EM 100

DECISION SUPPORT SYSTEMS:

Tools for Implementing Water Conservation Best Management Practices in Texas

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Precision Irrigators Network

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Authors:

Josh Bynum, *Graduate Student, Department of Soil and Crop Sciences*

Tom Cothren, *Professor, Department of Soil and Crop Sciences*

Tom Marek, *Amarillo Research and Extension Center*

Giovanni Piccinni, *Crop Physiologist, Uvalde Agricultural Research and Extension Center*

Editing and Formatting:
Danielle Supercinski*Project Manager, Texas Water Resources Institute*

Cecilia Wagner, *Project Manager, Texas Water Resources Institute*

Edited and published
by the
Texas Water Resources Institute, part of Texas A&M AgriLife
1500 Research Parkway, Suite A240
2118 TAMU
College Station, TX 77843-2118

Texas Agricultural Experiment Station, Texas A&M University

Texas AgriLife Research and Extension Center, Uvalde, TX 78801
http://uvalde.tamu.edu/
Ph: 830.278.9151 Fax: 830.278.1570

Texas AgriLife Research and Extension Center, Amarillo, TX 79106
http://amarillo.tamu.edu/
Ph: 806.677.5600 Fax: 806.677.5644

Department of Soil and Crop Sciences, College Station, TX 77843
http://soilcrop.tamu.edu/
Ph: 979.845.0360 Fax: 979.845.0456

Texas A&M AgriLife, Texas Water Resources Institute, College Station, TX 77843
http://twri.tamu.edu
Ph: 979.845.1851 Fax: 979.845.8554

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DECISION SUPPORT SYSTEMS:
Tools for Implementing Water Conservation Best Management Practices in Texas

Introduction

Identifying best management practices (BMPs) promoting greater water use efficiency while maintaining crop yields is essential to the future of Texas cropping systems. Available water for irrigated crops is vital for sustaining crop production throughout the state. However, the availability of this water for irrigation is diminishing through competition by urban development and, in some regions such as the Edwards Aquifer, is falling under state regulation. The awareness and improvement of efficient irrigation and best management practices to conserve water while maintaining crop production will help preserve the aquifer levels and increase water savings to producers.

One component of BMPs for conserving water use is the application of decision support systems (DSS) that are used as tools for implementing irrigation BMPs. This DSS guide was developed as a complement to TWDB Report 362, "Water Conservation Best Management Practices Guide," which is a more comprehensive report on water conservation including an "Agricultural Irrigation Water Use Management" BMPs section. The full TWDB Report 362 can be found at: http://www.twdb.state.tx.us/assistance/conservation/consindex.asp.

DSS include the Texas High Plains Evapotranspiration Network (TXHPET), the Precision Irrigators Network (PIN) and the Crop Production Management (CroPMan) model. These DSS strive to promote grower awareness of water conservation strategies. Irrigation conservation strategies are proposed to result in savings of approximately 1.4 million acre-feet per year by 2060 (TWDB and TWRI).

TXHPET operates 18 meteorological stations located in 15 counties across the Texas North Plains and Texas South Plains. The regional coverage of TXHPET is estimated at 4 million irrigated acres. The network offers insight to evapotranspiration (ET)-based crop water use that producers and agricultural consultants can reference when making decisions on when and how much to irrigate their crops. This information is available to data users via fax or online (http://txhighplainset.tamu.edu) and currently results in approximately 300,000 downloads or faxes annually.

The PIN program was formed in 2004 with a goal of saving millions of gallons of water annually by reducing irrigation water use by as much as 20 percent over several years and currently supports several crops (corn, cotton, sorghum, wheat) in seven counties of South Central Texas. Cooperation of the PIN programs consists of area producers, Texas Agricultural Experiment Station researchers, Texas Cooperative Extension personnel, San Antonio Water System, Edwards Aquifer Authority, Texas Water Resources Institute, Texas Water Development Board, Uvalde County Underground Water Conservation District and Wintergarden Water Conservation District. The PIN database will allow producers to gain historical and real-time information for better management of irrigation scheduling. The PIN program estimates that when all irrigators in the Edwards Aquifer region implement limited irrigation scheduling, approximately 50,000 to 60,000 acre-feet of water can be saved per year and made available for purposes other than agriculture.

CroPMan is a computer model designed to aid producers and agricultural consultants in optimizing crop management and maximizing production and profit through a production-risk approach. CroPMan will help growers identify limitations to crop yield, assist in making replant decisions and help recognize management practices that reduce the impact of agriculture on soil erosion and water quality. CroPMan is a Windows-based application program that can be downloaded from the CroPMan Web site (http://cropman.brc.tamus.edu).

Most Currently Developed DSS

TXHPET

Total crop water demand can be estimated by ET. ET represents the combination of water lost through evaporation of moist soil and wet surfaces, and the water lost through plant leaves by transpiration. Data collected from the 18 weather stations that make up the TXHPET are used to calculate daily reference crop (well-watered grass or alfalfa) ET. Based on the ET of the reference crop, specific ET values for individual crops are then produced.

For example, when using TXHPET, sum up the daily ET values from the nearest weather station for your crop of interest for a week. If no rainfall occurred during the week to replenish the crop water demand, the summation of ET is the amount of irrigation required to prevent crop stress. The use of TXHPET allows producers the ability to make in-season irrigation decisions.

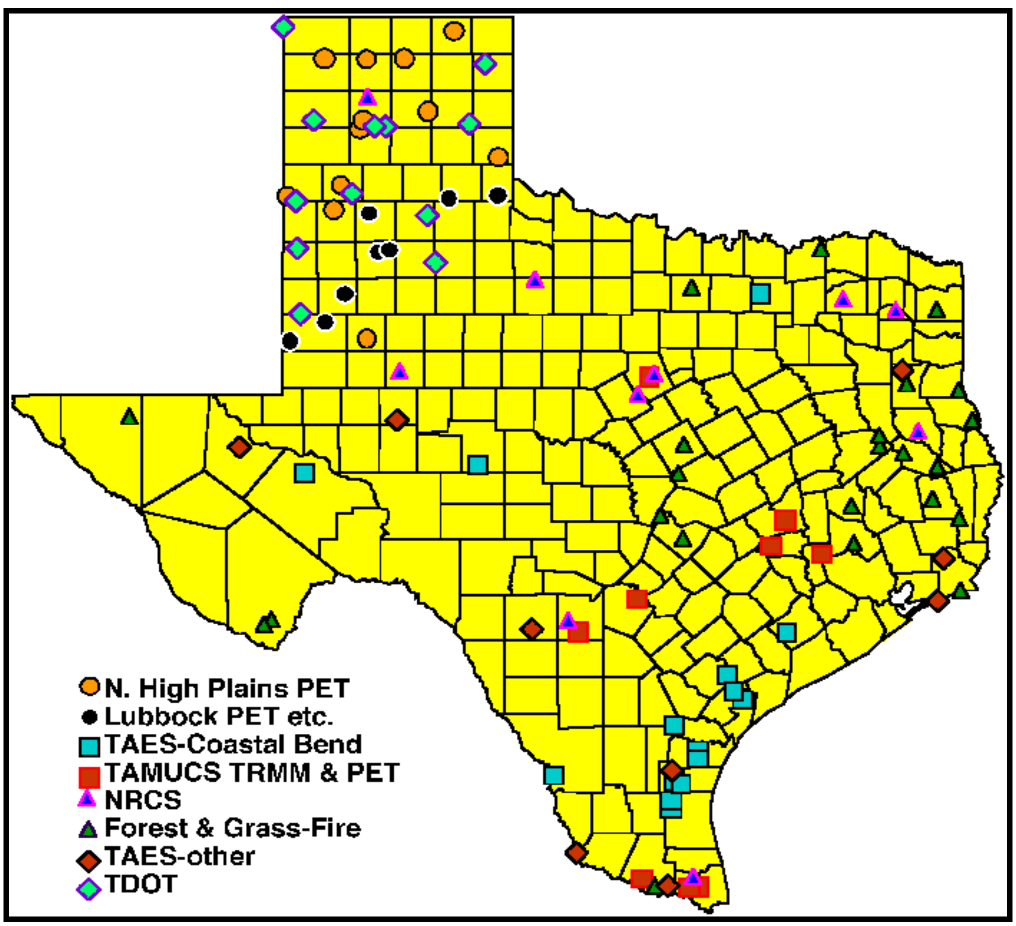


Figure 1. PET networks across Texas provide regional data to guide producers' irrigation decisions.

PIN
The formation of PIN has greatly impacted producer awareness of water conserving strategies. The increasing value of water in the Edwards Aquifer region has challenged PIN to search for management practices allowing efficient crop water use. Data in the Edwards Aquifer region suggests that ET overestimates the amount of irrigation needed (Falkenberg et al., 2006). Water savings in this region are possible without depletion of yield when only 75 percent of the ET is replenished with irrigation. The PIN program allows producers to precisely manage their irrigation scheduling in-season in a way that maximizes their returns and ensures irrigation water for coming years.

CroPMan
CroPMan is a Windows-based computer application model that can simulate crop management practices and climatic and edaphic conditions allowing producers to see the impact on crop yield, soil properties, soil erosion, profitability and nutrient/pesticide fate. CroPMan permits agricultural consultants and producers to form strategic assessments over years for best management practices and also allows them to run real-time analysis to determine the amount and timing of irrigation. Of the DSS discussed, CroPMan is the only system that allows producers the advantage of long-term planning for the future.

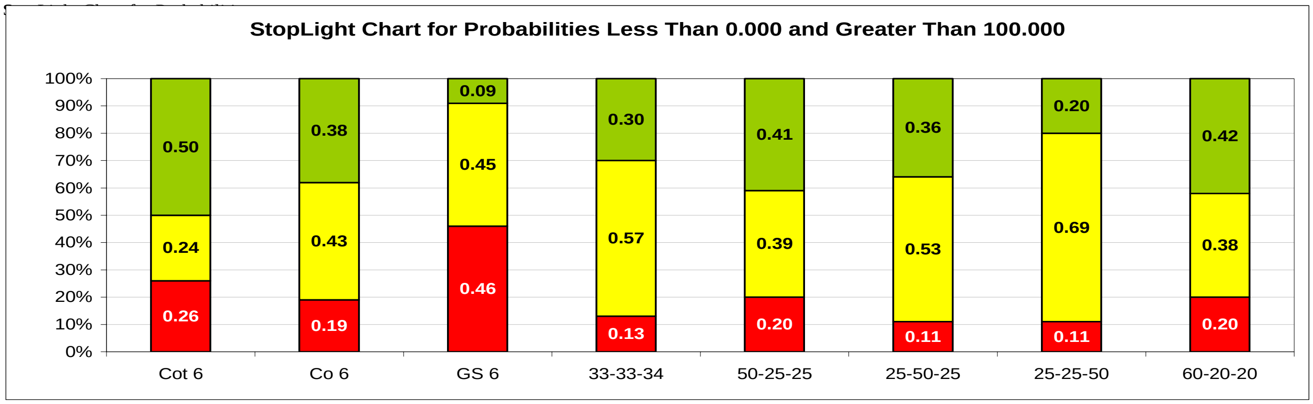
Potential Cost and Water Savings from Adopting and Implementing a DSS

Crop	Current mean water usage	Simulated water usage to maintain yield at current water usage under varying irrigation types			Irrigated crop acreage in region[1]	Potential water savings[2]		
	inches/acre/year	*inches/acre/year*			*Acres*	*acre-ft/year*		
		Furrow	Sprinkler-LEPA	Buried Drip (12")		Furrow	Sprinkler-LEPA	Buried Drip (12")
Corn	24	14	14	12	54100	45083	45083	54100
Cotton	21	19	19	17	62000	10333	10333	20667
Grain Sorghum	18	10	10	8	95500	63667	63667	79583
Sugarcane	30	24	22	22	40500	20250	27000	27000

1 Data collected from the NASS 2005 census data in Cameron, Willacy, Hidalgo and Starr counties.

2 Water savings for each irrigation type is based on total acreage of crop.

Table 1. Potential water savings while maintaining yield from implementing decision support systems.



Mean	$133.33	$94.63	$11.22	$79.04	$93.13	$83.45	$62.60	$101.17
StDev	235.76	101.97	63.69	82.72	118.39	75.19	65.74	140.99
CV	176.83	107.75	567.57	104.66	127.13	90.10	105.01	139.36
Min	-$240.47	-$37.31	-$97.00	-$90.97	-$128.71	-$67.09	-$79.39	-$151.06
Max	$944.57	$405.25	$153.93	$338.42	$492.80	$300.35	$265.66	$583.15

Figure 2. Probabilities for net returns associated with the percent of total irrigation water available applied to either cotton, corn or grain sorghum.

Figure 2 indicates the probability of net returns based on the percentage of acres planted to cotton, corn and/or grain sorghum based on 2 acre-feet per year of available irrigation. The red indicates the probability that net returns will be less than $0.000 per acre, yellow indicates net returns ranging from $0.000 to $100.000 per acre, and green indicates the probability of net returns exceeding $100.000 per acre. The first bar represents a farmer placing all his/her acres in cotton production. The second bar displays the probability for returns if a producer chooses to grow corn on all his/her acres. The third bar corresponds to the probability of net returns per acre if all the acres are planted to grain sorghum. The rest of the bars indicate the probability of net returns if producers' acres are split into cotton, corn and grain sorghum. The numbers on the x-axis below each bar represent the percent of total acres planted to cotton, corn or grain sorghum. For example, the bar on the far right is the probability of net returns when 60 percent of the acres are planted to cotton, 20 percent are planted to corn and 20 percent are planted to grain sorghum.

How to Use a DSS

Case 1 – TXHPET

Steps:

1. To look at daily water use and other climatic factors for your region, go to http://txhighplainset.tamu.edu.
2. From the homepage (Figure 3) click on the Weather Data tab.

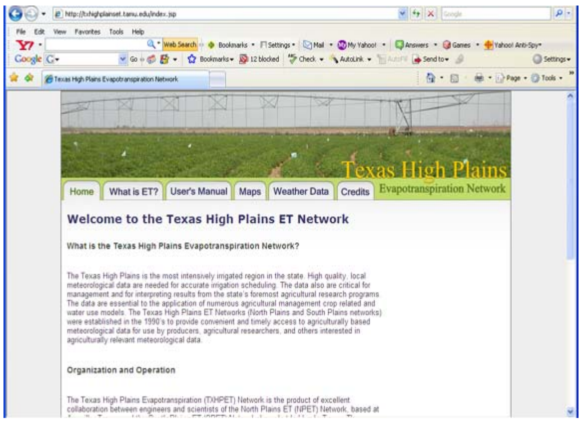


Figure 3. Homepage of the Texas High Plains Evapotranspiration Network (http://txhighplainset.tamu.edu).

Figure 4. Options for daily reading data.

3. Once weather data has been selected, click on "Daily" to receive daily readings.
4. The Daily Weather Page (Figure 4) will open and ask the user to select a location, type of data (i.e. crop water use), dates for viewing, units of measurement and how the users want to view the data.
5. After the information is submitted a data report will be generated. For example, Figure 5 is the result of selecting Dalhart as the location, water use for short-season corn during the time range of May 1, 2007 through May 13, 2007. The units selected are English and the report is in table format.

Data Table

Starting Date: 5 / 1 / 2007 0 : 0 am Ending Date: 5 / 13 / 2007 0 : 0 am Units: english

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Dalhart

Date	Crn PD1 SS (in)
05/01/2007	0.07
05/02/2007	0.03
05/03/2007	0.06
05/04/2007	0.08
05/05/2007	0.08
05/06/2007	0.07
05/07/2007	0.07
05/08/2007	0.04
05/09/2007	0.06
05/10/2007	0.08
05/11/2007	0.11
05/12/2007	0.11
05/13/2007	0.12

Figure 5. Short-season corn water use in Dalhart, Texas, for May 1 through May 13, 2007.

When using tables such as that in Figure 5 as a guide for making irrigation decisions, sum the water-use column and subtract the amount of rainfall received by the farm of interest. If the number is less than zero, no irrigation is needed. If the number is above zero, that is the amount of irrigation needed to prevent crop-water stress.

Case 2 – PIN

Precise calculation of ET is crucial to meeting the proper water demand by the crop. Figure 6 illustrates several methods and their calculation of ET throughout part of the corn growing season.

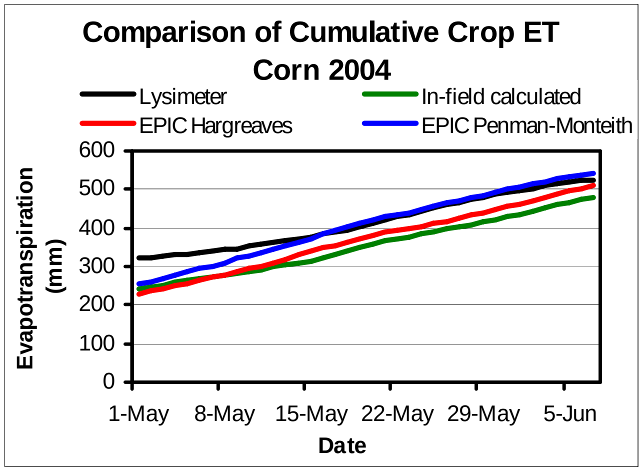


Figure 6. Calculation of evapotranspiration of corn using four different methods.

Steps:

1. To calculate or determine ET, go to the Texas A&M University Agricultural Research and Extension Center at Uvalde homepage at http://uvalde.tamu.edu.

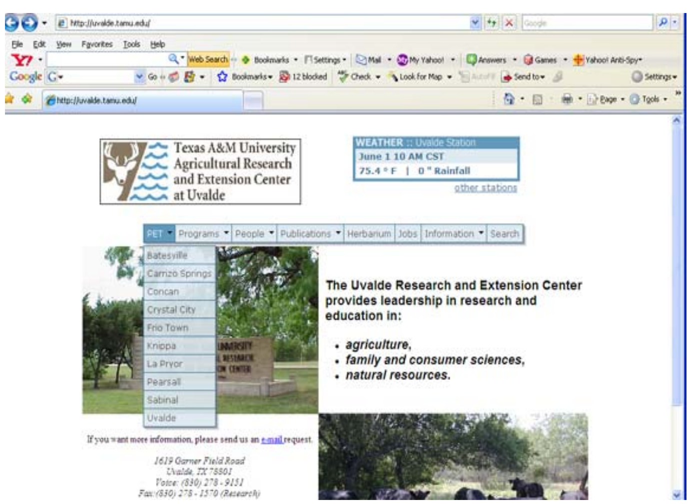


Figure 7. Agricultural Research and Extension Center Web site homepage at http://uvalde.tamu.edu.

2. On the homepage (Figure 7), click PET and select the county nearest your location of interest. For example if your farm is located in Uvalde County, click on Uvalde.
3. Click on the date of interest to identify the crop-water use and climate for that date. In the example below, May 17, 2007, was selected for determination of cotton water use.

COTTON

Water Use

Seed Date	Acc GDD	Growth Stage	Day	3day	7day	Seas. in.
			----in/d----			
03/15	511	1st Sqr	.09	.09	.08	1.8
03/25	410	1st Brch	.06	.06	.05	1.3
04/05	297	Emerged	.04	.05	.05	0.8
04/15	250	Emerged	.04	.05	.05	0.6

Figure 8. Water use table for cotton selected for May 17, 2007.

When reading the table as in Figure 8, users should choose the date that most closely approximates their planting date. The "Growth Stage" column should be close to the maturity of the user's crop. The "Day" column represents the amount of ET lost by the crop for May 17. The "3 day" and "7 day" columns are the average daily ET for the previous 3 and 7 days, respectively. The "Seas. in." column reports the total water lost through ET for the growing season up to May 17.

When making irrigation decisions, sum the amount of daily ET for a given number of days. If the amount of daily ET is not replenished by rainfall, then that is the amount of irrigation required to prevent crop water stress.

Case 3 – CroPMan

Implementing CroPMan must first begin with calibration to the user's region. Ongoing research is being conducted to validate CroPMan in all regions of Texas. The validation procedure uses actual measured yield points in comparison with CroPMan simulated yields. An example of sugarcane yield validation in the Lower Rio Grande Valley can be seen in Figure 9.

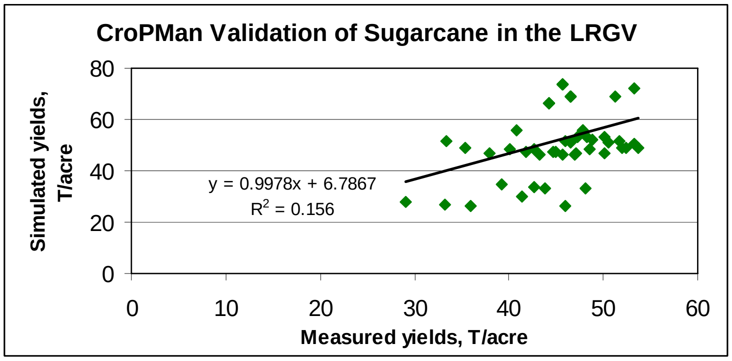
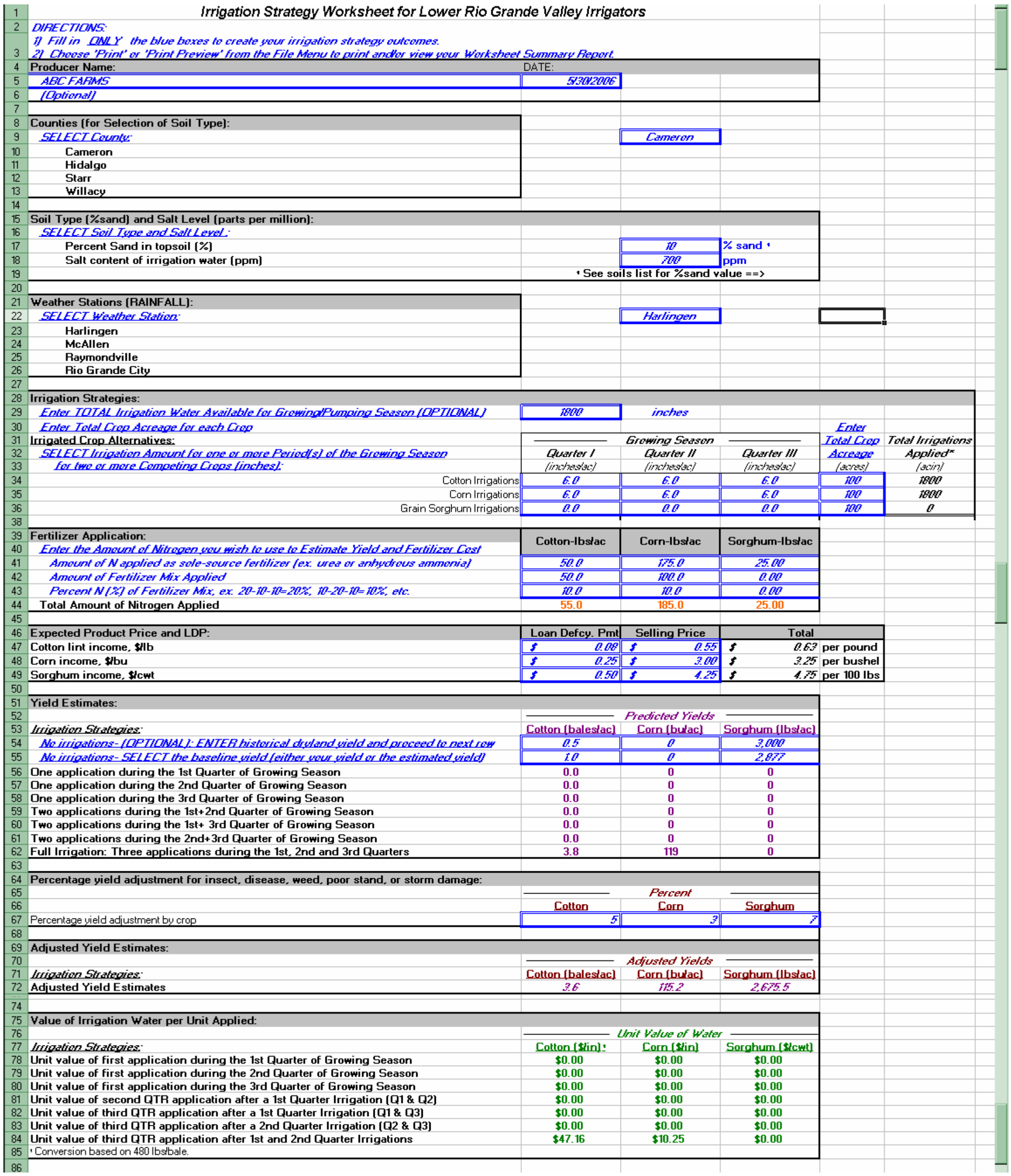


Figure 9. Validation of CroPMan for sugarcane yields using research data.

Figure 10. The CroPMan homepage at http://cropman.brc.tamus.edu.

Steps:

1. From the homepage (Figure 10), click on "Decision Aids" and then select "IRRIG-AID." The irrigation strategy worksheet (Figure 11) will appear.
2. When all the necessary worksheets are filled in a profit analysis of irrigated crops spreadsheet (Figure 12) is generated to guide producers in the best management decision for their crop.



1	*Irrigation Strategy Worksheet for Lower Rio Grande Valley Irrigators*					
2	*DIRECTIONS:*					
	1) Fill in ONLY the blue boxes to create your irrigation strategy outcomes.					
3	*2) Choose 'Print' or 'Print Preview' from the File Menu to print and/or view your Worksheet Summary Report.*					
4	Producer Name:	DATE:				
5	*ABC FARMS*	*5/30/2006*				
6	*(Optional)*					
7						
8	Counties (for Selection of Soil Type):					
9	*SELECT County:*		*Cameron*			
10	Cameron					
11	Hidalgo					
12	Starr					
13	Willacy					
14						
15	Soil Type (%sand) and Salt Level (parts per million):					
16	*SELECT Soil Type and Salt Level :*					
17	Percent Sand in topsoil (%)		*10*	% sand ¹		
18	Salt content of irrigation water (ppm)		*700*	ppm		
19		¹ See soils list for %sand value ==>				
20						
21	Weather Stations (RAINFALL):					
22	*SELECT Weather Station:*		*Harlingen*			
23	Harlingen					
24	McAllen					
25	Raymondville					
26	Rio Grande City					
27						
28	Irrigation Strategies:					
29	*Enter TOTAL Irrigation Water Available for Growing/Pumping Season (OPTIONAL)*	*1800*	*inches*			
30	*Enter Total Crop Acreage for each Crop*				*Enter*	
31	Irrigated Crop Alternatives:		*Growing Season*		*Total Crop*	*Total Irrigations*
32	*SELECT Irrigation Amount for one or more Period(s) of the Growing Season*	*Quarter I*	*Quarter II*	*Quarter III*	*Acreage*	*Applied**
33	*for two or more Competing Crops (inches):*	*(inches/ac)*	*(inches/ac)*	*(inches/ac)*	*(acres)*	*(ac/in)*
34	Cotton Irrigations	*6.0*	*6.0*	*6.0*	*100*	*1800*
35	Corn Irrigations	*6.0*	*6.0*	*6.0*	*100*	*1800*
36	Grain Sorghum Irrigations	*0.0*	*0.0*	*0.0*	*100*	*0*
38						
39	Fertilizer Application:	Cotton-lbs/ac	Corn-lbs/ac	Sorghum-lbs/ac		
40	*Enter the Amount of Nitrogen you wish to use to Estimate Yield and Fertilizer Cost*					
41	*Amount of N applied as sole-source fertilizer (ex. urea or anhydrous ammonia)*	*50.0*	*175.0*	*25.00*		
42	*Amount of Fertilizer Mix Applied*	*50.0*	*100.0*	*0.00*		
43	*Percent N (%) of Fertilizer Mix, ex. 20-10-10=20%, 10-20-10=10%, etc.*	*10.0*	*10.0*	*0.00*		
44	Total Amount of Nitrogen Applied	55.0	185.0	25.00		
45						
46	Expected Product Price and LDP:	Loan Defcy. Pmt	Selling Price	Total		
47	Cotton lint income, $/lb	$ 0.08	$ 0.55	$ 0.63	per pound	
48	Corn income, $/bu	$ 0.25	$ 3.00	$ 3.25	per bushel	
49	Sorghum income, $/cwt	$ 0.50	$ 4.25	$ 4.75	per 100 lbs	
50						
51	Yield Estimates:					
52			*Predicted Yields*			
53	*Irrigation Strategies:*	Cotton (bales/ac)	Corn (bu/ac)	Sorghum (lbs/ac)		
54	*No irrigations- (OPTIONAL): ENTER historical dryland yield and proceed to next row*	*0.5*	*0*	*3,000*		
55	*No irrigations- SELECT the baseline yield (either your yield or the estimated yield)*	*1.0*	*0*	*2,877*		
56	One application during the 1st Quarter of Growing Season	0.0	0	0		
57	One application during the 2nd Quarter of Growing Season	0.0	0	0		
58	One application during the 3rd Quarter of Growing Season	0.0	0	0		
59	Two applications during the 1st+2nd Quarter of Growing Season	0.0	0	0		
60	Two applications during the 1st+ 3rd Quarter of Growing Season	0.0	0	0		
61	Two applications during the 2nd+3rd Quarter of Growing Season	0.0	0	0		
62	Full Irrigation: Three applications during the 1st, 2nd and 3rd Quarters	3.8	119	0		
63						
64	Percentage yield adjustment for insect, disease, weed, poor stand, or storm damage:					
65			*Percent*			
66		Cotton	Corn	Sorghum		
67	Percentage yield adjustment by crop	*5*	*3*	*7*		
68						
69	Adjusted Yield Estimates:					
70			*Adjusted Yields*			
71	*Irrigation Strategies:*	Cotton (bales/ac)	Corn (bu/ac)	Sorghum (lbs/ac)		
72	Adjusted Yield Estimates	*3.6*	*115.2*	*2,675.5*		
74						
75	Value of Irrigation Water per Unit Applied:					
76			*Unit Value of Water*			
77	*Irrigation Strategies:*	Cotton ($/in) ¹	Corn ($/in)	Sorghum ($/cwt)		
78	Unit value of first application during the 1st Quarter of Growing Season	$0.00	$0.00	$0.00		
79	Unit value of first application during the 2nd Quarter of Growing Season	$0.00	$0.00	$0.00		
80	Unit value of first application during the 3rd Quarter of Growing Season	$0.00	$0.00	$0.00		
81	Unit value of second QTR application after a 1st Quarter Irrigation (Q1 & Q2)	$0.00	$0.00	$0.00		
82	Unit value of third QTR application after a 1st Quarter Irrigation (Q1 & Q3)	$0.00	$0.00	$0.00		
83	Unit value of third QTR application after a 2nd Quarter Irrigation (Q2 & Q3)	$0.00	$0.00	$0.00		
84	Unit value of third QTR application after 1st and 2nd Quarter Irrigations	$47.16	$10.25	$0.00		
85	¹ Conversion based on 480 lbs/bale.					
86						

Figure 11. Irrigation strategy worksheet for Lower Rio Grande Valley irrigators.

	A	B	C	D	E
1	PROFIT ANALYSIS OF IRRIGATED CROPS				
2	*Fill in ONLY the blue boxes to calculate your Profit Analysis*				
3	Income:		Cotton	Corn	Sorghum
4	Per Acre		($/ac)	($/ac)	($/ac)
5	Dryland	-	$ -	$ -	$ 127.09
6	One application during the 1st Quarter of Growing Season	-	$ -	$ -	$ -
7	One application during the 2nd Quarter of Growing Season	-	$ -	$ -	$ -
8	One application during the 3rd Quarter of Growing Season	-	$ -	$ -	$ -
9	Two applications during the 1st+2nd Quarter of Growing Season	-	$ -	$ -	$ -
10	Two applications during the 1st+ 3rd Quarter of Growing Season	-	$ -	$ -	$ -
11	Two applications during the 2nd+3rd Quarter of Growing Season	-	$ -	$ -	$ -
12	Full Irrigation: Three applications during the 1st, 2nd and 3rd Quarters	-	$ 1,091.89	$ 374.49	$ -
13					
14					
15	Expenses:		Irrigation cost		Irrigation cost
16	Per Acre	$/Unit	Based on Fuel Type		ENTER Your estimate
17	Select Fuel Type (Option: To customize go to "IRRG COST CALC" SHEET)	*None*	$ -	OR	$ *1.50*
18	cost per acre/inch		Cotton	Corn	Sorghum
19			($/ac)	($/ac)	($/ac)
20	Select Irrigation Cost/inch	$ *1.50*	$ 27.00	$ 27.00	$ -
21	Fertilizer (N costs only) Unit Cost/lb	$ *0.40*	$ 22.00	$ 74.00	$ 10.00
22	Mixed Fertilizer (Other excluding N) Total Cost/ac		$ *8.00*	$ *16.00*	$ -
23	Additional or Other Costs/ac (see note below*)		$ *268.79*	$ *78.19*	$ *58.71*
24	Annual Interest Rate (6 months interest expense)	*7.00%*	$ 11.40	$ 6.83	$ 2.40
25	Total	-	$ 337.19	$ 202.02	$ 71.11
26					
27	Net Income:		Cotton	Corn	Sorghum
28	Per Acre				
29	Net Income ($/ac)		$ 754.70	$ 172.47	$ 55.97
30	Total Crop Acreage (acres)		100	100	100
31	TOTAL Net Income ($)		$ 75,469.69	$ 17,246.85	$ 5,597.33
32	* Additional Costs for Irrigated Crops: Cotton=$268.79, Corn=$78.19, Sorghum=$80.79				
33	Additional Costs for Dryland Crops: Cotton=$188.78, Sorghum=$58.71				
34	http://agecoext.tamu.edu/budgets/district/12/2006/				
35	Visit this site to review/update cost estimates for additional costs				

YIELD CALC / PROFIT / IRRG COST CALC / REPORT

Figure 12. Profit analysis of irrigated crops.

Conclusion

Producers must begin exercising best management practices to ensure the sustainability of their farm for future years. The above mentioned DSS will aid producers in managing their production risk, while maintaining profitable yields and conserving irrigation water. By implementing the above DSS, producers will be making educated, economically sound decisions on which crop to plant, how much and when to apply irrigation, and other crop management decisions in an effort to maximize water use efficiency and profits.

References

Falkenburg, N.R., G. Piccinni, J.T. Cothren, D.I. Leskovar, and C.M. Rush. 2006. Remote sensing of biotic and abiotic stress for irrigation management of cotton. *J. Agri. Water Management 87:23-31*.

Porter, D., T. Marek, T. Howell, L. New. 2005. *The Texas High Plains Evapotranspiration Network User Manual*. AREC 05-37.

Schattenberg, P. 2004. *Group 'PIN'-pointing irrigation use to conserve water, profit*. AgNews. Retrieved May 3, 2007. http://agnews.tamu.edu/dailynews/stories/SOIL/Dec1604a.htm

Smith, R. 2001. CroPMan offers growers super model. *Southwest Farm Press*. Retrieved May 3, 2007. http://southwestfarmpress.com/mag/farming_cropman_offers_growers/

TWDB and TWRI. 2006. An Assessment of Water Conservation in Texas Prepared for the 80th Texas Legislature. Retrieved June 27, 2007. http://www.twdb.state.tx.us/publications/reports/TWDBTSSWCB_80th.pdf.