IRRIG-AID

Irrigation Strategy Worksheet

For

Lower Rio Grande Valley Producers

Prepared by M. Magre, Dr. W. Harman, Dr. T. Gerik, and E. Steglich

Blackland Research and Extension Center Report 06-02

May, 2006

INTRODUCTION AND OVERVIEW

As part of the **Rio Grande Basin Initiative**, specifically *Task 4: On-Farm Irrigation System Management*, a hands-on spreadsheet decision tool was developed to assess the risk of various crop, soil, and irrigation practices, as well as quantify economic trade-offs in allocating soil and water resources to various cropping alternatives. This instrument will assist producers in achieving efficient water allocations thereby maximizing profitability. Step-by-step instructions for using this tool are presented here.

The producer or user may obtain a copy of this tool from the Decision Aid's web page on the CroPMan web site at http://cropman.brc.tamus.edu/.

DOWNLOADING THE WORKSHEET

After the file is downloaded or copied onto the hard drive and the security clearance is granted, simply double click the file from the Windows Explorer File Manager (Figure 1).

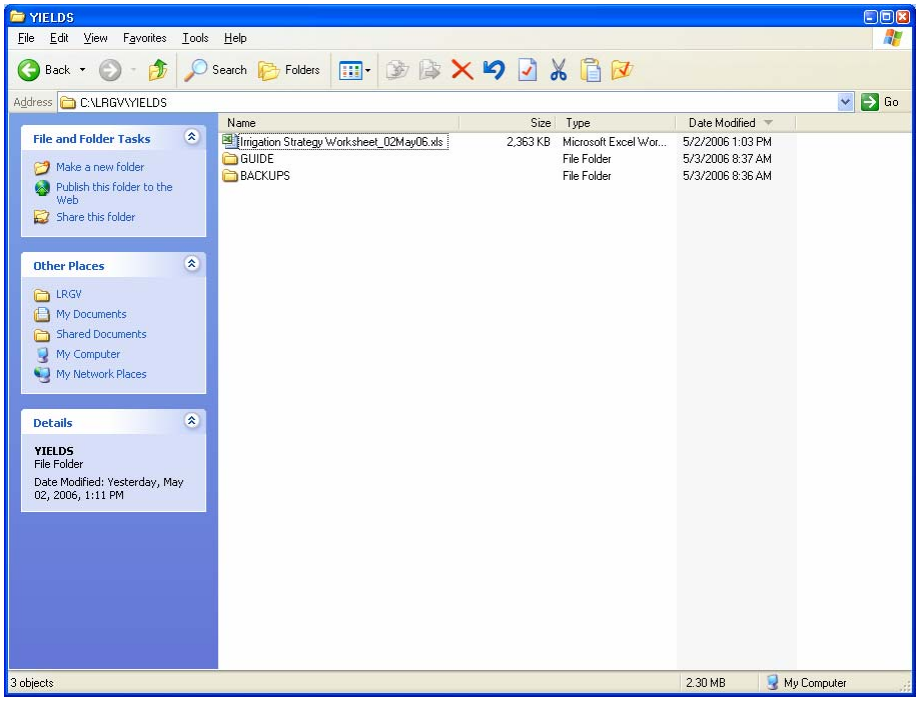
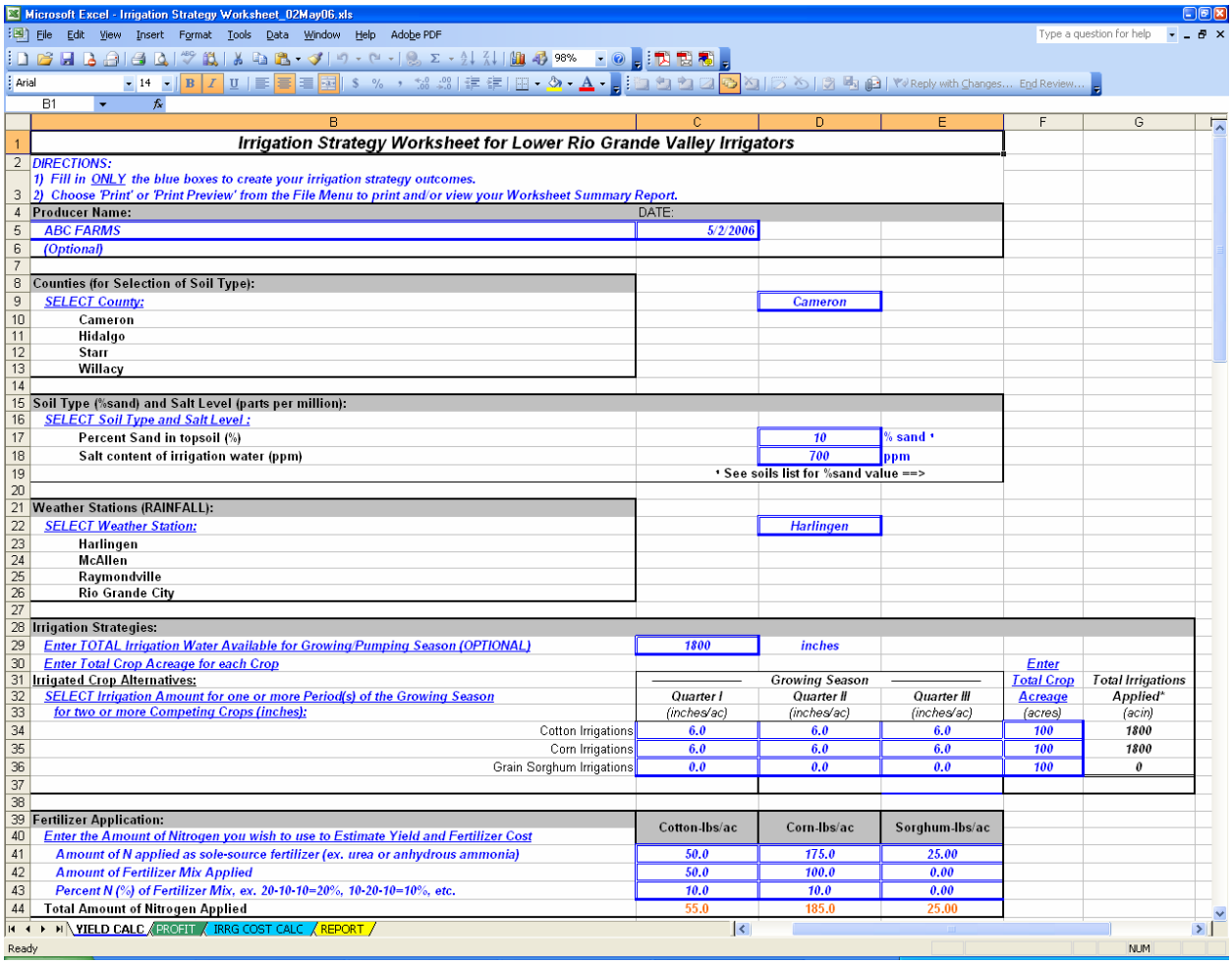


Figure 1: Open File from Windows Explorer

The file will look like the sample in Figure 2 below:



Microsoft Excel - Irrigation Strategy Worksheet_02May06.xls

Irrigation Strategy Worksheet for Lower Rio Grande Valley Irrigators

DIRECTIONS:
1) Fill in ONLY the blue boxes to create your irrigation strategy outcomes.
2) Choose 'Print' or 'Print Preview' from the File Menu to print and/or view your Worksheet Summary Report.

Producer Name:	DATE:
ABC FARMS	5/2/2006
(Optional)	

Counties (for Selection of Soil Type):	
SELECT County:	Cameron
Cameron	
Hidalgo	
Starr	
Willacy	

Soil Type (%sand) and Salt Level (parts per million):		
SELECT Soil Type and Salt Level :		
Percent Sand in topsoil (%)	10	% sand *
Salt content of irrigation water (ppm)	700	ppm
	* See soils list for %sand value ==>	

Weather Stations (RAINFALL):	
SELECT Weather Station:	Harlingen
Harlingen	
McAllen	
Raymondville	
Rio Grande City	

Irrigation Strategies:					
Enter TOTAL Irrigation Water Available for Growing/Pumping Season (OPTIONAL)	1800	inches			
Enter Total Crop Acreage for each Crop				Enter Total Crop Acreage	
Irrigated Crop Alternatives:	Growing Season				
SELECT Irrigation Amount for one or more Period(s) of the Growing Season for two or more Competing Crops (inches):	Quarter I (inches/ac)	Quarter II (inches/ac)	Quarter III (inches/ac)	Total Crop Acreage (acres)	Total Irrigations Applied* (acin)
Cotton Irrigations	6.0	6.0	6.0	100	1800
Corn Irrigations	6.0	6.0	6.0	100	1800
Grain Sorghum Irrigations	0.0	0.0	0.0	100	0

Fertilizer Application:	Cotton-lbs/ac	Corn-lbs/ac	Sorghum-lbs/ac
Enter the Amount of Nitrogen you wish to use to Estimate Yield and Fertilizer Cost			
Amount of N applied as sole-source fertilizer (ex. urea or anhydrous ammonia)	50.0	175.0	25.00
Amount of Fertilizer Mix Applied	50.0	100.0	0.00
Percent N (%) of Fertilizer Mix, ex. 20-10-10=20%, 10-20-10=10%, etc.	10.0	10.0	0.00
Total Amount of Nitrogen Applied	55.0	185.0	25.00

YIELD CALC | PROFIT | IRRG COST CALC | REPORT

Ready

Figure 2: Yield Calculation

This spreadsheet tool contains four sheets as indicated by the colored tabs in Figure 2:

YIELD CALC **IRRG COST CALC**
PROFIT **REPORT**

The **YIELD CALC** sheet is the yield calculation sheet where the user provides the necessary basic input for potential crop acreage and the specific irrigation, soil, and other information which is used to estimate production yields and returns. The **PROFIT** sheet utilizes the information from these estimated yields to calculate the user's profit analysis. Part of this includes the ***Irrigation Cost Calculator***, included on the **IRRG COST CALC** sheet, whose costs may be adjusted independently. Finally, the **REPORT** provides the user with an irrigation strategy summary based on the inputs provided by the user.

YIELD CALCULATIONS

Most of the necessary information is entered into the **YIELD CALC** sheet by the user. To aid the user in entering this input, the fields which require user information are designated with blue

borders or boxes and/or drop down menus from which to make selections; directions in text are also found on the left in the same blue color. There are optional fields that simply customize the output for printing; for example, the name of the producer and date may be entered or left as a generic label.

1. Select County

The user must select the county in which the appropriate soil information will be taken from the county drop down menu as illustrated in Figure 3.

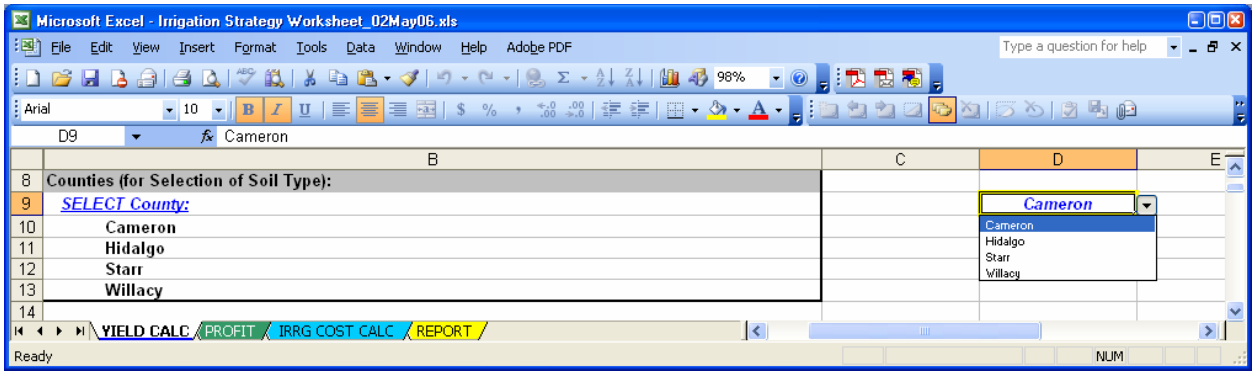


Figure 3: Select County

The soil table for each county will be listed to the right of the county selection; the user may use the scroll bar at the bottom of the page to scroll to the right side of the sheet and back. An example for Cameron County is found in Figure 4:

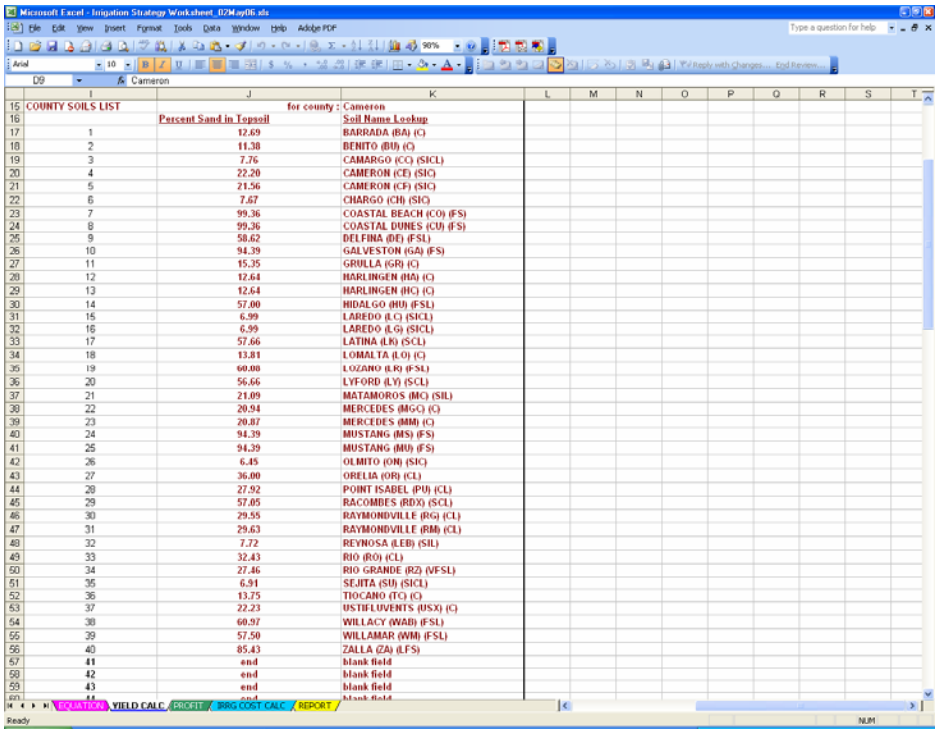


Figure 4: View County Soils

2. Select Soil Type and Salt Level

Next, the user will need to enter the amount of sand in the topsoil found in the soil table (% sand value). Enter the sand content in the soil as listed in the soil table. Some fields may have different soil types and in this case, the user may want to assess yields and profits for each soil.

Also, at this point enter the salt concentration in the irrigation water, if any (Figure 5).

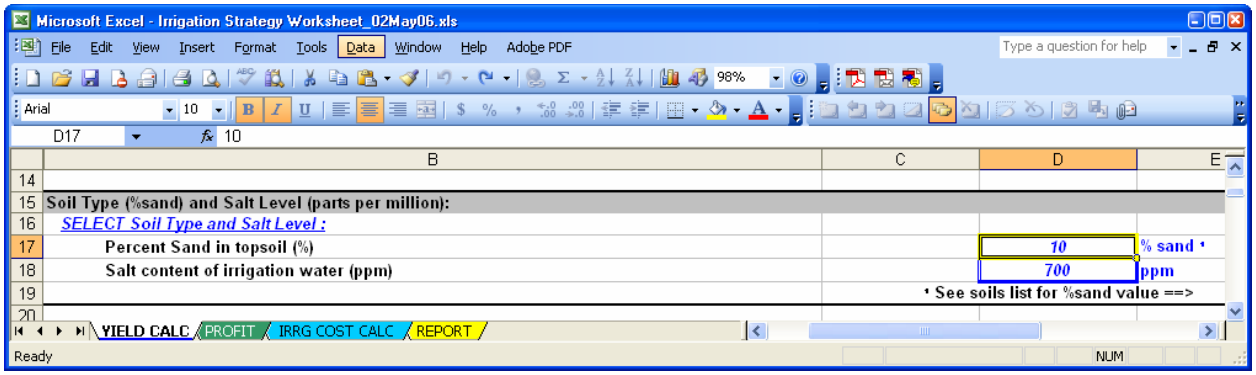


Figure 5: Select Soil Type and Salt Level

3. Select Weather Station

Next, the user will enter the location of the weather station which the production area is nearest, i.e. enter the station from which the user prefers to use historical weather for precipitation and temperatures (Figure 6).

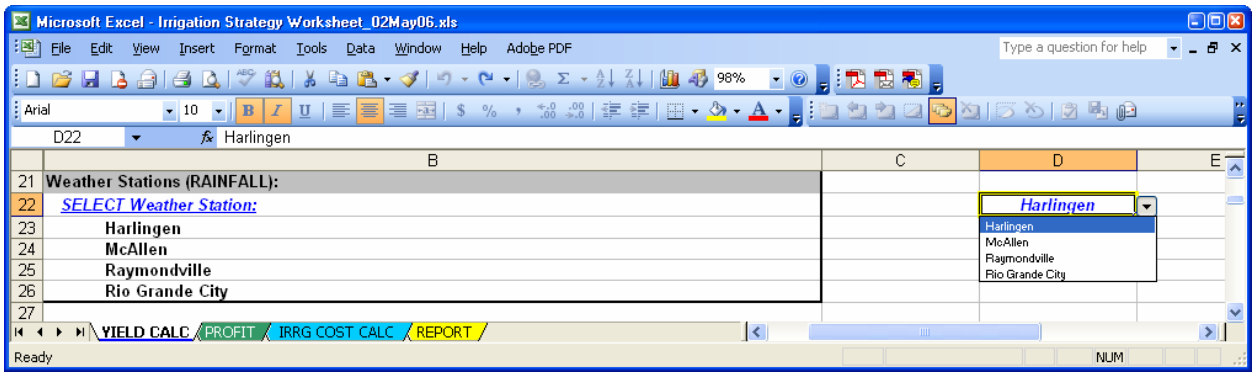


Figure 6: Select Weather Station

4. Enter Irrigation and Crop Acreage Data

In the next step, the user has an option to enter the total irrigation water available for the growing or pumping season (cell C29) (Figure 7). In column F, the user must enter the crop

acreage for each of the three competing crops: cotton, corn, and sorghum. Each crop has a cell for the irrigation amount to be applied during each of the first three quarters of the growing season (columns C, D, and E). Note: The fourth quarter of crop development (after seed fill and dry down) is excluded. Based on these inputs, the total irrigation applied will be calculated in column G.

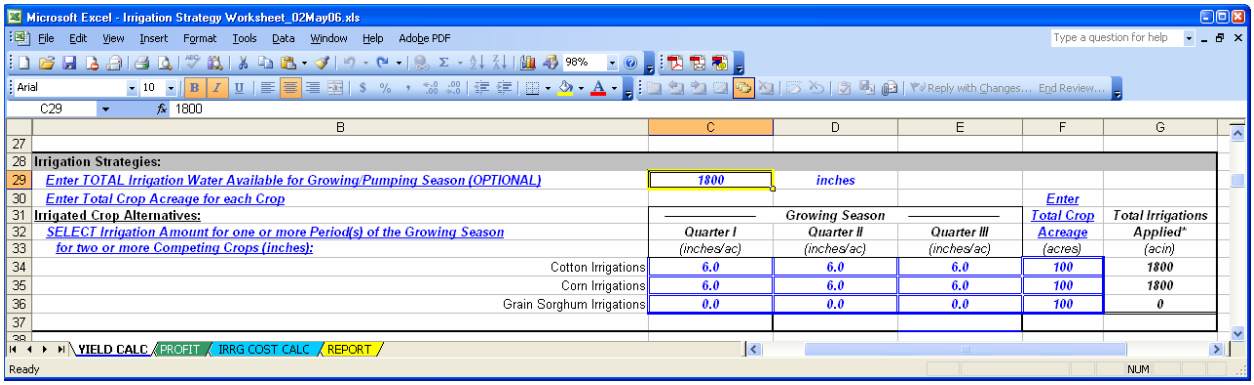


Figure 7: Enter Irrigation and Acreage Data

5. Enter Fertilizer Data

The next section is used to specify fertilizer application (Figure 8). For each crop, enter the amount of nitrogen (N) that is applied as the sole source of fertilizer, some mixture or combination of fertilizers, and the associated portion of N within that mixed fertilizer (Rows 41, 42 and 43, respectively). The calculated amount used in estimating the user's crop yield will be listed at the bottom in orange lettering. The user may make adjustments in Rows 41-43 if the total amount of N calculated in Row 44 does not accurately reflect the desired amount of N.

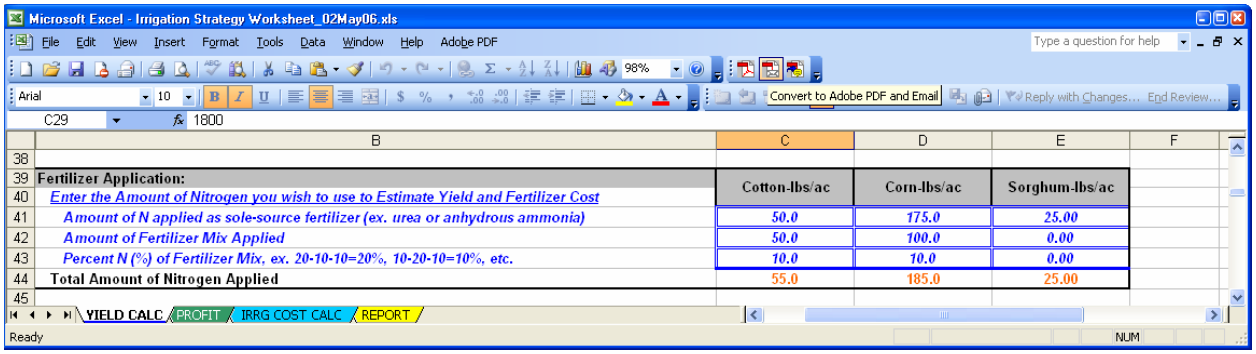


Figure 8: Enter Fertilizer Data

6. Enter Expected Prices/Loan Deficiency Payment

Next, the user will enter the expected prices for each crop along with any expected loan deficiency payment rates using the noted rate/unit (Figure 9).

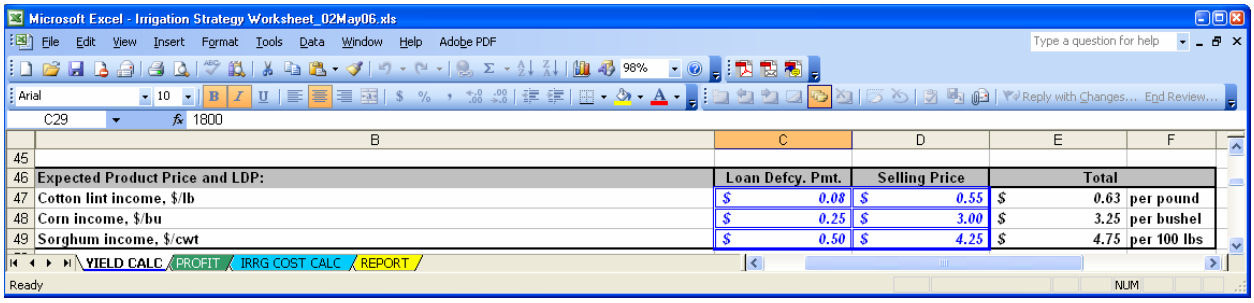


Figure 9: Enter Expected Prices/Deficiency Payment Rates

7. Enter/Select Baseline Yields

Based on all of the above information, a model estimated with regression analysis is used to produce a yield estimate for each crop for a specific level of irrigation during the growing period (Figure 10). Each model and its parameters can be found in the Appendix at the end of this report.

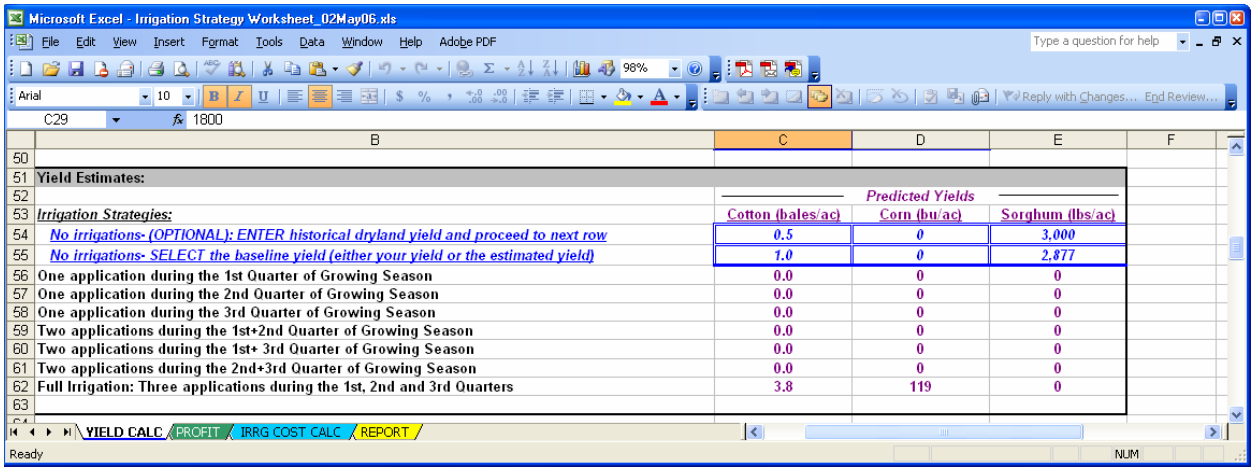


Figure 10: Yield Estimate

The user has an option to enter a dryland yield in row 54 based on historical production. In row 55, the user must select either the model's estimated baseline yield or the user's yield from line 54. Using the irrigation amounts entered in rows 34-36, yields will be calculated and appear in the appropriate row for each crop. For example, as indicated on row 34 (Figure 7), cotton has (3) six-inch irrigations so only one yield will appear in row 62; 3.8 bales per acre will result from applying three irrigations to the cotton crop along with the entries for soil, salt concentration, fertilizer, etc. Conversely, no irrigation water was allocated to the grain sorghum crop so the result will be zero irrigated yields for all scenarios. Each line in rows 56-62 represents the yield resulting from the total number of irrigations (specifically the amount(s) within irrigations) for the associated period of the growing season, i.e. quarter(s) 1, 2, and/or 3.

8. Percentage yield adjustment for insect, disease, weed, poor stand, or storm damage

The user may need to enter a yield adjustment to account for pests, diseases, damage, etc. Collectively, this adjustment is made by entering a percentage reduction in the yield, for example, five percent for cotton (Figure 11).

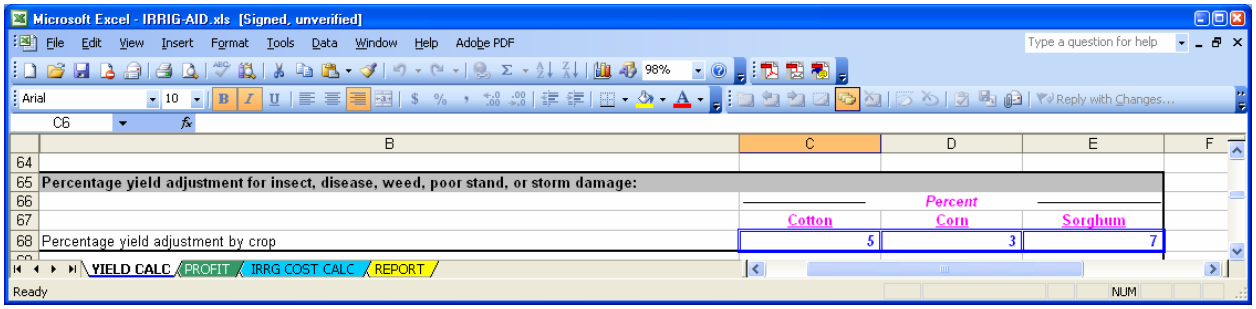


Figure 11: Percentage Yield Adjustment

The associated unit value of the last irrigation(s) is/are calculated below in ($/inch) for each crop-irrigation scenario.

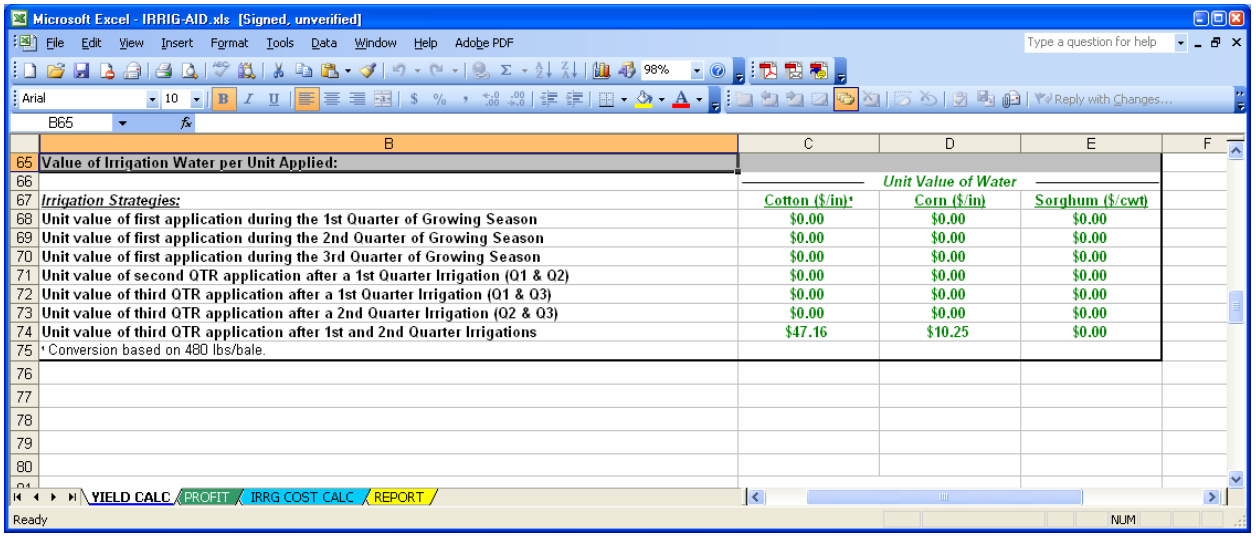


Figure 12: Value of Irrigation Water per Unit Applied

These values are used to allocate water among competing crops to achieve the highest value per unit applied of the last irrigation (Figure 12). The unit value of water is calculated using the following formula:

$$VW = (Y_I - Y_{I-1}) \times P \div IRG$$

where,

$VW = unit\ value\ of\ water \quad (\$/inch)$

$Y_I = Estimated\ yield\ resulting\ from\ current\ irrigation\ strategy \quad (unit/acre)$

$Y_{I-1} = Yield\ resulting\ from\ previous\ irrigation\ strategy\ or\ dryland\ yield \quad (unit/acre)$

$P = Expected\ price\ (\$/unit)$

$IRG = Irrigation\ amount\ from\ current\ irrigation\ strategy \quad (inches)$

Note: These values reflect the unit value of water based on the actual yields before any yield adjustments due to pests, weather, etc., are made; however, the yield adjustments are reflected on the **PROFIT** sheet when determining income from yield. The user can review the **PROFIT** analysis and make adjustments to input prices. Click the **PROFIT** tab/sheet (Figure 13).

Microsoft Excel - IRRIG-AID.xls

	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)		$ 314.62	$ 173.28	$ 105.96
24	Annual Interest Rate (6 months interest expense)	7.00%	$ 13.01	$ 10.16	$ 4.06
25	Total	-	$ 384.63	$ 300.44	$ 120.02
26					
27	Net Income:		Cotton	Corn	Sorghum
28	Per Acre				
29	Net Income ($/ac)		$ 707.26	$ 74.05	$ 7.07
30	Total Crop Acreage (acres)		100	100	100
31	TOTAL Net Income ($)		$ 70,726.28	$ 7,405.03	$ 706.96
32	Additional Costs for Irrigated Crops:		314.62	173.28	141.92
33	Additional Costs for Dryland Crops:		152.13	109.66	105.96
34	http://agecoext.tamu.edu/resources/crop-livestock-budgets.html				
35	Visit this site to review/update cost estimates for additional costs				

YIELD_CALC | PROFIT | IRRG COST CALC | REPORT

Ready CAPS NUM

Figure 13: Profit Analysis of Irrigated Crops

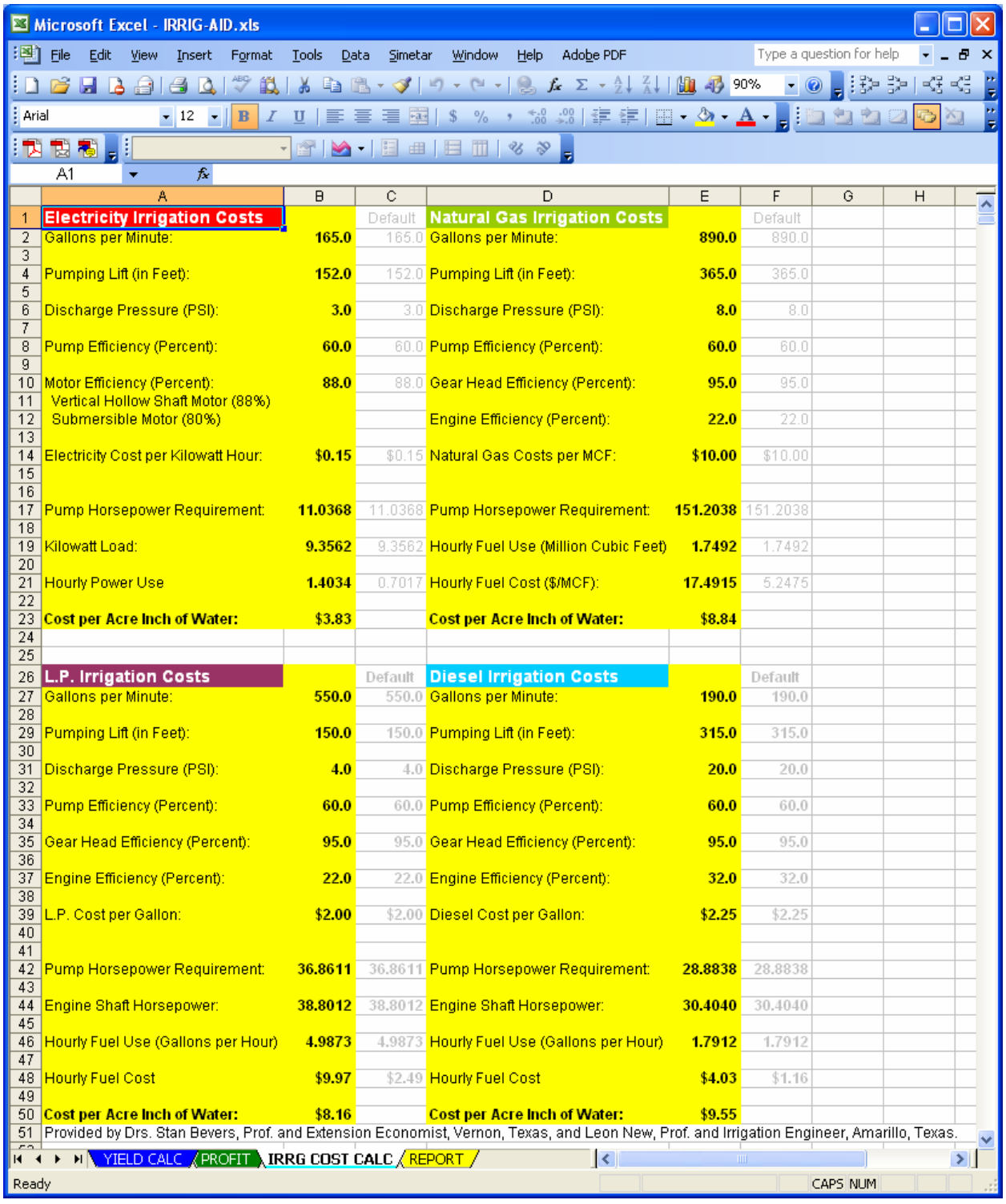
PROFIT ANALYSES

The **PROFIT** analysis sheet is used to calculate the user's profits for each of the competing crops. In the first section of the profit sheet, net income/acre is calculated based on the applied amounts of irrigation and yields calculated from the associated irrigation amounts on the **YIELD CALC** sheet. If no irrigations were applied, as in our example for grain sorghum, then the income from the dryland yield will appear. In the second section of the profit sheet, the user may enter the expenses (per acre) and finally, the last section calculates the total net income by crop. The second section, Expenses, requires input from the user as indicated in blue lettering and/or blue bordered cells or boxes:

1. Enter Irrigation Cost or Calculate Pumping Cost

The user enters a flat rate for irrigation cost (cost per acre/inch) in cell E17 if there is no energy requirement for pumping as in cases of multiple irrigation district flat rate charges (Figure 13). Alternately, for a pumping cost of irrigation, the user must enter the fuel type from the drop down menu in cell B17 and a default irrigation cost using the specified fuel type will appear in cell C17. However, with energy prices being volatile, the user should always check the fuel price in the ***Irrigation Cost Calculator.*** Click **IRRG COST CALC** to customize fuel prices and other pumping plant specifications (Figure 14).

In addition to checking the specific fuel price, the user should make appropriate pumping plant adjustments including pumping lift, discharge pressure, engine or electric motor horsepower, design specifications on gear heads (turbine pumps) and engines, and fuel price. Thus, the **IRRG COST CALC** tab/sheet allows the user to customize pumping plant information and recalculate irrigation costs using specific fuels including electricity, gas, L.P. or natural gas.



Microsoft Excel - IRRIG-AID.xls

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	A	B	C	D	E	F
1	**Electricity Irrigation Costs**		Default	**Natural Gas Irrigation Costs**		Default
2	Gallons per Minute:	**165.0**	165.0	Gallons per Minute:	**890.0**	890.0
4	Pumping Lift (in Feet):	**152.0**	152.0	Pumping Lift (in Feet):	**365.0**	365.0
6	Discharge Pressure (PSI):	**3.0**	3.0	Discharge Pressure (PSI):	**8.0**	8.0
8	Pump Efficiency (Percent):	**60.0**	60.0	Pump Efficiency (Percent):	**60.0**	60.0
10	Motor Efficiency (Percent):	**88.0**	88.0	Gear Head Efficiency (Percent):	**95.0**	95.0
11	Vertical Hollow Shaft Motor (88%)					
12	Submersible Motor (80%)			Engine Efficiency (Percent):	**22.0**	22.0
14	Electricity Cost per Kilowatt Hour:	**$0.15**	$0.15	Natural Gas Costs per MCF:	**$10.00**	$10.00
17	Pump Horsepower Requirement:	**11.0368**	11.0368	Pump Horsepower Requirement:	**151.2038**	151.2038
19	Kilowatt Load:	**9.3562**	9.3562	Hourly Fuel Use (Million Cubic Feet)	**1.7492**	1.7492
21	Hourly Power Use	**1.4034**	0.7017	Hourly Fuel Cost ($/MCF):	**17.4915**	5.2475
23	**Cost per Acre Inch of Water:**	**$3.83**		**Cost per Acre Inch of Water:**	**$8.84**	
26	**L.P. Irrigation Costs**		Default	**Diesel Irrigation Costs**		Default
27	Gallons per Minute:	**550.0**	550.0	Gallons per Minute:	**190.0**	190.0
29	Pumping Lift (in Feet):	**150.0**	150.0	Pumping Lift (in Feet):	**315.0**	315.0
31	Discharge Pressure (PSI):	**4.0**	4.0	Discharge Pressure (PSI):	**20.0**	20.0
33	Pump Efficiency (Percent):	**60.0**	60.0	Pump Efficiency (Percent):	**60.0**	60.0
35	Gear Head Efficiency (Percent):	**95.0**	95.0	Gear Head Efficiency (Percent):	**95.0**	95.0
37	Engine Efficiency (Percent):	**22.0**	22.0	Engine Efficiency (Percent):	**32.0**	32.0
39	L.P. Cost per Gallon:	**$2.00**	$2.00	Diesel Cost per Gallon:	**$2.25**	$2.25
42	Pump Horsepower Requirement:	**36.8611**	36.8611	Pump Horsepower Requirement:	**28.8838**	28.8838
44	Engine Shaft Horsepower:	**38.8012**	38.8012	Engine Shaft Horsepower:	**30.4040**	30.4040
46	Hourly Fuel Use (Gallons per Hour)	**4.9873**	4.9873	Hourly Fuel Use (Gallons per Hour)	**1.7912**	1.7912
48	Hourly Fuel Cost	**$9.97**	$2.49	Hourly Fuel Cost	**$4.03**	$1.16
50	**Cost per Acre Inch of Water:**	**$8.16**		**Cost per Acre Inch of Water:**	**$9.55**	
51	Provided by Drs. Stan Bevers, Prof. and Extension Economist, Vernon, Texas, and Leon New, Prof. and Irrigation Engineer, Amarillo, Texas.					

YIELD CALC | PROFIT | IRRG COST CALC | REPORT

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Figure 14: Irrigation Cost Calculator

2. Select Irrigation Cost per Inch

The next step is to select the irrigation cost per inch or select between the costs from the ***Irrigation Cost Calculator*** on the **IRRG COST CALC** tab/sheet or the flat rate cost entered by the user. This is done in cell B20 and facilitates the calculation of irrigation cost per inch on a crop-by-crop basis. The irrigation cost by crop is then calculated in cells C20, D20, and E20.

3. Fertilizer Unit Cost ($/lb)

Fertilizer cost per pound must be entered and the associated costs by crop will be calculated based upon this entry. This cost is for nitrogen fertilizer ***ONLY***. The cost of any other fertilizer applied may be entered in the next step.

4. Mixed Fertilizer Cost ($/ac)

If any other fertilizers including a mixed fertilizer were used, the user would enter the cost of those additional fertilizers, ***EXCLUDING Nitrogen,*** here.

5. Additional Other Costs

The additional other costs include seed, labor, pesticides, fuel, and repairs. Do not include interest on operating capital. Examples of default costs have already been entered based on County extension information (http://agecoext.tamu.edu/budgets/district/12/2006/) but the user may change them as necessary. These costs are found in the footnote at the end of the **PROFIT** sheet:

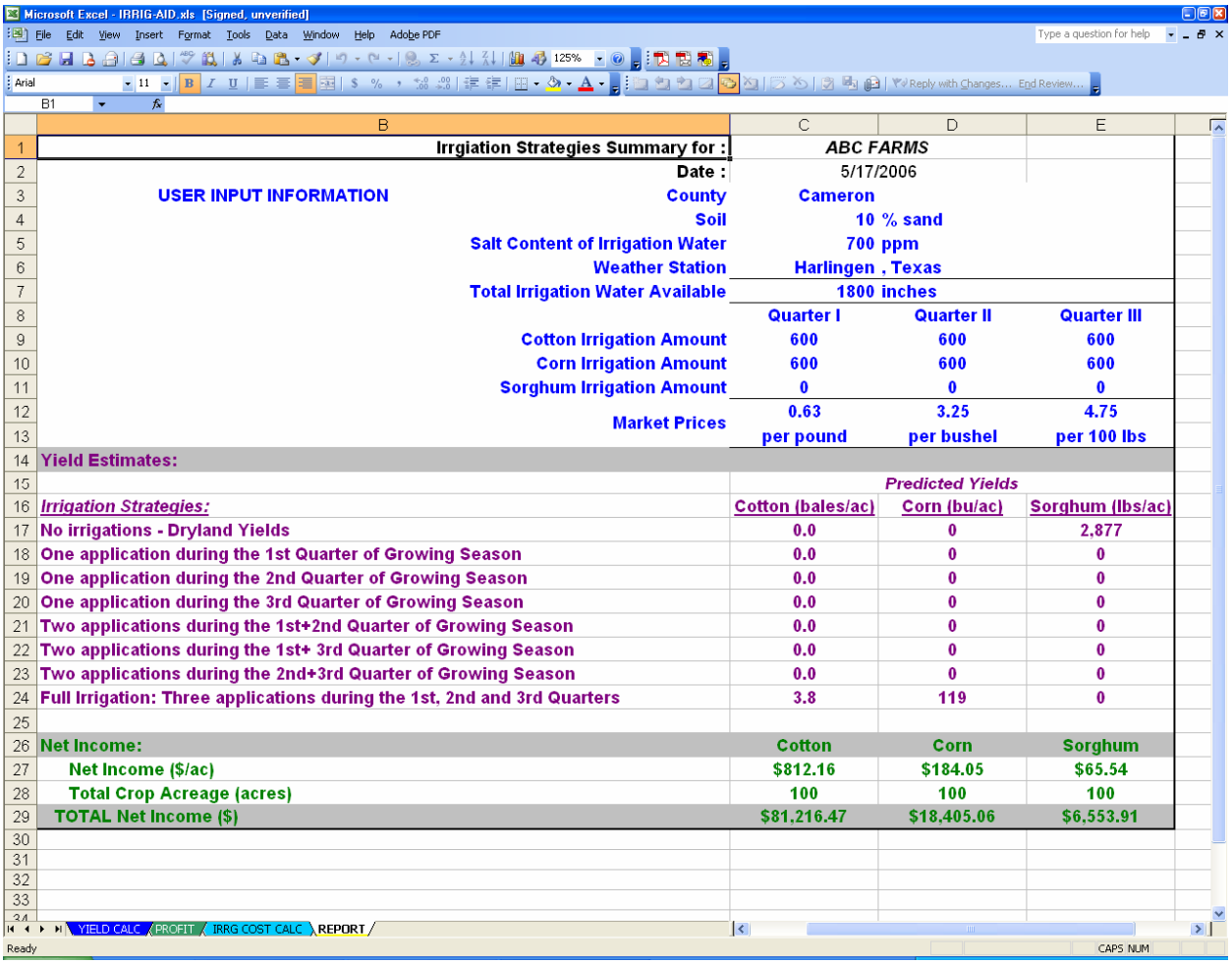
	Cotton	Corn	Sorghum
1/ Additional Costs for Irrigated Crops:	314.62	173.28	141.92
Additional Costs for Dryland Crops:	152.13	109.66	105.96

6. Interest Rate

An interest rate on operating costs is used to calculate the interest costs. This rate can represent the rate of borrowed capital or the "opportunity cost" of savings if owned capital is used for operating in lieu of being in a savings account or other type short-term investment. Since the loan period is typically less than or equal to 6 months, only that portion of the cost should be included. This calculates the interest on operating costs. After all of the expenses have been entered, the user will see the calculated net income based on the entries from both the **YIELD CALC** sheet and **PROFIT** sheet.

SUMMARY REPORT

Click the **REPORT** tab/sheet to preview the summary report (Figure 15). The user may print the report using the standard Windows printing procedure by selecting "Print" from the File Menu.



	B	C	D	E
1	**Irrgiation Strategies Summary for :**	*ABC FARMS*		
2	**Date :**	5/17/2006		
3	**USER INPUT INFORMATION** **County**	Cameron		
4	**Soil**	10 % sand		
5	**Salt Content of Irrigation Water**	700 ppm		
6	**Weather Station**	Harlingen , Texas		
7	**Total Irrigation Water Available**	1800 inches		
8		**Quarter I**	**Quarter II**	**Quarter III**
9	**Cotton Irrigation Amount**	600	600	600
10	**Corn Irrigation Amount**	600	600	600
11	**Sorghum Irrigation Amount**	0	0	0
12	**Market Prices**	0.63	3.25	4.75
13		per pound	per bushel	per 100 lbs
14	**Yield Estimates:**			
15			*Predicted Yields*	
16	*Irrigation Strategies:*	Cotton (bales/ac)	Corn (bu/ac)	Sorghum (lbs/ac)
17	No irrigations - Dryland Yields	0.0	0	2,877
18	One application during the 1st Quarter of Growing Season	0.0	0	0
19	One application during the 2nd Quarter of Growing Season	0.0	0	0
20	One application during the 3rd Quarter of Growing Season	0.0	0	0
21	Two applications during the 1st+2nd Quarter of Growing Season	0.0	0	0
22	Two applications during the 1st+ 3rd Quarter of Growing Season	0.0	0	0
23	Two applications during the 2nd+3rd Quarter of Growing Season	0.0	0	0
24	Full Irrigation: Three applications during the 1st, 2nd and 3rd Quarters	3.8	119	0
25				
26	**Net Income:**	**Cotton**	**Corn**	**Sorghum**
27	Net Income ($/ac)	$812.16	$184.05	$65.54
28	Total Crop Acreage (acres)	100	100	100
29	**TOTAL Net Income ($)**	$81,216.47	$18,405.06	$6,553.91

Figure 15: Summary Report

APPENDIX: ESITMATED REGRESSION EQUATIONS

Cotton:

$$Y_{CT} = -0.5657 + 0.01836\ \text{PRCP} - 0.00021609\ \text{PRCP}^2 + 0.03847\ \text{SAND} - 4.25\text{E}-04\ \text{SAND}^2 - 6.80\text{E}-08\ \text{SALT}^2 - 0.00573\ \text{FERT}_N + 0.00009212\ \text{FERT}_N^2 + 0.18771\ \text{IRGQ}_1 + 0.08602\ \text{IRGQ}_2 + 0.20636\ \text{IRGQ}_3 - 0.00713\ \text{IRGQ}_1^2 + 0.00878\ \text{IRGQ}_2^2 - 0.00454\ \text{IRGQ}_3^2 - 0.00003008\ (\text{PRCP} * \text{SAND}) - 0.00090535\ (\text{SAND} * \text{IRGQ}_1) - 0.00027997\ (\text{SAND} * \text{IRGQ}_2) + 0.00009717\ (\text{SAND} * \text{IRGQ}_3) + 1.16\text{E}-04\ (\text{SAND} * \text{FERT}_N) - 1.30\text{E}-08\ (\text{SAND} * \text{FERT}_N)^2$$

$$R^2 = 0.9300$$

Corn:

$$Y_{CN} = -73.95672 + 1.67683\ \text{PRCP} - 0.02226\ \text{PRCP}^2 - 0.00278\ \text{SAND}^2 - 0.00000352\ \text{SALT}^2 + 0.93042\ \text{FERT}_N - 0.00093166\ \text{FERT}_N^2 + 10.91003\ \text{IRGQ}_1 + 13.01075\ \text{IRGQ}_2 + 12.64652\ \text{IRGQ}_3 - 0.19613\ \text{IRGQ}_1^2 - 0.30529\ \text{IRGQ}_2^2 - 0.46789\ \text{IRGQ}_3^2 - 0.03544\ (\text{SAND} * \text{IRGQ}_1) - 0.01925\ (\text{SAND} * \text{IRGQ}_2) - 0.01651\ (\text{SAND} * \text{IRGQ}_3) + 0.01215\ (\text{SAND} * \text{FERT}_N) - 5.6374\text{E}-07\ (\text{SAND} * \text{FERT}_N)^2 - 0.00354\ (\text{PRCP} * \text{SAND}) - 4.129\text{E}-10\ (\text{SALT} * \text{FERT}_N)^2 - 0.09673\ (\text{IRGQ}_1 * \text{FERT}_N) - 0.12741\ (\text{IRGQ}_2 * \text{FERT}_N) - 0.09038\ (\text{IRGQ}_3 * \text{FERT}_N) + 0.00003375\ (\text{IRGQ}_1 * \text{FERT}_N)^2 + 0.00005077\ (\text{IRGQ}_2 * \text{FERT}_N)^2 + 0.00003409\ (\text{IRGQ}_3 * \text{FERT}_N)^2 + 0.0002159\ (\text{SALT} * \text{IRGQ}_1)$$

$$R^2 = 0.8254$$

Grain Sorghum:

$$Y_{GS} = -902.17002 + 60.82618\ \text{PRCP} - 0.72885\ \text{PRCP}^2 + 84.07226\ \text{SAND} - 0.88736\ \text{SAND}^2 - 0.00019841\ \text{SALT}^2 + 18.19746\ \text{FERT}_N + 489.06582\ \text{IRGQ}_1 + 260.78004\ \text{IRGQ}_2 + 275.88367\ \text{IRGQ}_3 - 46.93631\ \text{IRGQ}_1^2 - 18.4113\ \text{IRGQ}_2^2 - 14.97199\ \text{IRGQ}_3^2 - 0.11651\ (\text{PRCP} * \text{SAND}) - 1.06825\ (\text{SAND} * \text{IRGQ}_1)^2 + 0.94025\ (\text{SAND} * \text{IRGQ}_2)^2 + 1.319\ (\text{SAND} * \text{IRGQ}_3)^2 - 0.20497\ (\text{SAND} * \text{FERT}_N) + 0.0000018\ (\text{SAND} * \text{FERT}_N)^2$$

$$R^2 = 0.8704$$

Model Parameter Description:

Variable Name	Description	Units
PRCP	Precipitation	inches
SAND	Sand Content in Topsoil	percent
SALT	Salt Content in Irrigation Water	parts per million
$FERT_N$	Nitrogen Fertilizer	lbs/acre
$IRGQ_1$	Irrigation Amount in Quarter 1	inches
$IRGQ_2$	Irrigation Amount in Quarter 2	inches
$IRGQ_3$	Irrigation Amount in Quarter 3	inches