Effects of Winter Cover Cropping on Radiation Dynamics for Micro-irrigated Pistachio

2024 UC STATEWIDE PISTACHIO DAY

January 17th, 2024 – Visalia Convention Center, CA

Daniele Zaccaria, Ph.D.

Associate Professor & Agricultural Water Management Specialist, L.A.W.R. Department - UC Davis

Ph.: (530) 219-7502 Email: dzaccaria@ucdavis.edu https://lawr.ucdavis.edu/people/faculty/zaccaria-daniele

CONTEXT & BACKGROUND

In the US, winter cover cropping is among conservation agriculture practices. However, cover crops are not widely adopted in the semi-arid Western states. In California, cover crops are grown on less than 5% of farmland (Soil Health Institute, 2019)

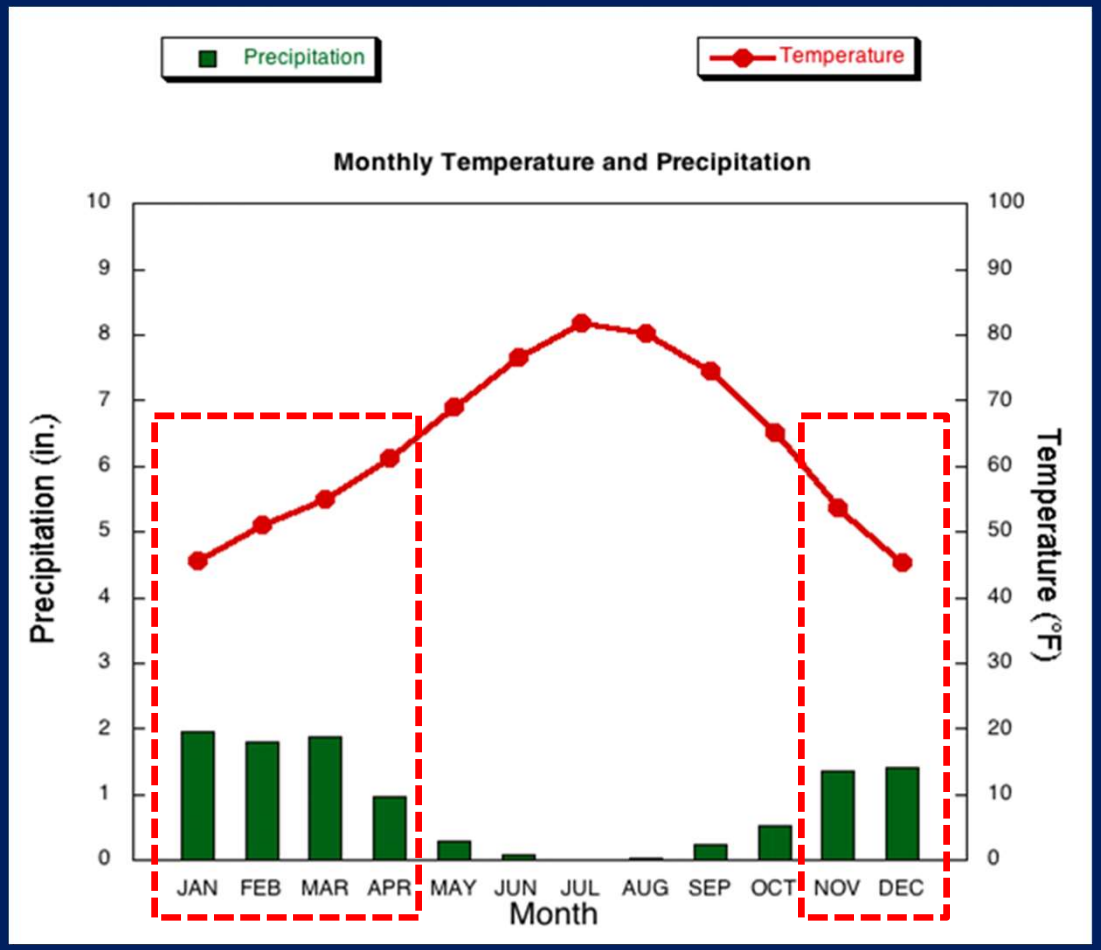
Main reasons for low adoption are the lack of accurate water-related information (i.e., uncertainties about water amounts needed to establish & maintain cover crops) and lack of information about costs & benefits associated with winter cover cropping

CONTEXT & BACKGROUND CONT.D'

In California's Central Valley, winter cover crops are grown when evaporative demand is lowest but precipitation is greatest

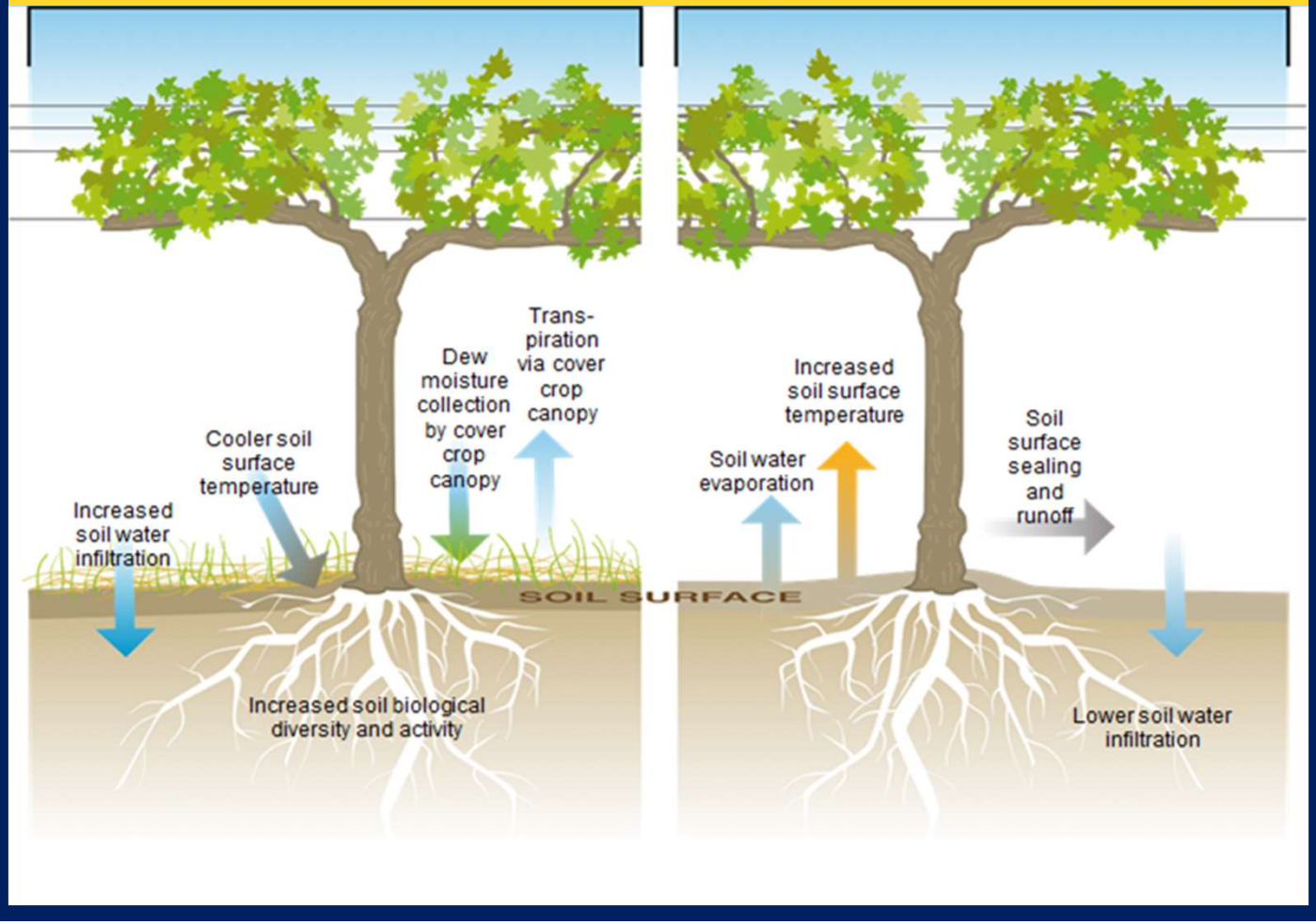
Seeded from late October thru January

Terminated from late March thru April



POTENTIAL BENEFITS & MECHANISMS OF ACTION

Cover cropped soil surface vs. Bare soil surface soil



Several studies documented significant medium & long-term benefits

Soil quality (Haruna & Nkongolo, 2015)

- ✓ Better Soil Aggregation & Stability, Improved Infiltration & Porosity (Nouri et al. 2019). https://youtu.be/K2fsvPTmIF0
- ✓ Increased Soil Moisture Storage (Mitchell, et al. 2021)
- ✓ Less Soil Surface Sealing & Crusting (Folorunso et al. 1992)
- ✓ Improved Soil Health Indicators (Sharma et al. 2018)

Water quality and quantity

- ✓ Control soil erosion (Joyce, et al. 2002; De Baets, et al. 2011)
- ✓ Effectiveness of salt leaching for the same amount of water applied (Gabriel, et al. 2012)

While multiple benefits can be anticipated from cover crops, growers still lack practical information to decide if the potential water benefits are worth the operational costs and potential hurdles associated with winter cover cropping

MOTIVATION BEHIND RESEARCH ON COVER CROPPING FOR PISTACHIO

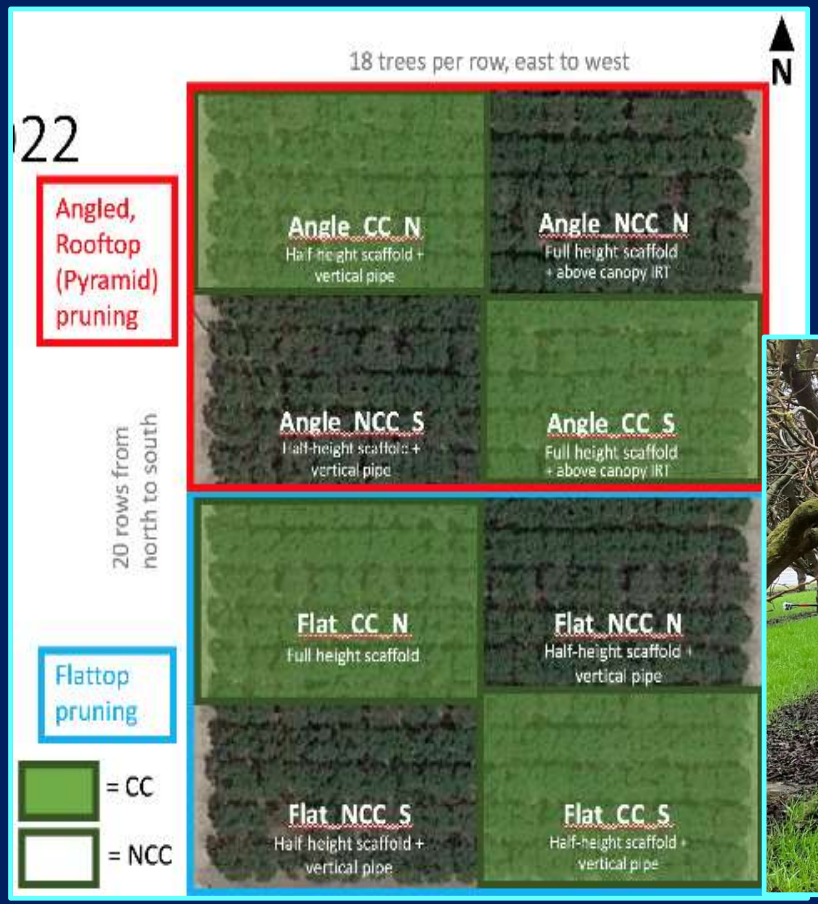
Cover cropping is being promoted by Federal and State Agencies (CDFA – Healthy Soil Program; NRCS) through Climate-Smart Financial Incentives aimed to improve soil health and mitigate effects of climate variability and climate change

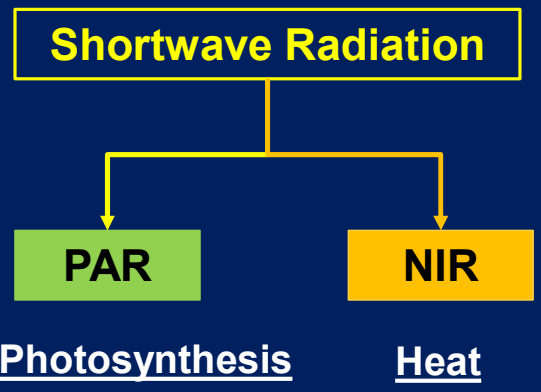
ffects of cover crops on
ıbitat, and root health

2022 - UC Davis team established a field trials in a mature micro-irrigated pistachio orchard @ UC Kearney Research and Extension Center

Collect field data to document comparative information on how winter cover crops & inactive vegetation residues affect reflection of the incoming solar radiation and its partition between the PAR vs. NIR

Does winter cover cropping affects the amount of PAR & NIR intercepted by tree canopies relative to bare ground?





HYPOTHESIS

The cover crop active vegetation & dead residues onto the row-middles may reflect and re-distribute part of the incoming solar radiation

=> increase the total light interception by trees => higher transpiration and net CO_2 assimilation relative to clean-cultivated floor (bare ground)

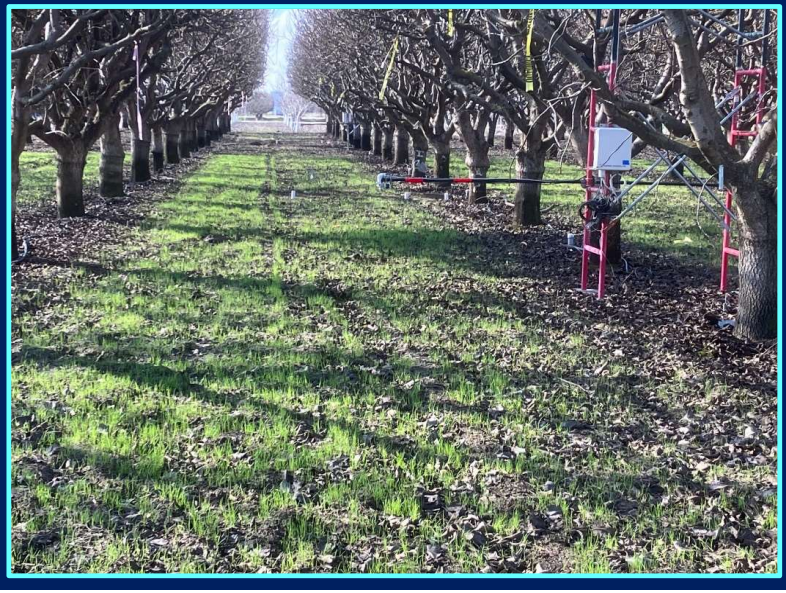
POSSIBLE MECHANISMS

- ✓ Improve light penetration & distribution within the tree canopy (up to + 40 - 50%);
- ✓ Increase the Photosynthetic Active surface of the trees, and the net CO_2 assimilation per unit of water evapotranspired;
- ✓ Improve soil oxygen conditions => better root activity, improved water & nutrient uptake;
- ✓ Increase the fraction of **tree transpiration** versus **soil evaporation**

REFLECTIVE GROUND COVER IN ORCHARDS
(capture and re-direct specific radiation towards canopy & fruits)





Shortwave Radiation

PAR — **Photosynthesis**

NIR — **Heat**

Kearney Pistachio Orchard Status: No Leaves.
Late Winter/Early Spring. Young CC. NCC weed-free.

April 4 – April 18, 2023

CC *Flat_CC_N*

NCC *Flat_NCC_N*

Kearney Pistachio Orchard Status: Leaves on. Spring. CC green, active growth. NCC weed-free.

April 28 – May 10, 2023

CC *Flat_CC_N*

NCC *Flat_NCC_N*

Kearney Pistachio Orchard Status: Nearly-Full Canopy. Early Summer. CC mowed; dried residue. NCC weed-free.

June 7 – 19, 2023

CC *Flat_CC_N*

NCC *Flat_NCC_N*

Kearney Pistachio Orchard Status: Full Canopy

Max LAI. Late Summer. CC mowed; dried residue. NCC weed-free

August 12-19, 2023

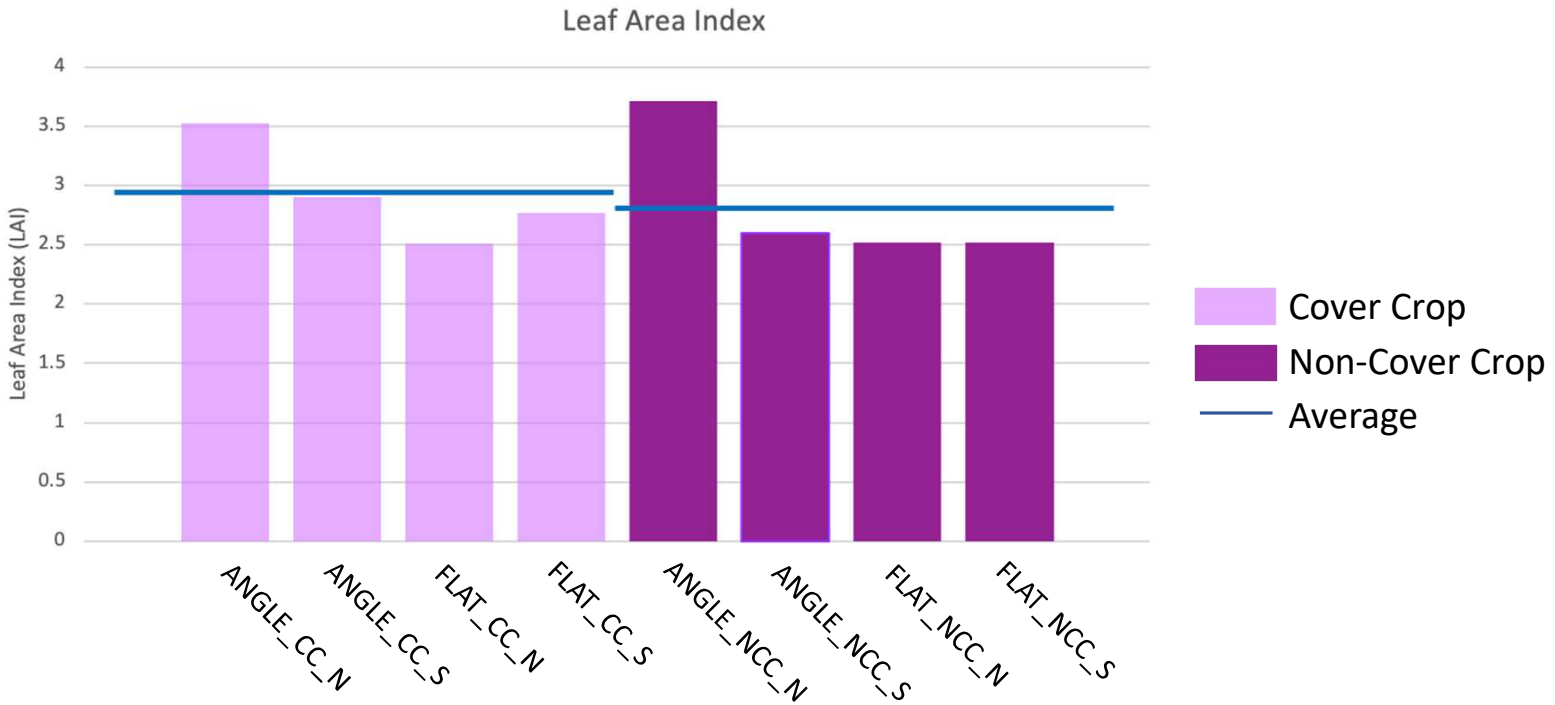
CC *Flat_CC_N*

NCC *Flat_NCC_N*

Leaf Area Index

June 7 – 19, 2023

<u>Kearney Pistachio Orchard Status:</u>
Leaf on. Early Summer. CC mowed; dried residue. NCC weed-free.



Leaf Area Index

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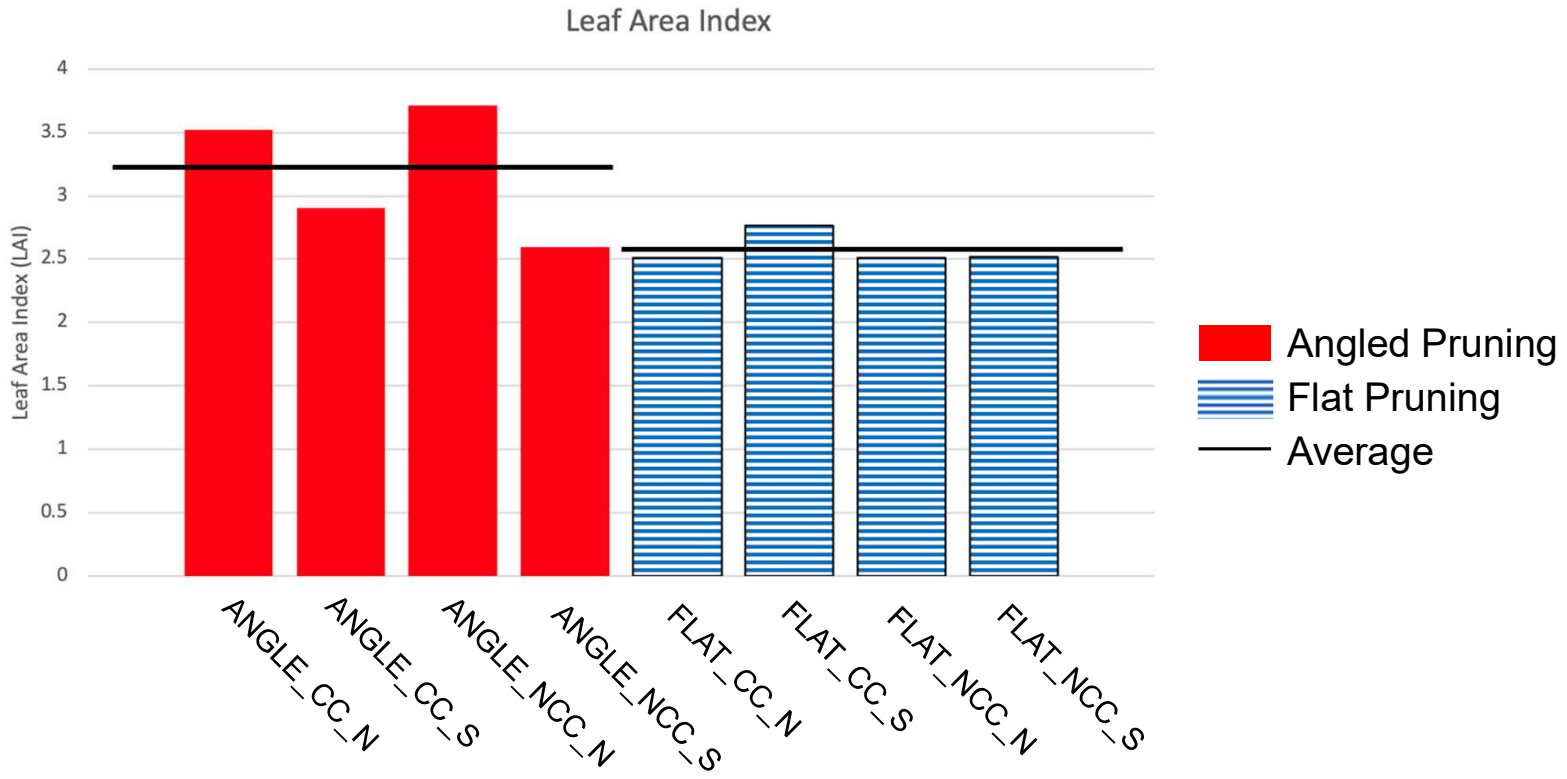
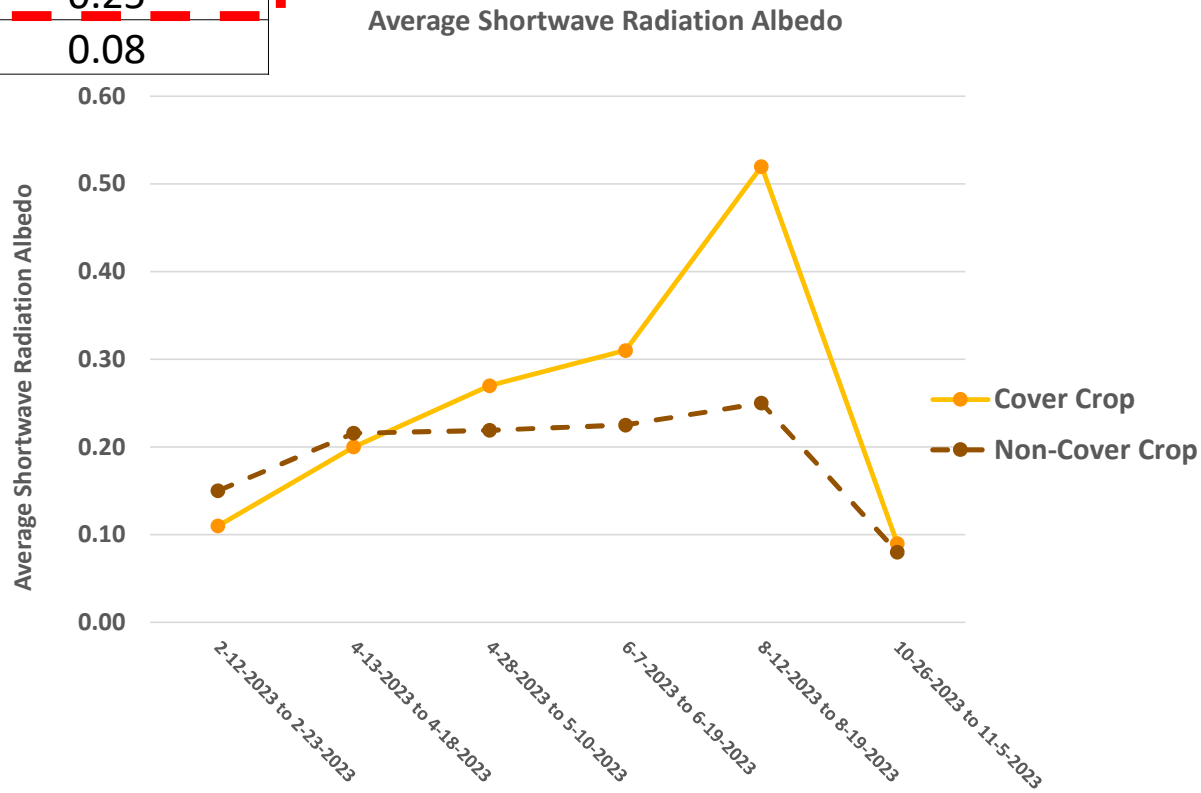


Total Shortwave Radiation Albedo Averages		
Date	**Cover Crop**	**Non-Cover Crop**
February 12-23, 2023	0.11	0.15
April 13-18, 2023	0.20	0.22
April 28 – May 10, 2023	0.27	0.22
June 7-19, 2023	0.31	0.23
August 12-19, 2023	0.52	0.25
Oct. 26 – Nov. 5, 2023	0.09	0.08

Albedo = Reflected Rad. / Incoming Rad.

Key message:

Cover-cropped floor reflects more incoming light than bare ground from May thru August (23% - 110%)

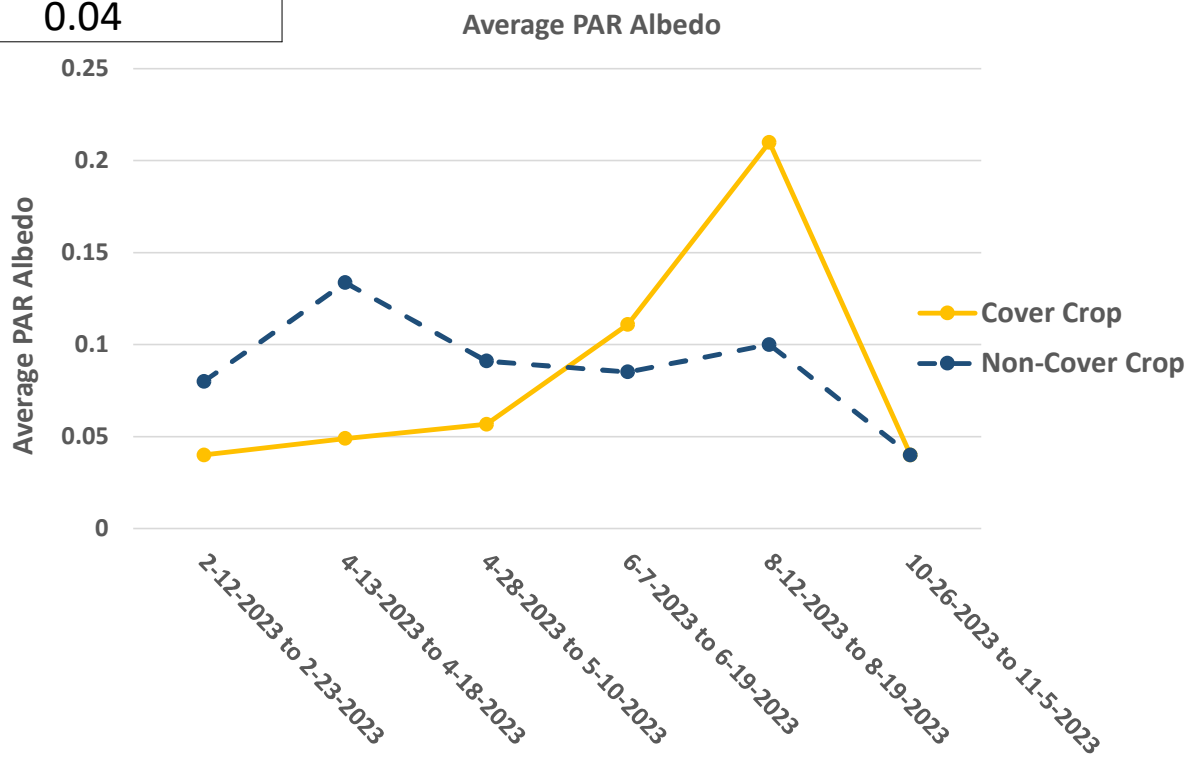


PAR Albedo Averages		
Date	**Cover Crop**	**Non-Cover Crop**
February 12-23, 2023	0.04	0.08
April 13-18, 2023	0.05	0.13
April 28 – May 10, 2023	0.06	0.09
June 7-19, 2023	0.11	0.09
August 12-19, 2023	0.21	0.10
Oct. 26 – Nov. 5, 2023	0.04	0.04

Albedo = Reflected Rad. / Incoming Rad.

Key message:

Cover-cropped floor reflects more PAR light than bare ground from June thru August (22% - 110%)

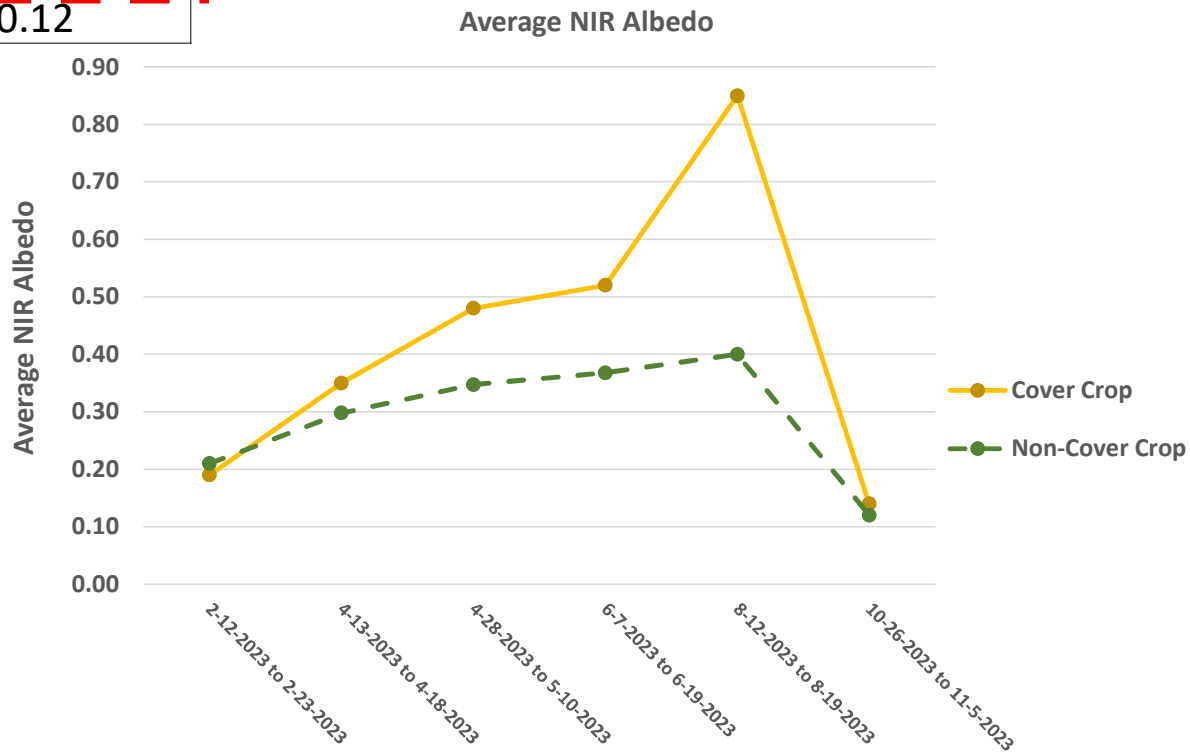


NIR Albedo Averages		
Date	**Cover Crop**	**Non-Cover Crop**
February 12-23, 2023	0.19	0.21
April 13-18, 2023	0.35	0.30
April 28 – May 10, 2023	0.48	0.35
June 7-19, 2023	0.52	0.37
August 12-19, 2023	0.85	0.40
Oct. 26 – Nov. 5, 2023	0.14	0.12

Albedo = Reflected Rad. / Incoming Rad.

Key message:

Cover-cropped floor reflects more NIR radiation than bare ground from April thru August (17% - 115%)



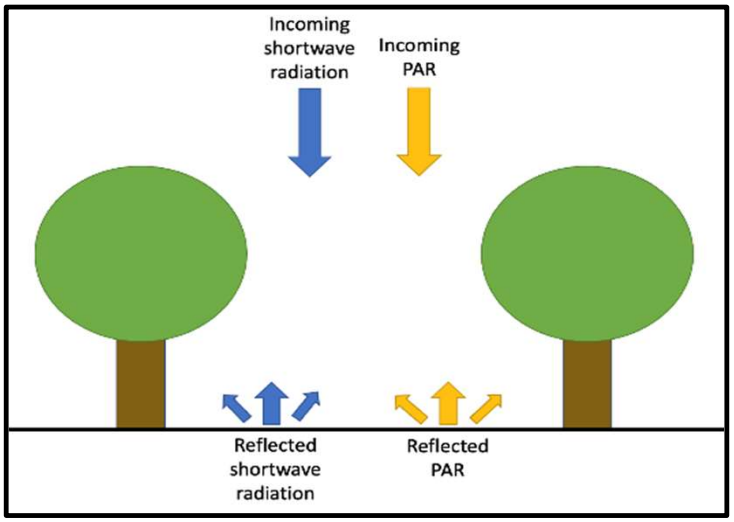
Ceptometer Scan: August 11, 2023

- Measured in two-tree quadrants per replicate block.

- The intercepted PAR is very close in June and equal in August for CC and NCC plots. So, Ceptometer data is very dependent on LAI as it shows the CC or NCC reflective properties.

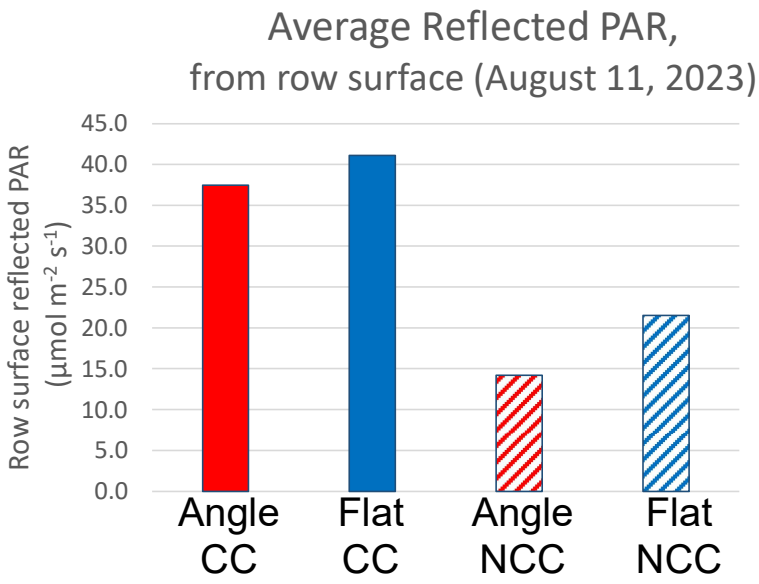
<u>Kearney Pistachio Orchard Status:</u>
Leaf on. Late Summer. CC mowed; dried residue. NCC mostly weed-free.

Ceptometer Scan Results: August 11, 2023



- 85% of the direct PAR is intercepted, absorbed, reflected, or scattered by both angled and flat pruned canopies;.
- 15% of the direct PAR reached the row-middle surface
- **Cover Cropped sites: More PAR reflected by row surface than in NCC sites** (in June and Aug. scans)

- We saw similar relationships (greater PAR reflected from surface in CC vs. NCC sites) in a young pistachio orchard with CC and NCC in Yolo County in Summer 2023.



2022 & 2023 Yield Data

Average fresh, wet yield per sample tree (lbs):

Treatment	2022 (lbs)	2023 (lbs)
Angled	29.0	62.0
Flat	15.9	63.0
CC	22.1	63.3
NCC	22.8	61.7

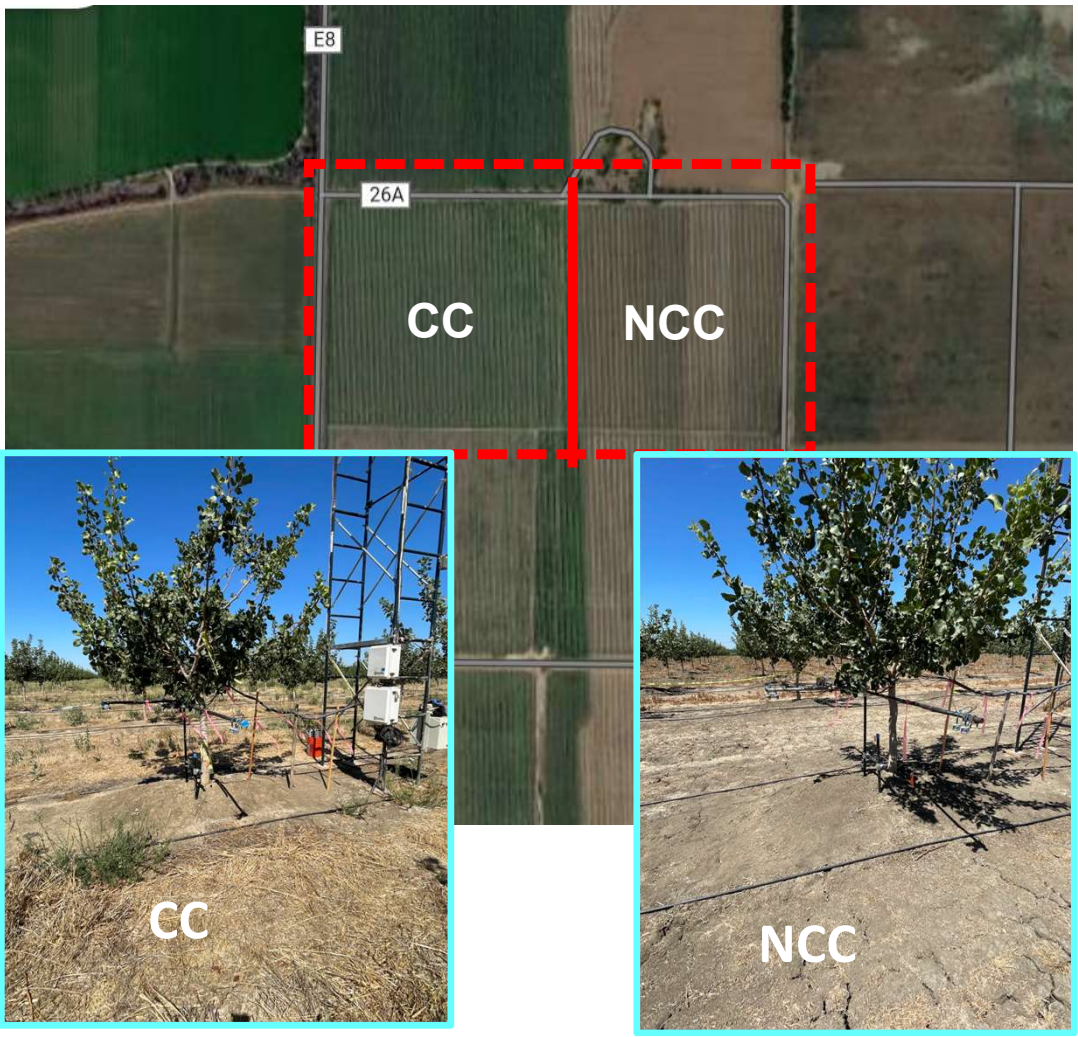
2023 Total Yield Data

This is the fresh, wet yield measured directly after shaking, so it does include some leaves and small twigs, and nuts are still in-shell

2023 Kearney Orchard, 56 Sample Trees:

- Angle pruning: 3,472 lbs
- Flat pruning: 3,530 lbs
- NCC: 3,455 lbs
- CC: 3,547 lbs

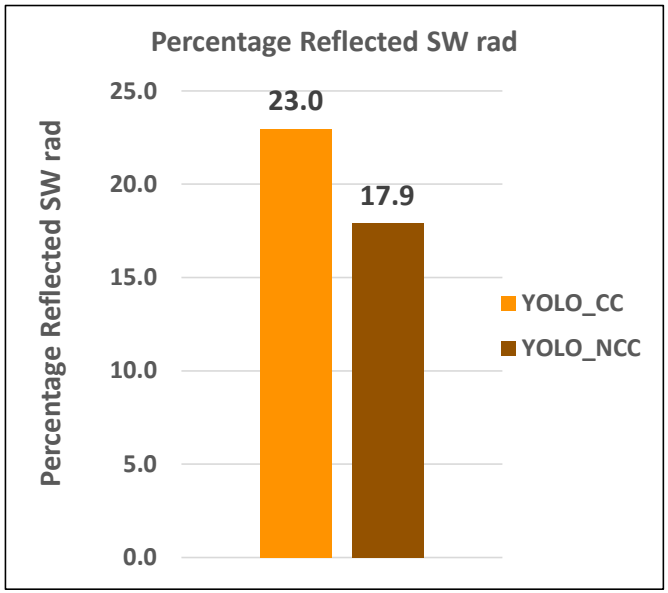
2023 – Research in a Young (6th leaf) Pistachio Orchard near Davis, CA

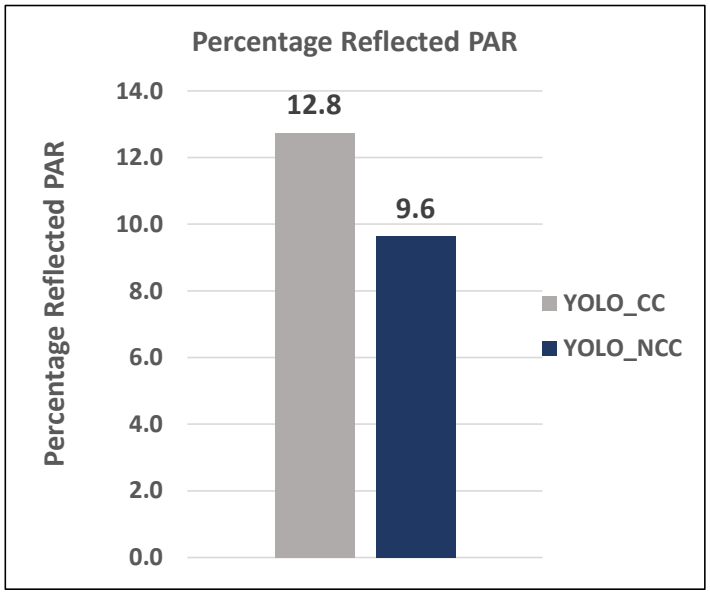


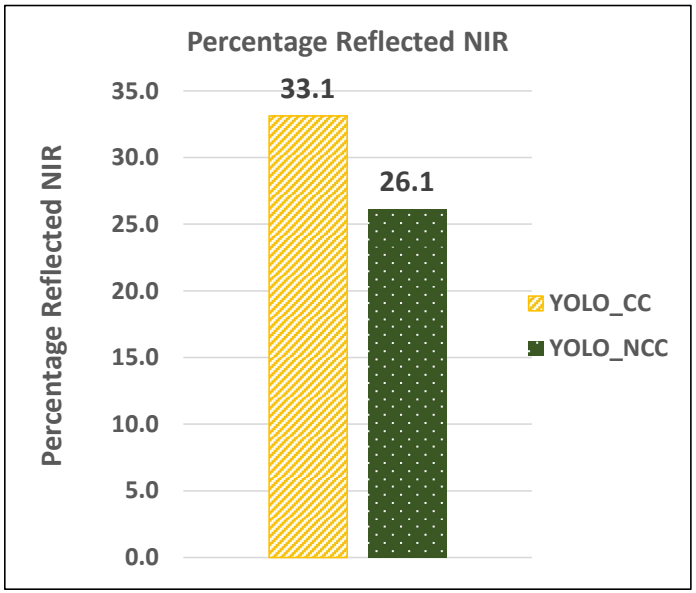
OBJECTIVES

1. Measure actual ET in cover-cropped (CC) vs. clean-cultivated (NCC) blocks;
2. Measure incoming and reflected radiation in cover-cropped vs. clean-cultivated blocks;
3. Identify inaccuracy and errors of Satellite Remote Sensing models (OpenET) in cover-cropped vs. clean-cultivated blocks against ground-measured ET

Yolo County Young Pistachio Data:
July 14 – August 30, 2023







About ~ 28% more reflected total SW radiation in <u>cover-cropped</u> block

About ~ 35% more reflected PAR radiation in <u>cover-cropped</u> block

About ~ 27% more reflected NIR radiation in <u>cover-cropped</u> block

TAKE-HOME MESSAGES

Data from 2022-23 show that PAR and NIR albedo are markedly greater for cover-cropped orchards compared to clean-cultivated orchards in late spring & summer

WHEN TREES HAVE LEAVES ON

A BIT MORE NIR THAN PAR IS REFLECTED BY THE COVER CROP, WHICH LIKELY LEADS TO MORE TREE TRANSPIRATION TO DISSIPATE HEAT

(if soil moisture is available)

THE STUDY ORCHARDS WERE DOUBLE-DRIP IRRIGATED

2023 WAS THE WETTEST YEAR ON RECORD => SURFACE NEARLY ALWAYS WET

The radiation balance & partition between PAR vs. NIR components were possibly affected by the nearly-constant wetness of the topsoil layer both in the cover-cropped and clean-cultivated plots during spring and early summer

CONCLUSION: MUCH MORE TO LEARN ON THE RADIATION DYNAMICS!!

TEAM EFFORT & WORK IN PROGRESS

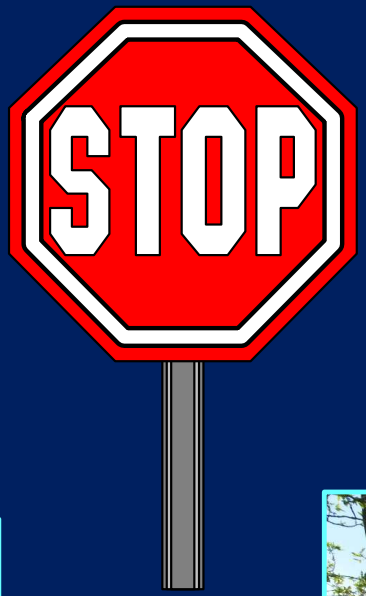
ACKNOWLEDGEMENTS

PARTNERS: Kyaw Tha Paw U, Mae Culumber, Blake Sanden, Rick Snyder, Bruce Lampinen, Pasquale Steduto.

COLLABORATORS: **Jenae Clay**, **Kristen Shapiro**, Clayton Kleppinger, Sam Metcalf, Lorenzo Cigarra (Chile), Fernando Gomez (Chile), Octavio Lagos (Chile)

FARM MANAGERS: Dan Spalding, James Nichols, John Gebhardt, Nick Edsall

FUNDING AGENCIES: Pistachio Research Board; UC ANR operational budget



QUESTIONS??

https://www.youtube.com/watch?v=mTNLx6LzEt0&t=64s

RESEARCH ARTICLE

Impacts of winter cover cropping on soil moisture and evapotranspiration in California's specialty crop fields may be minimal during winter months

Results from a 3-year study suggest that processing tomato and almond growers can adopt winter cover cropping without changing irrigation practices.

by Alyssa DeVincentis, Samuel Sandoval Solis, Sloane Rice, Daniele Zaccaria, Richard Snyder, Mahesh Maskey, Anna Gomes, Amélie Gaudin and Jeffrey Mitchell

Online: https://doi.org/10.3733/ca.2022a0001

Water usage for agricultural production has become a focus of attention among researchers, growers, policymakers and the general public as the combination of climate change and population growth threatens the availability of freshwater resources (IPCC 2014). For irrigated agriculture to be sustainable, land use decisions must consider water as a limiting factor; however, empirical data on water implications of many sustainable agricultural practices is lacking (Iglesias and Garrote 2015; Rodriguez et al. 2009). The lack of such information can lead to low adoption of sustainable agricultural practices, such as with winter cover cropping in California (Carlisle 2016).

Although winter cover crops — a wide variety of plants that includes native grasses or seed mixes of annual grasses and legumes — have emerged as a sustainable agricultural management practice, they are not yet commonly adopted in the semi-arid Western states and are grown on less than 5% of farmland in California (Soil Health Institute 2019), potentially due to uncertainties about the water required to establish and maintain a cover crop and the costs associated with cover cropping. Winter cover crops grow in the cool season between specialty crop production cycles

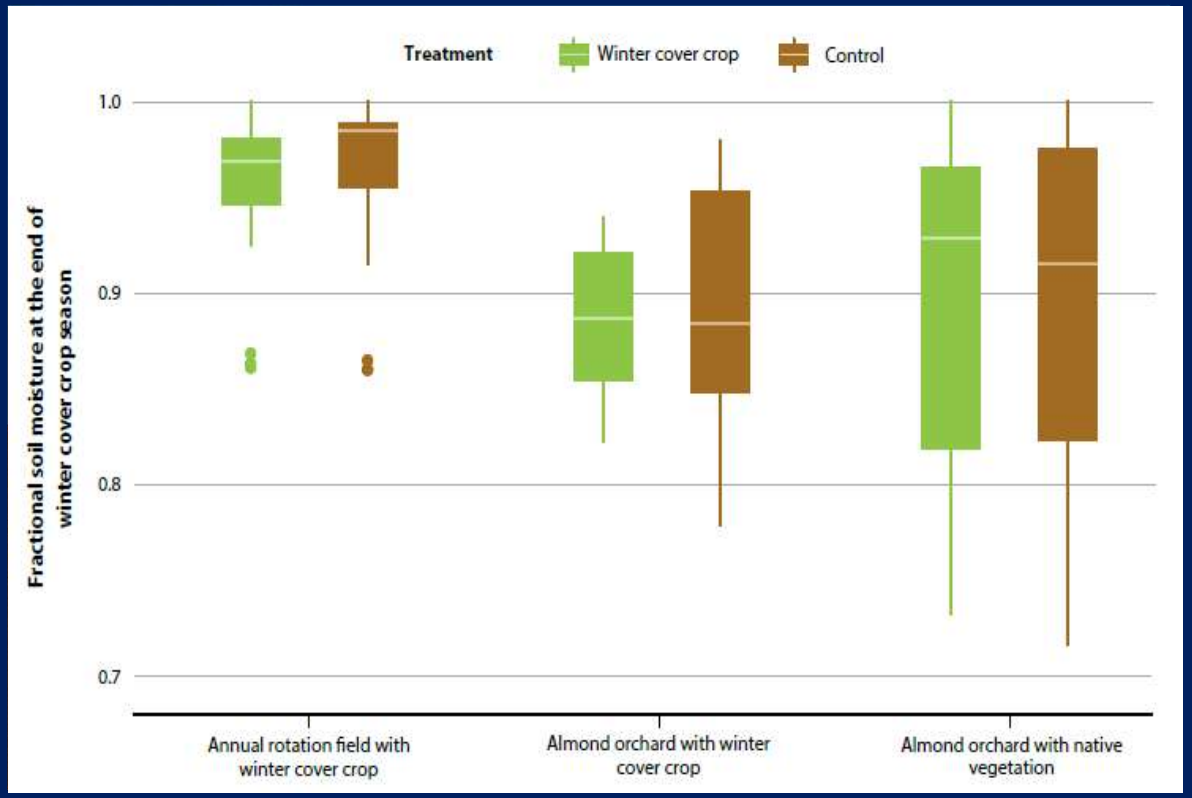
Abstract

As fresh water supplies become more unreliable, variable and expensive, the water-related implications of sustainable agriculture practices such as cover cropping are drawing increasing attention from California's agricultural communities. However, the adoption of winter cover cropping remains limited among specialty crop growers who face uncertainty regarding the water use of this practice. To investigate how winter cover crops affect soil water and evapotranspiration on farm fields, we studied three systems that span climatic and farming conditions in California's Central Valley: processing tomato fields with cover crop, almond orchards with cover crop, and almond orchards with native vegetation. From 2016 to 2019, we collected soil moisture data (3 years of neutron hydroprobe and gravimetric tests at 10 field sites) and evapotranspiration measurements (2 years at two of 10 sites) in winter cover cropped and control (clean-cultivated, bare ground) plots during winter months. Generally, there were not significant differences in soil moisture between cover cropped and control fields throughout or at the end of the winter seasons, while evapo-transpirative losses due to winter cover crops were negligible relative to clean-cultivated soil. Our results suggest that winter cover crops in the Central Valley may break even in terms of actual consumptive water use. California growers of high-value specialty crops can likely adopt winter cover cropping without altering their irrigation plans and management practices.

Co-authors Alyssa DeVincentis and Sloane Rice install surface renewal equipment at Davis. New UC field research indicates that growers who farm processing tomatoes and almond trees in the Central Valley can potentially benefit from soil health advantages associated with winter cover cropping without increasing their water footprint. *Photo:* Jose Pablo Ortiz Partida

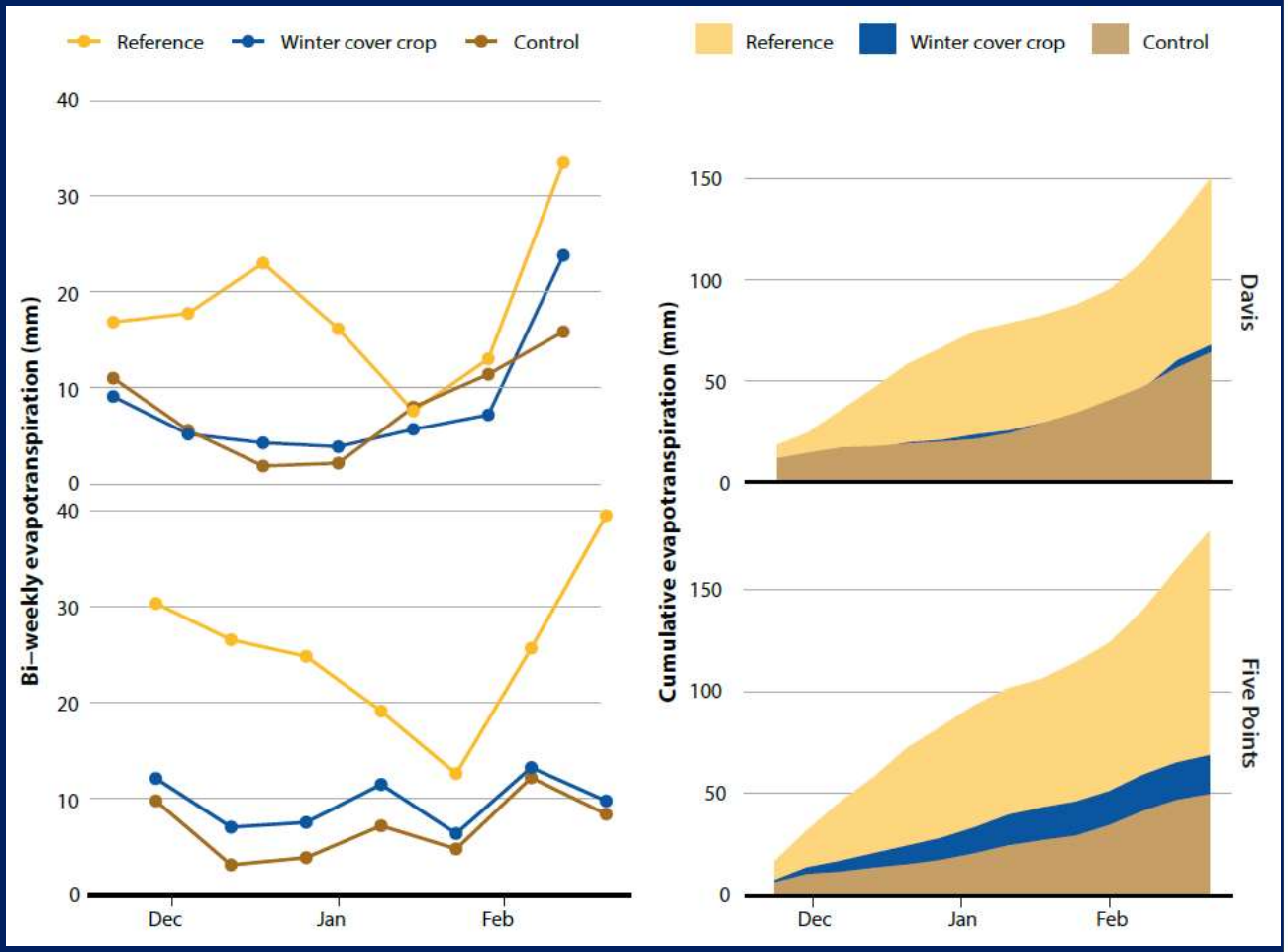
Negligible differences in soil moisture at the end of the 2017-2018 winter season

(DeVincentis et al., 2022 – California Agriculture)



Negligible differences in seasonal ETa from Nov. 15th to Feb. 20th

(DeVincentis et al., 2022)



The difference in seasonal ETa was 0.12 in. (3 mm) at the Davis site and 0.7 in. (18 mm) at the Five Points site.

Bi-weekly ETa at Davis showed that during period of abundant rain (Jan ‘18) the ETa was higher in bare ground soil than cover cropped soil (due to higher soil evaporation from bare ground).

In the drier climate of Five Points, bi-weekly ETa was slightly greater in cover-cropped soil than bare ground.

However, the measured ETa may also have included the condensed moisture captured by the cover crop from fog and dew.

RESEARCH ARTICLE

Impacts of winter cover cropping on soil moisture and evapotranspiration in California's specialty crop fields may be minimal during winter months

Results from a 3
cover cropping

by Alyssa DeVincentis, S
Jeffrey Mitchell

Online: https://doi.org/10

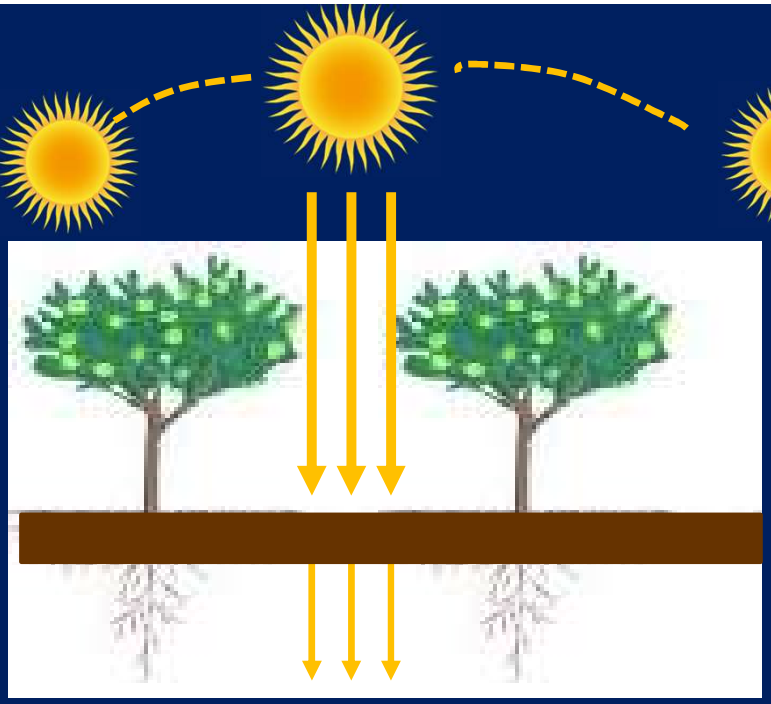
RESEARCH ARTICLE

Long-term reduced tillage and winter cover crops can improve soil quality without depleting moisture

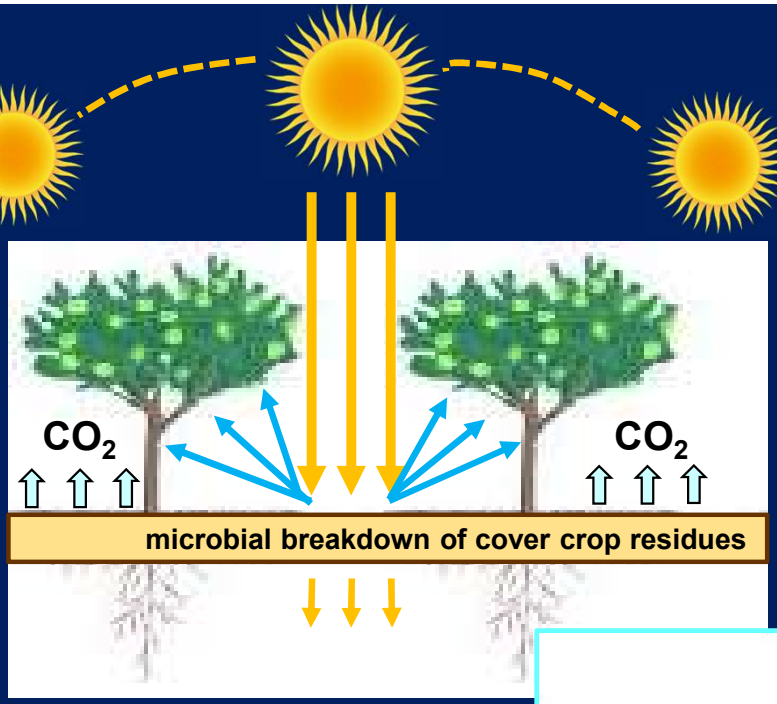
Long-term reduced-disturbance tillage and winter cover cropping can improve San Joaquin Valley soil quality without depleting soil moisture.

by Anna Gomes, Alyssa J. DeVincentis, Samuel Sandoval Solis, Daniele Zaccaria, Daniel Munk, Khaled Bali, Anil Shrestha, Kennedy Gould and Jeffrey Mitchell

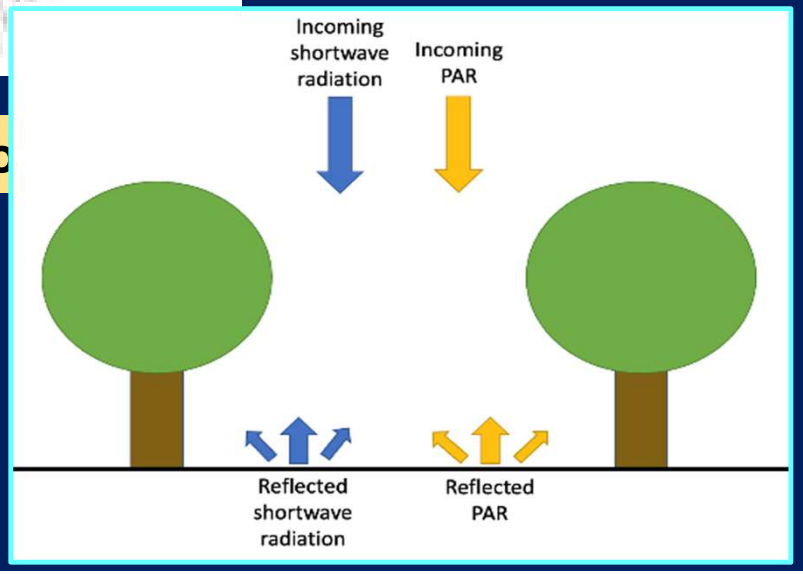
Online: https://doi.org/10.3733/ca.2023a0001

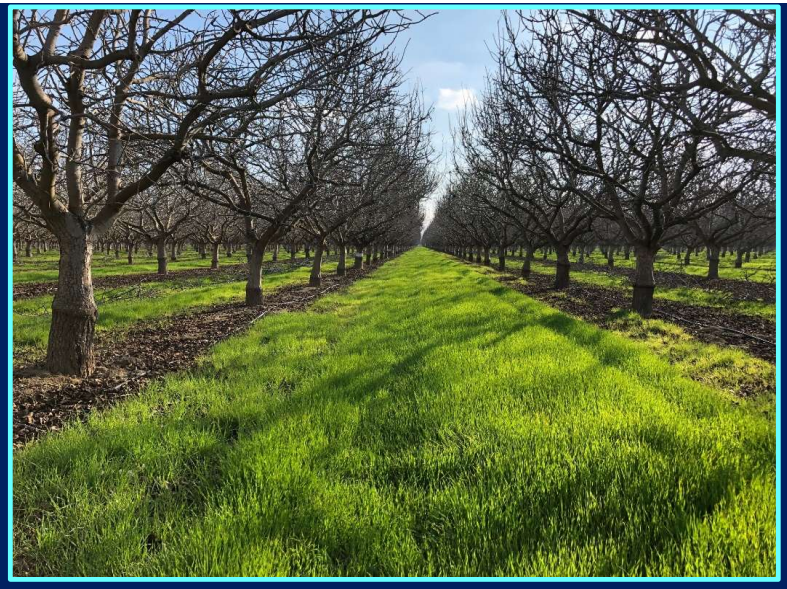


Clean-cultivated orchard floor



Orchard floor with cc





2022 & 2023 Yield Data

Average fresh, wet yield per sample tree (lbs):

Treatment	2022 (lbs)	2023 (lbs)
Angled	29.0	62.0
Flat	15.9	63.0
CC	22.1	63.3
NCC	22.8	61.7

Young Pistachio Orchard Status: Full Canopy. Summer. CC mowed; dried residue with some weed growth; NCC mostly weed-free.

August 9th, 2023 at the Young Pistachio sites near Davis, CA

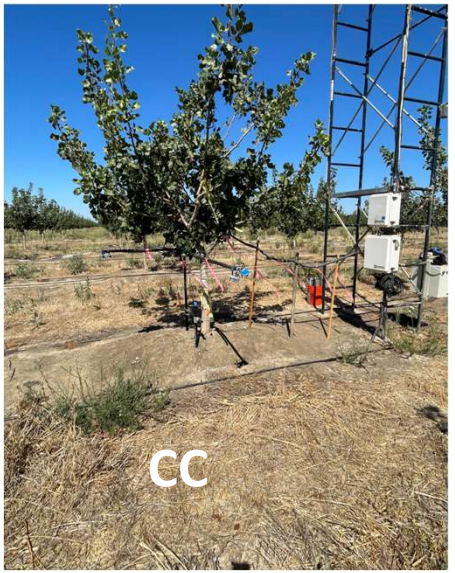
Cover-cropped block

Clean-cultivated block

Data for Young Pistachio near Davis, CA

July 14 – August 30, 2023

% Reflectivity	Cover-cropped block	Clean-cultivated block
PAR % reflection	12.8	9.6
NIR % reflection	33.1	26.1
Ratio of NIR/PAR reflection	2.60	2.71
LAI	0.35	0.32
Albedo	**Cover-cropped block**	**Clean-cultivated block**
PAR albedo (approximate)	0.130	0.098
NIR albedo (approximate)	0.338	0.266



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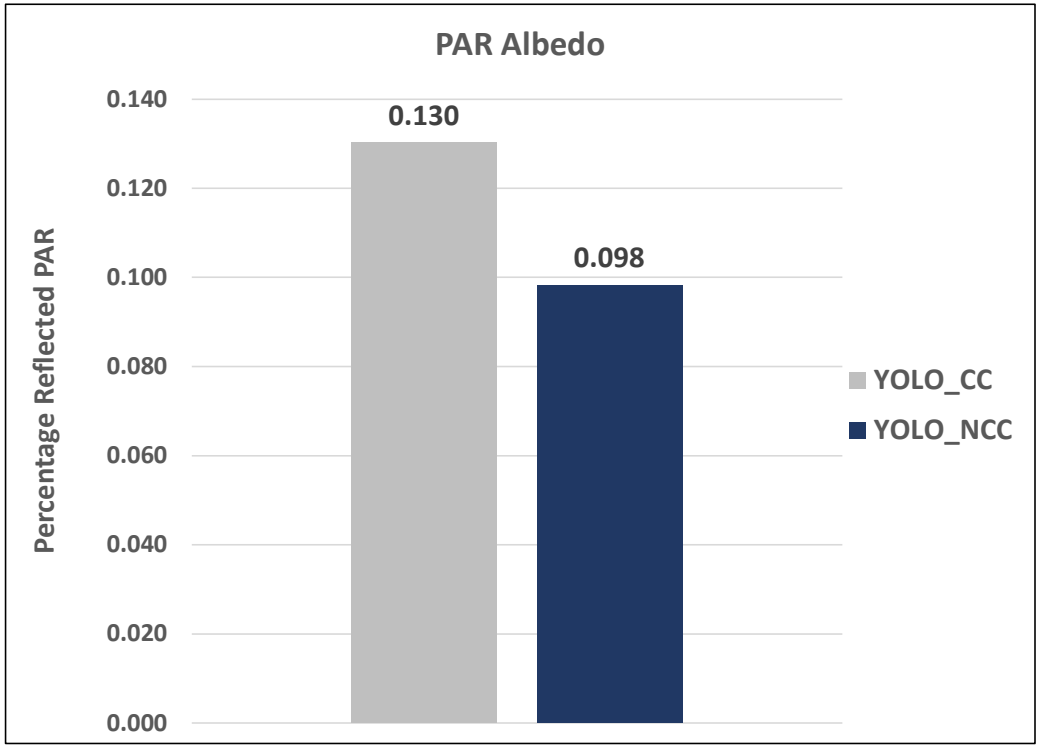
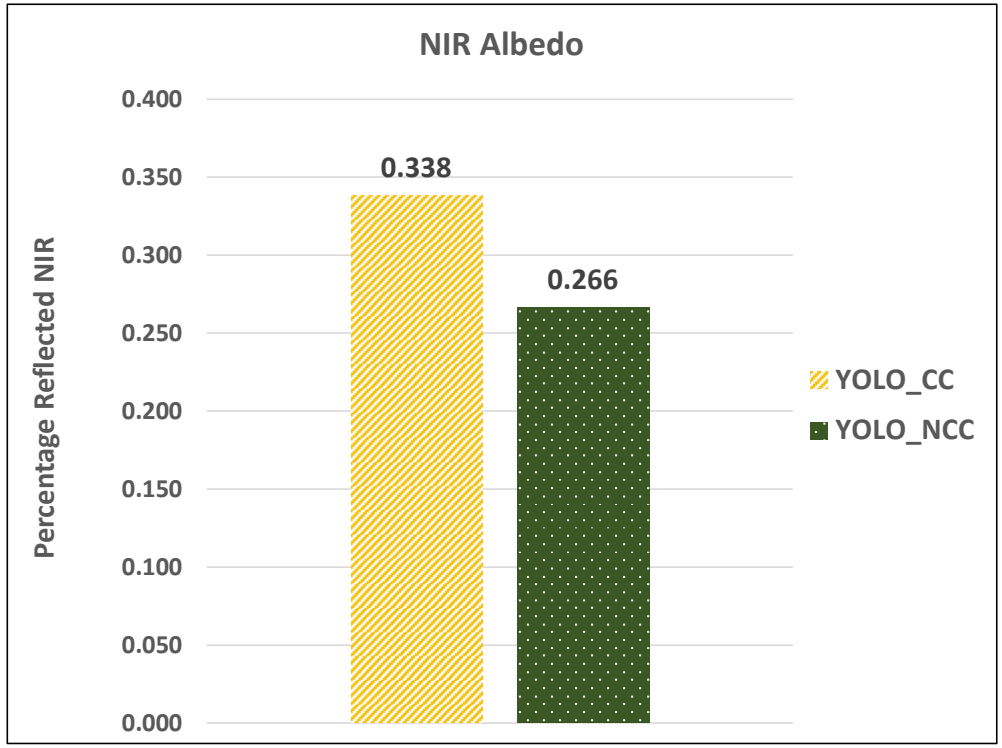
Albedo = Reflected Rad. / Incoming Rad.





About ~ 35% higher PAR albedo in <u>cover-cropped</u> block

About ~ 27% more reflected NIR radiation in <u>cover-cropped</u> block