

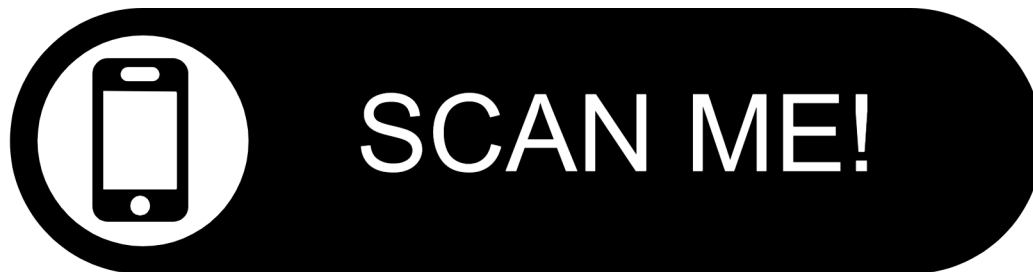
# Predicting alfalfa yield and quality using FARMs

Isaya Kisekka

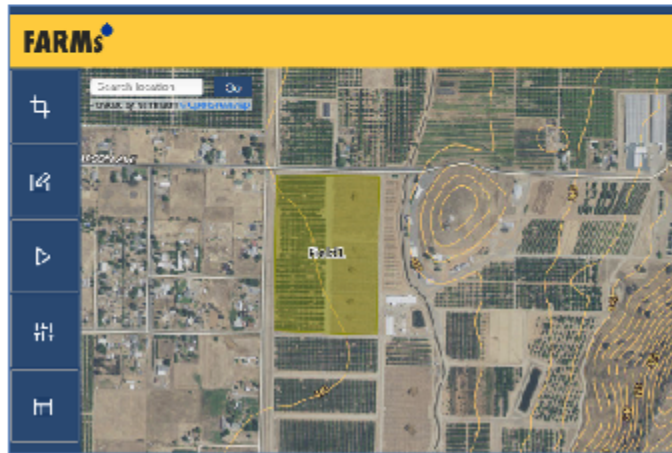
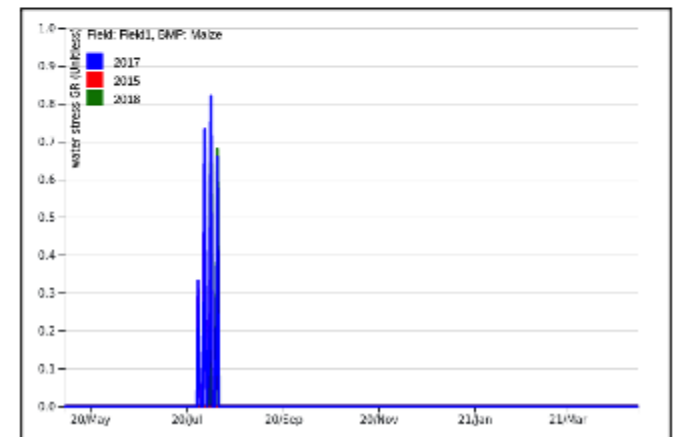
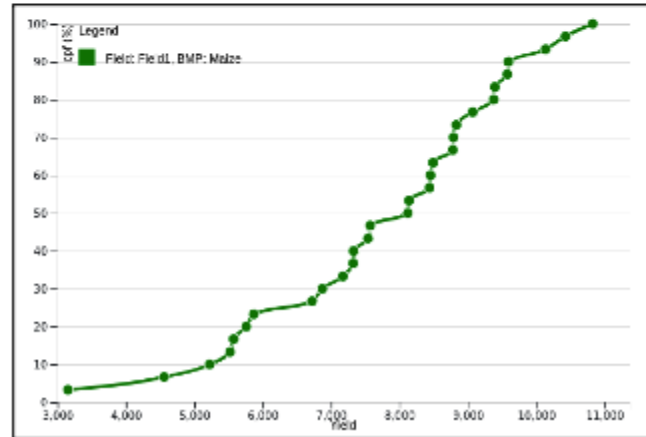
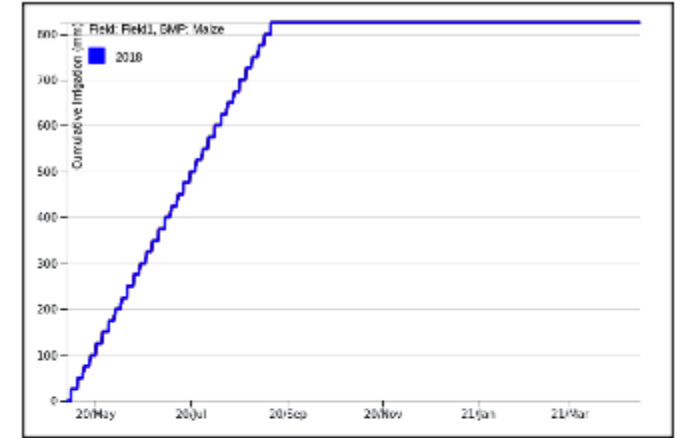
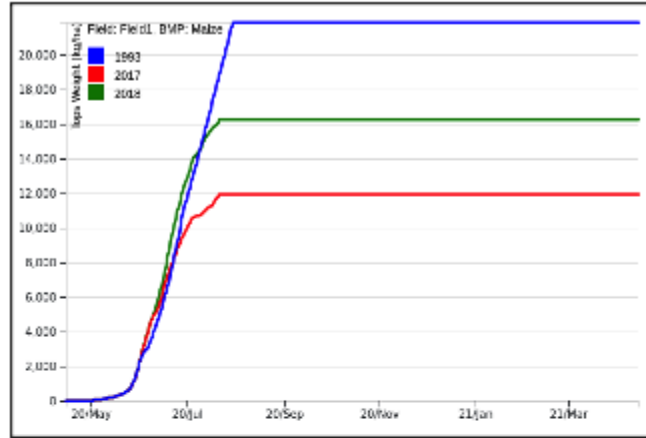
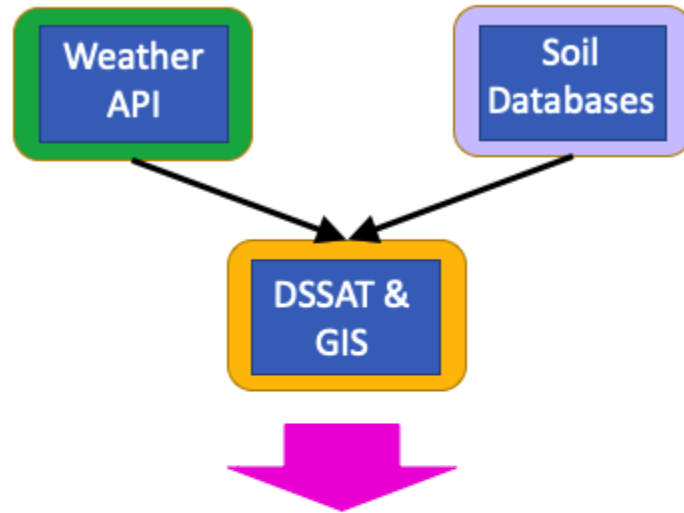
UC Davis

World Alfalfa Congress

Nov. 14 – 17 San Diego California



# What is FARMs (Food, Agriculture, and Resource Management system)? Is a web app for crop yield prediction



# Justification

- Alfalfa production is threatened by constrained water supplies and climate change e.g., multiyear droughts
- There is an urgent need to develop simple web and mobile-friendly apps that simulate crop response to the complex interactions between the **soil** (S), **environment** (E), **genetics** (G), and **management** (M)
- These web and mobile apps can be used for strategic (land-water allocation) and tactical decision-making (irrigation scheduling)

# Questions you can ask using FARMs

- Given a water allocation limit, should I spread my water over many acres (i.e., deficit irrigate) or concentrate it on fewer acres (i.e., maximize productivity on fewer acres)?
- How do various alfalfa varieties perform in different locations?
- How does irrigation management affect forage quality?





Open Access Article

FARMS: A Geospatial Crop Modeling and Agricultural Water Management System

by Jae Sung Kim and Isaya Kisekka

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Kim and Kisekka (2021). https://www.mdpi.com/2220-9964/10/8/553

## Register

Already have an account? [Log In](#).

Username:

Required. 150 characters or fewer. Letters, digits and @/./+/-/\_ only.

Email:

Required. Please input a valid email address.

First name:

Optional

Last name:

Optional

Password:

- Your password can't be too similar to your other personal information.
- Your password must contain at least 8 characters.
- Your password can't be a commonly used password.
- Your password can't be entirely numeric.

Password Confirmation:

Please enter the same password.

Registering login|

- Fields
- Scenarios
- Modeling



Zoom out to see the map of the world | FARMS can be used anywhere in the world



- Fields
- + New
- Scenarios
- Modeling



Zoom in to Imperial Valley California (West of San Diego)

Fields

+ New

Scenarios

Modeling



To create a field click “Field” > New > Draw Polygon

- Fields
- + New
- Scenarios
- Modeling

Cancel Save

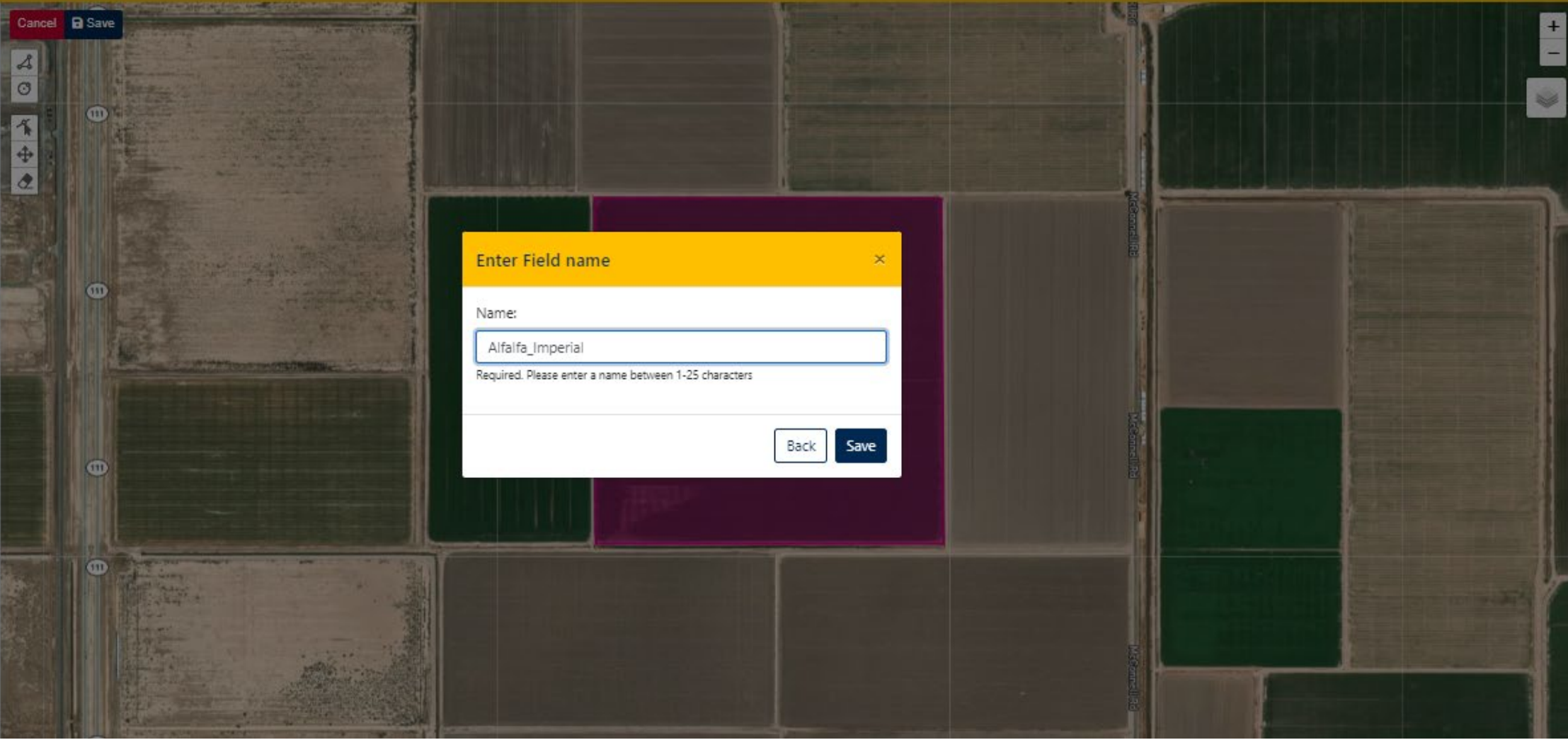


Fields

+ New




Scenarios

Modeling




Click Save and give the field a name (you might need to refresh to see the field you created)

# Defining Management Practices (Scenarios)

-  Fields
  -  Scenarios ▾
  -  Modeling
- + New**

## Scenario

 Create a new scenario or select an existing one to view it.

Click on “Scenarios

**1. Planting**

Date  Crop  Plants/m<sup>2</sup>  Method  Cultivar  + Add

**2. Irrigation**

Date  Depth (mm)  Method  + Add

**3. Fertilizer**

Date  Fertilizer  N (kg/ha)  P (kg/ha)  Method  + Add

**4. Tillage**

Date  Tillage  + Add

**5. Expected Harvest date**

Date  + Add

Management Table

Show  entries Search:

Type	date	opt1	opt2	opt3	opt4	delete
No data available in table						

Showing 0 to 0 of 0 entries Previous Next

Automatic Irrigation

Type	Depth	Threshold(%)	End Point(%)	Method	Amount(fixed)	AVWAT	IFREQ
<input type="text" value="Select"/>	<input type="text" value="mm"/>	<input type="text" value="%"/>	<input type="text" value="%"/>	<input type="text" value="Select"/>	<input type="text" value="mm"/>	<input type="text"/>	<input type="text" value="days"/>

Click on New and enter values on the next slide

**1. Planting**

Date: 2022-10-01    Crop: Alfalfa    Plants/m<sup>2</sup>: 40    Method: seed    Cultivar: AL0001:Aragon FD-7    + Add

**2. Irrigation**

Date: 2022-10-02    Depth (mm): 25    Method: Sprinkler(mm)    + Add

**3. Fertilizer**

Date: 2022-10-15    Fertilizer: Ammonium nitrate    N (kg/ha): 0    P (kg/ha): 10    Method: Broadcast, not incorporated    + Add

**4. Tillage**

Date: 2022-09-15    Tillage: Disk, tandem    + Add

**5. Expected Harvest date**

Date: 2023-10-31    + Add

Management Table

Show 10 entries    Search:

Type	date	opt1	opt2	opt3	opt4	delete
Tillage	2022-09-15	Disk, tandem				Delete
Planting	2022-10-01	Alfalfa	400	seed	AL0001:Aragon FD-7	Delete
Irrigation	2022-10-02	25	Sprinkler(mm)			Delete

Click “Add” after entering inputs in each category (You will see the management practice added below) then click Save and give the scenario a name e.g., Alfalfa\_Imperial



Management Table

Show 10 entries

Search:

Type	date	opt1	opt2	opt3	opt4	delete
Tillage	2022-09-15	Disk, tandem				Delete
Planting	2022-10-01	Alfalfa	400	seed	AL0001:Aragon FD-7	Delete
Irrigation	2022-10-02	25	Sprinkler(mm)			Delete
Fertilizer	2022-10-15	Ammonium	0	100	Broadcast, not incorporated	Delete
Harvest						Delete
Harvest						Delete
Harvest						Delete
Harvest						Delete
Harvest	2023-05-31					Delete
Harvest	2023-06-30					Delete

**Enter Scenario Name** ×

Name:

Showing 1 to 10 of 14 entries

Previous **1** 2 Next

Automatic Irrigation

Type	Depth	Threshold(%)	End Point(%)	Method	Amount(fixed)	AWWAT	IFREQ
Automatic with Fixed Amount	100	50	100	Sprinkler, mm	25	-99	3

Remember to save scenario

- Fields
- Scenarios
- Modeling

Field

BMP

Run

To run the model select your field and scenario and click run

- Fields
- Scenarios
- Modeling

Field  
Alfafa\_Imperial

BMP  
Alfafa\_Imperial

Run

Show 10 entries Search:

3. Select Output: select

Showing 1 to 1 of 1 entries Previous 1 Next

Select > Forage Yield

Field  
Alfalfa\_Imperial

BMP  
Alfalfa\_Imperial

Run

Show 10 entries Search:

3. Select Output: select

- select
- Tops Weight
- Forage Yield
- Grain Weight
- water stress GR
- N stress
- Water Productivity
- Yield
- Cumulative Nitrate Leach
- Cumulative Irrigation
- Crude Protein

Showing 1 to 1 of

Previous 1 Next

View graphs for model predicted alfalfa yield

Field:

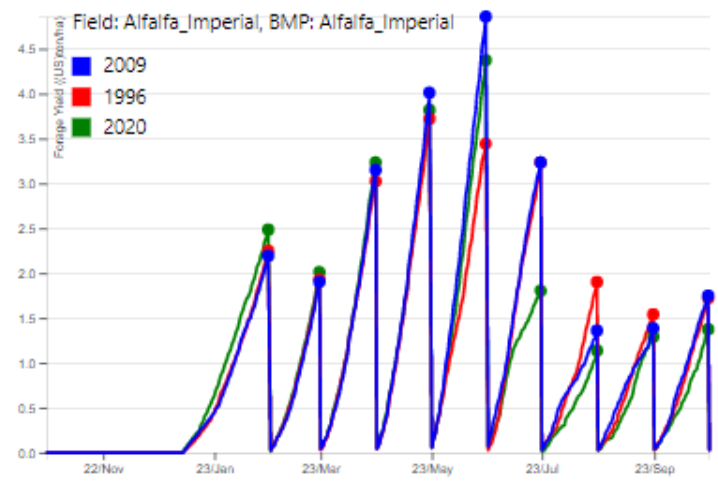
BMP:

Show  entries Search:

3. Select Output:

4. Select Unit:

Showing 1 to 2 of 2 entries



Alfalfa yield for example alfalfa field in Imperial Valley 9 cuts (tons/ha): **Variety FD 7**

Field:

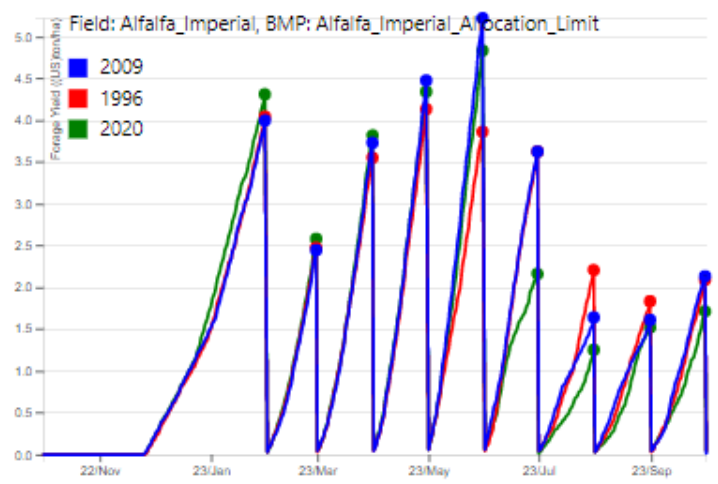
BMP:

Show  entries Search:

3. Select Output:

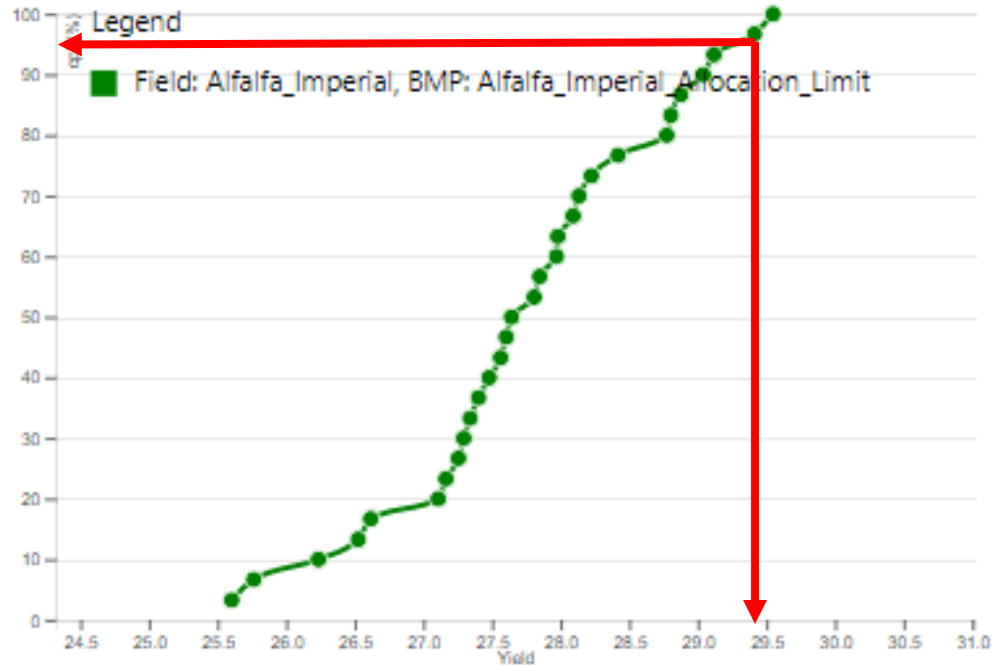
4. Select Unit:

Showing 1 to 2 of 2 entries

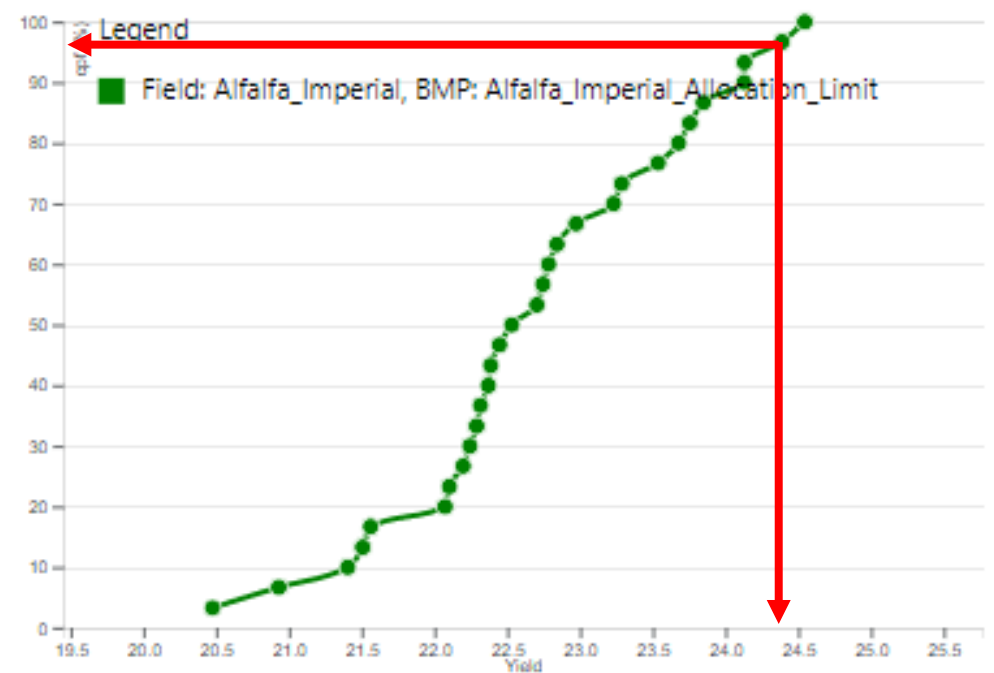


Alfalfa yield for an example alfalfa field in Imperial Valley 9 cuts (tons/ha): **Variety FD 9**

# Assessing the effect of alfalfa variety on yield potential



Formal Dormancy  
Rating (FD): 9



Formal Dormancy  
Rating (FD): 7

# Comparing FARMs predictions to UC Davis alfalfa variety trial yields for Imperial (El Centro)

**Table 3. 2019 Yields. El Centro Alfalfa Cultivar Trial (Trial planted 10/19/16)**

Note: Single year data should not be used to evaluate alfalfa varieties or choose alfalfa cultivars

	FD	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9	YEAR	% of CUF101
		29-Jan	19-Mar	24-Apr	31-May	27-Jun	23-Jul	27-Aug	9-Oct	18-Nov	TOTAL	
		Dry t/a										
<b>Released Varieties</b>												
106T701	10	0.98 (18)	1.49 (7)	2.10 (19)	2.37 (8)	3.12 (2)	2.00 (2)	1.51 (3)	1.06 (11)	1.14 (5)	15.76 (4)	A B C D 127.8
6906N	10	0.96 (20)	1.38 (18)	2.16 (9)	2.39 (6)	3.02 (11)	1.73 (17)	1.39 (14)	0.94 (23)	0.95 (22)	14.93 (16)	C D E F G 121.0
UC-impalo	9	1.07 (8)	1.39 (15)	2.15 (12)	2.14 (26)	2.95 (16)	1.69 (21)	1.35 (18)	1.04 (13)	1.07 (11)	14.86 (18)	D E F G 120.5
Fertillac 11	11	0.95 (22)	1.42 (14)	2.13 (15)	2.25 (17)	2.96 (14)	1.71 (19)	1.32 (22)	0.95 (22)	1.03 (16)	14.71 (19)	D E F G 119.3
UC-Hghline	9	1.01 (15)	1.45 (11)	2.12 (17)	2.29 (12)	2.83 (23)	1.64 (23)	1.32 (21)	0.87 (26)	0.97 (20)	14.50 (21)	E F G H 117.6
AFX 1060	10	0.85 (28)	1.19 (29)	2.03 (22)	2.22 (21)	2.94 (18)	1.80 (10)	1.40 (13)	0.97 (20)	0.83 (28)	14.24 (22)	F G H I 115.4
Fertillac 10	10	0.97 (19)	1.35 (22)	2.13 (16)	2.28 (13)	2.86 (22)	1.53 (24)	1.25 (25)	0.87 (25)	0.88 (25)	14.12 (24)	F G H I J 114.5
59N49	9	1.00 (16)	1.26 (26)	1.94 (27)	2.22 (23)	2.56 (28)	1.36 (28)	1.19 (27)	0.77 (30)	0.74 (30)	13.03 (28)	J K L 105.7
UC-Obola	9	0.79 (30)	1.13 (30)	1.88 (29)	2.16 (25)	2.67 (26)	1.43 (27)	1.18 (29)	0.82 (27)	0.83 (27)	12.89 (29)	K L 104.5
CUF101	9	0.81 (29)	1.26 (28)	1.84 (30)	2.00 (30)	2.40 (30)	1.35 (30)	1.11 (30)	0.80 (28)	0.77 (29)	12.33 (30)	L 100.0
<b>Experimental Varieties</b>												
118T816	11	1.11 (3)	1.55 (2)	2.24 (3)	2.37 (9)	3.18 (1)	2.01 (1)	1.59 (1)	1.17 (2)	1.17 (4)	16.37 (1)	A 132.7
1014T552	10	1.23 (1)	1.58 (1)	2.15 (11)	2.47 (1)	2.97 (12)	1.84 (7)	1.45 (9)	1.17 (3)	1.27 (2)	16.12 (2)	A B 130.7
1014T549	10	1.12 (2)	1.52 (4)	2.11 (18)	2.26 (15)	2.96 (15)	1.88 (5)	1.57 (2)	1.32 (1)	1.28 (1)	16.03 (3)	A B C 129.9
108T813	10	1.10 (6)	1.51 (5)	2.20 (5)	2.41 (3)	3.03 (8)	1.79 (12)	1.49 (4)	1.09 (6)	1.10 (8)	15.73 (5)	A B C D 127.5
1011T105	10	1.10 (5)	1.48 (8)	2.14 (13)	2.25 (16)	3.04 (7)	1.87 (6)	1.46 (7)	1.16 (4)	1.13 (7)	15.63 (6)	A B C D E 126.7
1012T408	10	1.01 (14)	1.53 (3)	2.25 (2)	2.42 (2)	3.05 (6)	1.74 (15)	1.44 (11)	1.07 (9)	1.03 (13)	15.54 (7)	A B C D E 126.0
105T286	10	1.11 (4)	1.47 (10)	2.21 (4)	2.39 (7)	2.97 (13)	1.78 (14)	1.48 (5)	1.03 (14)	1.08 (10)	15.51 (8)	A B C D E 125.8
1012T402	10	0.94 (23)	1.36 (20)	2.19 (7)	2.40 (5)	3.12 (3)	1.91 (3)	1.39 (14)	1.07 (10)	1.06 (12)	15.45 (9)	A B C D E 125.2
1014T013	10	0.96 (21)	1.44 (12)	2.29 (1)	2.41 (4)	3.06 (5)	1.82 (9)	1.44 (10)	0.97 (19)	1.03 (15)	15.42 (10)	A B C D E 125.0
1111T108	11	1.04 (9)	1.48 (9)	2.20 (6)	2.32 (10)	3.08 (4)	1.80 (11)	1.38 (17)	0.97 (20)	0.98 (19)	15.24 (11)	A B C D E F 123.5
1013M185	10	0.98 (17)	1.34 (23)	2.17 (8)	2.29 (11)	3.02 (9)	1.88 (4)	1.47 (6)	1.05 (12)	1.01 (18)	15.22 (12)	A B C D E F 123.4
UCExp-HD	9	1.02 (12)	1.43 (13)	2.14 (14)	2.24 (18)	2.88 (21)	1.83 (8)	1.40 (12)	1.14 (5)	1.10 (9)	15.17 (13)	B C D E F 123.0
109T901	10	1.07 (7)	1.50 (6)	2.00 (24)	2.12 (28)	2.91 (19)	1.72 (18)	1.45 (8)	1.09 (7)	1.20 (3)	15.06 (14)	B C D E F 122.1
UC-2705	9	1.02 (11)	1.39 (17)	2.06 (21)	2.23 (19)	2.94 (17)	1.78 (13)	1.35 (19)	1.08 (8)	1.13 (6)	14.97 (15)	B C D E F G 121.4
1013T184	10	1.03 (10)	1.39 (16)	2.07 (20)	2.22 (22)	3.02 (9)	1.73 (16)	1.39 (16)	1.02 (15)	1.02 (17)	14.90 (17)	C D E F G 120.8
1114T010	11	0.90 (27)	1.37 (19)	2.16 (10)	2.26 (14)	2.90 (20)	1.71 (20)	1.28 (23)	1.00 (18)	0.93 (23)	14.51 (20)	E F G H 117.7
1113T186	11	1.01 (13)	1.29 (24)	2.00 (23)	2.13 (27)	2.79 (24)	1.65 (22)	1.32 (20)	1.02 (16)	0.97 (21)	14.19 (23)	F G H I J 115.0
UC-2693	9	0.93 (24)	1.35 (21)	1.95 (26)	2.23 (19)	2.68 (25)	1.46 (26)	1.23 (26)	1.00 (17)	1.03 (14)	13.87 (25)	G H I J K 112.5
1114T012	11	0.92 (25)	1.26 (27)	1.94 (28)	2.10 (29)	2.56 (29)	1.49 (25)	1.27 (24)	0.93 (24)	0.90 (24)	13.37 (26)	H I J K L 108.4
UC-2671	9	0.91 (26)	1.27 (25)	1.99 (25)	2.17 (24)	2.65 (27)	1.35 (29)	1.18 (28)	0.78 (29)	0.85 (26)	13.14 (27)	I J K L 106.6
MEAN		1.00	1.39	2.10	2.27	2.90	1.71	1.37	1.01	1.02	14.76	
CV		14.33	9.12	10.68	9.71	10.36	13.77	12.91	11.67	9.36	8.02	
LSD (0.1)		0.14	0.12	0.22	0.22	0.30	0.23	0.17	0.12	0.09	1.16	

<https://alfalfa.ucdavis.edu/+producing/variety/apr/APR-2019.pdf>



Field  
Alfalfa\_Imperial

BMP  
Alfalfa\_Imperial

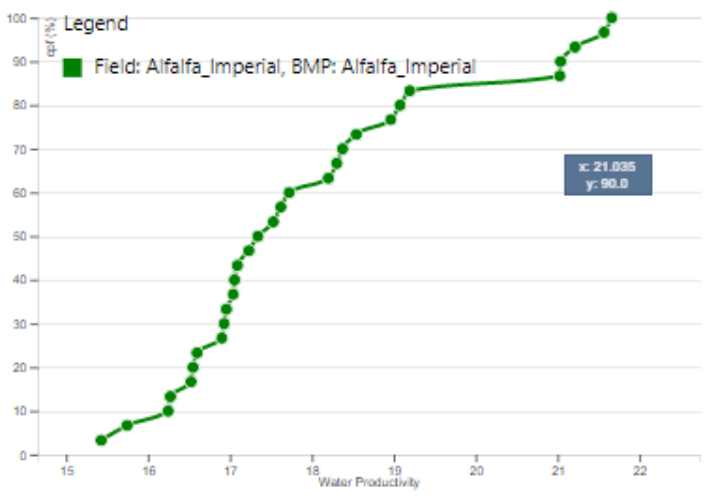
Run

Show 10 entries Search:

3. Select Output: Water Productivity

4. Select Unit: kg/m<sup>3</sup>

Showing 1 to 2 of 2 entries Previous 1 Next



Crop per drop: Water productivity of alfalfa under full irrigation

Field: Alfalfa\_Imperial

BMP: Alfalfa\_Imperial

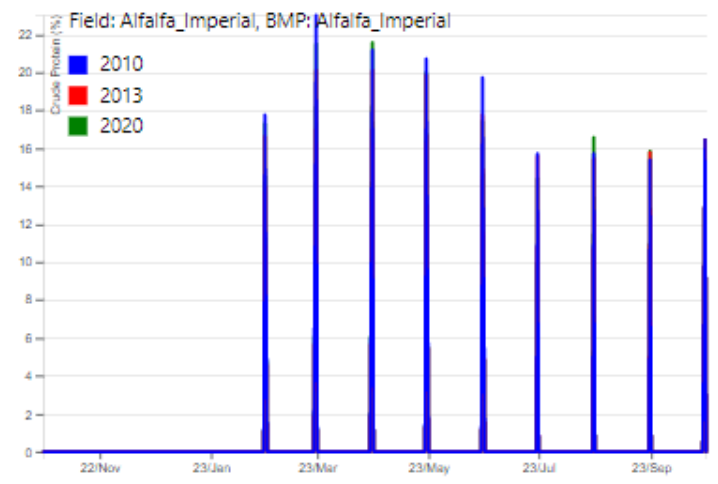
Run

Show 10 entries Search:

3. Select Output: Crude Protein

4. Select Unit: %

Showing 1 to 2 of 2 entries Previous 1 Next



Alfalfa quality expressed as crude protein.

BMP

Alfalfa\_Imperial

Run

Show 10 entries

Search:

3. Select Output: Cumulative Irrigation

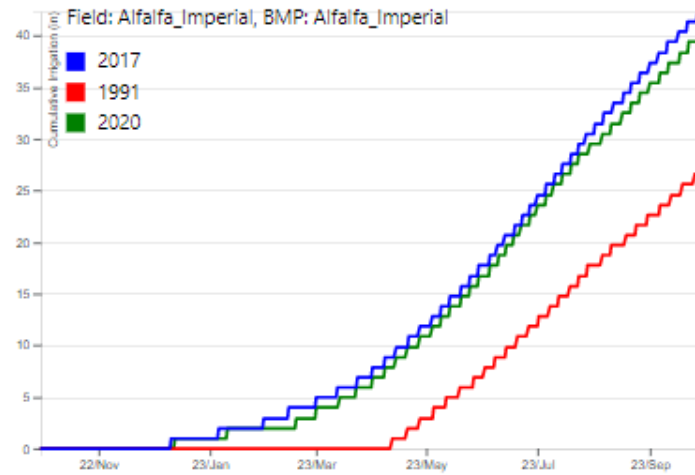
4. Select Unit: in

Showing 1 to 2 of 2 entries

Previous

1

Next



Predicted alfalfa net irrigation requirement

# Predicting the impact of water allocation limits on alfalfa yield

Field

Alfalfa\_Imperial

BMP

Alfalfa\_Imperial\_Allocation\_Limit

Run

Show 10 entries

Search:

3. Select Output: Forage Yield

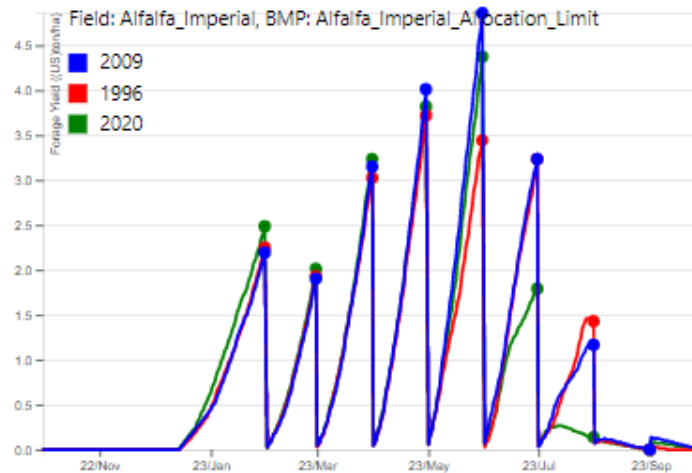
4. Select Unit: (US)ton/ha

Showing 1 to 2 of 2 entries

Previous

1

Next



Reducing irrigation by 50% significantly reduces yield of later cuttings ~0 tons/ac of the last two cuts

Field

Alfalfa\_Imperial

BMP

Alfalfa\_Imperial\_Allocation\_Limit

Run

Show 10 entries

Search:

3. Select Output: Crude Protein

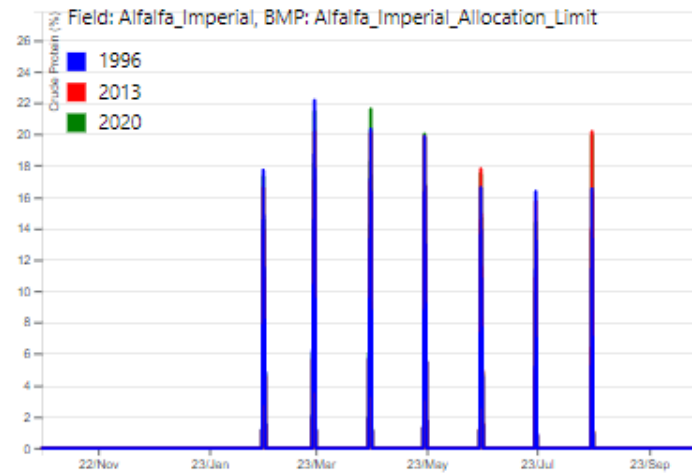
4. Select Unit: %

Showing 1 to 2 of 2 entries

Previous

1

Next



Notice increase in crude protein as yield decrease for the later cuttings.

Field

Alfalfa\_Imperial

BMP

Alfalfa\_Imperial\_Allocation\_Limit

Run

Show 10 entries

Search:

3. Select Output: Cumulative Irrigation

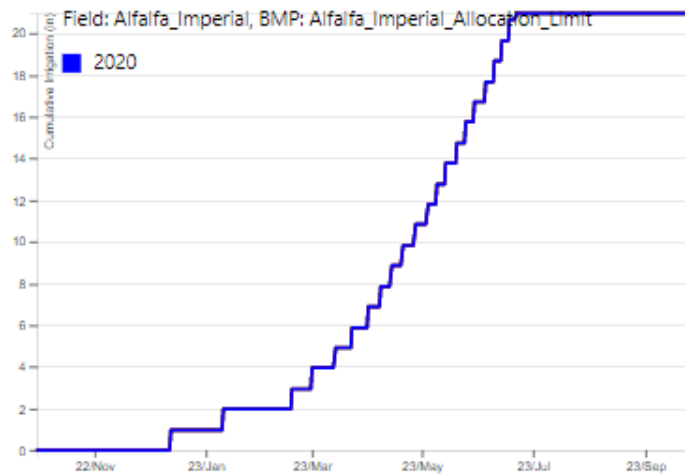
4. Select Unit: in

Showing 1 to 2 of 2 entries

Previous

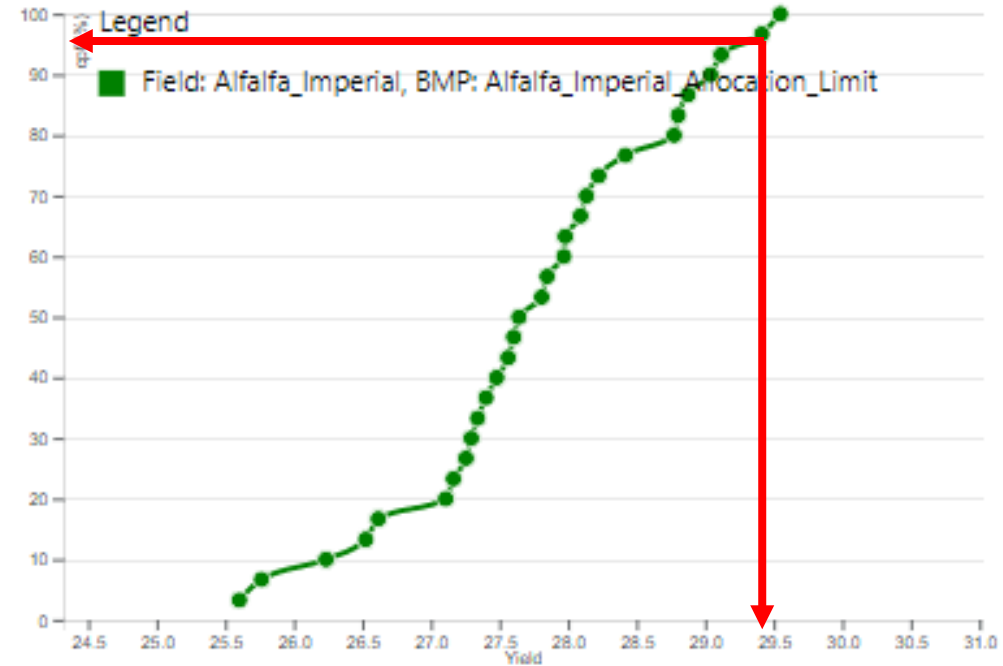
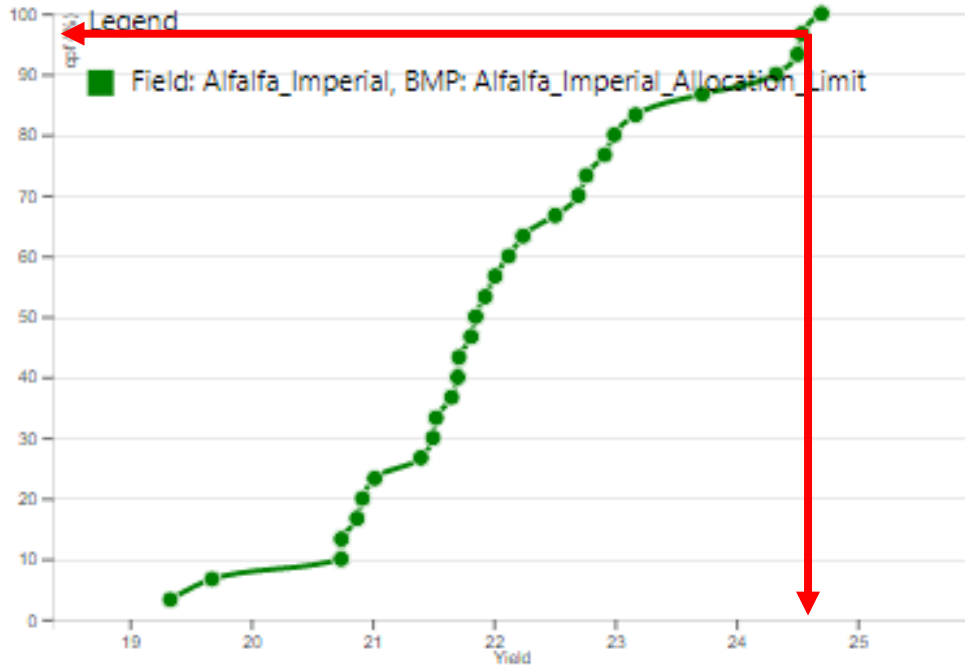
1

Next



FARMS cuts off irrigation when total cumulative irrigation reaches water allocation some time in July in 2020.

# Effect of deficit irrigation on yield



Deficit irrigation: Irrigation frequency limited to 7 days

Full irrigation



# Other resources

- Weather and Climate Data: NASA Power: <https://power.larc.nasa.gov/>
- Soil data: Gridded Global Soil Info:  
<https://www.isric.org/explore/soilgrids>
- A video tutorial on how to use the FARMs web app is available at the following url: <http://kisekka.ucdavis.edu/software/farms/>.
-

# Thank you!

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