

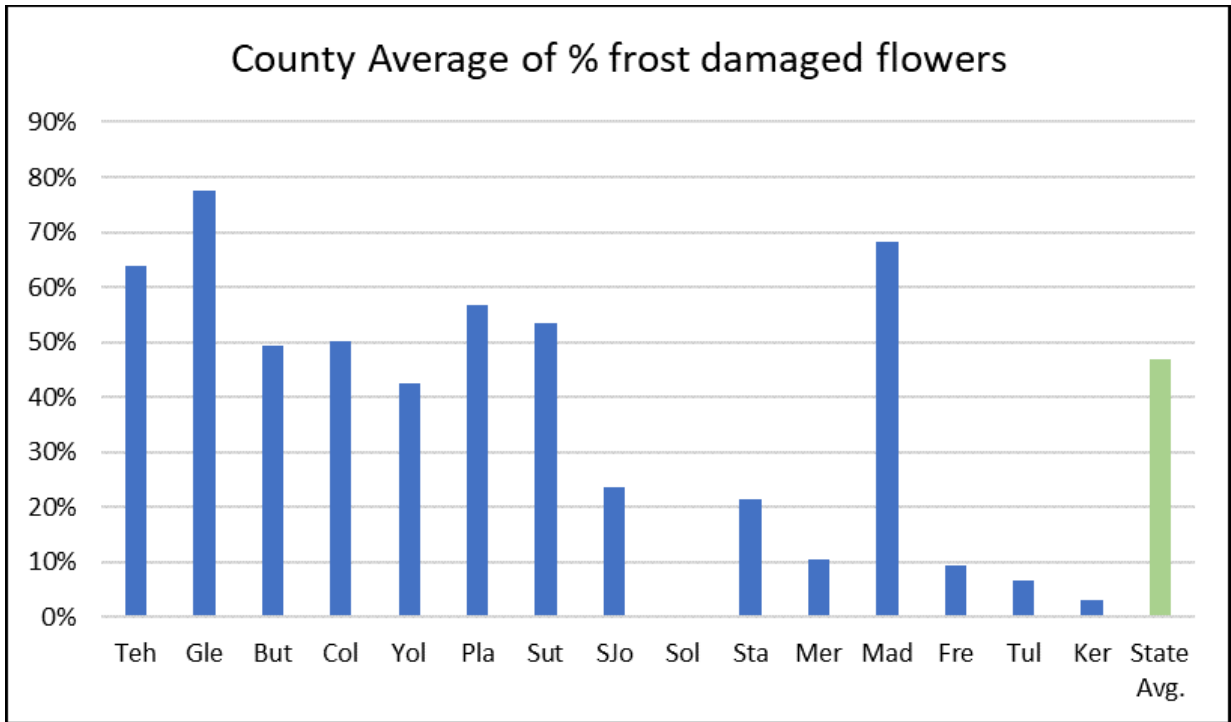
Statewide almond frost damage survey 2022

Integral Ag., Inc.

CDFA – California county map

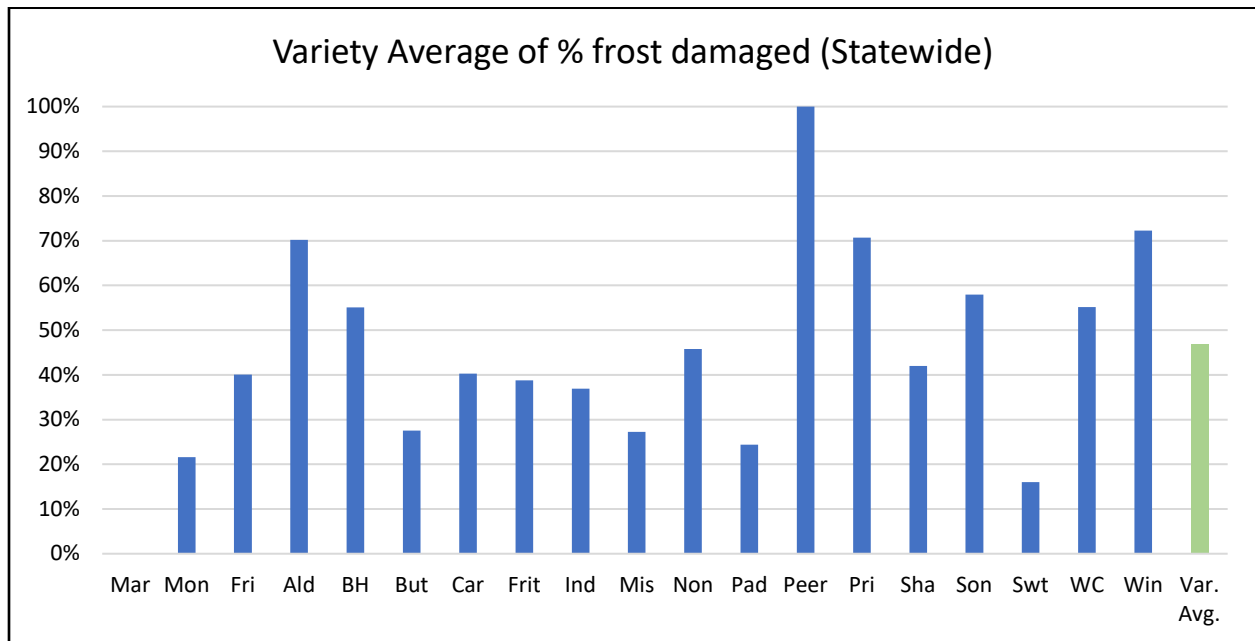
Please keep in mind we do not collect the same number of samples in each county.





* Please note that Solano (Sol) could likely change as we have some more ranches still to inspect there.

Across the entire state this past week we cut a total of 57,924 flowers and found a total of 25,766 frost damaged flowers for a state average of 47%. Dead flowers do not directly equal yield reduction, because at low levels of frost damage the tree can compensate by growing larger nuts. Also, only 30-50% of the flowers are going to become nuts. It has been documented that spurs cannot set a crop every year and have to take a year or two off, so many flowers are going to drop regardless of frost.



We collected 1,267 individual block variety samples across California.

On the mornings of February 24th, 25th, and 26th different areas of the state experienced different durations of below freezing temperatures. While we heard of places reaching 25°F or lower (seems like everyone heard someone reached 21°F or 22°F) we never were shared any records for the blocks that we watch that ever reached those temperatures. So, there could be worse damage in some areas of the state, some areas could be better for that matter; this report summarizes that frost damage we found at our client's properties.

Most commonly we were told that on farm temperatures reached a low of 27°F and 28°F. It appears to us that it was the duration that each ranch was below freezing which primarily led to the extent of frost damage. Some ranches would reach 32°F at midnight or 1am and 28°F at 6 am, while others would reach 32°F at 3am and 28°F at 6am. This would mean one ranch would be below freezing for 6 hours and the other for only half the time, but both made it down to 28°F and the amount of frost damage was greater at the ranch that spent more time below freezing.

The amount of frost protection (applied water) did appear to significantly reduce the amount of frost damage for ranches and blocks that reached a low of 28°F compared to ranches that did not do frost protection, and we did have a few that did not run water for frost protection and others that were caught in the middle of doing ground work. However, at ranches that reached 27°F or 26°F and spent 8 hours plus below freezing it was hard for us to see the impacts of running water for frost protection in our damage estimates. But for the majority of the state, I think it would have been much, much worse without frost protection and we would have seen even lower temperatures at our blocks. When we walked into the orchards without frost protection flowers and leaves would be crunchy (see photo above) and were often 100% loss.



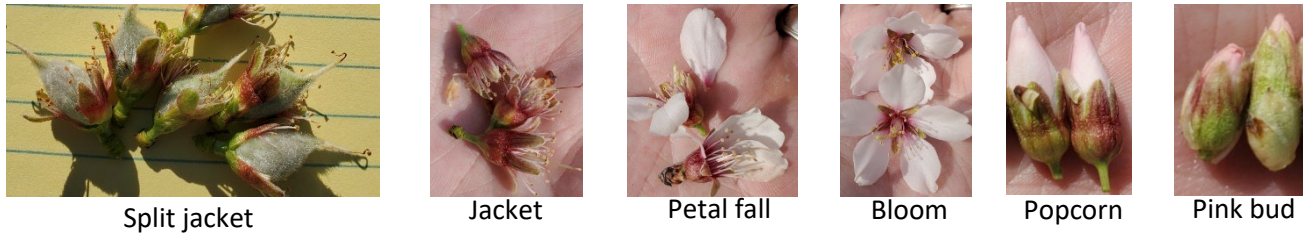
We observed many different block patterns of frost damage over much of the state. In general edges (1st and 2nd trees), drive roads, salt areas, and low spots (cold settling areas) had 3 to 4 times higher damage than the average healthy interior samples. Our data set is almost exclusively interiors, with some low spots, but edges were not included. This means



that our state wide estimate for our growers could be a little on the low side because 5-10% of almond acreage is an edge and so would be worse than our estimate. These two photos are examples of what the interior of a frost damaged flower can look like. We found that it was best to wait until the second day after the frost event to see the majority of damage. When you look the day of, sometimes the lesser damage can slip by on some varieties, while some varieties are very obvious within 3 hours.



The stage of the flowers had a large impact on the level of frost damage for most ranches and varieties. Of course, we ran into the ranches and blocks that were just too cold for too long and even the blooms were dead. The more mature the flower stage, like split jacket, the more frost damage we observed.



For most ranches and blocks, if petal fall and jacket stage were present with an ovule (not empty jacket) they suffered 2 times more frost damage than the open bloom. We rarely found frosted popcorn flowers. Below are some tables of our bloom ratings from around the state the night before the first freeze to demonstrate how different ranches had much different flower stages present depending on where in the state they were located. The percentage abundance of the different flower stages on each variety during the frost events led to variation in total frost damage. We cut a representative percent of flowers in each stage at the time we inspected. The first table below is an example of a typical bloom rating for the night before the first freeze in the San Joaquin Valley.

	DORMANT	GREEN BUD	PINK BUD	POPCORN	OPEN BLOOM	PETAL FALL	JACKET	SPLIT JACKET
Independence	0	0	0	2	98	0	0	0
Nonpareil	0	0	0	5	94	1	0	0
Price	0	0	0	15	85	0	0	0
Sonora	0	0	0	2	97	1	0	0

The table below is an example of a ranch that was far behind when the frost hit the San Joaquin Valley.

	DORMANT	GREEN BUD	PINK BUD	POPCORN	OPEN BLOOM	PETAL FALL	JACKET	SPLIT JACKET
Butte	0	0	30	40	30	0	0	0
Monterey	0	0	5	35	60	0	0	0
Nonpareil	0	0	0	25	75	0	0	0
Padre	0	0	80	15	5	0	0	0

This table below is a typical bloom rating for the night before the freeze in the Sacramento Valley.

	DORMANT	GREEN BUD	PINK BUD	POPCORN	OPEN BLOOM	PETAL FALL	JACKET	SPLIT JACKET
Independence	0	0	0	0	74	15	10	1
Monterey	0	0	0	0	70	20	10	0
Nonpareil	0	0	0	0	58	25	15	1
Wood Colony	0	0	0	0	90	9	1	0

This is an example of a ranch that was very far along when the frost hit in the Sacramento Valley

	DORMANT	GREEN BUD	PINK BUD	POPCORN	OPEN BLOOM	PETAL FALL	JACKET	SPLIT JACKET
Aldrich	0	0	0	0	0	1	89	10
Monterey	0	0	0	0	40	9	46	5
Nonpareil	0	0	0	0	35	12	40	12
Sonora	0	0	0	0	60	20	20	0

In general, the average Northern California ranch was 5 to 7 days ahead of the average south valley ranch in bloom progress, with some ranches in the north very far ahead, while in the south valley we had some ranches that were very far behind. This flower variation, along with the variation in temperatures led to vastly different outcomes at the individual ranch level and even more so over large geographic regions even though growers told us they experienced similar temperatures.

A couple days after the frost you could see the areas of the ranch where the cold air settled by the presence of the brown or tan flower petals that would give the tree an odd color. We ran into a lot of flowers that had visual frost



damage from a distance like this photo with the brown petals, but often when we cut those there was fewer damaged flowers than would be expected. The pretty white flower on the right was likely in the popcorn stage during the frost. So, just the presence of frosted petals that were burnt and tan did not always equal a frost damaged nut in many areas of the state..

We cut many flowers from the lower canopy and the upper canopy, inside the trees and outside the trees, east and west sides, north and south sides. We did occasionally find more damage on the outer edge of the trees versus the interior of the trees when the interiors were very crowded with branches, which we think offered some extra protection, but exterior flowers were further along and confound the comparison. Occasionally east sides of trees and north sides of trees were slightly worse than west sides and south sides, but this was really only observed at blocks which hedged rows on mature trees and we were only seeing a couple percent difference in damaged flowers, not meaningful. We did not find a difference between upper and lower canopy in the north state or the south valley, some samples from the top would be higher and then some from the lower canopy could be higher, so we did not detect a height difference. Mushroom shaped canopies did offer some protection of the lower wood when the orchard was all grown together, otherwise we did not see a difference. We did note that around missing trees inside blocks you had a chance to run into more frost damage on the trees around the missing one. Also, older orchards tended to fair better than younger orchards, perhaps more canopy or just more wood to radiate heat, we are not sure why but younger orchards suffered more damage than older orchards side by side pretty much everywhere. The pattern within an orchard or down a row struck us, we would be sampling and then just hit a tree that was totally frosted in all the samples and there was no obvious visual reason why that tree would be any different than the ones around it. There may be a tree health component we are not aware of yet.

Thank you for your time,

All of us at Integral Ag.