UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Guide to 2020-21 cover crop trials in the Southern San Joaquin Valley

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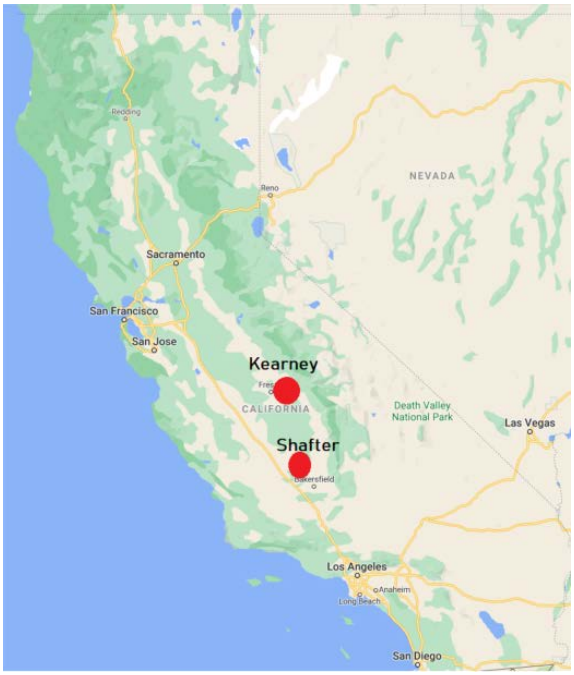
Cover crops provide many benefits to growers, including:

- Improving water infiltration
- Reducing wind & water erosion
- Reducing nitrate leaching
- Reducing compaction
- Fixing nitrogen
- Improving soil structure
- Increasing soil organic matter
- Providing resources for beneficial insects

However, low winter rainfall discourages many growers in the southern San Joaquin Valley from planting cover crops. For these trials, we aimed to answer the following questions:

- Which cover crop mixes can survive without supplemental irrigation in this area?
- How much irrigation do these plants need to thrive?
- Can we see any effects on the soil after just 1 season?

We set up 2 trials at University of California research farms, in Shafter (Kern County) and in Parlier (Fresno County). The research farm in Parlier is called the Kearney Agriculture Research and Extension Center and will be referred to as “Kearney” for the remainder of this report.



Location of trials

Shafter cover crop establishment and termination methods

Pre-irrigated on Oct. 21, 2020

Disked to kill weeds on Oct 29, 2020

Planted with a cone seeder on Nov. 5, 2020

Irrigated every other week if it didn't rain until Jan 12, 2021

Disked to terminate on Mar. 18, 2021

The sprinkler system created an irrigation gradient. The plants closest to the sprinklers received about 2.7" of supplemental irrigation in addition to 2.1" of precipitation. The plants farther away received about 0.6" of irrigation (2.7" of total water).

Kearney cover crop establishment and termination methods

The field was disked 2 weeks before planting and prepared with a springtooth harrow 1 week before planting. We did not pre-irrigate the fields prior to planting. Instead, we waited for rain before seeding. By the time we planted, Kearney had received about 2 inches of rain.

Planted with a seed drill on December 18, 2021

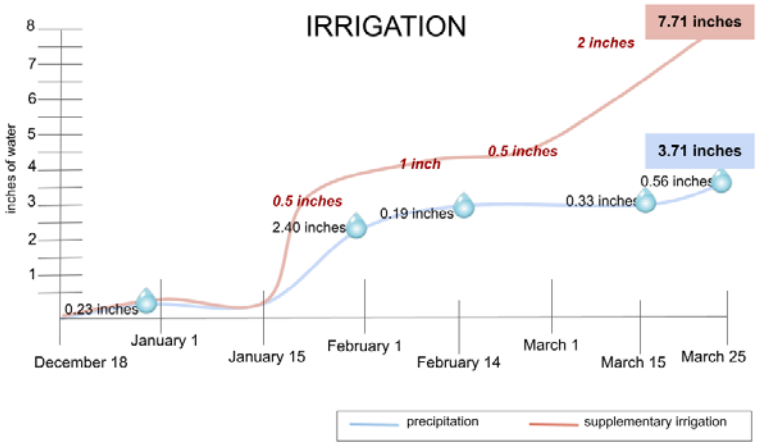
We replicated this trial in two fields. Each field was split in half, with half of the field receiving supplemental irrigation from sprinklers and the other half being completely dependent on rainfall.

FIELD 1

Irrigated	Non-irrigated

FIELD 2

Irrigated	Non-irrigated



The blue line represents the water the cover crops received from rainfall - in total, 3.71 inches. The red line represents irrigation events throughout the trial - only the irrigated half of each field received this supplemental irrigation, which amounted to an additional 4 inches of water than the non-irrigated half received.

Cover crops were terminated on March 22 by mowing and disking them into the soil.

Cover Crop Mixes Overview

Mix name	Trial location	Observed Benefits	Observed Drawbacks	Cost/lb	Seeding rate/acre
Soil builder 1	Shafter	Suppressed weeds, attracted bees, decomposed quickly	Do not plant before a brassica cash crop. 6' tall.	$0.55/lb (conventional)	50-100 lb/acre
Soil builder 2	Kearney	Suppressed weeds, attracted bees	Do not plant before a brassica cash crop. When planted later, takes a long time for radish to grow	$1.45/lb (organic)	50-100 lb/acre
Barley & common vetch	Shafter	Suppressed weeds. Only 3-4' tall.	Tied up nitrogen. Munched on by hare.	$0.66/lb (conventional)	50-100 lb/acre
Barley & purple vetch	Kearney	Less biomass produced which may be beneficial if you need a grass that can decompose faster	Vetch did not grow well, barley did not suppress weeds as effectively as other grasses	$1.21/lb (organic)	50-100 lb/acre
Rye & peas	Shafter	Suppressed weeds, bloomed early	Tied up nitrogen for decomposition. 6-7' tall.	$0.66/lb (conventional)	60-100 lb/acre
Rye & peas	Kearney	Rye suppressed weeds	Peas did not grow as well. Lots of rye biomass, which may take a long time to decompose	$1.15/lb (organic)	60-100 lb/acre
Brassica mix	Shafter	Suppressed weeds, attracted bees, decomposed quickly	Do not plant before a brassica cash crop. 6' tall.	$2.25/lb (conventional)	8-15 lb/acre
Multiplex	Kearney	Triticale decomposed faster than other grasses	Did not suppress weeds	$1.23/lb (organic)	50-100 lb/acre
Soil health	Shafter	Suppressed weeds, attracted bees	Tied up nitrogen for decomposition. 6-7' tall. Do not plant before a brassica cash crop.	$1.75/lb (conventional)	50 lb/acre

Overall conclusions

- In both locations and in all the mixes, the grasses and brassicas dominated.
- The legumes did not do very well, because the soil already contained plenty of nitrogen and we did not irrigate enough to enable them to compete with the other species in the mixes.
- Even in the non-irrigated plots, the mixes still provided cover and held onto the soil. This improves water infiltration and soil structure and reduces wind and water erosion.
- The cover crops provided resources for beneficial insects like bees and ladybugs.
- Merced rye was most competitive with weeds.
- Brassicas are a great option if you are looking to provide pollinator resources.

Cover Crop Species Composition

	Soil Builder 1	Soil Health	Brassica Mix	Simple Mix 1	Simple Mix 2	Soil Builder 2	Multiplex
GRASSES	Shafter	Shafter	Shafter	Shafter/Kearney	Shafter/Kearney	Kearney	Kearney
Triticale	X					X	X
Barley				X			
Rye		X			X		
LEGUMES							
Peas	X				X	X	X
Vetch	X	X		X		X	X
Berseem Clover		X					
BRASSICAS							
Yellow mustard	X		X				
Radish	X	X	X			X	
Nemfix mustard			X				
“Bracco” white mustard		X	X				
Canola			X				

Cover Crop Profile: SOIL BUILDER 1

Potential benefits: Reduce erosion, suppress weeds, scavenge nutrients, reduce soil compaction, attract bees
Species: 55% triticale, 20% pea, 10% radish, 5% yellow mustard, 10% common vetch
Location: Shafter

Non-irrigated soil builder mix on March 11, 2021. Photo taken from above.

Weed suppression
There were no weeds weighed in any of the sample plots for the soil builder mix.

Biomass
The irrigated sample plot produced 16,995 lb/acre of dry biomass, while the non-irrigated plot produced 6,488 lb/acre.

Plant tissue nitrogen
The plant tissue for the irrigated plot was 3.12% nitrogen, which led to a C:N ratio of 12.99. For the non-irrigated plot, the tissue was 3.45% nitrogen, with a C:N ratio of 11.80.

Soil nitrate
The soil nitrate on April 21 (5.5 weeks after termination) was 41 mg/kg in the irrigated plot. Before planting, the nitrate level was 42 mg/kg. This mix took up the soil nitrate and then decomposed quickly after termination.

Overall impression
Even though legumes made up 30% of this mix, they rarely appeared in any of the plots. The brassicas and triticale completely dominated the mix. However, this is a good mix for those who want to get a little bit of everything. The legumes might do better in your field if they get more water and your soil contains less nitrogen at planting.

Irrigated soil builder mix on March 11, 2021.

Left: Non-irrigated sample plot on March 17, 2021.
Right: Irrigated sample plot on March 17.

Cover Crop Profile: SOIL BUILDER 2

Benefits: Reduce erosion, suppress weeds, scavenge nutrients, reduce soil compaction, attract bees, fix nitrogen
Species: 60% triticale, 20% pea, 10% radish, 10% purple vetch
Location: Kearney

Irrigated Soil Builder 2 mix on March 22, 2021

Weed Suppression

The radish and triticale did a good job of shading weeds compared to other mixes though weeds were still 43% of the irrigated side of the field and 33% of the non-irrigated.

Non-irrigated Soil Builder 2 species composition on March 25, 2021. From left to right: peas, radish, purple vetch, triticale, weeds.

Biomass

The irrigated plots produced 2,905 lbs/acre of total biomass, of which 1,275 lbs/acre was weeds and 1,630 lbs/acre was cover crop biomass. The non-irrigated plots produced 2,461 lbs/acre of total biomass, of which 1,006 lbs/acre was weeds and 1,455 lbs/acre was cover crop biomass.

Plant tissue nitrogen:

The plant tissue for the irrigated plot was 3.65% nitrogen. Multiplying this by the total irrigated biomass, the plant residues contributed 106 lbs. N/acre back to the soil For the non-irrigated plot, the tissue was 3.20% nitrogen. Multiplying this by the total non-irrigated biomass, plant residues contributed 79 lbs. N/acre back to the soil.

Height differences between irrigated (left) and non-irrigated (right) radish on March 25, 2021.

Soil Nitrate

The soil nitrate on April 28 (5 weeks after termination) was 28 mg/kg in the irrigated plot and 14 mg/kg in the non-irrigated plot. It is not clear why we saw these differences - perhaps it had to do with a smaller accumulation of biomass in the non-irrigated plots, contributing less total nitrogen to the soil, or more soil moisture on the irrigated side may have facilitated faster cover crop residue decomposition. The non-irrigated plots also had a greater composition of triticale in the final mix (52%) compared to the irrigated plots (39%). Higher percentage of grass may have resulted in a higher C:N ratio and greater immobilization of available N.

Overall impression

Legumes performed poorly, making up only 1% of the final mix. The brassicas and triticale dominated the mix and weed pressure was high. However, the radish flowers resulted in ample resources for pollinators and a lot of bees were observed visiting the flowers. Therefore, if you are interested in planting cover crops to provide resources for pollinators, planting radish or another brassica would be a good option. Triticale and radish performed similarly in both irrigated and non-irrigated plots, so would be good options if you do not have access to irrigation.

A honeybee visiting the irrigated radish flowers.

Cover Crop Profile: BARLEY & COMMON VETCH

Potential benefits: Reduce erosion, suppress weeds, scavenge nutrients, fix nitrogen
Species: 70% barley, 30% common vetch
Location: Shafter

Non-irrigated barley & common vetch mix on March 11, 2021. Photo taken from above.

Weed suppression
There were no weeds weighed in any of the sample plots for the barley & common vetch mix.

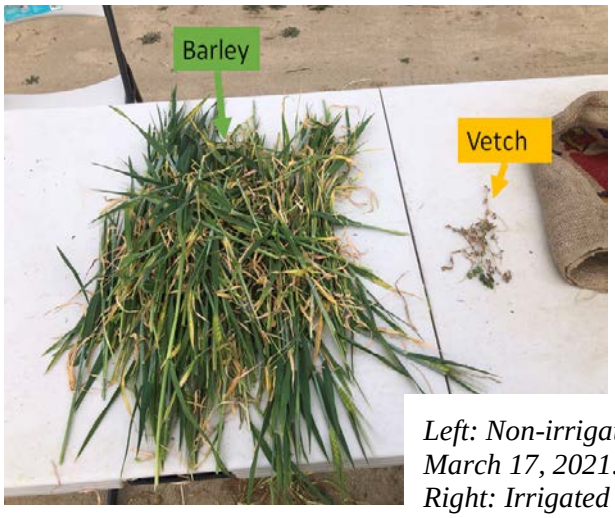
Biomass
The irrigated sample plot produced 20,376 lb/acre of dry biomass, while the non-irrigated plot produced 3,032 lb/acre.

Plant tissue nitrogen
The plant tissue for the irrigated plot was 1.98% nitrogen, which led to a C:N ratio of 21.68.
For the non-irrigated plot, the tissue was 2.30% nitrogen, with a C:N ratio of 19.03.

Soil nitrate
The soil nitrate on April 21 (5.5 weeks after termination) was 17.2 mg/kg in the irrigated plot. Before planting, the nitrate level was 42 mg/kg. This mix took up the soil nitrate and then took a while to decompose after termination, tying up the soil nitrogen.

Overall impression
The vetch made very little contribution to this mix, especially in the non-irrigated plots. However, barley is a nice cover crop to plant if you don't want it to get too tall. It's good for reducing nitrate leaching and keeping your soil covered.

Irrigated barley & common vetch mix on March 11, 2021.



Left: Non-irrigated sample plot on March 17, 2021.
Right: Irrigated sample plot on March 17.

Cover Crop Profile: BARLEY & PURPLE VETCH

Benefits: Reduce erosion, scavenge nutrients, fix nitrogen
Species: 70% barley, 30% purple vetch
Location: Kearney

Non-irrigated barley & purple vetch mix on March 22, 2021. Weed pressure was strong in these plots.

Weed Suppression

The barley did not do a great job of outcompeting weeds, as it was slower growing and did not accumulate as much biomass as rye and triticale. The irrigated plots were 50% weeds at termination and the non-irrigated plots were 66% weeds at termination.

Biomass

The irrigated side of the field produced 2,073 lbs/acre of total biomass, of which 1,015 lbs/acre was weeds and 1,057 lbs/acre was cover crop biomass.The non-irrigated side produced 1,829 lbs/ acre of total biomass, of which 1,381.4 lbs/ acre was weeds and 448 lbs/acre was cover crop biomass. The barley did not grow as well under non-irrigated conditions, which contributed to the low biomass. Purple vetch did not grow well under irrigated or non-irrigated conditions, making up 1% of the irrigated biomass and less than 1% of the non-irrigated biomass.

Irrigated barley & purple vetch mix on March 22, 2021.The barley height was not very different from the non-irrigated plots, but overall, the barley established a better stand and put on more biomass than non-irrigated plots.

Plant tissue nitrogen:

The plant tissue for the irrigated plot was 3.48% nitrogen. Multiplying this by the total biomass, the plant residues contributed 72 lbs N/acre back to the soil. For the non-irrigated plot, the tissue was 3.33% nitrogen. Multiplying this by the total biomass, the plant residues contributed 60 lbs N/acre back to the soil

Soil Nitrate

The soil nitrate on April 28 (5 weeks after termination) was 27 mg/kg in the irrigated plot and 15 mg/kg in the non-irrigated plot. Again, perhaps the difference in soil nitrate had to do with a smaller accumulation of biomass in the non-irrigated plots or more soil moisture on the irrigated side may have facilitated faster cover crop residue decomposition.

Overall impression

The purple vetch performed poorly in both irrigated and non-irrigated sides of the field. There were significant differences in barley biomass accumulation between the irrigated and non-irrigated plots. Therefore, if you do not have access to irrigation for your cover crops, barley may not be the best option.

Cover Crop Profile: MERCED RYE & DUNDALE PEAS

Potential benefits: Reduce erosion, suppress weeds, scavenge nutrients, reduce soil compaction, fix nitrogen, attract bees.
Species: 40% Merced rye, 60% Dundale peas
Location: Shafter & Kearney

Non-irrigated rye & peas mix on March 11, 2021. Photo taken from above.

Shafter Observations

Weed suppression

Less than 1% of the biomass from the irrigated plots were from weeds. In 3 of the 4 non-irrigated plots sampled, there were no weeds weighed. In the 4th plot, weeds represented 3% of the dry biomass.

Biomass

The irrigated sample plot produced 13,385 lb/acre of dry biomass, while the non-irrigated plot produced 7,325 lb/acre.

Plant tissue nitrogen

The plant tissue for the irrigated plot was 1.56% nitrogen, which led to a C:N ratio of 27.73.
For the non-irrigated plot, the tissue was 1.98% nitrogen, with a C:N ratio of 21.68.

Soil nitrate

The soil nitrate on April 21 (5.5 weeks after termination) was 19.2 mg/kg in the irrigated plot. Before planting, the nitrate level was 42 mg/kg. This mix took up the soil nitrate and then took a while to decompose after termination, tying up the soil nitrogen.

Overall impression

The peas provided very little biomass for this mix, especially in the non-irrigated plots. However, Merced is a good cover crop to plant if you want to smother weeds and don't have much water.

Irrigated rye & peas mix on March 11, 2021.

Left: Non-irrigated sample plot on March 17, 2021.
Right: Irrigated sample plot on March 17.

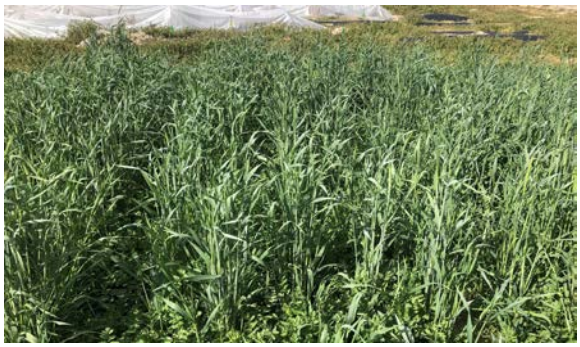
Cover Crop Profile: MERCED RYE & DUNDALE PEAS (cont.)

Kearney Observations:

Non-irrigated rye & peas mix on March 22, 2021.

Weed Suppression

Merced rye performed the best in terms of weed suppression, as it accumulated the most biomass quickly, taking off especially when temperatures warmed up in March. The weeds were low growing and did not seem to prevent the rye from putting on biomass. Additionally, the total biomass accumulation including weeds was 2.6 times greater in the irrigated plots than the non-irrigated plots.



Irrigated rye & peas mix on March 22, 2021.

Biomass

The irrigated side of the field produced 4,902 lbs/ acre of total biomass, of which 1,981 lbs/acre was weeds and 3,011 lbs/acre was cover crop biomass. The non-irrigated side produced 1,916 lbs/ acre of total biomass of which 417 lbs/acre was weeds and 1,500 lbs/acre was cover crop biomass. Peas did not grow well under irrigated or non-irrigated conditions, making up less than 1% of the irrigated biomass and 1% of the non-irrigated biomass.

Irrigated rye & peas mix on March 22, 2021.

Plant tissue nitrogen:

The plant tissue for the irrigated plot was 2.83% nitrogen. Multiplying this by the total biomass, the plant residues contributed 138.7 lbs N/acre back to the soil. For the non-irrigated plot, the tissue was 2.92% nitrogen, meaning that the plant residues contributed 56 lbs N/acre back to the soil.

Soil Nitrate

The soil nitrate on April 28 (5 weeks after termination) was 28 mg/kg in the irrigated plots and 9 mg/kg in the non-irrigated plot. Just as with the other plots at Kearney, the difference in soil nitrate may have to do with a smaller accumulation of biomass contributing less total N in the non-irrigated plots and more soil moisture on the irrigated side may have facilitated faster cover crop residue decomposition.

Overall impression

The peas performed poorly in both irrigated and non-irrigated sides of the field. There were significant differences in rye biomass between the irrigated and non-irrigated plots. That being said, the non-irrigated rye still accumulated more biomass than irrigated barley and irrigated triticale, so it would still be a good grass to plant if irrigation is not available. The rye also matured faster and was slower to breakdown. Therefore, if you plan to incorporate residues, it is important to leave enough time for the rye to decompose before planting into it to avoid risking immobilization of nutrients for the following crop.

Cover Crop Profile: BRASSICA POLLINATOR MIX

Benefits: Attract bees, suppress weeds, scavenge nutrients, reduce soil compaction
Species: 35% canola, 15% white mustard, 15% "Nemfix" brown mustard, 20% daikon radish, 15% common yellow mustard
Location: Shafter

Weed Suppression
There were no weeds weighed in any of the sample plots for the brassica pollinator mix.

Biomass
The irrigated sample plot produced 11,518 lb/acre of dry biomass, while the non-irrigated plot produced 9,128 lb/acre.

Plant tissue nitrogen
The plant tissue for the irrigated plot was 3.04% nitrogen, which led to a C:N ratio of 12.75.
For the non-irrigated plot, the tissue was 3.22% nitrogen, with a C:N ratio of 11.98.

Soil nitrate
The soil nitrate on April 21 (5.5 weeks after termination) was 41 mg/kg in the irrigated plot. Before planting, the nitrate level was 42 mg/kg. This mix took up the soil nitrate and quickly decomposed after termination, making those nutrients available for the next crop.

Overall impression
This is a great mix if you want to provide forage for pollinators and don't have much water. It grows very tall but breaks down quickly. Don't plant this mix before a brassica cash crop, like broccoli or kale.

Non-irrigated brassica pollinator mix on March 11, 2021. Photo taken from above.

Irrigated brassica pollinator mix on March 11, 2021.

Cover Crop Profile: SOIL HEALTH MIX

Benefits: Reduce erosion, suppress weeds, reduce nitrate leaching, fix nitrogen, reduce compaction, attract bees
Species: 30% Merced Ryegrain, 20% Berseem Clover, 10% 'Bracco' White Mustard, 30% Common Vetch, 10% Radish
Location: Shafter

Non-irrigated soil health mix on March 11, 2021. Photo taken from above.

Weed suppression
There were no weeds weighed in any of the sample plots for the soil health mix.

Biomass
The irrigated sample plot produced 21,625 lb/acre of dry biomass, while the non-irrigated plot produced 4,510 lb/acre.

Plant tissue nitrogen
The plant tissue for the irrigated plot was 1.85% nitrogen, which led to a C:N ratio of 24.05.
For the non-irrigated plot, the tissue was 3.00% nitrogen, with a C:N ratio of 15.42.

Soil nitrate
The soil nitrate on April 21 (5.5 weeks after termination) was 25.9 mg/kg in the irrigated plot. Before planting, the nitrate level was 42 mg/kg. This mix took up the soil nitrate and took a while to decompose, tying up the nitrogen in the soil.

Overall impression
This is a good mix for providing pollinator resources and reducing nitrate leaching. The legumes did not make much of a contribution to the overall biomass. The rye and brassicas dominated the mix. The rye made the biomass decompose slowly.

Irrigated soil health mix on March 11, 2021.

Left: Non-irrigated sample plot on March 17, 2021.
Right: Irrigated sample plot on March 17. 2021

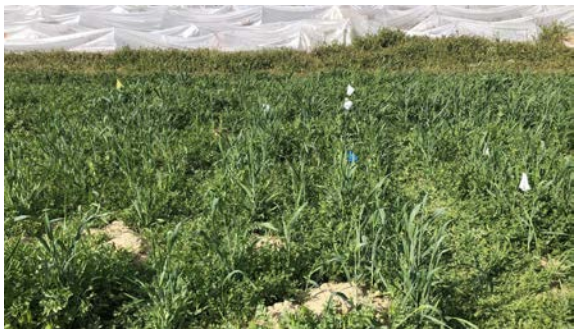
Cover Crop Profile: MULTIPLEX MIX

Benefits: Reduce erosion, reduce nitrate leaching, fix nitrogen
Species: 30% triticale, 40% Dundale peas, 30% purple vetch
Location: Kearney

Non-irrigated multiplex mix on March 22, 2021.

Weed Suppression

Multiplex performed the worst in terms of weed suppression, which was likely because the mix was only 30% triticale and the rest was legumes, which did not grow very well. Despite being 70% of the seed mix, legumes made up only 2% of the final biomass in both irrigated and non-irrigated plots. Weeds, on the other hand, were 71% of the biomass in the irrigated plots before termination and 76% of the non-irrigated plots before termination.



Non-irrigated soil health mix on March 22, 2021.

Biomass

The irrigated side of the field produced 2,422 lbs/acre of total biomass, of which 1,552 lbs/acre was weeds and 1,630 lbs/acre was cover crop biomass. The non-irrigated side produced 3,093 lbs/acre of total biomass, of which 1,958 lbs/acre was weeds and 1,455 lbs/acre was cover crop.

Plant tissue nitrogen:

The plant tissue for the irrigated plot was 3.17% nitrogen. Multiplying this by the total biomass, the plant residues contributed 76.8 lbs N/acre back to the soil. For the non-irrigated plot, the tissue was 2.92% nitrogen, meaning the plant residues contributed 90 lbs N/acre back to the soil.

Soil Nitrate

The soil nitrate on April 28 (5 weeks after termination) was 29 mg/kg in the irrigated plots and 14 mg/kg in the non-irrigated plot. Just as with the other plots at Kearney, the difference in soil nitrate may have to do with a smaller accumulation of cover crop biomass or more soil moisture on the irrigated side facilitating faster residue decomposition.

Triticale roots anchoring the soil in place, reducing erosion.

Overall impression

The legumes performed poorly in both irrigated and non-irrigated sides of the field. There were no significant differences in triticale biomass between the irrigated and non-irrigated plots. Therefore, triticale would not be a bad option if you are unable to irrigate your cover crops, however, consider seeding it at a higher rate so it can better compete with weeds. The triticale was also less mature at termination and decomposed faster than the Merced rye, which could be beneficial if you are incorporating the residue and planting shortly after.

SOURCES

United States Department of Agriculture Natural Resource Conservation Service - California. (2018, January). *Cover crop chart: Common cover crops for California*. https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/capmctn13333.pdf

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