopy, then inadequate chilling is to blame. Generally, low-chill years occur when the fog blanket is lost. When fog is present, there is little direct solar radiation of the buds. Without the cooling and shading fog, the top and south side of the tree receives more direct radiation than the more shaded north side. This higher radiation results in excessive bud temperatures reducing effective winter chilling on the more exposed south side and top of the trees. As a result, the north side accumulates more chilling and will bloom and push leaves before the south side and top of the tree. The purpose of measuring "Winter Warm Hours greater than 65 °F" is as a proxy for a "rough" estimate for direct solar radiation that a tree receives during the fall and winter. Hourly air temperatures greater than 65 °F are rare when the fog blanket is in place but common on cloudless and clear fall and winter days. Our assumption then is that the more hours of temperatures greater than 65 °F were logged, the more direct solar radiation the buds received. In 2015, Chill Portions were low (Column G), Chill hours were low (Column H) and Winter Warm Hours were high (Column I). From these data, I suggest the lack of bloom in 2015 was at least in part, due to insufficient chilling. Later in this article, I will suggest an additional reason that bloom and thus yield, failed in 2015. Again, this time in 2018, Chill Portions (Col. G) were only 57, which explains the observed high variability in bloom between the south and north sides of the tree (Col. D). In contrast to the low Chill Portions (Col. G) in 2018, the hours below 45 °F were near average for the Jasmine Trial at 886 (Col. H). Interestingly, the calculation of Chill Portions is adjusted downward for warm fall and winter temperatures whereas accumulated Chill Hours are not. However, for 2018, as can be seen in Column I, accumulated Winter Warm Hours were greater than 200, which probably reduced the effectiveness of the average accumulation of Chill Hours which occurred that year. Thus looking at both Chill Hours (Col. H) in combination with Warm Hours (Col. I) provides a similar picture as generated by Chill Portions (Col. G) alone. The observation that bloom variability between the north and south sides of the tree was only high in 2018 (and bloom non-existent in 2015), suggests that insufficient chilling in this relatively high elevation orchard was only a potentially bloom-limiting factor in these two years. What caused the additional bloom variability (Col. E) across the entire tree canopy in 2018, and in 2021 and 2022? Later in this article, I will suggest another variable that may have played a role in the bloom variability present in 2018, 2021 and 2022.

Importantly, note in Table 1, that nut yield in 2018, even though bloom variability was high, was greater than 1000 lbs./acre (Col. J). Trees produce many more flowers than will ever set fruit. Thus, the tree can lose many flowers because of weather-related extremes and still produce economic nut yield. In general, whether adequate fall and winter chilling was achieved, is most accurately determined by looking the uniformity of the bloom among the top, south and north sides of the tree canopy rather than at yield in the fall. Following this reasoning, the observation that Chill Portions were only 60 (Col. G) in 2017, while bloom variability was low (Col. D), suggests that the threshold for adequate chilling using Chill Portions resides somewhere below 60. In 2017, the number of Warm Winter Hours were only 106, which is below average and which played a less limiting role in minimizing the effectiveness of the 836 Chill Hours accumulated (Col. H) for this crop year.

As questioned briefly above, in Table 1, there is bloom-variability data present that does not appear to be related to fall and winter chilling. The values for Chill Portions, Chill Hours and Winter Warm Hours do not appear to explain the high variability in bloom across the entire tree canopy (Col. E) some years when this variability is present equally across the tree and when differences between the top and sides of the tree canopy are not apparent. Note that Chill Portions in 2022, where the highest ever measured at this trial at 71, yet the bloom uniformity across the tree (Col. E) was "high". In addition, the modeled chill variables appear to do little to explain the differences in the length of the bloom period among years (Col. F). In 2020, the length of the bloom period was 22 days (Col. F), bloom variability by either measure of the canopy was low (Cols. D and E) and chill based on the models (Cols G, H and I) appeared non-limiting in breaking endodormancy. What caused this long bloom period in 2020?

Some years ago, I published results from a research project in which I correlated a range of weather variables with Kerman yield over a 30 or so year period (https://journals.ashs.org/hortsci/view/journals/hortsci/52/4/article-p598.xml).

The Kerman orchards, from which these data originated, were on similar rootstocks, optimally or near-optimally irrigated and fertilized, so weather played the dominant role related to yield. One of the significant correlations with yield was the variable "number of hours above 80 °F during the period from March 20 through April 25". The resulting regression equation demonstrated that, on average, for every hour above 80 °F during this period, marketable yield was reduced 13.8 lbs/acre. Based on this previous finding, this variable was calculated for the temperature data for the Jasmine Trial. This variable appears in Column H, in Table 2 below.

Table 2. Tree bloom variability, chilling portions, warm temperatures and GDD heat units during the generic SJV bloom period and yield of Kerman at the Jasmine Trial Site in Kern County from 2014 – 2022. The superscript numbers in the Table headings indicate that that particular variable is further explained in Table 4, below.									
A	B	C	D	E	F	G	H	I	J
Harvest Year	Chil -ling Year	Tree age years	Tree bloom variability between sides of tree canopy[4]	Tree bloom Variability, across tree[5]	Length of bloom bloom period, days[6]	Chill Por- tions[1]	Hours > 80 °F in bloom period[9]	GDD in bloom period[7]	Yield of Kerman, lbs/acre[8]
2014		4					73	441	0
2015	2014-15	5	No bloom	No bloom	No bloom	56	74	447	0
2016	2015-16	6	Low	Low	16	64	64	431	915
2017	2016-17	7	Low	Low	17	60	16	355	3293
2018	2017-18	8	High	High	19	57	76	436	1137
2019	2018-19	9	Low	Low	15	66	56	435	3473
2020	2019-20	10	Low	Low	22	62	25	300	3109
2021	2020-21	11	Low	High	13	64	74	444	4081
2022	2021-22	12	Low	High	10	71	65	449	102
Average					**16**	**63**	**58**	**415**	**1790**

Table 2, basically, contains the same data as are present in Table 1 with some additions. Chill Portions (Col. G) remains as a proxy of the chill models, in general. Based on the results from the regressions equations in the paper discussed above, accumulated "Hours Greater than 80°F" during the generic bloom period (March 22 – April 25) for pistachios in the SJV have been added in Column H and Growing Degree Days (GDD) in Column I. Growing Degree Days is a measure of the heat present during the generic bloom period. In Table 2, as might be expected, there appears to be some correlation during the generic bloom period between accumulated "Hours Greater Than 80 °F" (Col. H) and "GDD" (Col. I). When one was high the other was high, except most notably in 2019. There appears to be somewhat of a correlation during the generic bloom between accumulated "Hours Greater than 80 °F" (Col. H) and bloom variability (Cols. D and E) especially when the hours in Column H exceeds 74. Again, there appears to be little correlation between "Hours Greater than 80 °F" (Col. H) or "GDD" (Col. I) and yield.

Calculation of GDD (Col. I) suggested a reason for the long 22 day length of the bloom period in 2020 at 22 days (Col. F). The bloom period in 2020 was cool and wet. The cool wet weather was reflected in the GDD accumulation for the generic bloom period in this orchard at only 300 GDD in 2020. Biological processes slow down when there is less heat. The next lowest GDD accumulation was in 2017 at 355 GDD. These data suggest that the GDD threshold for a more normal bloom period of 15 – 17 days from initial bud swell to full bloom (at this site where chilling may be more borderline) falls somewhere between 300 and 355 GDD (as calculated using a base temperature of 50 °F with not upper temperature cutoff).

After looking at the data in Table 2, it suggested that higher temperatures in some years during bloom might play an important part in explaining the amount and type of variability seen during the bloom period. Air temperature accumulations presented in Tables 1 and 2, above, were calculated for the generic bloom period of pistachio in the SJV. It appeared from these tables that it might be informative to calculate temperature accumulations during or within the actual observed bloom period of Kerman by year in this orchard. However, when during the bloom period the hours should be accumulated and at what threshold was not clear. Observations made of trees during bloom in 2022 at the Jasmine Trial suggested an answer. In April 2022, I published a short edition of this newsletter as a heads up to the industry at the following link. https://cekern.ucanr.edu/news_80/https___cekern.ucanr.edu_news_80_Pistachio_Notes_Newsletter/?newsletteritem=92893

Generally, this newsletter article expressed my concern at the appearance of the bloom. The flowers and their rachises looked like they had been "fried" and honeybee activity in the male catkins, which was usually high, was practically non-existent. This low bee activity characterized even the experimental male varieties that appeared to be near full bloom. That newsletter was based on observations that I made on morning of April 7, before the plus 90 °F temperatures hit the SJV later that day. Kerman, on April 7, was already near or at full bloom, although it was apparent that the flowers appeared damaged and many would never open. So, whatever happened to the flowers happened before the very hot 90°F temperatures occurred and prior to full bloom. Since this multi-year data set had very few recorded temperatures above 90°F, I chose 85 °F as a hypothetical air temperature threshold in which damage to flowers could begin to be severe and hypothesized that the damage probably occurred sometime from initial bud swell to the appearance of the first blooms. This new variable was placed in Table 3 Column H, below, along with other variables, based on temperature that appeared to be the most valuable from Tables 1 and 2 as discussed above.

Table 3. Tree Bloom Variability, Length of the Kerman bloom period, Chilling Portions, GDD heat units, accumulated air temperature Hours Greater than 85 °F during the actual Kerman bloom and yield of Kerman at the Jasmine Trial Site in Kern County from 2014 – 2022. The superscript numbers in the Table headings indicate that that particular variable is further explained in Table 4, below.

A	B	C	D	E	F	G	H	I	J
Harvest Year	Chilling Year	Tree age, years	Tree bloom variability between sides of tree canopy[4]	Tree bloom variability across tree[5]	Length of bloom period, days[6]	Chill portions[1]	Hours > 85 °F From bud swell to first bloom[10]	GDD in bloom period[7]	Yield of Kerman lbs/acre[8]
2014		4							0
2015	2014-15	5	No bloom	No bloom	No bloom	56	15?	447	0
2016	2015-16	6	Low	Low	16	64	0	431	915
2017	2016-17	7	Low	Low	17	60	0	355	3293
2018	2017-18	8	High	High	19	57	6	436	1137
2019	2018-19	9	Low	Low	15	66	0	435	3473
2020	2019-20	10	Low	Low	22	62	0	300	3109
2021	2020-21	11	Low	High	13	64	5	444	4081
2022	2021-22	12	Low	High	10	71	12	449	102
Average					16	63	3	**415**	1790

The data from this analysis in Table 3 shows that temperatures greater than 85 °F (Col. H) occurred in the actual observed early bloom period during three years, 2018, 2021 and 2022, only. Note that it was in these same years, 2018, 2021 and 2022, when bloom variability across the tree canopy (Col. E) was high, even ignoring differences seen in 2018 between the sides of the tree. High temperatures during bloom, also, may be responsible, at least in part, for the complete absence of bloom previously discussed in 2015. There were flower buds on the tree going into the 2015 bloom period. Although it was not possible to calculate the actual bloom period of Kerman in 2015 since there was no bloom, there were 15 hours above 85 °F from March 11 through

April 1 at the Jasmine Trial. This accumulation, included two hours above 90 °F on March 27, which suggests hot temperatures in the early bloom period in 2015, may have contributed to the general industry-wide harvest disappointment that year, in addition to what happened at the Jasmine Trial. In Table 3, in 2015, chill was low in the Jasmine Trial at 56 chill portions, although that chill value, in itself, does <u>not</u> appear to me to be sufficient to explain the complete absence of bloom at Jasmine in these 6th-leaf trees. These data suggest that in 2015 there may have been a double whammy of low chill and unusually warm temperatures during bloom that resulted in no bloom at Jasmine and poor bloom and yields across the industry that year. However, in general, a quick look at Table 3, demonstrates that there appears to be little correlation between nut yield (Col. J) and bloom variability observations (Cols. D-F) and temperature-based variables (Cols. G – I), except perhaps in the more extreme "double whammy" year of 2015 and the very hot spring in the 2022 crop year.

The alternate bearing habit of pistachio can confound correlations of air temperatures measurements and yield. For example, in October of 2021, it was obvious that number of flower buds for the 2022 season were lower than normal on Kerman trees. The observation that flower bud numbers were comparatively low before the chilling and bloom periods, suggest the low yields in 2022 may partially be due to alternate bearing because of the 4081 lb./acre yield produced, in 2021, the previous year (Col. J). In 2022, Kerman yields were only 100 lbs./acre, which suggests that yields were affected by more than just an off-year in the alternate bearing cycle. Yield in 2022, likely, was impacted significantly by adverse hot temperatures during bloom discussed in this article. When initial flower bud numbers are low, for any reason, poor chilling and "hot" blooms will affect yield to a greater extent, since there are fewer buds to compensate for damaged non-viable buds. However, in this trial, in general, the yields in any given year were probably below the threshold where alternate bearing begins to be an important factor in determination of pistachio yield.

Another observation that is worth noting in Table 3 is the extremely short bloom periods (Col. F) in 2021 and 2022. Based on the other years in the table when bloom variability was low, a typical bloom period for the Jasmine Trial appears to be about 16 days. In 2021 and 2022, bloom durations were only 13 and 10 days respectively. In 2021 and 2022, many people remarked to me that the bloom period was very long, even endless. That was my memory as well. However, the data tell a different story. I think the bloom period just seemed to be long, since we were all waiting for damaged and non-viable inflorescences to bloom, which many never did. Many of these flowers simply dried up and fell from the tree. Alternatively, if they did slowly bloom, they did not produce any nuts. At Jasmine, I observed that flower buds of Golden Hills and Lost Hills pushed out about 4 or 5 days before Kerman, which is normal. However, Kerman appeared to slow down and was at full bloom about the same time as Golden Hills and Lost Hills. Normally, of course, for equal-aged trees at the same location, Kerman will be at full bloom 4 or 5 days after Golden Hills and Lost Hills. However, there was very little total bloom on Kerman. I suspect that the hot temperatures destroyed the viability of the later-blooming cohort of the Kerman inflorescences on the tree, giving the impression that full bloom was earlier than usual. Alternatively, it might be that the relatively few Kerman inflorescences moved through the bloom stages more rapidly since there was less competition for carbohydrates. In any case, a <u>radically</u> shorter bloom duration does not appear to be a positive occurrence.

Table 4. Specific Information explaining how bloom variability was reported and how temperature-related variables, which appear in Tables 1-3 above, were calculated with regard to thresholds and calendar periods.
[1]Accumulated chill portions calculated from Oct. 1 - Feb. 28
[2]Accumulated chill hours less than 45 °F summed from Nov. 1 - Feb. 28
[3]Accumulated hours over 65 °F summed from Nov. 15 - Feb. 15
[4]This was the variability in bloom stages of the inflorescences on the north versus south side of the tree during bloom. High variability indicates that there were a wide range of bloom stages from bud swell through late bloom present between the north vs south side of the tree. Low variability indicates that the inflorescences on the tree sides tree were at more similar bloom stages.
[5] This was the variability in bloom stages of the inflorescences across the entire tree canopy during bloom without noticeable difference from north or south side of the canopy. High variability indicates that there was a wide range of bloom stages from bud swell through late bloom during bloom. Low variability indicates that the inflorescences on the tree were all at more similar stages during bloom.
[6] From initial bud swell to full bloom in days for the Kerman cultivar.
[7] Growing Degree Days (GDD) Calculated on an hourly basis; Base 50 ° F; no upper cutoff
[8] Reported as edible (i.e. marketable) yield adjusted to 5% moisture in lbs./acre
[9] Generic or typical blooming period for pistachio in days in the San Joaquin Valley of California summed from March 22 – April 25.
[10]Actual accumulated hourly air temperatures greater than 85 °F summed during the observed period during bloom for each year from initial bud swelling to appearance of the first blooms for Kerman.

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Summary of Observations and Tentative Conclusions

The data presented in this article suggest the following:

Air temperature models and hourly temperature accumulations made during the fall/winter chilling period and during bloom can help explain observed differences in the uniformity of bloom and duration of the bloom period.

By utilizing these temperature models and accumulations, and by observing the uniformity and duration of bloom, growers may garner useful information on the effectiveness of the pollination period and possible effects on harvest yield in the fall.

Observations from this study suggest that using more than one model to estimate the effectiveness of the chilling period in breaking endodormancy may be beneficial. In this study, "Chill Portions" in combination with "Chill Hours < 45°F" and "Winter Warm Hours > 65 °F", provided more information in evaluating the effectiveness of the chill period than any single method. "Chill Portions" values less than 60 were associated with increased bloom variability among the south side and top of the tree canopy as compared to the north side of the canopy. Values for accumulated "Chill Hours < 45°F" that were lower than 850 did not appear to be associated with non-uniform bloom unless the accumulated "Winter Warm Hours > 65 °F" exceeded 175.

To help ensure adequate pollination fall/winter chilling must be sufficient but as demonstrated by the data from 2022, good chilling is not enough to ensure a uniform bloom.

To help ensure adequate pollination, these data suggest that there must be enough heat for normal floral development, but temperatures, especially from bud swell to the opening of the first flowers, must not be too hot to cause floral damage. To maximize flower viability, temperatures during the entire bloom period should not exceed 80 °F (26.7 °C). Developing inflorescences during the early bloom period (from initial bud swell to first flowering) appear to cross a potential survivability threshold when air temperatures exceed 85 °F (29.4 °C).

There must be enough heat present during the bloom period for floral development to proceed at a normal rate. The "normal" duration in days from this experimental orchard appears to be approximately 16 days from initial bud swell to full bloom assuming at least 350 GDD during the typical San Joaquin County bloom period. Bloom duration, during the generic blooming period from March 22 to April 25, appeared normal at 355 GDD (base 50, no upper cutoff) but was greatly extended at 300 GDD.

Differences in bloom uniformity, with the north side of the tree blooming and pushing out leaves well before the south and top sides, suggests that fall/winter chilling was inadequate. Differences in bloom uniformity across the entire canopy, with no differences between the top or north or south sides of the tree canopy, suggest that hot air temperatures (>85 °F) during the early bloom period were the cause of this type of variability.

Average bloom duration from initial bud swell to full bloom is about 16 days. Bloom durations notably less or greater than this in this study were associated with increased bloom variability but not always.

The warming climate and the topography of the SJV is making it more difficult to emulate the climate in pistachio's area of origin in Central Asia. Our new climate normal appears to produce a level of fall/winter chilling that is borderline for breaking endodormancy resulting in greater variability in bloom. The decrease in fall/winter chilling in the SJV has been reported by a number of researchers. The purpose of this article was to focus attention on the possible detrimental effects on flower viability of warmer than desirable temperatures during the early bloom period. The threat of excessively warm temperatures during bloom has not been widely discussed in the literature or around the tables in SJV coffee shops. Excessively warm temperature during bloom may have been more of a historical threat to viable bloom and pollination than insufficient fall/winter chilling. Observational evidence suggests that warmer temperatures during spring, frequently, appear to have exceeded the threshold for development of viable flowers. Pistachio is especially at risk of encountering higher bloom temperatures, for example, than are stone fruits. Pistachio blooms later in the spring. This later-blooming characteristic can be an advantage in areas where late frosts are a problem. For example, it is not unusual for almond to be damage by late frosts in the SJV. However, the bloom period of pistachio, which is later in the spring, is associated with higher spring temperatures anyway. Additionally, as the climate warms, temperature stability decreases, and spikes in spring temperature could become more frequent. Inadequate chilling compounds the problem with the risk of high spring temperatures, since inadequate chilling results in a later average bloom date. The later the bloom date, the higher the risk for warmer temperatures and flower damage.

U.S. EPA Proposed Changes to Rodenticide Labels for Agricultural Use: Opportunity for Public Comment

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Rodents cause substantial damage and health risks in agricultural productions systems through direct consumption of fruit, nuts, and vegetative material; damage to the plant (e.g., girdling of stems and trunks); by providing a food safety hazard from contamination; damage to irrigation infrastructure; damage to farm equipment; burrow systems posing a hazard to farm laborers; posing a health risk through potential disease transmission; and increased soil erosion by water channeling down burrow systems, among other potential damage outcomes. They also cause substantial damage and food contamination risks in livestock holding facilities, food processing facilities, barns, and other agricultural-related structures. As such, effective management is needed to minimize these risks. The use of rodenticides is often considered the most efficacious and cost-effective tool for managing rodent pests and as such, it is often included in Integrated Pest Management (IPM) programs designed to mitigate rodent damage and health risks. Given the significance of rodenticides in managing rodent pests, it is important to know that the U.S. EPA has recently released a list of Proposed Interim Decisions (PIDs) for public comment that, if approved, will substantially alter if and how rodenticides may be used to manage rodent pests in the near future. As such, we felt it was important to inform California's agricultural producers as to the extent of these proposed changes, and if you are so inclined, we have provided a link for you to provide public comment on the PIDs, as well as links to contact your Senate and Congressional representatives to ensure your opinion is heard.

All rodenticides are currently under review. These include first-generation anticoagulants (FGARs; chlorophacinone, diphacinone, and warfarin), second-generation anticoagulants (SGARs; brodifacoum, bromadiolone, difethialone, and difenacoum), zinc phosphide, strychnine, bromethalin, and cholecalciferol. Of these, only FGARs, zinc phosphide, and strychnine have labels for use against field rodents (e.g., ground squirrels, pocket gophers, voles, rats, and mice found in agricultural fields), but not all of these active ingredients can be used for all rodent species. As always, it is imperative to fully read a rodenticide's label before determining if it is appropriate for use against a particular species and in a specific situation. That said, the following are some significant changes that have been proposed that you should be aware of. Other potential changes have been proposed as well, so please check out the PIDs for additional details (linked at the end of this document).

1. All rodenticides for field applications will become restricted-use products. This means that applicators will need to be certified to use restricted-use products in these settings. They will also have increased reporting requirements for their use.
2. Aboveground applications would be eliminated in rangeland, pastureland, and fallow land. This is a substantial deviation, as many/most applications in these areas have traditionally been through broadcast

applications or spot treatments. This change would leave only bait stations for ground squirrels and voles.

3. Within-burrow applications of FGARs will generally not be allowed in croplands during the growing season. This would eliminate FGAR application for pocket gophers for much of the year, and would eliminate it for all uses in some crops (e.g., citrus and alfalfa in certain areas of the state).
4. Carcass searches will be required every day or every two days (starting 3-4 days after the initial application), depending on the product used and where applied, for at least two weeks after the last application of the rodenticide. When carcasses are found, they must be disposed of properly. Any non-target mortalities must be reported to the U.S. EPA. Collectively, this will require a major increase in labor, potentially making rodenticide applications impractical in many settings.
5. Extensive endangered species designations are anticipated that will limit or eliminate the potential to apply rodenticides. This could have large-scale impacts, although the full extent is not known at this time.
6. New labels will require the use of a PF10 respirator and chemical resistant gloves during application. This is a substantial change for some rodenticide labels, requiring fit testing for all applicators, with the requirement of respirators ultimately making rodenticide application more physically challenging.

Additional details on these proposed changes can be found at the following websites:

1. Anticoagulant PID: https://www.regulations.gov/document/EPA-HQ-OPP-2015-0778-0094
2. Zinc phosphide PID: https://www.regulations.gov/document/EPA-HQ-OPP-2016-0140-0031
3. Strychnine PID: https://www.regulations.gov/document/EPA-HQ-OPP-2015-0754-0025
4. Bromethalin and cholecalciferol PID: https://www.regulations.gov/document/EPA-HQ-OPP-2016-0077-0024

As mentioned previously, these proposed changes are likely to have a substantial impact on the use of rodenticides in agricultural settings. However, these changes are currently open for public comment. If you would like to comment on these proposed changes, the required links and useful guidance can be found at the following website: https://responsiblerodenticides.org/.

You may also comment on these proposed changes to your Senate and Congressional representatives. If you are unsure who they are or how to contact them, check out: https://www.congress.gov/contact-us.

NOTE TO READERS: The first deadline for making comments to the U.S. EPA is, unfortunately past, and that is the fault of Farm Advisor Craig Kallsen, getting this newsletter out too late. U.C. Specialist Roger Baldwin sent this newsletter article to Craig Kallsen early enough that time for comments would remained has this newsletter gone out in a more timely fashion. However, this issue will be on-going and contacting your Senate and Congressional representatives remains good advice. There undoubtedly, will be time for further comments at a later date, so staying up on this issue is imperative.

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