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Insights: Water & Drought Online Seminar Series

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University of California, Agriculture and Natural Resources
California Institute for Water Resources
& Strategic Water Initiative

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Managing corn under California's drought conditions

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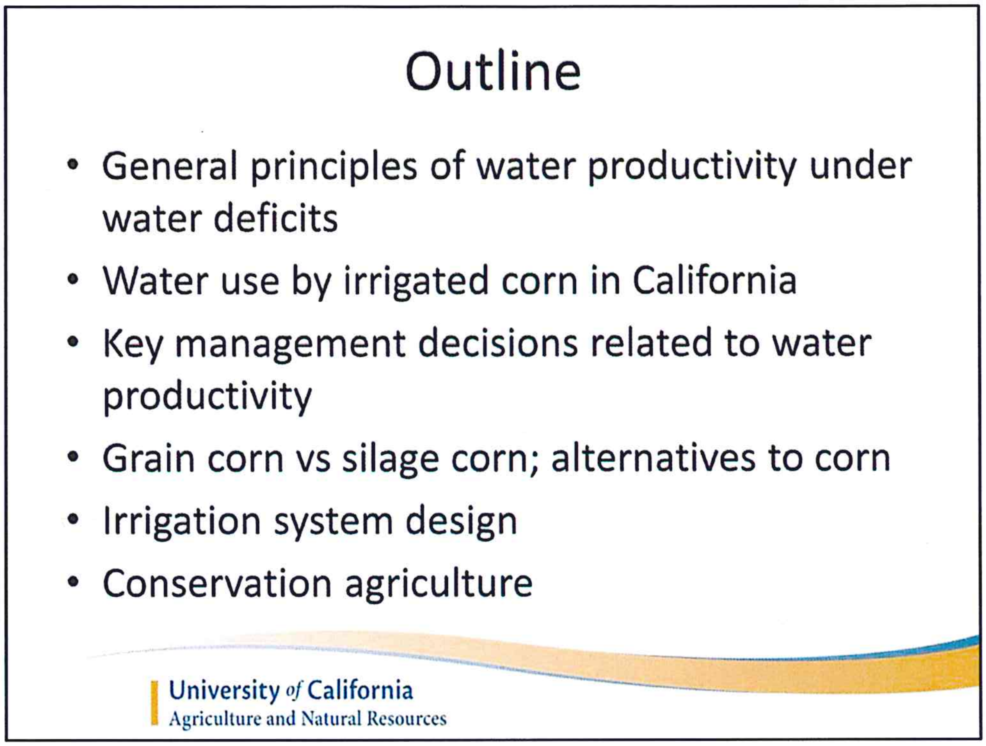
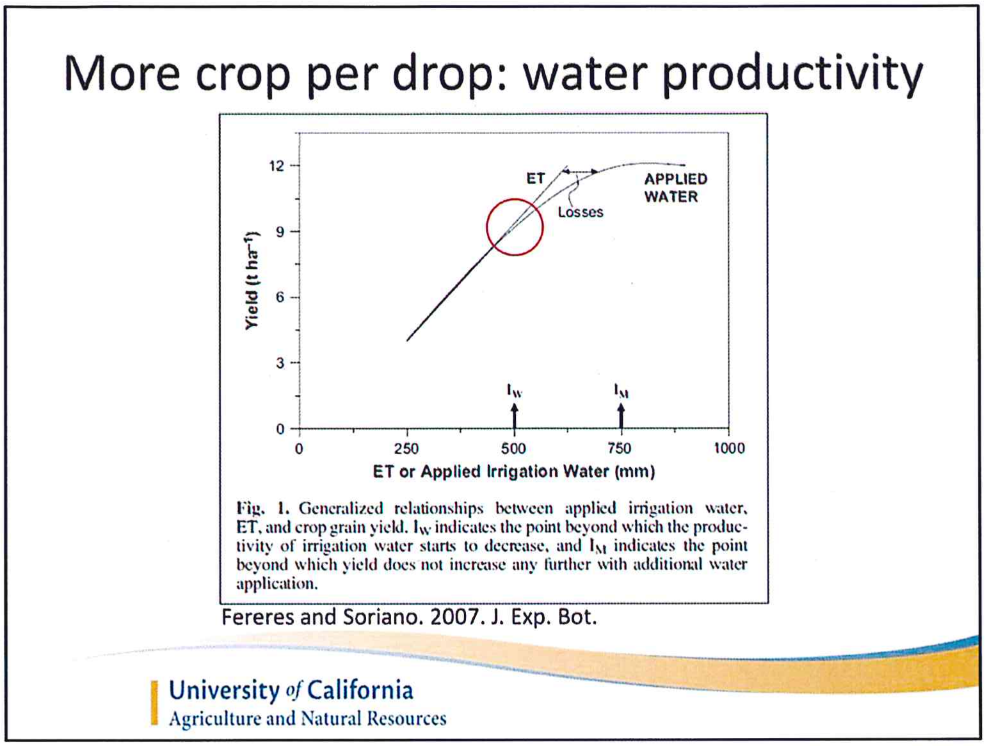
Hi.

- My name is Mark Lundy, and I'm an agronomy advisor with UC Cooperative Extension, serving Colusa, Sutter and Yuba Counties in the Sacramento Valley.
- Today, I am going to present some information on managing corn under the drought conditions we are currently experiencing in California.
- I'd like to acknowledge the contributions to this presentation from my colleagues here at the University of California as well as the contributions cited in this presentation from research and extension folks at other universities and research organizations.



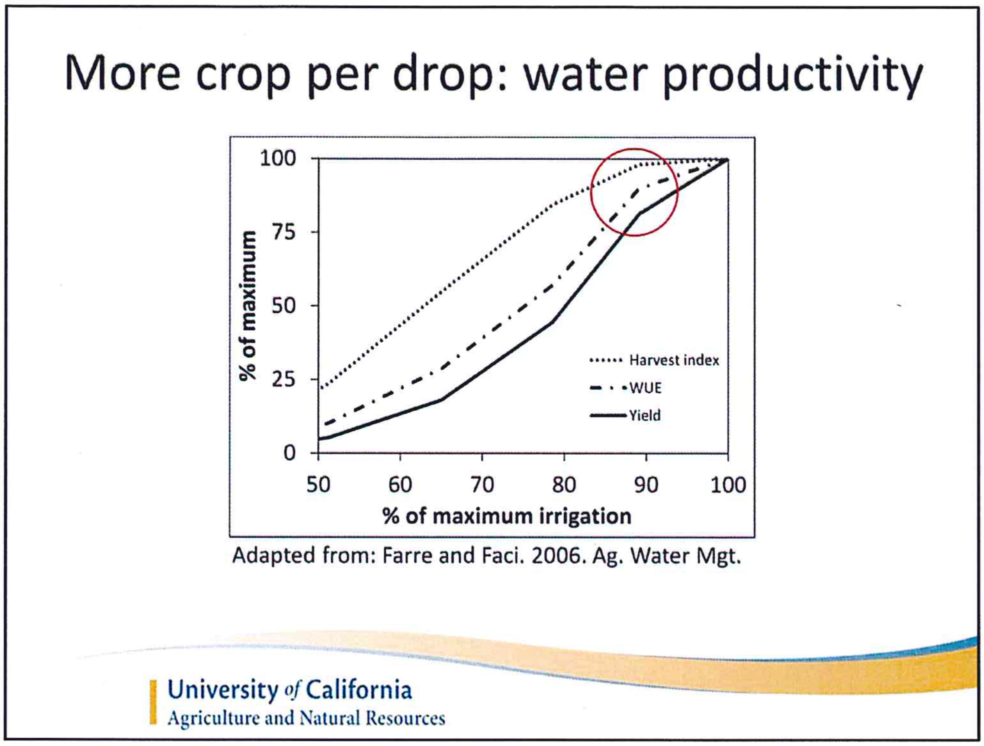
First, I'll give an overview of what this presentation will cover:

- We'll look at some general principles of water productivity under conditions of water deficits
- We'll look specifically at water use by irrigated corn crops in California
- We'll pinpoint management decision that might optimize water productivity
- We'll briefly explore some of the water use differences between grain corn and silage corn, and we'll mention some possibilities for other crops that might be more amenable than corn to water scare situations.
- Finally, we'll talk more broadly about how irrigation system design and cropping system approaches can contribute to increased water productivity.



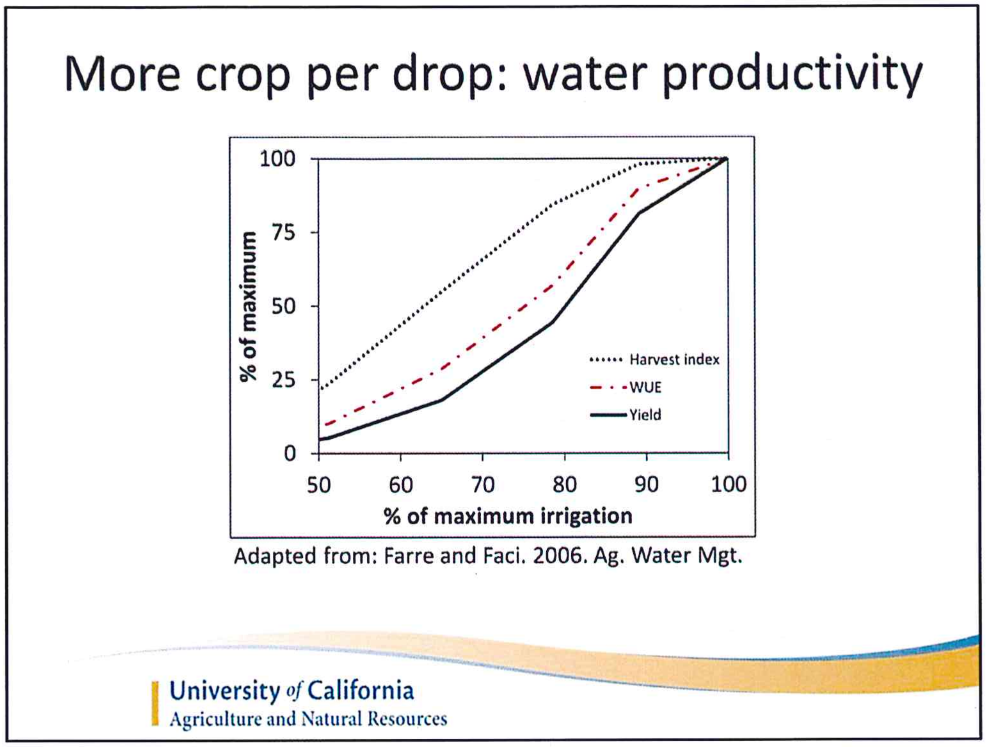
Now, I've already mentioned the phrase "water productivity" several times, so I want take a second to explain what I mean:

- This figure is showing the yield response of a crop to two things:
    1. The straight line shows increases in ET, which is evapotranspiration, or the total amount of water that leaves the crop surface, both from the crop itself (transpiration) or directly from the soil (evaporation);
    2. The other more curved line is the yield response to applied water, or irrigation.
- Obviously, the amount you irrigate is going to determine how much water there is for the crop to use, and at lower yield levels ET and irrigation are very closely coupled.
- However, as you move toward the upper end of the yield curve, you start to get less crop per drop of water applied. This feature of diminishing returns at high levels of productivity is true for many resources in agricultural systems. So, when a resource, like water, is scare, we want to manage our system to optimize the returns to that resource rather than maximizing productivity.
- In other words, we have to accept a lower yield so that we can instead get the most yield for the least amount of water.



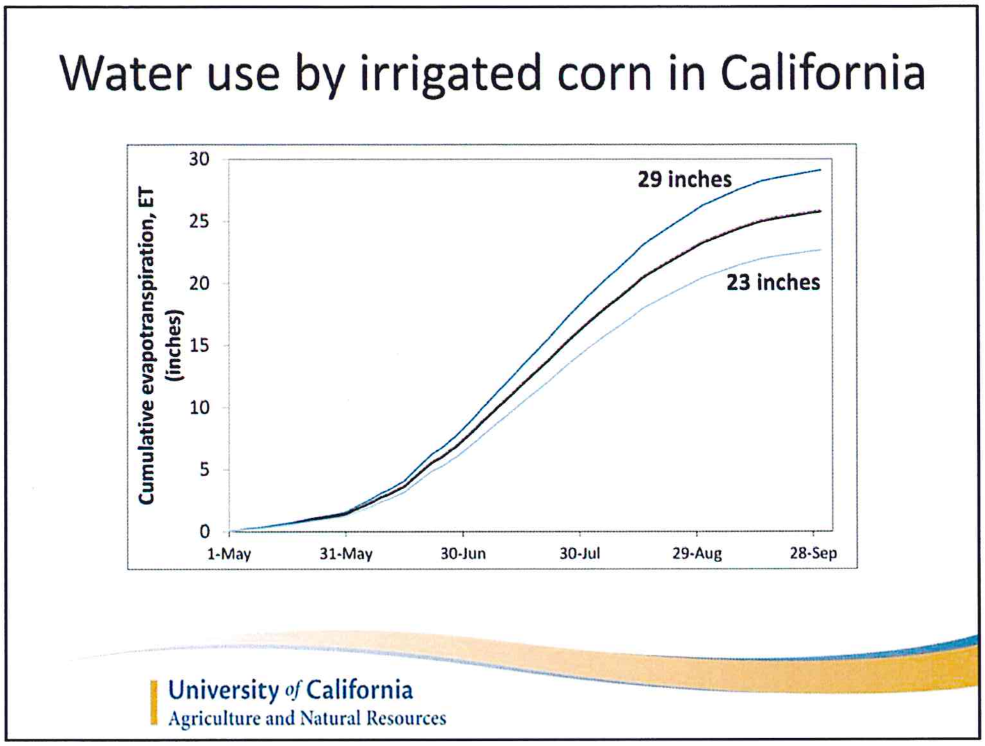
Now, not every crop will respond to water deficiency in the same way. And, unfortunately for corn, even marginal deficiencies in water will reduce overall productivity.

- This figure is showing the percent loss in yield, water use efficiency and harvest index as a function of the irrigation deficit.
- While there is a decline at each level of water deficit, the decline is least steep at a little more than 10% deficit.
- So, in a water scare situation, a grower of corn might accept that applying around 90% of normal irrigation will result in the most amount of crop for the least amount of water.



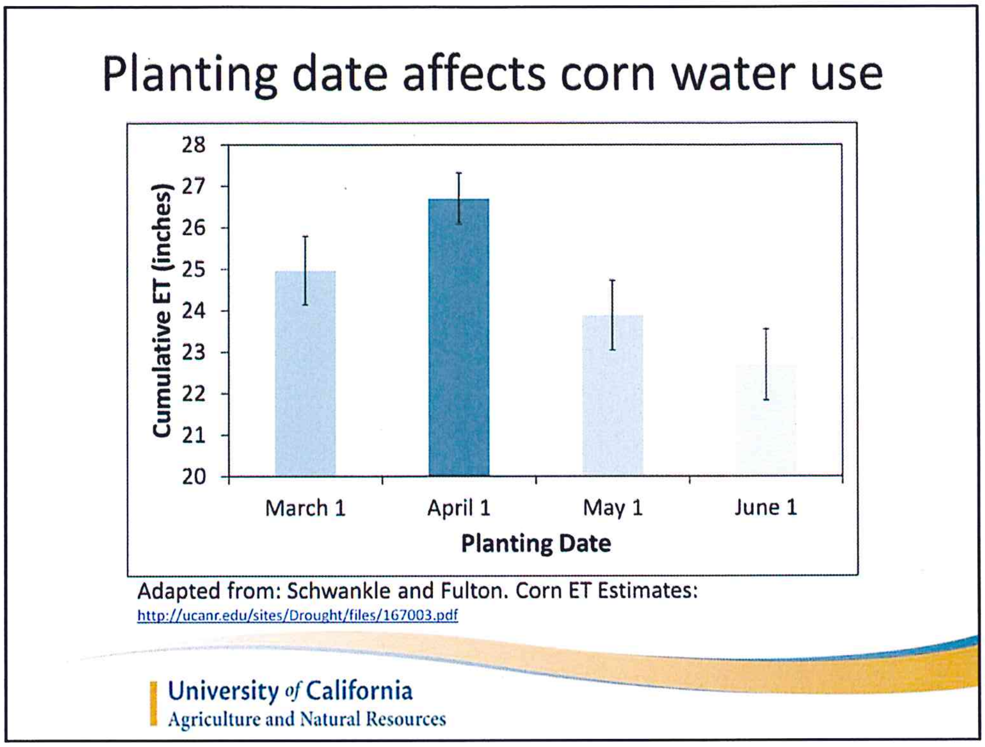
And just to clarify, this is represented by the line for water use efficiency, which is depicted in red now.

- We want to target that point at which the increase in Water Use Efficiency starts to plateau.



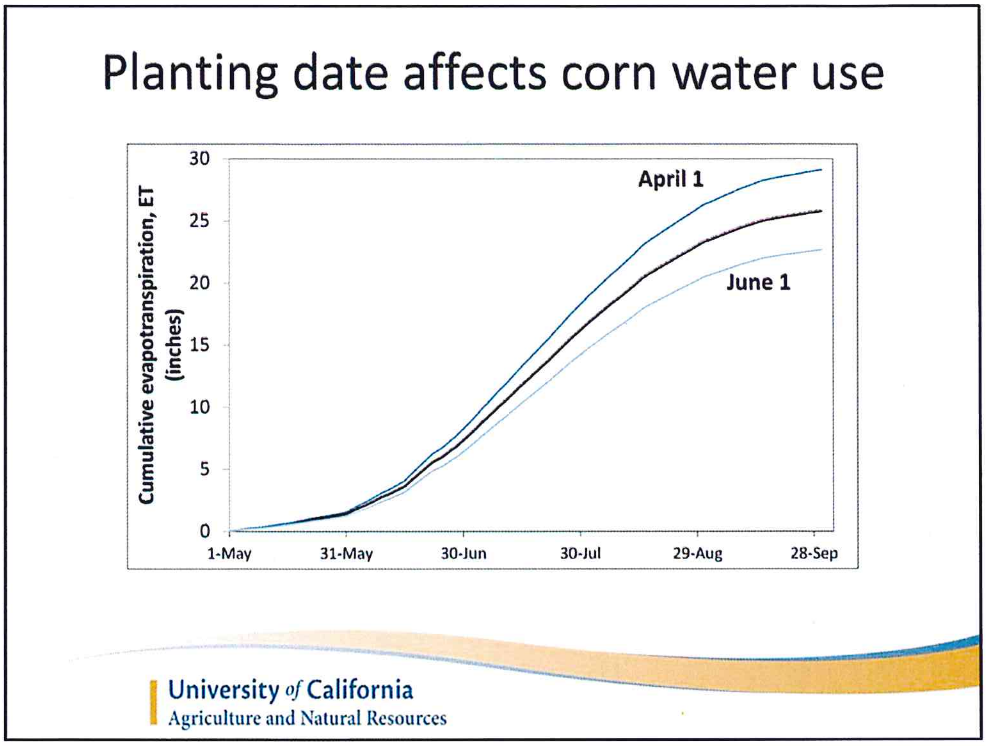
So, let's move from these general principles into more specific information about corn water use across a season in California.

- The vertical axis of this graph is the cumulative total of water, in inches, that a corn crop uses over the course of a season.
- The horizontal axis is time, starting with a May 1st planting date in this example.
- The black, middle line, which we will use to illustrate some points about management timing represents about 26 inches of cumulative Evapotranspiration across the growing season: that is how much total water is leaving the crop both through transpiration and evaporation.
- But the range for corn crops in California, represented by the blue lines, is between about 23 and 29 inches of water in a season.



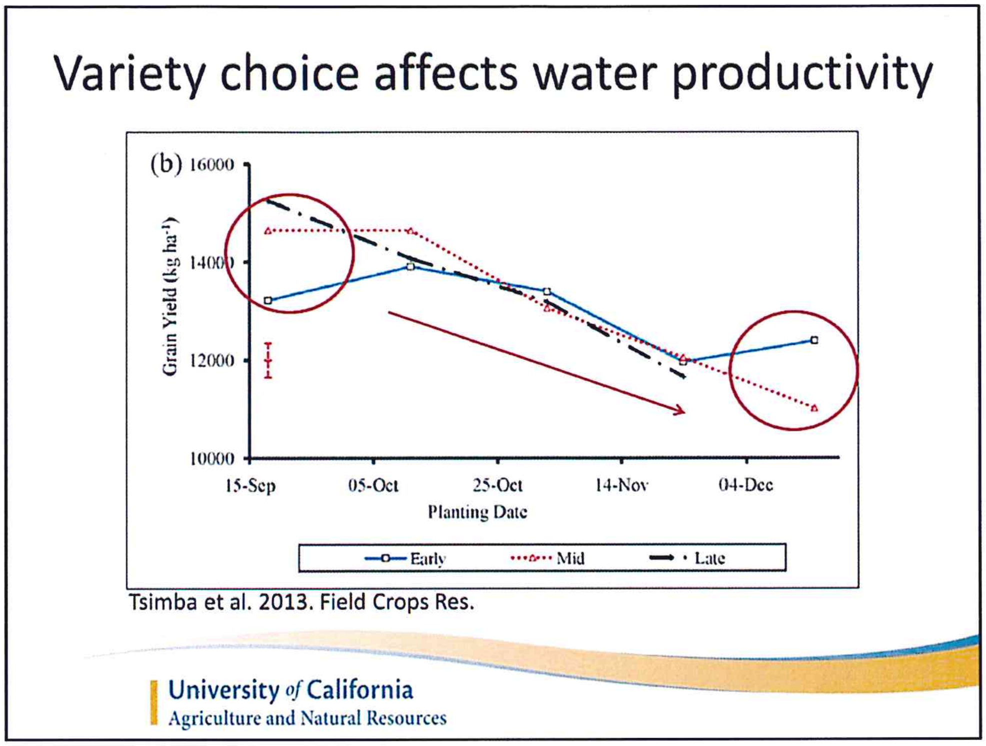
What explains the differences in this range?

- Well, there will always be some variation from site-to-site and year-to-year
- But, there is also a measurable difference in water use by the crop based on planting date.
- This figure is showing that crops planted later in the season, when the weather is hotter, use less water than crops planted earlier, which, with cooler temperatures, develop more gradually and have access more abundant soil water supplies from being at the tail-end of the rainy season.



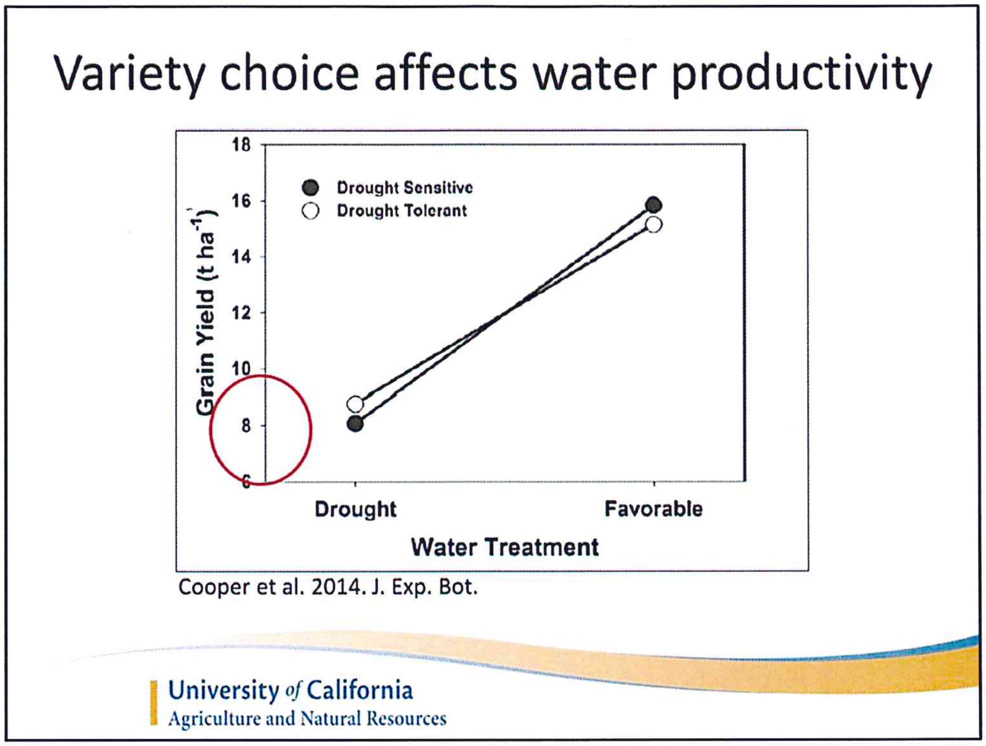
So moving back to our water use ranges by corn in California:

- A crop planted in April is more likely to be at the high end of this range
- And a crop planted in June is more likely to be at the low end of this range



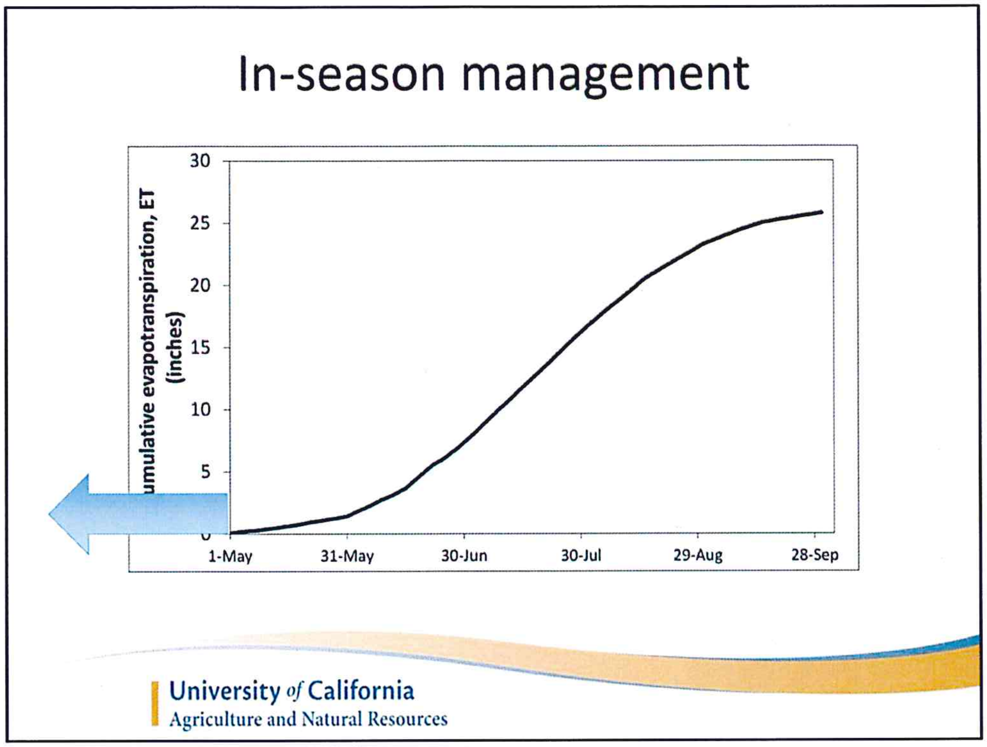
However, using less water by developing quicker, during the hotter portion of the season, comes at a cost:

- That quicker development generally means less time to produce yield components and results in lower overall productivity.
- This figure is showing three corn varieties with different durations and different planting dates.
- The blue line is a short, or early maturing variety; whereas the red and black lines are longer, mid-to-late maturing varieties.
- Regardless of the variety type, the trend is for lower yields at later planting dates.
- However, at early planting dates, the varieties that require more days for development do better than the short-season variety.
- And at the later planting date, the shorter duration variety does better because there is less of a penalty for the quicker development with this variety.
- So, planting a short-duration variety late in the growing season might result in the greatest potential for water productivity by the crop.



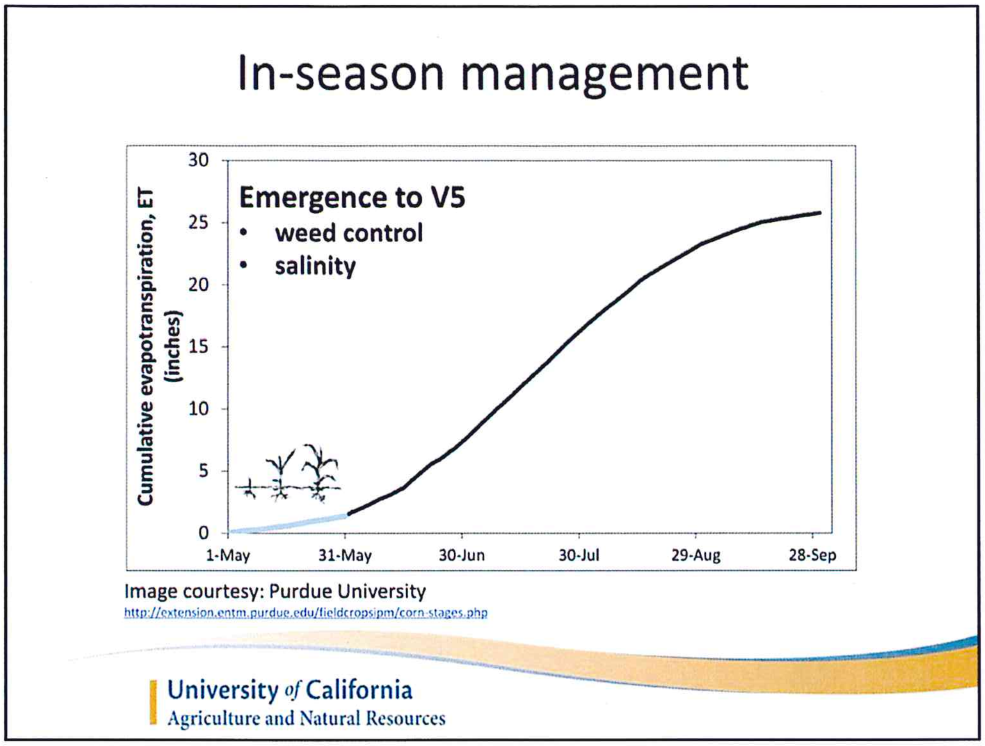
There is a similar dynamic among varieties that are bred for drought tolerance versus drought sensitive varieties:

- Under drought conditions, which have lower overall potential for yield, the drought tolerant varieties do better.
- Whereas, under favorable water conditions, the drought sensitive varieties are more productive.
- So we are starting to see a trend: there is going to be a productivity tradeoff for corn crops that optimize water use.



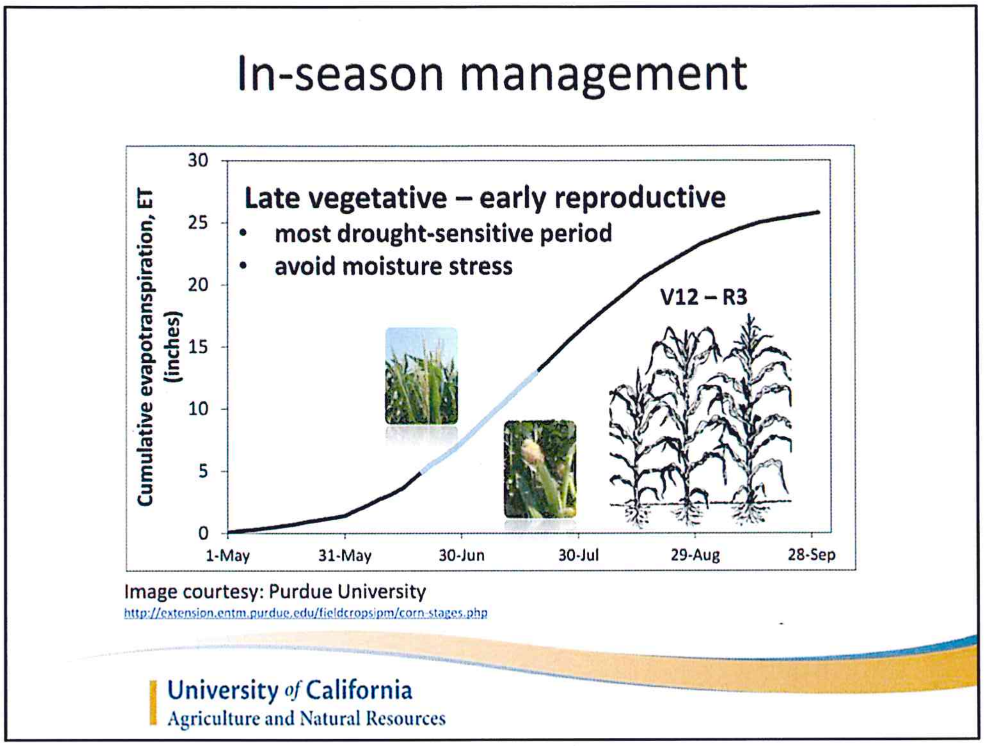
Our goal is to make those tradeoffs as painless or as minimal as possible.

- Up to this point, we've talked about pre-season decision such as planting date and variety choice. And we'll touch on how land preparation can affect water availability when we discuss Conservation Agriculture.
- But let's turn now to in-season management of corn and focus on how it can influence water productivity.



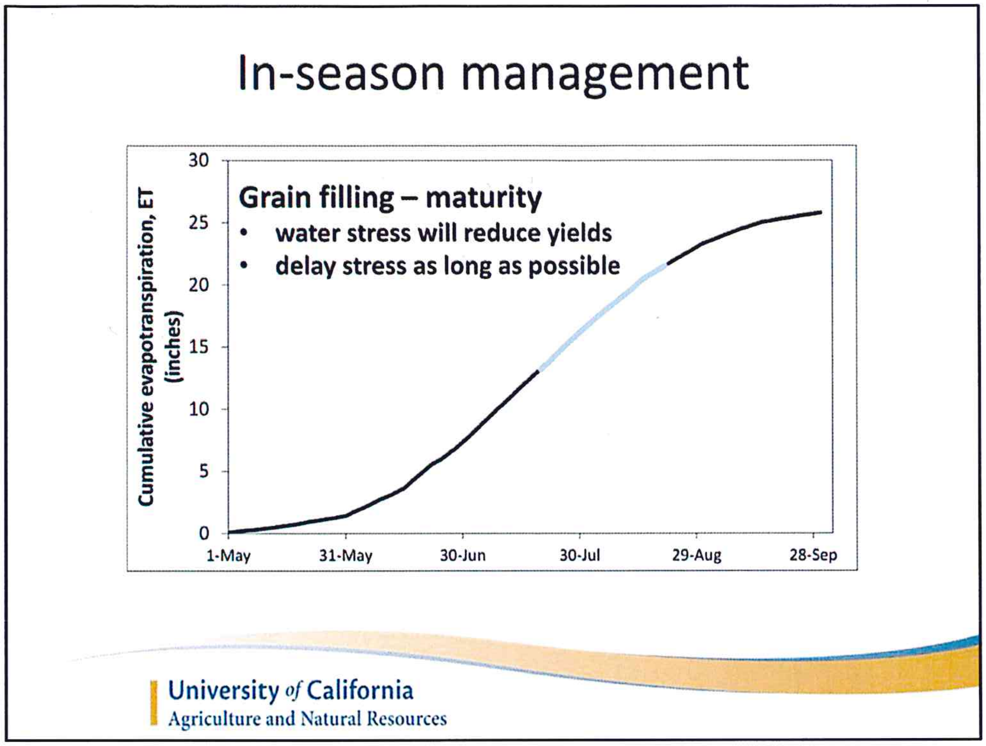
The first period I want to talk about is the early vegetative growth stage.

- Now, there is not much absolute demand for water during this period, but there are a couple things that might have a lasting affect on the water productivity of the crop during this period of growth.
- The 1st is weed competition:
    1. Weeds can directly deduct water from the soil profile, making it unavailable to the crop itself.
    2. They can also force the corn crop to devote more resources to above ground growth, since they're competing for light, and as a result they devote less resources to developing their root systems, which will impact the volume of the soil the corn can later draw from for water.
- The 2nd thing to keep in mind during this stage is salinity:
    1. With less surface water available, more groundwater is going to be used in a drought. Well water tends to be lower in quality with higher salt concentrations. Salinity effects are most detrimental to the corn plant early in its growth.
    2. So, if a grower has multiple sources of water, using the higher quality water early in the season would be advisable.



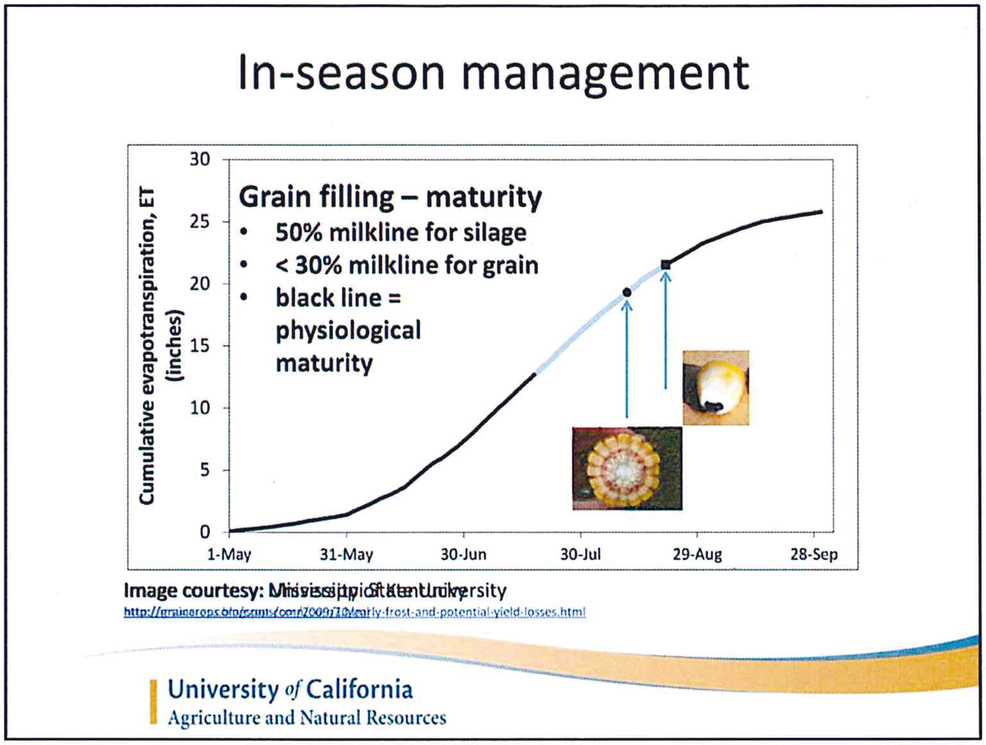
The next period that I'll point out is the late vegetative to early reproductive growth phase. Tasseling marks the end of vegetative growth and silking marks the start of the reproductive growth.

- The 2 weeks prior to and following this transition are the worst times to stress corn.
- Stress during this period will result in disproportionately large reductions in yield.
- So, if there is a time to irrigate, it is during this period.



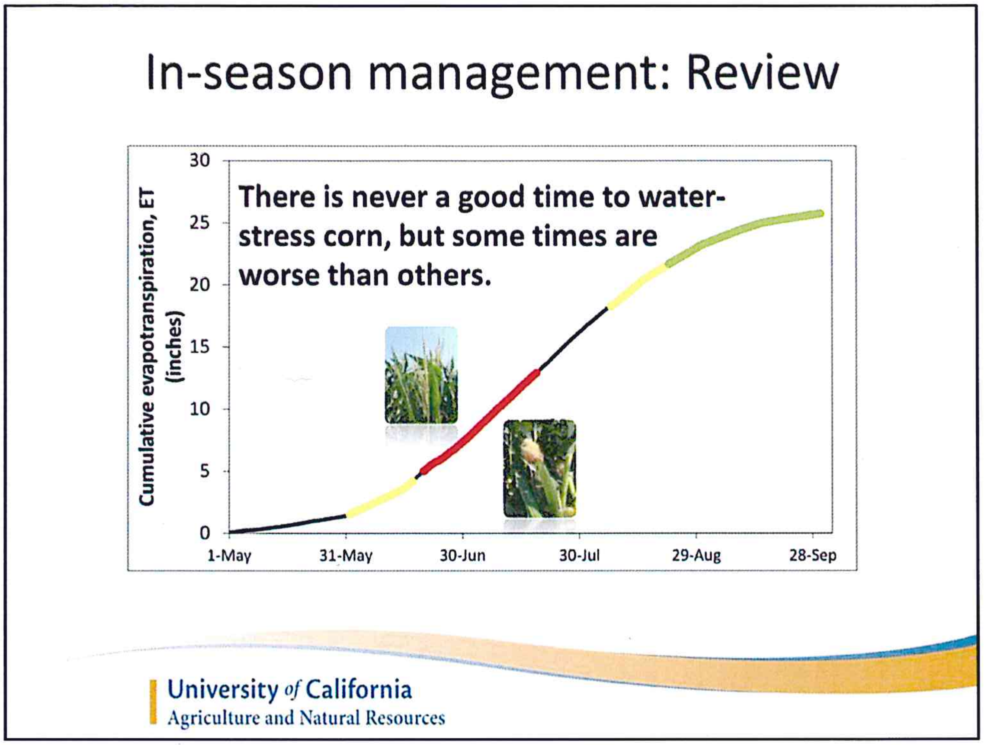
Finally, let's look at water demand during the grain-filling period:

- Like with all other stages of growth, stress during this period will reduce yields.
- However, at this point, the crop's root system is fully developed and it can translocate water to grain.
- Avoiding stress as long as possible is the best bet.
- However, the tail-end of the crops maturation might be an opportunity to save a little water with less consequence than at other stages.



Also, it's important to know when the crop is at maturity b/c irrigation after maturity is wasted:

- For silage, the rule of thumb is about 50% milkline; for grain, the black abscission layer indicates that the grain is mature.
- As you can see, there is a marginal savings of water, maybe 1-1.5 inches for a silage crop versus a grain crop because it reaches maturity earlier.



So, to review:

- There is never a good time to water-stress corn, but some times are worse than others.
- The worst time is during the weeks leading up to and following tassling and silking, when pollination is occurring.
- If you must stress the crop, the mid-vegetative and late stages of grain filling are the times that will probably have the least yield consequence.
- And be sure to quit irrigating after the crop has reached maturity.

Alternatives to corn: sorghum

- Varieties available that harvest for silage 90 to 110 DAP
  - 38 varieties tested in UC program
- 16 to 18 inches ET
- 9.5 to 13.5 inches applied water
- Deeper rooted than corn
- 22 to 28 tons/acre silage
- **BUT:** lower feed quality than corn silage
  - Brown midrib sorghum (BMR) varieties offer better feed quality
  - BMR varieties less drought tolerant

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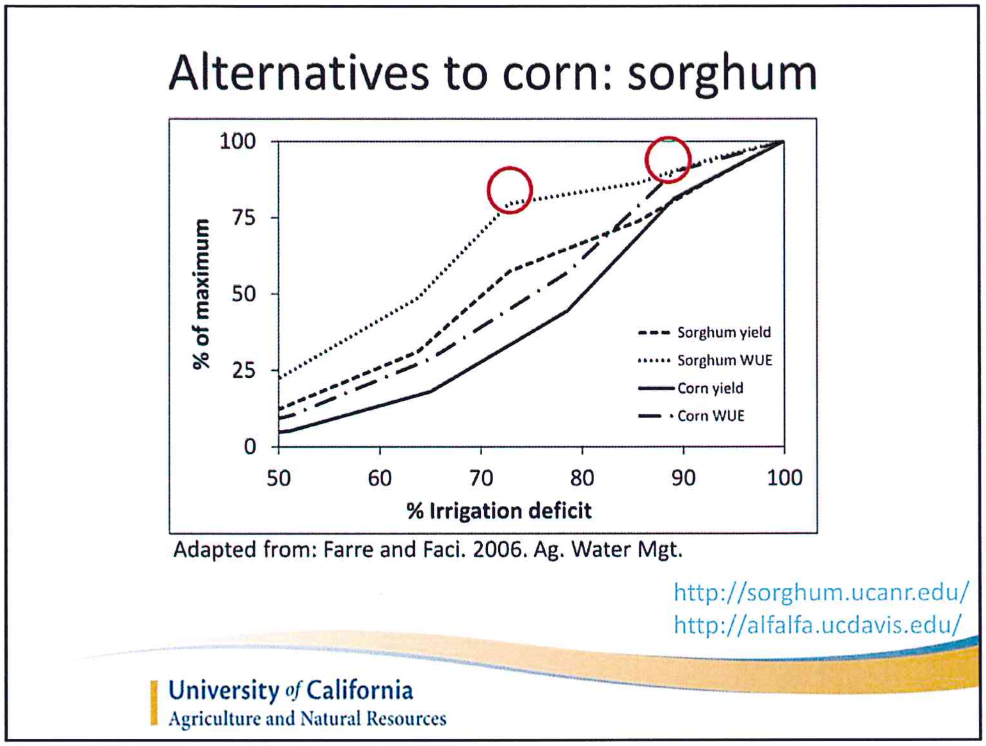
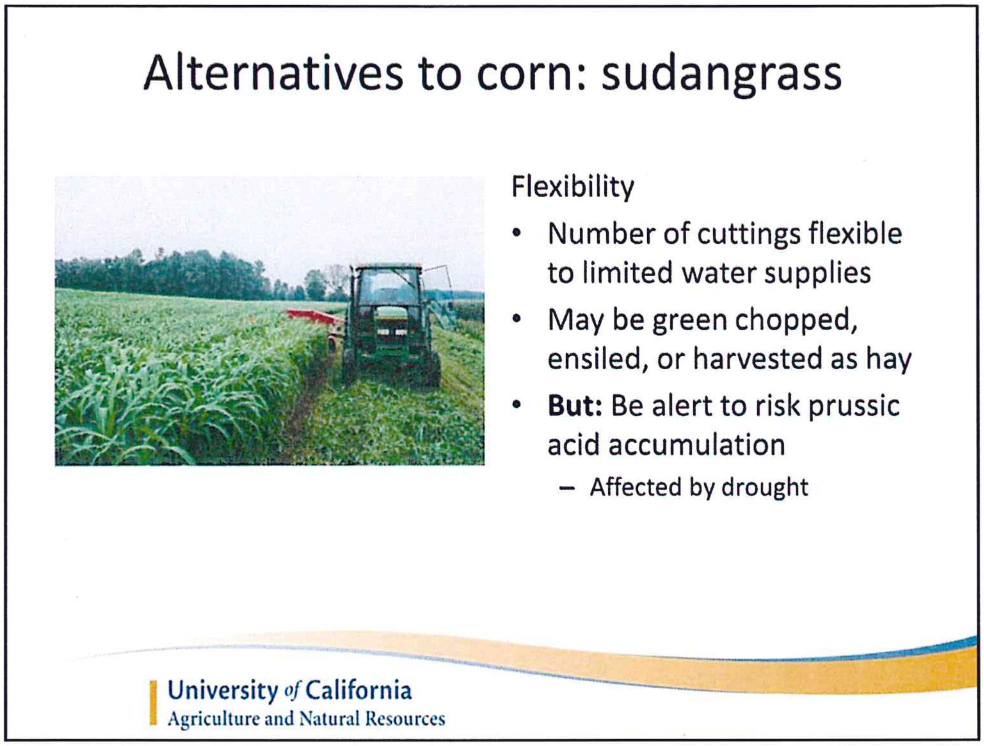
I mentioned briefly the marginal water savings of a corn silage crop versus a grain crop. Now I'd like to point out some potential increases in water productivity by growing an alternative crop to corn.

- There has been a lot of work done at the University of California on developing sorghum varieties for use here in the state.
- Sorghum has a more extensive root system and is better able to withstand water deficits than corn.
- Sorghum tends to be a shorter season crop than corn by about 10-20 days
- It uses about 6 inches less water overall
- While still producing good yields
- HOWEVER, like with most things in agriculture, there is a tradeoff, and in this case it is quality:
  - Brown midrib sorghum tend to be of better quality, but also are less drought resistant.



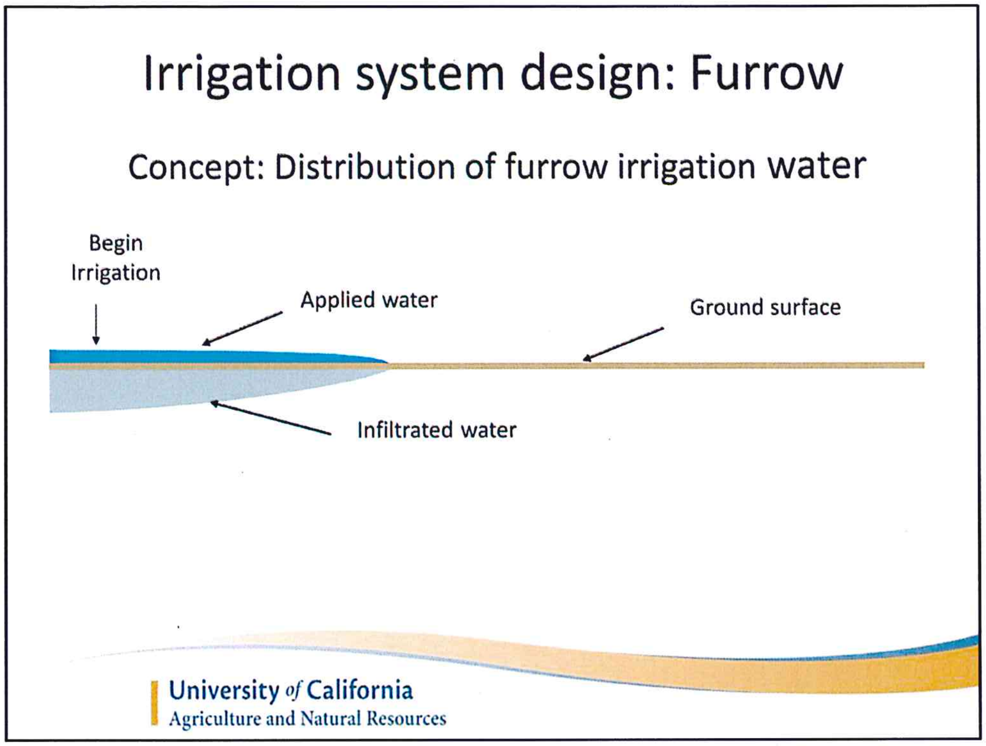
In this figure, I added sorghum's yield and water use efficiency to the earlier graph we looked at for corn;

- The place where sorghum's water use efficiency plateaus is at a much greater water deficit than corn.
- So, the penalty for water stress in sorghum is less severe.
- If you are interested in learning more about sorghum, there are resources in this seminar series and at sorghum.ucanr.edu and alfalfa.ucdavis.edu.



Another alternative to corn is sudangrass.

- Which is a flexible crop that can be green chopped, ensiled or harvested for hay
- Also, the number of cuttings is flexible, so if water supplies are uncertain, growing sudangrass will reduce the risk of crop failure relative to corn or sorghum crops that are harvested once.
- However, there is a risk of prussic acid accumulation in sudangrass and it is exacerbated by drought, so be sure to look into how to minimize that risk.

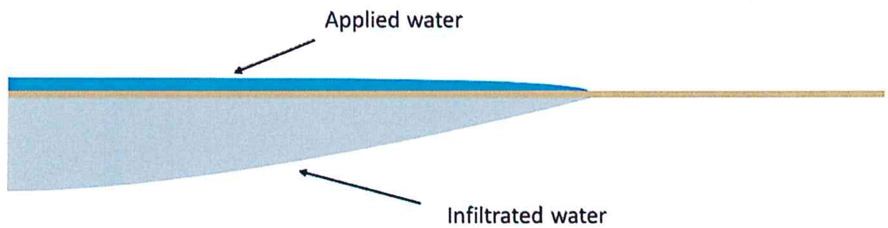


Now, irrigation system design is discussed more thoroughly in other seminars in this series, so I won't spend a lot of time on it.

- However, since corn is a low-value crop relative to others in California, it can only support limited capital investment, and furrow irrigation is one of the cheapest irrigation systems to implement.
- Unfortunately, furrow irrigation tends to be the least efficient system for water delivery.
- This schematic gives a picture of water moving across the soil surface and down into the soil profile in a furrow irrigated field.

Irrigation system design: Furrow

Distribution midway through set



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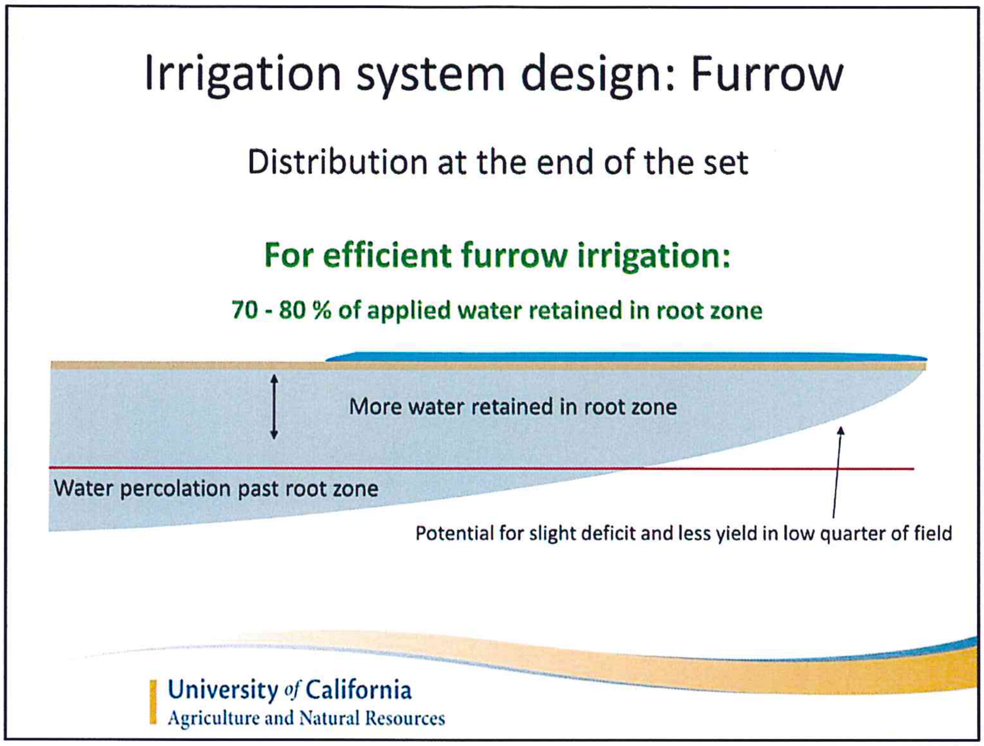
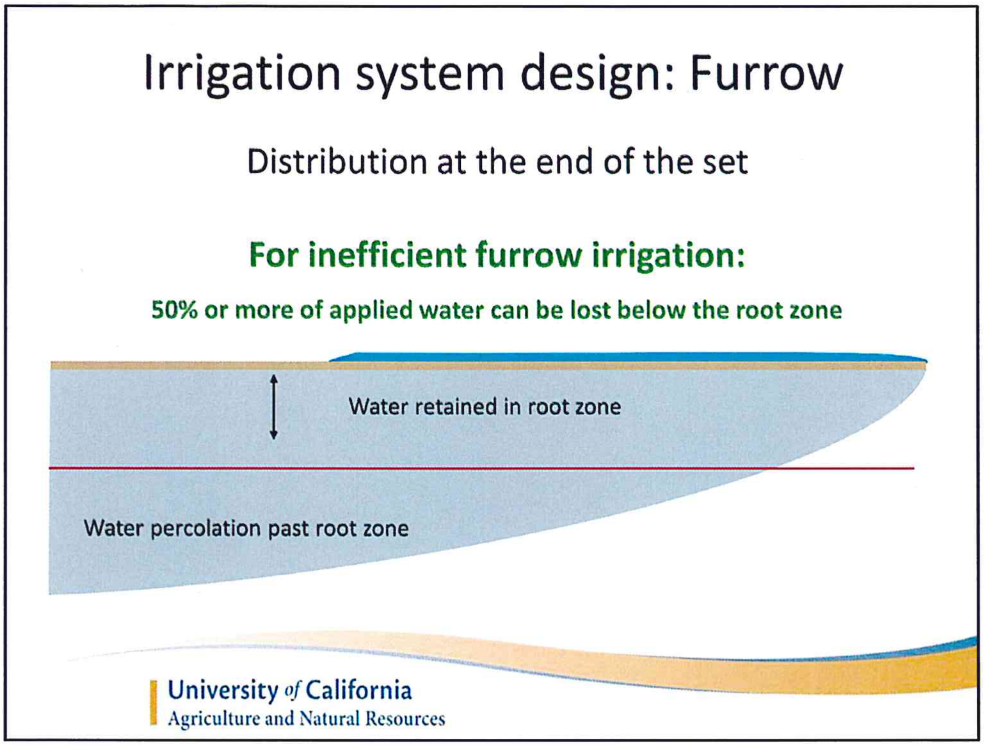


As is illustrated, when the water moves through the field via furrows, areas at the head of the field become saturated earlier than areas at the tail of the field.

- This results in losses below the root zone at the head and the potential for deficits at the tail.
- Shorter furrows & the use of torpedoes can minimize these differences.
- But even a highly efficient furrow irrigation system will lose 20-30% of its water beyond the root zone.



And inefficient furrow systems can lose 50% or more of the applied water.

Irrigation system design: Overhead

2009 WSREC Trial

- Overhead Season Total = **20.13** inches; **57** irrigation events
- Furrow Season Total (3 acres) = **32.76** inches; **11** irrigation events
- Tradeoff = $

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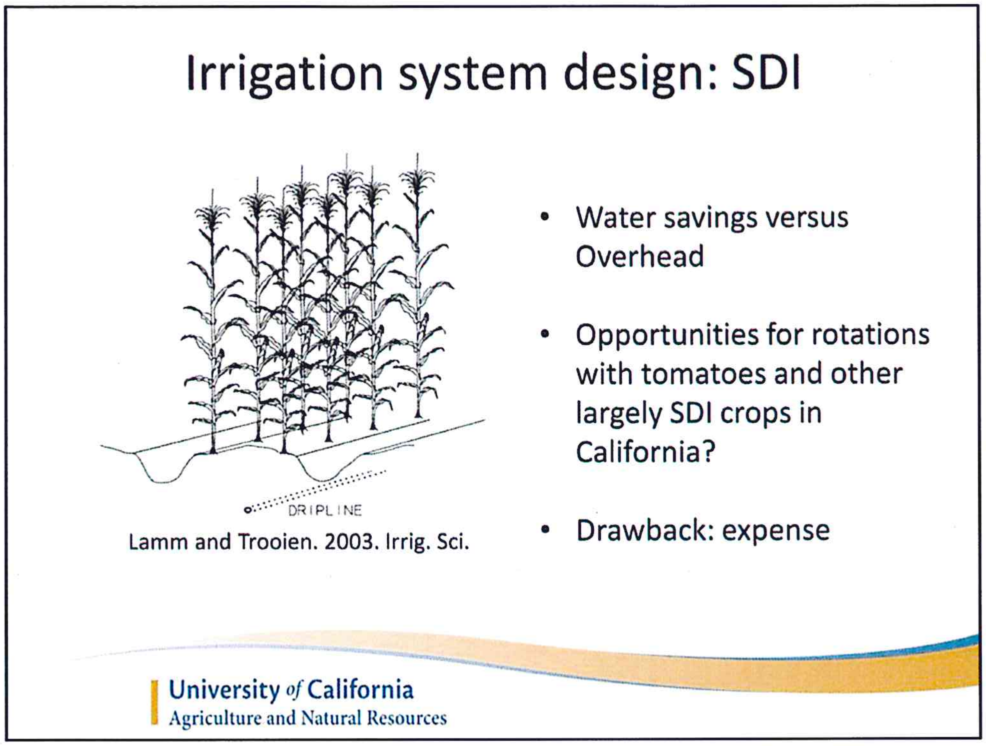
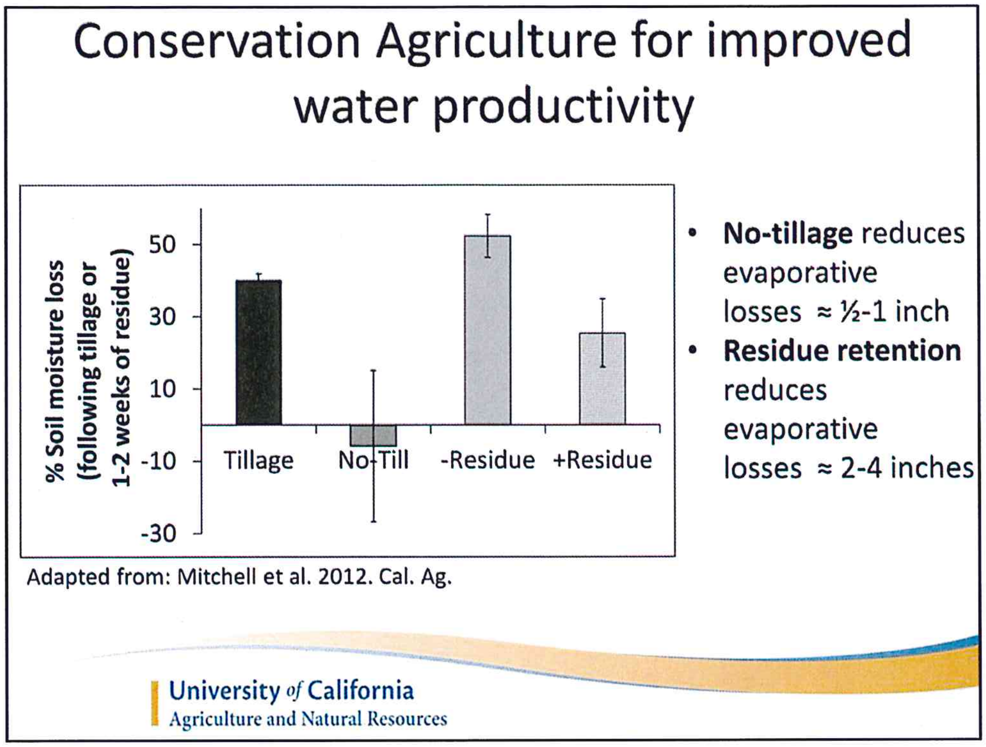
So, what are some alternatives?

- Overhead—center-pivot or wheel-line— low-flow systems can pinpoint the root zone more precisely in both space and time resulting in less total water applied.
- In one example from the West Side Research and Extension Center in 2009, Overhead provided 20 inches of water to a corn crop in 57 irrigation events,
- Whereas, furrow irrigation required almost 33 inches in 11 events to achieve a similar crop.
- So, there is a huge potential for water savings using overhead rather than furrow. However, it does come at a cost. And how that plays out for a grower depends on too many variables to discuss in this seminar. However, this is discussed elsewhere in the drought-related resources that this seminar is a part of.



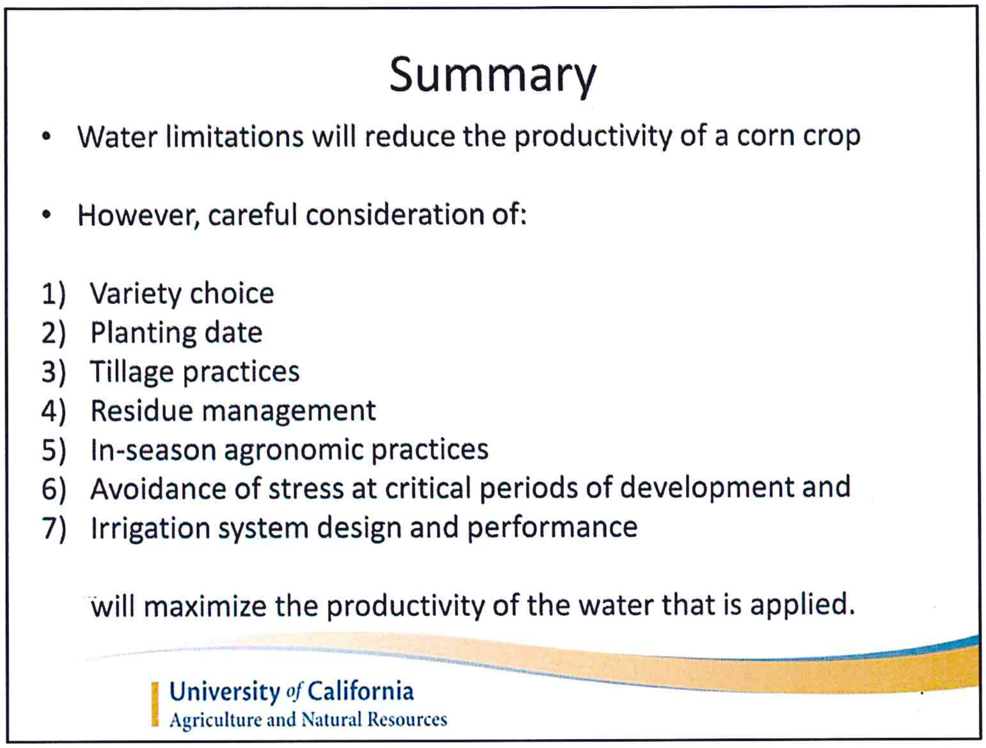
Another brief note on system design is Subsurface Drip Irrigation, also referred to as SDI:

- There has not been a lot of SDI in California corn. However, in crops that rotate with corn, such as tomatoes, SDI has become the standard.
- In other parts of the country SDI in corn has been shown to improve water use efficiency even compared to Overhead.
- However, it also tends to be more expensive than Overhead and certainly more expensive than furrow irrigation.
- But, with limited water supplies and other crops moving toward SDI, there is a strong incentive for figuring out how to grow corn economically using SDI.



Finally, as with irrigation systems, the topic of Conservation Agriculture is covered more thoroughly in another presentation by Jeff Mitchell, but I want to briefly point out how:

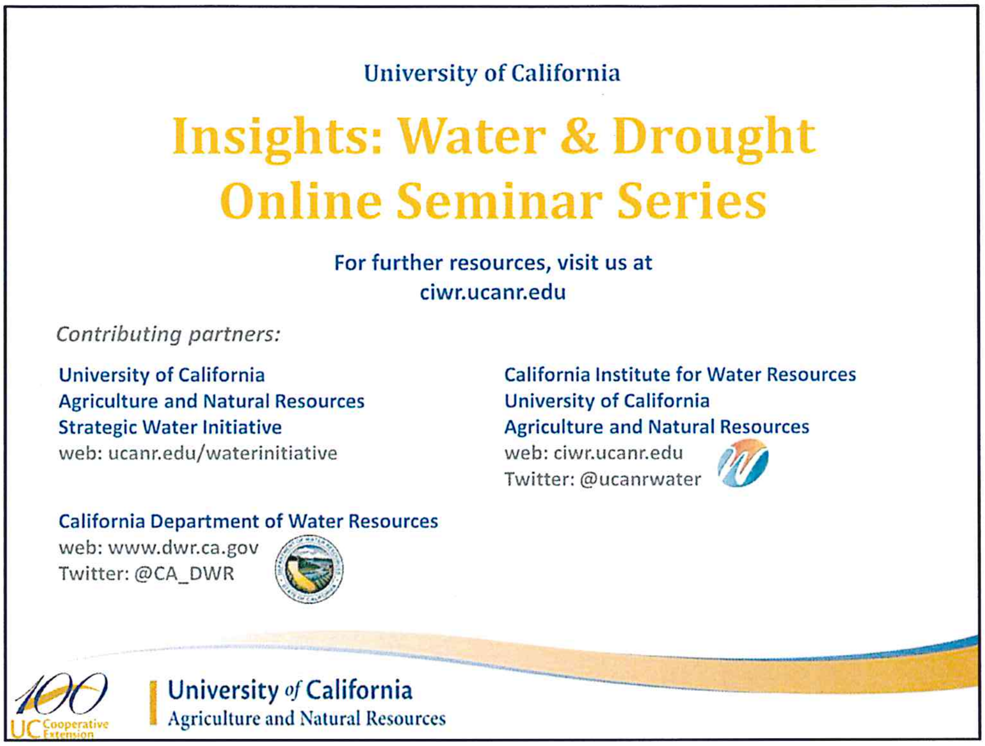
- Eliminating tillage prior to planting corn and retaining residues from the previous crop might impact the total amount of water available to the subsequent corn crop.
- This figure is a summary of some work done in the San Joaquin Valley where the change in soil moisture was measured following either tillage or no tillage and following residue removal versus residue retention.
- Basically, both tillage and residues work to keep moisture in the soil by cooling the soil and reducing evaporation.
- Extrapolated out, no tillage was estimated to save around ½ to 1 inch of water and residue retention around 2-4 inches of water across the season.
- Given the sensitivity of corn to drought stress, these are significant savings that could greatly improve its resiliency to reduced water supplies in California.



So, to summarize what we've covered in this seminar:

- Water limitations will reduce the productivity of a corn crop.
- However, careful consideration of:

  Variety choice, planting date, tillage practices, residue management, in-season agronomic practices, avoidance of stress at critical periods of development, and irrigation system design and performance
- will maximize the productivity of the water that is applied.



Thanks for your time and interest, and I'll look forward to seeing you out in the field!