

WATER AND NITROGEN MANAGEMENT USING CROPFLEX

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INTRODUCTION

Water and nitrogen are two crucial inputs in crop production that should be managed together. Deficiency of either input will result in yield reduction while over application of one or both will result in environmental pollution and eventually hurt the producer's bottom line. Over application of water results in deep percolation namely water percolates below the crops effective root zone and eventually reaches the ground water. Most of the nitrogen in the soil is in the form of Nitrate which is water soluble and moves with the water. The more nitrogen in the soil the more nitrate will be leached with each inch of deep percolated water. Therefore the goal is to apply the right amounts of water and nitrogen that satisfy crop requirements so minimum leaching will occur. Cropflex is a computer program that was designed to help producers achieve this goal. The goal of Cropflex is to provide irrigation and fertility management advice to assist producers in maintaining or increasing yields while minimizing the potential of water deep percolation and leaching nitrates. Cropflex is a decision support tool that integrates knowledge of experts, acquired field experience and research results and allow the user to have the benefit of employing this knowledge and complex processes that the model simulates without the need to understand them. The big advantage of such programs is that they afford the user to make decisions based on vast experience and accumulated knowledge without the need to acquire it. Cropflex encompasses years of knowledge research and experimentation and is ready to be used by producers for irrigation and fertilizers management.

PROGRAM OVERVIEW

Cropflex has a modular design and is composed of four main modules: irrigation management, fertilizer management, yield prediction, and leaching assessment modules. General location, soil, and crop information are stored in the system databases that are shared by all modules. The three modules pass information to each other to arrive at the desired recommendations. Several files are generated by the program in which location and field specific information are stored. The

software is a Windows 95 program and requires 3 megabytes of hard disk memory.

The program and documentation can be downloaded from the following web site:
<http://ccc.atmos.colostate.edu/~crop/>

Follow the instructions on the web site to download the program file and a crop data base "crop.db". A user manual is also available with detailed instructions of how to run and use the program. The user manual is saved as a zipped file and after downloading it should be unzipped before it can be read using "word". You can download a zip program "win.zip" from the link provided in our web site. Follow the user's manual for detailed instructions of how to use the program.

The knowledge used to drive the model's reasoning processes is located in a series of knowledge base files. These files remain external to the program itself so that the knowledge base can be customized as better or additional information (such as adding new crops) becomes available. Similarly, the program's knowledge of nitrogen, phosphorus, and potassium fertilizer materials is contained in a series of fertilizer library files. These libraries also can be accessed to change, delete, or add additional fertilizers to the system's knowledge.

IRRIGATION MANAGEMENT WITH CROPFLEX

Irrigation scheduling or the decision of when and how much to irrigate is done by Cropflex based on a soil water mass balance approach and the concept of a critical soil water content (depletion) level to trigger irrigation recommendations. Namely the program calculates the daily soil water balance and uses a critical level, which depends on the crop and the growth stage of the crop to trigger irrigation recommendation. Crop information and the critical soil water levels for each growth stage are stored in the crop data base which can be edited to adjust to local conditions. The soil water balance is calculated using daily climatic data to estimate crop water requirements (ET) using one of four ET models (users choice). Real time daily weather information is available on the CSU web site for different locations in Colorado. **<http://ccc.atmos.colostate.edu>**

The program displays the daily water balance in a tabular format and shows the daily water balance in the effective root zone. On the day that the available water in the root zone falls below the critical level the program displays a red faucet icon on the left side of the screen to indicate that irrigation is needed. If irrigation is not needed the program will forecast the water balance for the next few days to let the user know when the next irrigation will be needed. The information that the program displays can be used in different ways to aid in the irrigation decision making. If the information that you have to enter into the program is accurate and reliable you can simply follow the program's recommendations. It is recommended to initially verify the program's water balance calculations by monitoring the soil water content in the field and comparing it to the program's calculations. Or the

program's calculations can be used as an indication of when to start monitoring the soil water content in the field and make a decision based on field observations. In this case the water balance calculations can aid in the decision of how much to apply.

Once an irrigation is applied in the field it can be entered into the program by clicking on the corresponding date. A screen will pop up in which the amount applied can be entered. In the same screen the crop growth stage can be adjusted to actual growth stage observed in the field by selecting the appropriate stage from the pull down menu. Soil moisture can also be adjusted in the same screen to real field conditions, if available. These adjustments allow the user to correct the program estimations during the season to bring them closer to real life conditions.

CropFlex - corn01 - (Field:corn Location:rocky ford)										
Field	Crop	Growth Stage	Soil Moisture(n)	Next Irrigation	Irrigation Amount(n)					
corn	CORN	R6: Maturity	8.89	07/31/01 (ASAP)						
corn01 - (Field:corn Location:rocky ford)										
Date	GDD(°F)	Growth Stage	Root Depth(in)	Crop ET(in)	Eff. Irrig(in)	Rain(in)	Current Deficit(in)	Critical Deficit(in)	Irrigation needed(n)	
05/21/01	613	V7-18: Later L...	30.3	0.22		0.0	0.73	2.86		
05/22/01	628	V7-18: Later L...	30.8	0.22			0.95	2.92		
05/23/01	644	V7-18: Later L...	31.4	0.23			1.18	2.97		
05/24/01	658	V7-18: Later L...	32.0	0.25			1.43	3.02		
05/25/01	669	V7-18: Later L...	32.5	0.19			1.62	3.08		
05/26/01	695	V7-18: Later L...	33.1	0.20		0.1	1.75	3.13		
05/27/01	702	V7-18: Later L...	33.7	0.21			1.96	3.18		
05/28/01	718	V7-18: Later L...	34.2	0.22			2.19	3.24		
05/29/01	738	V7-18: Later L...	34.8	0.23			2.42	3.29		
05/30/01	751	V7-18: Later L...	35.4	0.18			2.60	3.34		
05/31/01	767	V7-18: Later L...	35.9	0.24			2.84	3.40		
06/01/01	785	V7-18: Later L...	36.5	0.28			3.12	3.45		
06/02/01	805	V7-18: Later L...	37.1	0.33		0.6	2.84	3.50		
06/03/01	820	V7-18: Later L...	37.6	0.24			3.08	3.56		
06/04/01	834	V7-18: Later L...	38.2	0.21			3.28	3.61		
06/05/01	850	Vt: Tasseling	38.8	0.27			3.55	3.66		
06/06/01	872	Vt: Tasseling	39.3	0.30			3.85	3.72	4.5	
06/07/01	894	Vt: Tasseling	39.9	0.25		0.4	3.71	3.77		
06/08/01	914	Vt: Tasseling	40.5	0.25			3.96	3.82	4.7	
06/09/01	933	Vt: Tasseling	41.0	0.32	2.5		1.73	3.88		
06/10/01	956	Vt: Tasseling	41.6	0.40			2.13	3.93		
06/11/01	979	Vt: Tasseling	42.2	0.44			2.56	3.99		
06/12/01	1002	Vt: Tasseling	42.7	0.43			2.99	4.04		
06/13/01	1019	Vt: Tasseling	43.3	0.32		0.1	3.25	4.09		
06/14/01	1031	Vt: Tasseling	43.8	0.30			3.55	4.15		
06/15/01	1050	Vt: Tasseling	44.4	0.32			3.87	4.20		
06/16/01	1068	Vt: Tasseling	45.0	0.38			4.25	4.25		
06/17/01	1090	Vt: Tasseling	45.5	0.41			4.66	4.31	5.5	
06/18/01	1111	Vt: Tasseling	46.1	0.42			5.07	4.36	6.0	
06/19/01	1127	Vt: Tasseling	46.7	0.24	2.5		2.76	4.41		
06/20/01	1146	R1: Silking	47.2	0.30		0.7	2.35	4.47		
06/21/01	1164	R1: Silking	47.2	0.25			2.60	4.47		
06/22/01	1185	R1: Silking	47.2	0.29			2.89	4.47		
06/23/01	1207	R1: Silking	47.2	0.32			3.21	4.47		
06/24/01	1229	R1: Silking	47.2	0.40			3.62	4.47		
06/25/01	1253	R1: Silking	47.2	0.37			3.99	4.47		
06/26/01	1278	R1: Silking	47.2	0.32			4.31	4.47		
06/27/01	1300	R1: Silking	47.2	0.33			4.64	4.47	5.5	

FERTILIZER MANAGEMENT WITH CROPFLEX

Cropflex can help the user decide how much Nitrogen (N) Phosphorus (P) and Potassium (K) to apply. P and K decisions are made on a seasonal basis. At the beginning of the season the user can consult the program and decide how much P and K he should apply to finish the crop. N consultations can be done on a seasonal basis and can be corrected in the middle of the season or a daily N balance in the soil displayed by the program can be used to apply N as needed.

In order to arrive at the NPK recommendations the program asks the user a series of questions during the fertilizer consultation, which is done at the beginning of the season or when a field is created in the program. The information that the program gathers includes soil test results, previous crop information tillage practices, field conditions and other information that is important for making the fertilizer recommendations. At the end of the information gathering session a fertilizer recommendation, NPK amounts to apply, is made. To finish the fertilizer recommendation session the program walks the user through a fertilizer raw material application, calculations. The user can specify which raw materials for fertilizing he wants to use and the program will calculate and display the amounts needed to supply the recommended amounts of NPK.

The calculated residual N in the soil is used as the initial N in the soil daily N balance. The daily N balance is recommended for producers that can apply N through the irrigation system. By using the daily N balance the user can manage N applications apply the minimum needed to satisfy crop requirement and thus minimize nitrate leaching.

For corn the program has another feature that makes N recommendations more accurate. A yield prediction model was developed and imbedded in the program. This model can predict the end of season corn yield after the first eight weeks of the season. The model uses the number of accumulated Growing Degree Days (GDD), planting date and plant population to predict the end of season yield. Having an educated guess of the end of season yield help the program and the user fine tune, N applications to actual crop requirements.

The daily N balance is displayed on the screen alongside the daily water balance. The first column after the date is the N available in the root zone for crop use and in case of deep percolation because of heavy rain or irrigation, for leaching also. If N was added the net amount can be added to the daily balance by clicking on the corresponding date. The last column indicates the amount of N leached because of deep percolation. This amount depends on the N available for leaching and the amount of deep percolation. The more N in the root zone the more it will be leached. Therefore using the daily N balance for "spoon feeding" is a recommended approach.

Applying N when the soil N reaches a low level and keeping the amount of N in the soil below a certain upper limit will help minimize leaching.

Location: rocky ford			
Soil Moisture(in)	Next Irrigation	Irrigation Amount(in)	
8.90	07/31/01 (ASAP)		

Date	N.Available(lbs/Acre)	N.App(lbs/Acre)	Crop Uptake(lbs/Acre)	Deep Perc(in)	N.Leached(lbs/Acre)
05/21/01	76		24		
05/22/01	75		26		
05/23/01	74		27		
05/24/01	73		28		
05/25/01	71		29		
05/26/01	70		31		
05/27/01	69		32		
05/28/01	67		34		
05/29/01	66		36		
05/30/01	64		37		
05/31/01	62		39		
06/01/01	61		41		
06/02/01	59		43		
06/03/01	57		45		
06/04/01	55		46		
06/05/01	53		48		
06/06/01	52		51		
06/07/01	49		53		
06/08/01	46		56		
06/09/01	44		58		
06/10/01	42		61	1.3	6
06/11/01	33		64		
06/12/01	80	50	66		
06/13/01	77		68		
06/14/01	75		70		
06/15/01	74		72		
06/16/01	71		75		
06/17/01	69		78		
06/18/01	66		81		
06/19/01	63		83		
06/20/01	61		85		
06/21/01	58		88		
06/22/01	56		90		
06/23/01	53		93		
06/24/01	50		96		
06/25/01	47		100		
06/26/01	44		103		
06/27/01	40		106		

ET CALCULATIONS

ET, which is the daily crop water use, is calculated on a daily basis using weather information entered by the user or downloaded from the CSU web site. The program has four optional models to calculate ET. The user can select his choice at any time, however the needed weather information for the specific model should be available. The daily weather information and the calculated daily ET are displayed in the daily weather table. The computer screen is divided into three sections to allow the program to display three tables at the same time. An irrigation need summary table, the daily weather table and the daily water and

N balance tables. This way the user can see all the information on one screen and draw his own conclusions.

CROP SOIL AND LOCATION INFORMATION

The program has three data bases, which can be edited by the user to change add or delete information. The crop data base includes information on the crop water use, root zone depth, growth stages and the corresponding sensitivity to water stress, and fertility information. Some of the crop information is represented in mathematical formulas, therefore it is recommended to consult a professional or the author before attempting to create a new crop. The soil data base includes the soil's water holding capacity information. The location information includes locations where weather stations are available and includes information needed for ET calculations.

SUMMARY

Cropflex is a decision support tool that combines water and fertility management. The program is flexible enough to be used in different management scenarios. Among the features that make the program flexible are the different display options, choice of units and models, ability to adjust the program's estimations to the observed parameters and other adjustments as outlined in the users manual. The author provides support and guidance in using the program for any interested party.

CropFlex - com01 - (Field:corn Location: rocky ford)

File Edit Databases Consult View Window Help



Field	Crop	Growth Stage	Soil Moisture(n)	Next Irrigation	Irrigation Amount(n)
corn	CORN	R6: Maturity	8.90	07/31/01 (ASAP)	

Date	Rain(n)	Tmin(°F)	Tmax(°F)	SolarRad(cal/cm2 day)	Min RH(%)	Max RH(%)	WindSpd(mi/day)	Etr(n)
05/02/01		41.5	61.4	155.8	46	95	69.8	0.08
05/03/01		38.6	44.7	116.2	77	98	28.2	0.04
05/04/01	0.6	40.1	45.8	84.1	83	99	170.1	0.04
05/05/01	0.5	39.3	49.3	149.8	79	98	158.9	0.06
05/06/01		38.3	66.4	700.3	32	99	142.4	0.24
05/07/01		41.6	66.4	532.3	46	97	104.5	0.18
05/08/01		45.3	80.2	731.8	14	97	80.8	0.27
05/09/01		49.0	89.3	697.4	8	91	91.7	0.31
05/10/01		46.4	88.5	604.2	10	93	119.4	0.31
05/11/01		47.6	72.4	390.9	38	98	46.5	0.14
05/12/01		49.3	86.2	668.3	13	88	80.5	0.28
05/13/01		52.6	89.4	710.3	12	66	110.9	0.33
05/14/01		54.3	89.7	670.9	15	81	63.9	0.28
05/15/01		53.8	90.6	697.2	11	82	62.1	0.29
05/16/01	1.6	54.0	91.5	669.9	14	99	89.0	0.30
05/17/01	0.2	57.8	68.3	247.5	54	87	113.6	0.12

com01 - (Field:corn Location: rocky ford)

Date	GDD(°F)	Growth Stage	Root Depth(n)	Crop ET(n)	Eff. Irrig(n)	Rain(n)	Current Deficit(n)	Critical Def	Date	N.Available(lbs/Acre)	N.App(lbs/Acre)	Crop Uptake(lbs/Acre)
05/21/01	613	V7-18: Later L...	30.3	0.22		0.0	0.73		05/21/01	76		24
05/22/01	628	V7-18: Later L...	30.8	0.22			0.95		05/22/01	75		26
05/23/01	644	V7-18: Later L...	31.4	0.23			1.18		05/23/01	74		27
05/24/01	658	V7-18: Later L...	32.0	0.25			1.43		05/24/01	73		28
05/25/01	669	V7-18: Later L...	32.5	0.19			1.62		05/25/01	71		29
05/26/01	685	V7-18: Later L...	33.1	0.20		0.1	1.75		05/26/01	70		31
05/27/01	702	V7-18: Later L...	33.7	0.21			1.96		05/27/01	69		32
05/28/01	718	V7-18: Later L...	34.2	0.22			2.19		05/28/01	67		34
05/29/01	738	V7-18: Later L...	34.8	0.23			2.42		05/29/01	66		36
05/30/01	751	V7-18: Later L...	35.4	0.18			2.60		05/30/01	64		37
05/31/01	767	V7-18: Later L...	35.9	0.24			2.84		05/31/01	62		39
06/01/01	785	V7-18: Later L...	36.5	0.28			3.12		06/01/01	61		41
06/02/01	805	V7-18: Later L...	37.1	0.33		0.6	2.84		06/02/01	59		43
06/03/01	820	V7-18: Later L...	37.6	0.24			3.08		06/03/01	57		45
06/04/01	834	V7-18: Later L...	38.2	0.21			3.28		06/04/01	55		46
06/05/01	850	V7-18: Later L...	38.8	0.27			3.55		06/05/01	53		48

Cropflex is Ready

Windows taskbar showing Start button, system tray, and open applications: WATER AND NITR..., Yahoo! Finance - Mi..., Inbox - Outlook Ex..., CropFlex - com01..., Document2 - Micros... Time: 12:52 PM