Irrigation Scheduling: Sensors, Technical Tools, and Apps

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All About Irrigation Workshop
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Irrigation Scheduling

- **A technique that involves:**
  - Determining how much water is needed
  - When to apply it to the field to meet crop demands.
- **The main purpose to schedul irrigation is:**
  - To increase the profitability and/or quality of the crop
  - By increasing the efficiency of using water and energy or
  - By increasing crop productivity.

Irrigation Scheduling

- According to the USDA NASS Irrigation is scheduled based on:

Irrigation Scheduling Method	Entire US (%)	AL (%)	FL (%)	GA (%)	SC (%)	MS (%)	VA (%)	NC (%)
Visible Stress	78	90	85	88	90	91	91	89
Feel of Soil	40	42	37	40	40	46	46	48
Soil Moisture Sensor	10	7	10	9	6	11	9	4
Scheduling Service	8	3	6	7	4	5	1	0.2
Weather Report	8	4	4	7	3	5	2	6
Calendar Schedule	21	16	14	12	17	15	22	15
When Neighbor Irrigates	6	0.6	2	2	2	6	1	1

Soil Water Holding Capacity Example

- **We have a soil with the infiltration rate and soil water holding capacity (SWHC) below, and a rooting depth of 12 inches, how much moisture will we store from a rain event that had a 1.5 in/hr intensity and a two hours duration, i.e. we caught 3 inches of rainfall in our rain gage?**
  - Infiltration rate is 1.0 in/hr
  - SWHC is 0.8-1.0 in/ft

Soil Water Holding Capacity Example

- **We have a soil with the infiltration rate and soil water holding capacity (SWHC) below, and a rooting depth of 12 inches, how much moisture will we store from a rain event that had a 1.5 in/hr intensity and a two hours duration, i.e. we caught 3 inches of rainfall in our rain gage?**
  - Infiltration rate is 1.0 in/hr
  - SWHC is 0.8-1.0 in/ft
  - We had the ability to infiltrate or "catch" approximately 2.0 inches of the event.
  - With a 12 inch or 1 foot rooting depth, only 1 inch of that was available to our crop.
  - This is the problem with blindly using the checkbook method and models that do not account for soil information!

Irrigation Cost (GA)

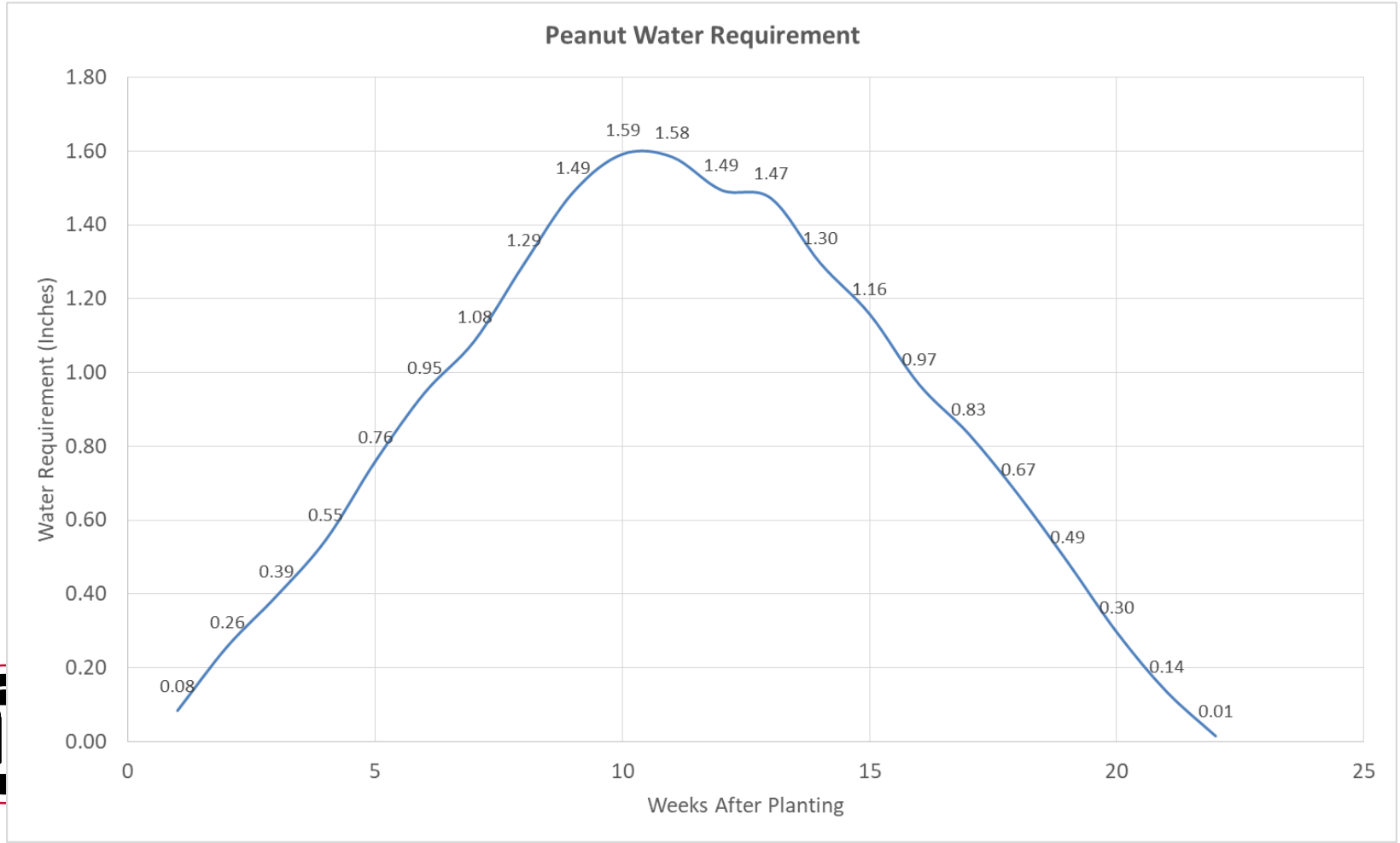
- Average Irrigation cost ~ $9.00/ac-in applied:
  - ~$7/ac-in for electric
  - ~$11/ac-in for diesel (2014 around $18/ac-in)
- So for 500 acres of irrigated land @ 10 inches of irrigation:
  - $45,000

Irrigation Design Considerations

- To meet peak crop demand (~2.0 inches per week) an irrigation system should be designed with a pumping capacity of approximately 6-7 gpm/acre.
- Don’t over demand a well with additional acreages or systems.

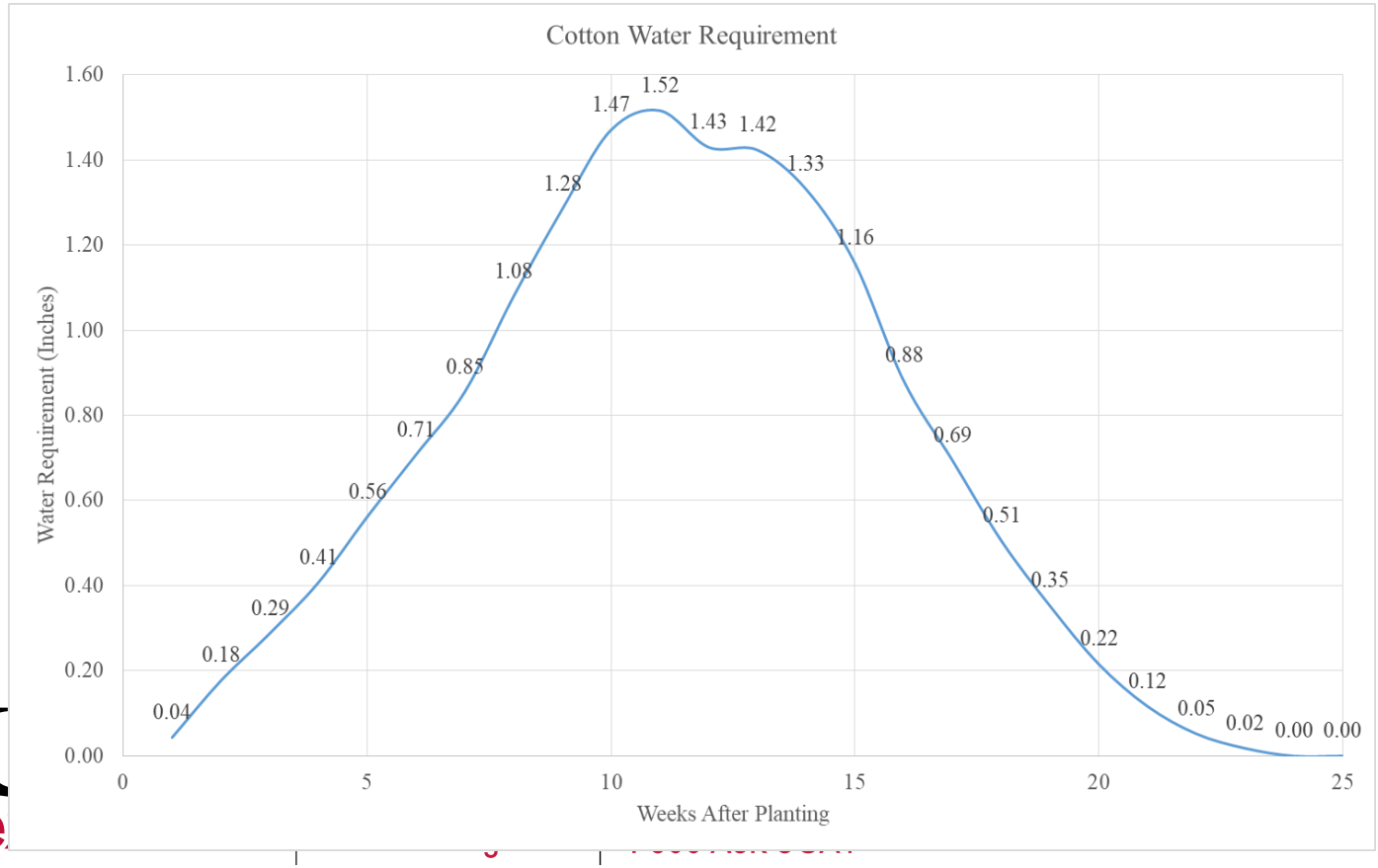
Water Requirements: Peanuts

- Peanut requires approximately 23” of water from planting until harvest (the curve below is @18”).



Water Requirements: Cotton

- Cotton's peak water demand begins once it begins to flower, it is critical that cotton be fully irrigated during bloom.

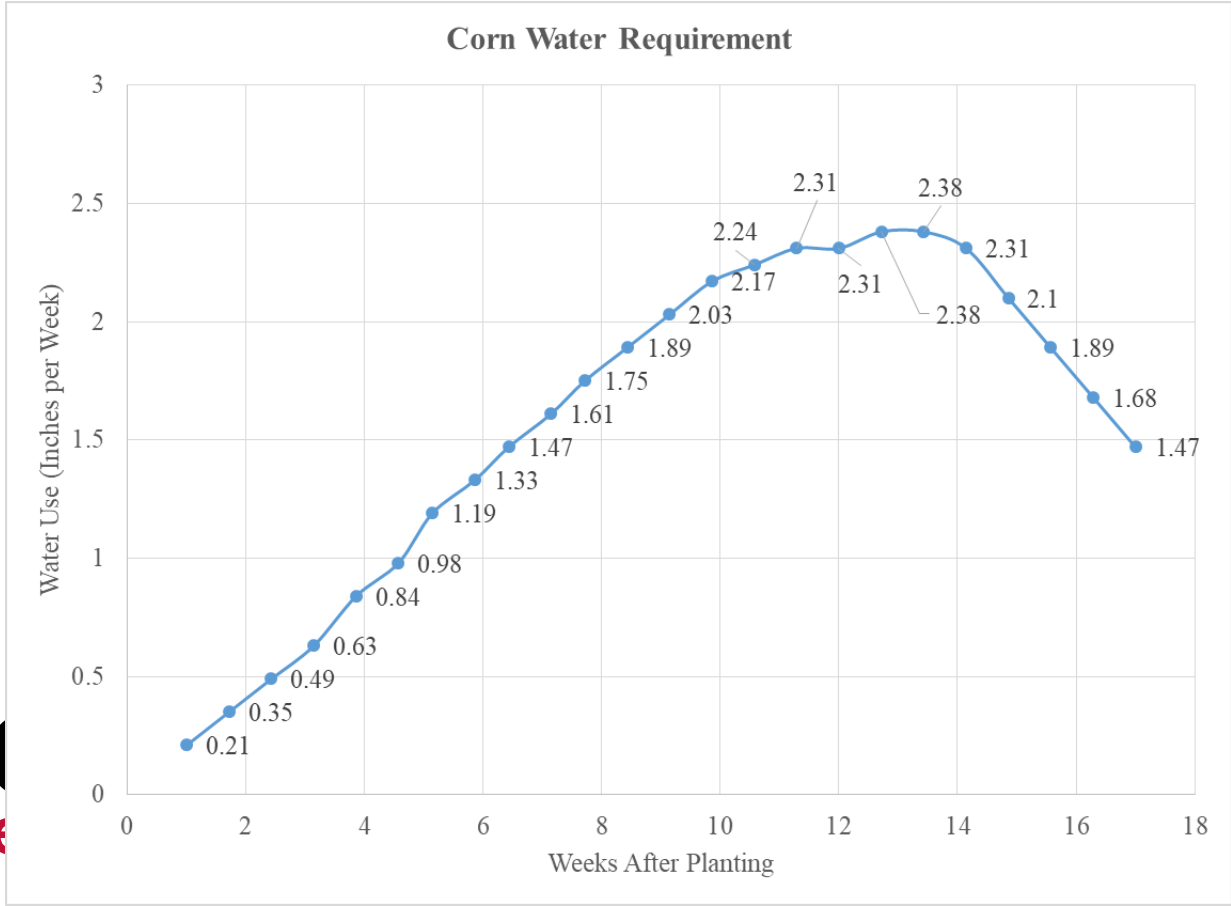


Water Requirements: Cotton

Cotton Irrigation Schedule				
Growth Stage	**DAP**	**Weeks after Planting**	**Inches/Week**	**Inches/Day**
Emergence	1 - 7	1	0.04	0.01
Emergence to First Square	8 - 14	2	0.18	0.03
	15 - 21	3	0.29	0.04
	22 - 28	4	0.41	0.06
	29 - 35	5	0.56	0.08
First Square to First Flower	36 - 42	6	0.71	0.10
	43 - 49	7	0.85	0.12
	50 - 56	8	1.08	0.15
First Flower to First Open Boll	57 - 63	9	1.28	0.18
	64 - 70	10	1.47	0.21
	71 - 77	11	1.52	0.22
	78 - 84	12	1.43	0.20
	85 - 91	13	1.42	0.20
	92 - 98	14	1.33	0.19
	99 - 105	15	1.16	0.17
	106 - 112	16	0.88	0.13
	113 - 119	17	0.69	0.10
First open boll to >60% Open Bolls	120 - 126	18	0.51	0.07
	127 - 133	19	0.35	0.05
	134 - 140	20	0.22	0.03
	141 - 147	21	0.12	0.02
	148 - 154	22	0.05	0.01
	155 - 161	23	0.02	0.00
Harvest	162 - 168	24	0.00	0.00
	169 - 175	25	0.00	0.00

Water Requirements: Corn

- Corn is known as a higher water using crop.
- Unlike cotton and peanuts typically on corn more water means higher yields.



Crop Growth Stage

Growth Stage	Days After Planting	Inches Per Day
Emergence and primary root developing.	0-7 8-12	.03 .05
Two leaves expanded and nodal roots forming.	13-17 18-22	.07 .09
Four to six leaves expanding. Growing point near surface. Other leaves and roots developing.	23-27 28-32 33-36	.12 .14 .17
Six to eight leaves. Tassel developing. Growing point above ground.	37-41 42-45	.19 .21
Ten to twelve leaves expanded. Bottom 2-3 leaves lost. Stalks growing rapidly. Ear shoots developing. Potential kernel row number determined.	46-50 51-54	.23 .25
Twelve to sixteen leaves. Kernels per row and size of ear determined. Tassel not visible but about full size. Top two ear shoots developing rapidly.	55-59 60-64	.27 .29
Tassel emerging, ear shoots elongating.	65-69	.31
Pollination and silks emerging.	70-74 75-79	.32 .33
Blister stage.	80-84	.33
Milk stage, rapid starch accumulation.	85-89	.34
Early dough stage, kernels rapidly increasing in weight.	90-94	.34
Dough stage.	95-99	.33
Early dent.	100-104	.30
Dent.	105-109	.27
Beginning black layer.	110-114	.24
Black layer (physiological maturity).	115-119	.21

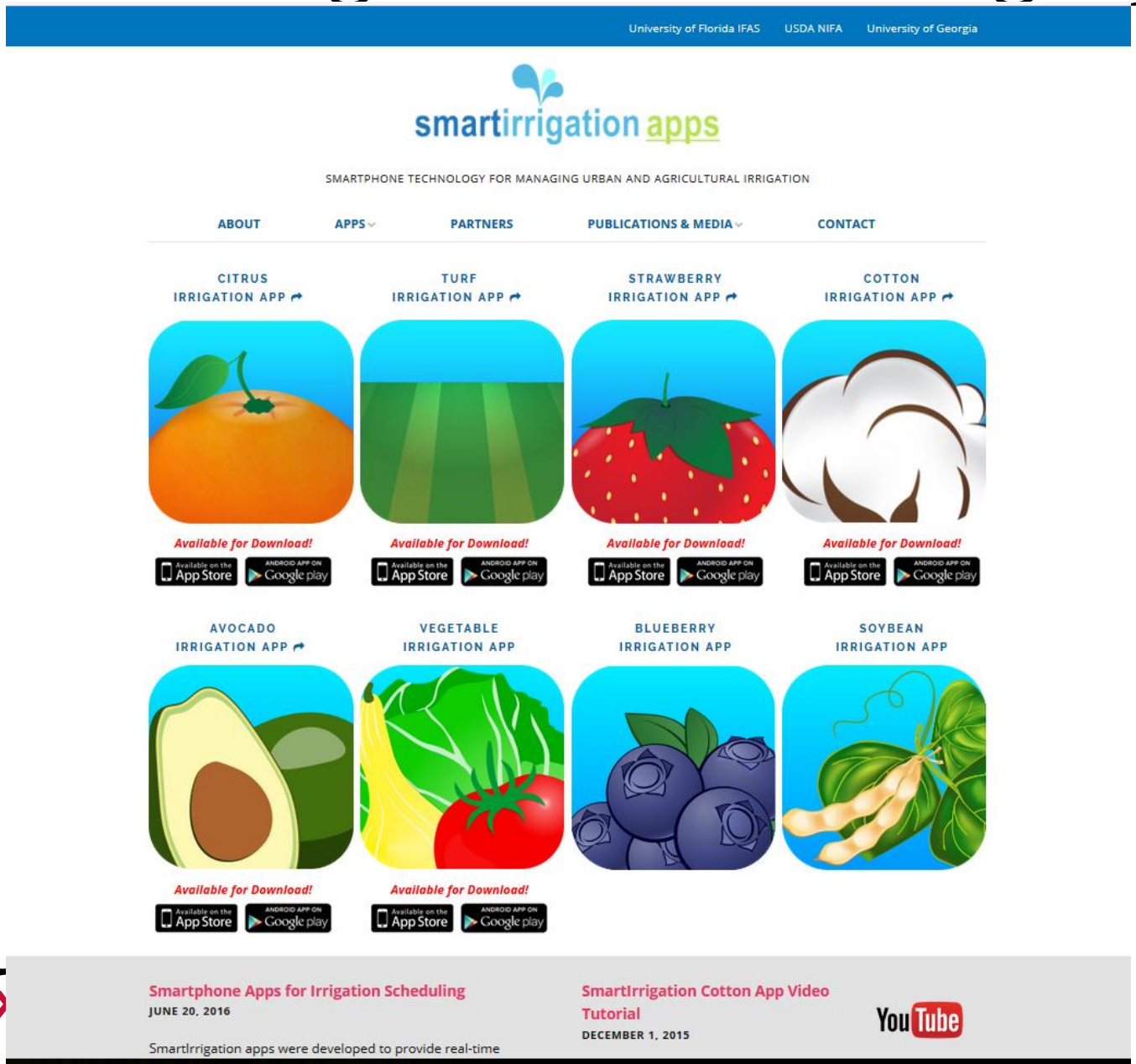
Water Requirements: Soybeans

- Soybeans peak water demand begins once it begins to flower up to full seed.

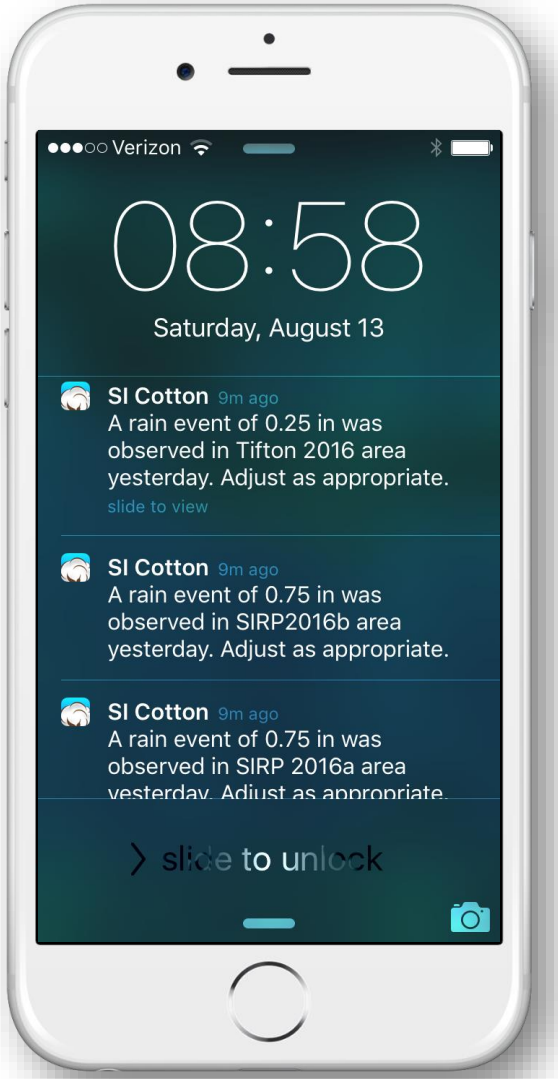
Growth Stage	Water Requirement	
	Per day	Per week
	---------- inches ----------	
Germination/Seedling	0.05 to 0.10	0.35 to 0.70
Vegetative Growth	0.10 to 0.20	0.70 to 1.40
Flower to Full Seed	0.25 to 0.35	1.75 to 2.45
Maturity to Harvest	0.05 to 0.20	0.30 to 1.40

Growth Stage	Trigger	Amount
Stand Establishment	Irrigate prior to planting	1 - 1.5"
Prior to 1st Bloom (VE – R1)	Wilting by late afternoon	1 – 1.5"
1st Bloom – Beginning Pod Elongation (R1 – R4)	Wilting by mid-day	1.0 – 1.5"
Beginning Seed – Full Seed (R5 – R6)	Keep from wilting	1.0 – 1.5"
Full Seed – Maturity (R6 – R7)	Wilting by late afternoon	1.0"

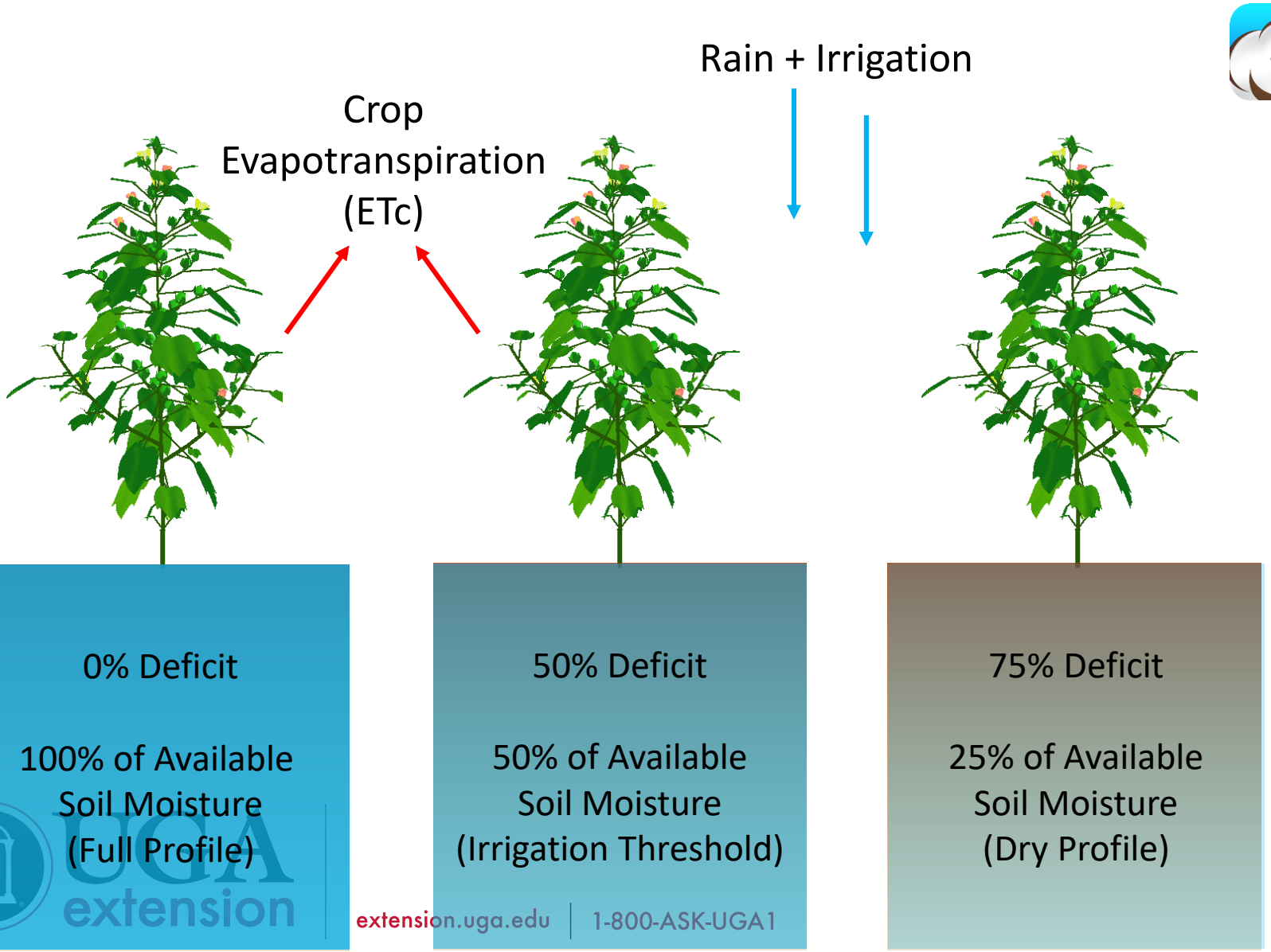
Cotton Irrigation Scheduling App



Cotton Irrigation Scheduling App



Cotton Irrigation Scheduling App

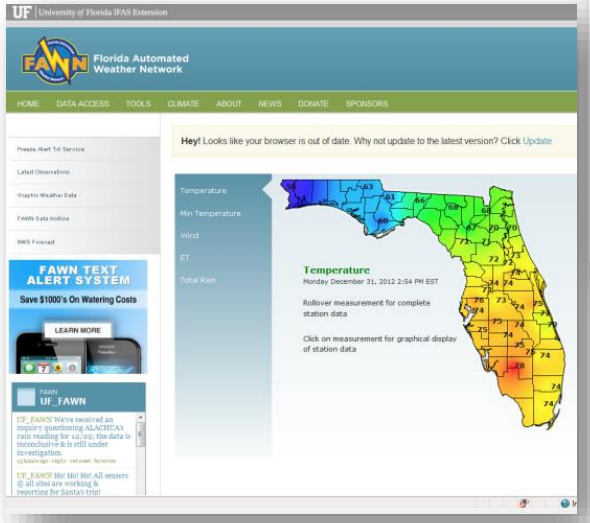


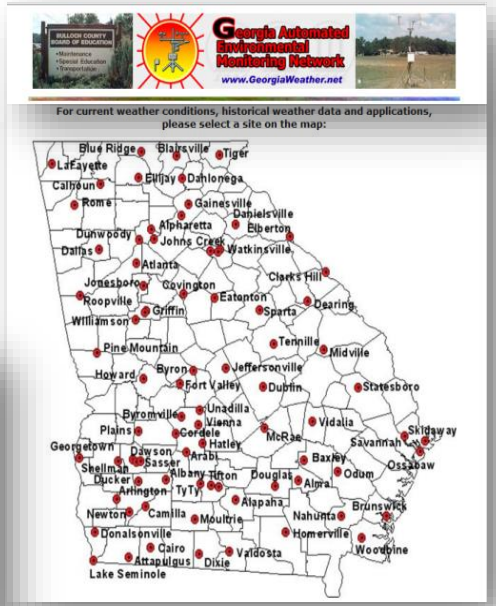
Cotton Irrigation Scheduling App

Meteorological Data

Crop coefficient approach for estimated ET

$$ETc = ETo \times Kc$$





where

ETc = estimated crop ET

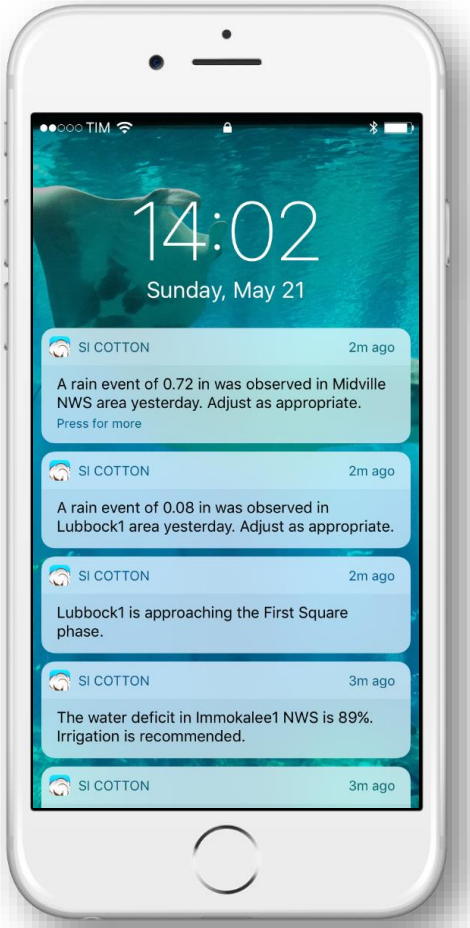
Kc = crop coefficient

ETo = Penman-Monteith reference ET (FAO-56)

Cotton Irrigation Scheduling App

For 2018:

- Release new version of the Cotton App that will use national gridded data sets for meteorological data
  - NOAA NWS RTMA for precipitation and temperature (2.5 km grid)
  - NOAA NWS FRET for ET (4 km grid)
- Regional crop coefficient curves
  - A curve will be assigned based on the region in which the user is located
  - Region based on geographic coordinates of the field



Cotton Irrigation 2013-2014

Method	Conservation Tillage		Conventional Tillage	
	Lint Yield (lb/ac)	Water Use (in)	Lint Yield (lb/ac)	Water Use (in)
Checkbook	1350	12.7	1150	12.2
Cotton App	1485	3.0	1259	3.0
CWSI	1430	5.0	1305	2.3
Irrigator Pro	1455	2.8	1200	4.3
Rainfed	1450	1.5	-	-
		2014		
Checkbook			1596	16.8
Cotton App			1573	10.1
Limited Water	1050	3.81		
Dryland	490	0.0		

2013 Rainfall = 27.4 in

2014 Rainfall = 11.1 in

Cotton Irrigation 2015-2016

Method	Conservation Tillage		Conventional Tillage	
	Lint Yield (lb/ac)	Water Use (in)	Lint Yield (lb/ac)	Water Use (in)
Checkbook	1560	6.5	1621	6.5
Cotton App	1643	5.0	1710	5.8
WaterMark (45 kPa)	1749	3.0	1661	7.8
Rainfed	1760	0.5	-	-
		2016		
Checkbook	909	8	724	8
Cotton App	1066	5.25	980	5.25
WaterMark (45 kPa)	1103	3.25	1233	2.25
Rainfed	1224	0.75	-	-

2015 Rainfall = 22.6 inches

2016 Rainfall = 25.8 inches

Cotton Irrigation 2017

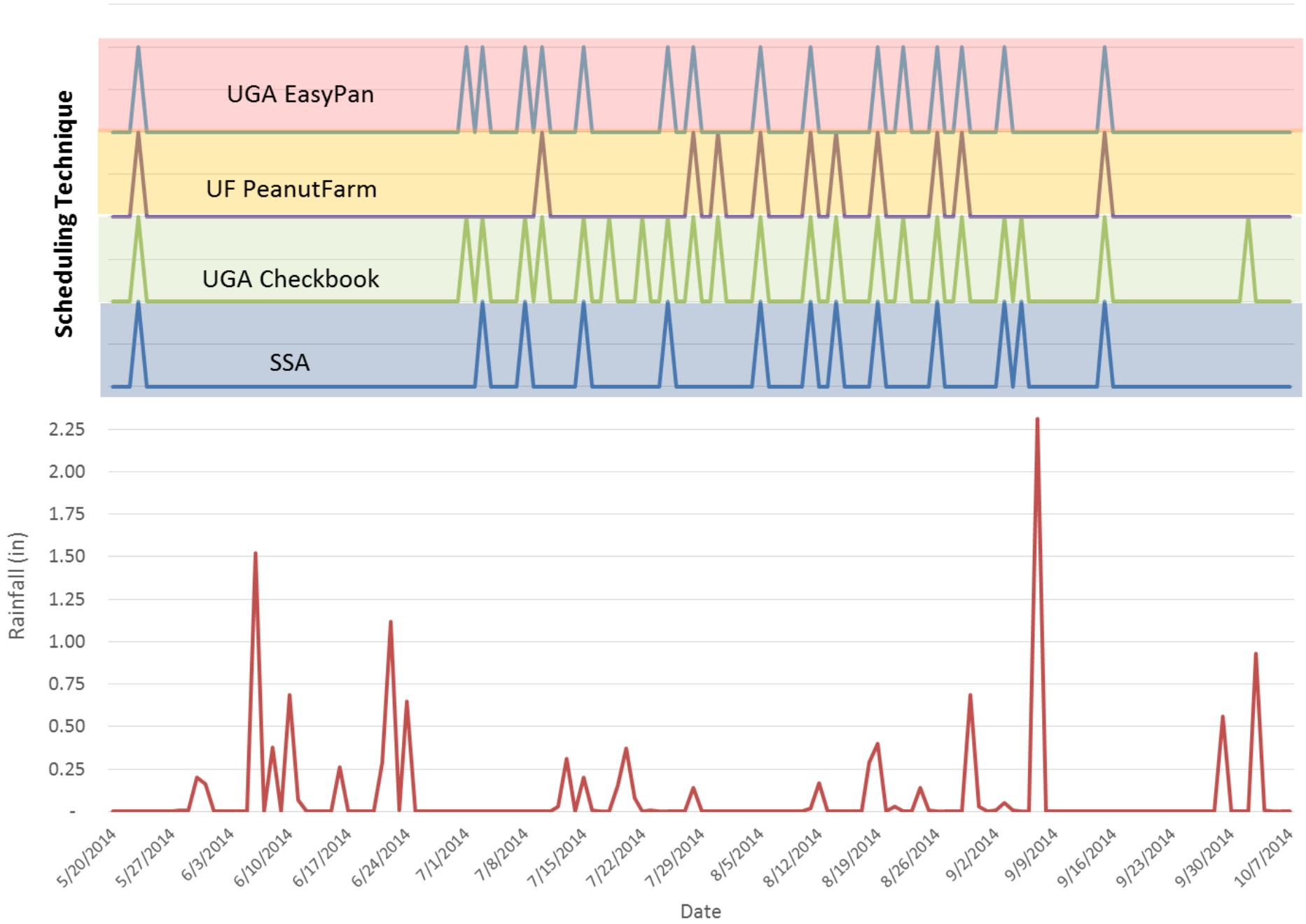
Method	Conservation Tillage		Conventional Tillage	
	Lint Yield (lb/ac)	Water Use (in)	Lint Yield (lb/ac)	Water Use (in)
Checkbook	1219	9.5	1162	9.5
Cotton App	1363	4.5	1387	4.5
WaterMark (45 kPa)	1334	1.75	1277	4.0
Rainfed	1300	0.5	-	-

Rainfall = 24.3 inches

Peanut Irrigation Scheduling 2014

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Yield (lb/ac)
Dryland	0.40	12.73	465.2
WaterMark (45 kPa)	9.40	21.73	6052.3
SmartCrop	6.40	18.73	5642.0
EasyPan	11.65	23.98	5725.0
UGA ET Checkbook	15.02	27.35	5025.5
UF Peanut Farm	7.90	20.23	4802.5

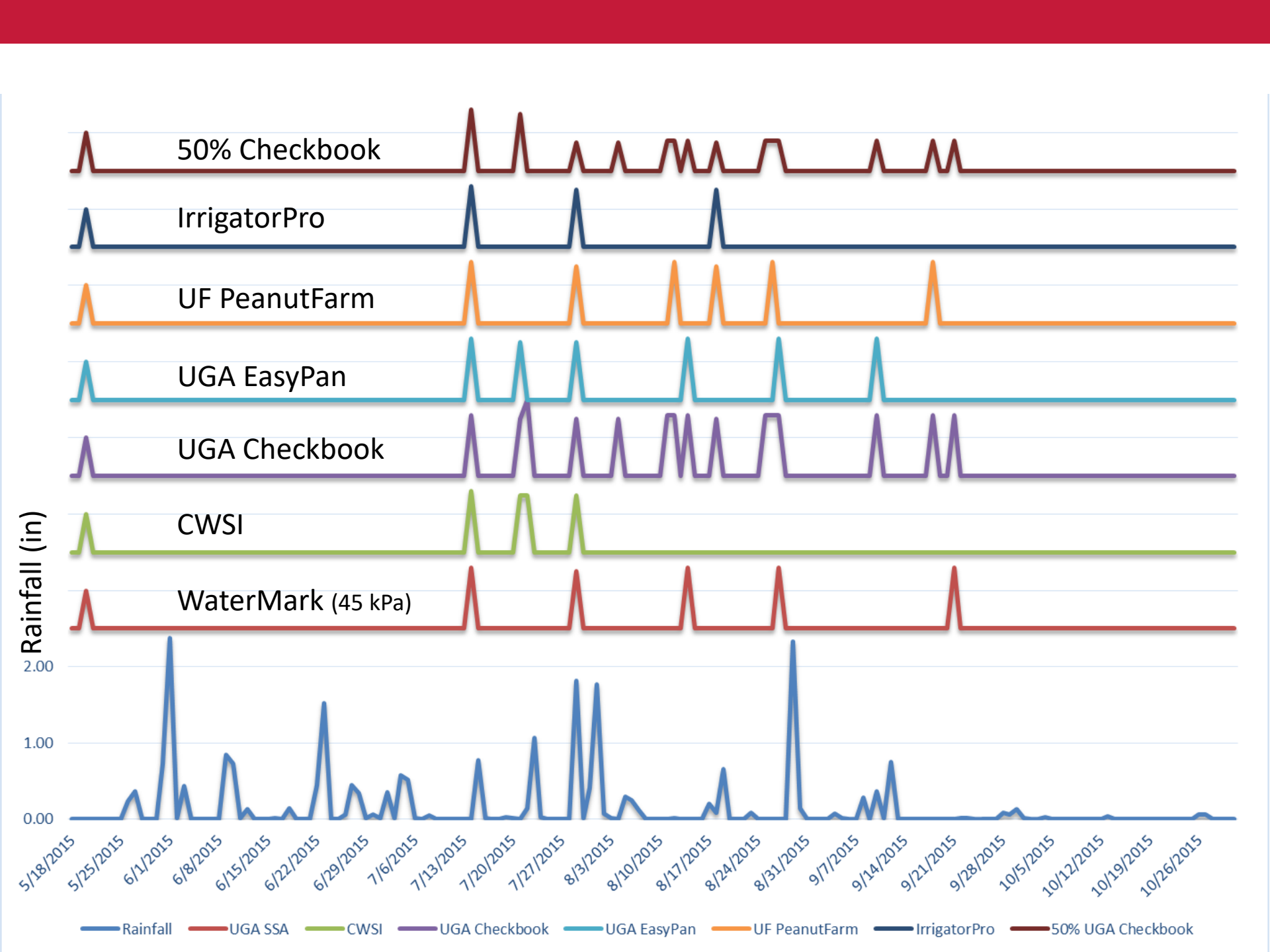
Planted: May 20, 2014
Dug: October 10, 2014
Harvested: October 17, 2014
Rainfall: 12.33 inches


Scheduling Technique
UGA EasyPan
UF PeanutFarm
UGA Checkbook
SSA
Rainfall (in)
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
-
5/20/2014
5/27/2014
6/3/2014
6/10/2014
6/17/2014
6/24/2014
7/1/2014
7/8/2014
7/15/2014
7/22/2014
7/29/2014
8/5/2014
8/12/2014
8/19/2014
8/26/2014
9/2/2014
9/9/2014
9/16/2014
9/23/2014
9/30/2014
10/7/2014
Date

Peanut Irrigation Scheduling 2015

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Yield (lb/ac)
Dryland	0.50	23.30	5193.6
WaterMark (45 kPa)	4.45	27.25	5478.6
CWSI	3.55	26.35	5172.8
UGA ET Checkbook	12.50	35.30	5313.4
UGA EasyPan	5.20	28.00	5404.9
UF PeanutFarm	5.20	28.00	5327.3
IrrigatorPro	2.80	25.60	5542.6
50% Checkbook	6.76	29.56	5176.1

Planted: May 18, 2015
Dug: October 5, 2015
Harvested: October 12, 2015
Rainfall: 22.65 inches

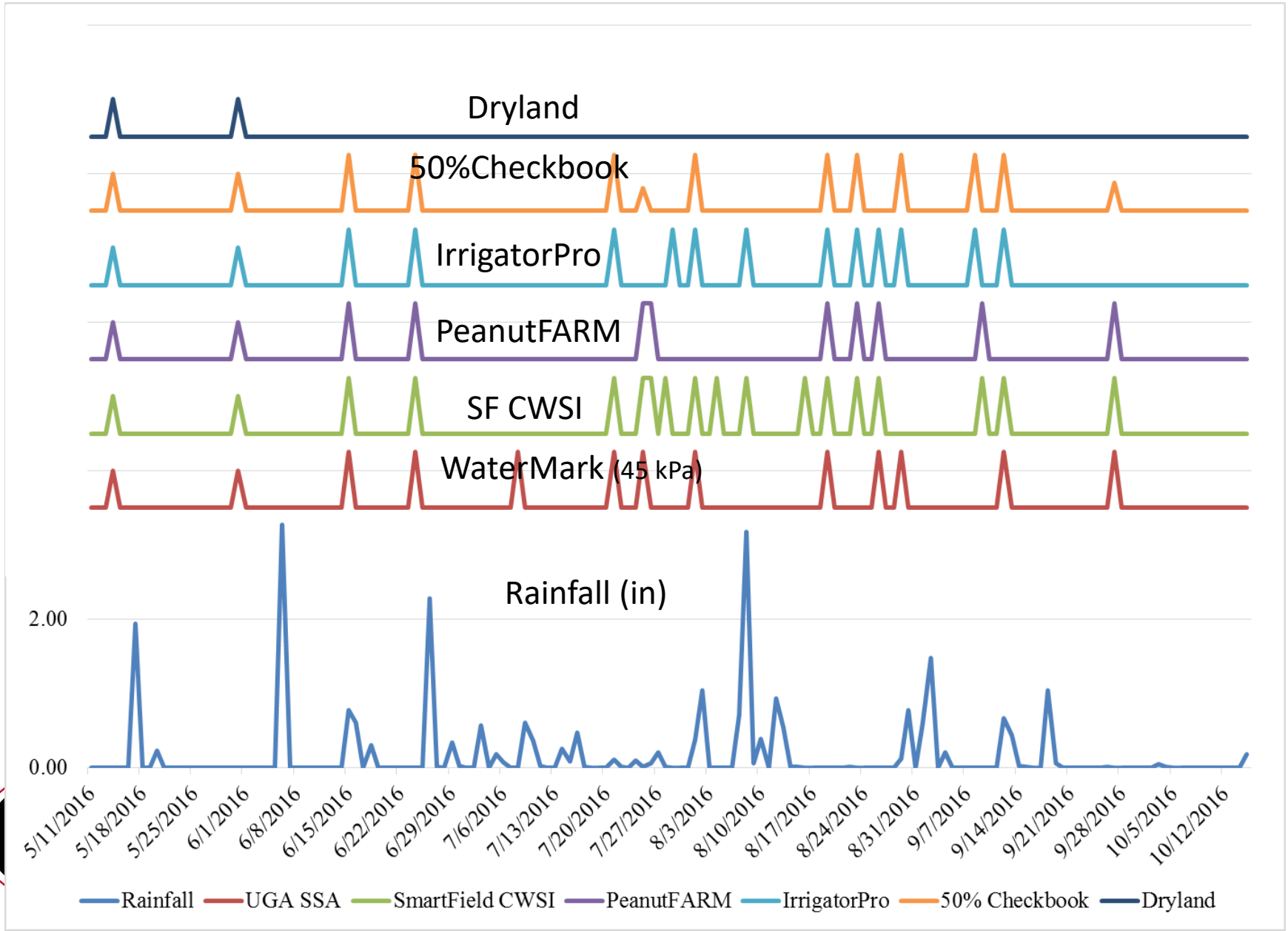

50% Checkbook
IrrigatorPro
UF PeanutFarm
UGA EasyPan
UGA Checkbook
CWSI
WaterMark (45 kPa)
Rainfall (in)
2.00
1.00
0.00
5/18/2015
5/25/2015
6/1/2015
6/8/2015
6/15/2015
6/22/2015
6/29/2015
7/6/2015
7/13/2015
7/20/2015
7/27/2015
8/3/2015
8/10/2015
8/17/2015
8/24/2015
8/31/2015
9/7/2015
9/14/2015
9/21/2015
9/28/2015
10/5/2015
10/12/2015
10/19/2015
10/26/2015
Rainfall
UGA SSA
CWSI
UGA Checkbook
UGA EasyPan
UF PeanutFarm
IrrigatorPro
50% UGA Checkbook

Peanut Irrigation Scheduling 2016

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Yield (lb/ac)
Dryland	1.00	26.80	**5249.0**
WaterMark (45 kPa)	9.25	35.05	**6292.0**
SmartField CWSI	13.00	38.80	**6019.0**
PeanutFARM	7.75	33.55	**6371.0**
IrrigatorPro	10.00	35.80	**6540.0**
50% Checkbook	8.43	34.23	**6367.0**

Planted: May 13, 2016
Dug: October 8, 2016
Harvested: October 15, 2016
Rainfall: 25.80 inches

Irrigation Timing and Frequency



Peanut Irrigation Scheduling 2017

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Yield (lb/ac)
Dryland	1.00	25.30	**5875**
WaterMark (45 kPa)	2.85	27.15	**6396**
Canopy Temp.	3.85	28.55	**6229**
PeanutFARM	5.50	29.80	**5936**
IrrigatorPro	4.00	28.30	**6260**
50% Checkbook	6.75	31.05	**6262**
Checkbook	10.50	34.80	**5749**
EasyPan	4.75	29.05	**5979**

Planted: May 16, 2017
Dug: September 28, 2017
Harvested: October 5, 2017
Rainfall: 24.3 inches

Economic Analysis

- Net dollar benefits of scheduling methods
- 2017 Estimated Costs from UGA Agricultural and Applied Economics Peanut Enterprise Budgets
  - Irrigation: $8.25/ac-in
  - Weed control: $44.35 dryland/$39.48 irrigated
  - Disease control: $46.92 dryland/$87.63 irrigated
  - Assume all other input costs are constant
  - Does not include opportunity cost of management
  - Current marketing price: $0.19/lb or $380/ton

Completed by: A. Rabinowitz

Net Benefit on 2014 Trial

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Georgia-06G	Georgia-12Y	TufRunner 511	TufRunner 727
Dryland	0.40	12.73	Base	Base	Base	Base
UGA SSA	9.40	21.73	$1,064.34	$903.50	$1,001.07	$836.93
SmartCrop	6.40	18.73	$949.31	$835.44	$1,028.67	$779.60
UGA EasyPan	11.65	23.98	$968.45	$859.39	$902.90	$752.09
UGA Checkbook	15.02	27.35	$798.96	$764.48	$689.84	$586.73
UF PeanutFarm	7.90	20.23	$758.71	$647.12	$808.87	$690.79

Rainfall = 12.33 in

Completed by: A. Rabinowitz

Net Benefit on 2015 Trial

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Georgia-06G	Georgia -12Y	TufRunner 511	TufRunner 727
Dryland	0.50	23.15	Base	Base	Base	Base
UGA SSA	4.45	27.10	-$48.15	$83.42	$76.76	-$166.49
UGA EasyPan	5.20	27.85	-$41.12	$6.33	$35.77	-$119.40
UGA Checkbook	12.50	35.15	-$90.06	-$163.46	-$52.67	-$66.87
PeanutFARM	5.20	27.85	-$86.09	$6.33	-$13.59	-$36.93
CWSI	3.55	26.20	-$35.12	-$52.11	$8.92	-$83.88
IrrigatorPro	2.80	25.45	-$83.99	$57.44	$200.74	-$76.12
50% UGA Checkbook	6.76	29.41	-$22.22	-$192.18	-$15.76	-$54.50

Rainfall = 22.65 in

Completed by: A. Rabinowitz

Net Benefit on 2016 Trial

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Georgia-06G	Georgia-12Y	TufRunner 511	TufRunner 727
Dryland	1.00	26.80	Base	Base	Base	Base
UGA SSA	9.25	35.05	$77.62	$61.16	$150.33	$87.68
PeanutFARM	7.75	33.55	$77.65	$128.86	$241.35	$38.33
CWSI	13.00	38.80	-$11.84	-$55.74	$123.50	-$10.47
IrrigatorPro	10.00	35.80	$213.64	$121.73	$164.26	$41.26
50% UGA Checkbook	8.43	34.23	$156.68	$5.78	$204.23	$94.49

Rainfall = 25.8 in

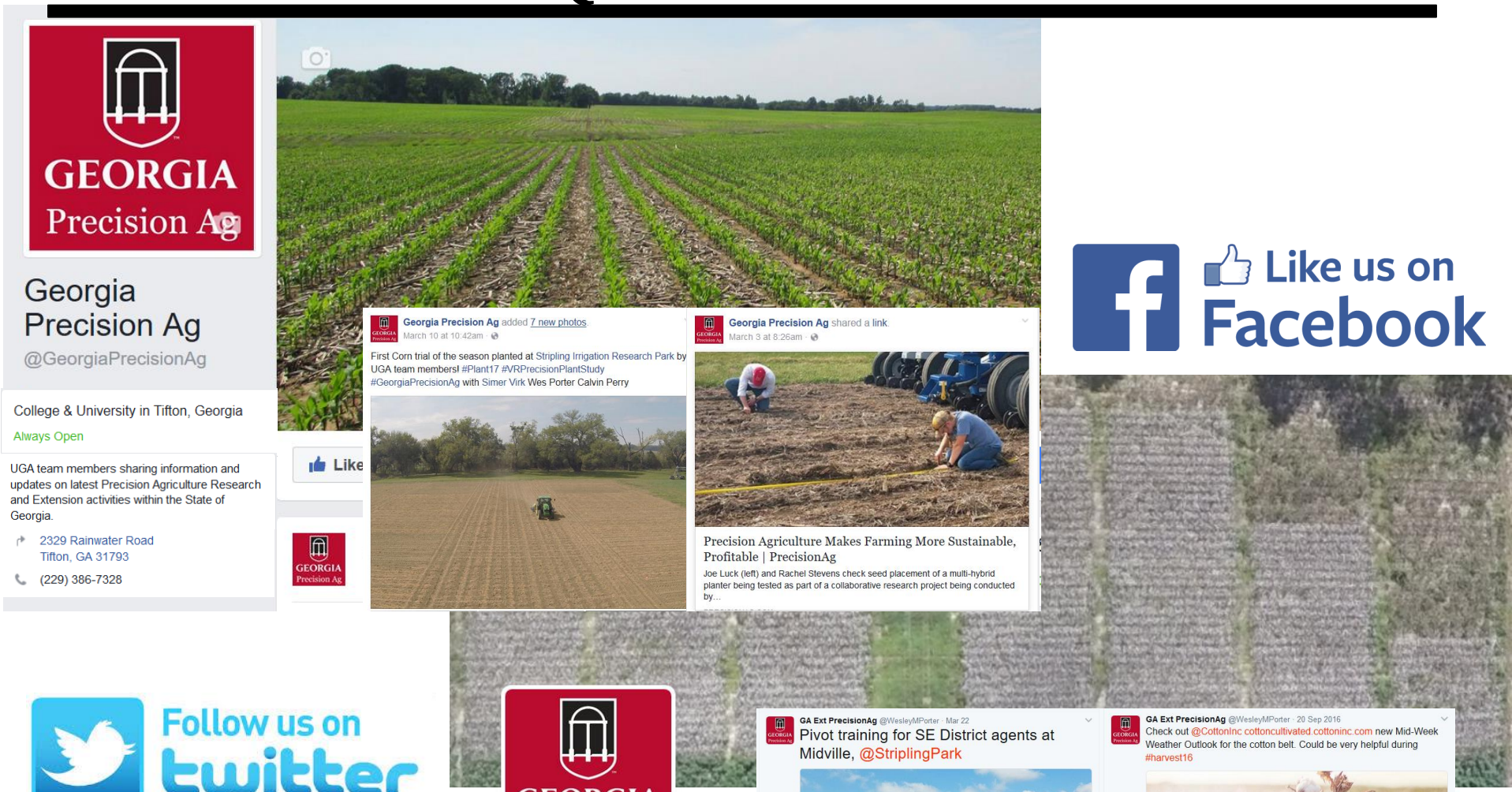
Completed by: A. Rabinowitz

Net Benefit on Average 2015-16 Trials

Irrigation Scheduling Method	Irrigation Amount (in)	Total Water (in)	Georgia-06G	Georgia-12Y	TufRunner 511	TufRunner 727
Dryland	0.75	24.98	Base	Base	Base	Base
UGA SSA	6.85	31.08	50.58	108.13	149.38	-3.56
UF PeanutFarm	6.48	30.70	31.62	103.44	149.72	36.54
CWSI	8.28	32.50	12.36	-18.08	102.05	-11.33
IrrigatorPro	6.40	30.63	100.67	125.43	218.34	18.41
50% UGA Checkbook	7.59	31.82	103.07	-57.36	130.08	55.84

Completed by: A. Rabinowitz

Questions??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March 10 at 10:42am
First Corn trial of the season planted at Stripling Irrigation Research Park by UGA team members! #Plant17 #VRPrecisionPlantStudy #GeorgiaPrecisionAg with Simer Virk Wes Porter Calvin Perry
Georgia Precision Ag shared a link
March 3 at 8:26am
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Joe Luck (left) and Rachel Stevens check seed placement of a multi-hybrid planter being tested as part of a collaborative research project being conducted by...
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Pivot training for SE District agents at Midville, @StriplingPark
GA Ext PrecisionAg @WesleyMPorter · 20 Sep 2016
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