VALIDATION OF CROPFLEX

A CROP MANAGEMENT PROGRAM

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Program Overview:

Cropflex is a flexible crop management computer program developed by the Department of Chemical and Bioresource Engineering and Cooperative Extension at Colorado State University. This easy to use tool provides irrigation and fertility management advice to assist producers maintain or increase yields while minimizing the potential of leaching nitrates into the groundwater. Studies have shown that costly applications of fertilizer can be substantially reduced without reducing yield. Cropflex is a decision support system based on heuristic as well as procedural knowledge.

Cropflex handles a variety of crops as long as the crop basic information exists in the program data base. Basic crop information has been developed for corn, alfalfa, sorghum, onions, potatoes and barley. Entering adding additional crops to the data base is simple and straight forward. As a matter of fact, all the data bases of the program can be accessed by the user and crop; soil and weather station information can be edited or new information can be entered. The program was developed for use by a producer with minimal computer experience and has self explanatory and easy to understand pull down menus. Cropflex can be run in Windows 95 or Windows 3.11 environments and is user and producer friendly.

Cropflex for Windows is composed of four components: irrigation scheduler, fertility scheduler, yield prediction module and a leaching assessment module. The purpose of the irrigation scheduler is to recommend the amount and timing of irrigation applications. The irrigation scheduler uses a soil water mass balance approach to calculate the soil moisture within the crop root zone for every day of the growing season. The amount of water used by the crop is calculated from reference evapotranspiration methods and corrected by the crop coefficient stored in the crop data base. It then uses pre-set, critical soil moisture depletion levels to determine if the current soil moisture is dry enough to warrant irrigation.

The fertility scheduler provides nitrogen, phosphorus, and potassium nutrient recommendations. It tells the user when to fertilize and how much fertilizer to apply in order to supply the crop's nutrient needs. The fertility scheduler uses a series of different methods to arrive at its nitrogen recommendation, including: the Colorado State University soil test method, the Nebraska soil test method for corn, the inorganic nitrogen mass balance, or crop uptake efficiency methods. Phosphorus and potassium nutrient recommendations are based on the Colorado State University soil test method. After the

recommendation is made the program will help the user in scheduling fertilizer applications for the season, including calculating the amount of source material to be used at each application. Since the fertilizer recommendation is based on the end of season yield, the preseason fertilizer recommendation is only a guess. A model to predict the end of season yield based on the number of growing degree days at the first four to eight weeks of the season was developed and incorporated into Cropflex. New soil test results taken after planting can be entered and will provide mid season fertilizer recommendations based on the predicted end of season yield. It will also provide mid season fertilizer recommendations without a new soil test. So far end of season yield prediction is available only for corn crop.

The leaching module assesses the amount of nitrate leached under the proposed irrigation and fertility management scheme. Leaching assessment can be done in the middle of the season, usually after the first mid season fertilizer recommendations and again at the end of the season. Deep percolation, nitrate available for leaching, and nitrate leached are estimated by the model. The user can then assess her/his water and management practices and take corrective measures if needed. The leaching module also estimates the yield reduction sustained if the nitrogen fertilizer is reduced to eliminate the leaching problem.

Cropflex has been developed to be used by any person who is involved in crop management. Weather information can be imported by the program using several weather file formats, thus eliminating the need to type weather data manually. The Windows environment allows the user to keep several screens open at the same time so the user can see a weather screen as well as irrigation scheduling and leaching screens for several fields at the same time.

Objectives:

Cropflex was validated in a field experiment by comparing various decisions made by Cropflex with those made by a human expert. Irrigation water recommendations from Cropflex were compared with those of the human expert. This comparison indicates whether Cropflex is meeting crop requirements while not over applying water; thereby reducing the chance of nitrate leaching.

Fertilizer recommendations from Cropflex and the human expert were compared to determine whether Cropflex recommendations meet crop nutrient requirements while reducing excess nitrogen available for leaching. Preseason and post-season soil nitrate profiles were also compared to detect nitrate movement through the soil and any possible leaching that may have occurred during the season. The most important comparison was that of the final yields of the two management practices.

Procedure:

Twelve test plots at the United States Department of Agriculture's Research Station in

Akron, Colorado were planted on May 1st to the corn variety Pioneer 3893. Due to cold dry conditions germination didn't occur until after an one inch irrigation on May 15th. The planting density was 30,000 plants per acre. The distribution of the test plots to Cropflex or human expert management was randomized. Six of these plots were managed by a human expert, and six were managed by Cropflex. Each of the plots consisted of ten rows with a thirty inch row spacing and a length of 175 ft.

The soil was a silty loam with a field capacity of 4.57 in/ft and a permanent wilting point of 1.83 in/ft. Irrigations were applied on these plots using a buried drip system with an application rate of 0.26 inches per hour.

Results and Data Analysis:

A preseason fertilizer consultation was run to begin the field study for the Cropflex managed plots. Using a yield goal of 150 bu/acre and a composite soil sample taken before planting, Cropflex recommended 101 lbs/acre of nitrogen be applied as fertilizer. The midseason nitrogen correction estimated end-of-season yield at 156 bu/acre, recommending an additional 92 lbs/acre of nitrogen be applied to complete the growing season. This 92 lbs/acre plus the 20 lbs/acre applied during the preseason totaled 112 lbs/acre nitrogen for the entire season.

The human expert determined that for 150 bu/acre yield goal 180 lbs/acre nitrogen was needed to meet the crop requirement. From this 180 lbs/acre nitrogen, 47 lbs/acre were subtracted to credit residual soil nitrogen to produce a fertilizer recommendation of 132 lbs/acre nitrogen. The human expert then applied 20 lbs/acre of nitrogen and 15 lbs/acre phosphate before planting. During the season the human expert applied 132 lbs/acre nitrogen in five fertigations using ammonium nitrate for a total of 152 lbs/acre for the entire season. This amounts to 40 lbs/acre more nitrogen applied by the human expert than by Cropflex management (Table 1).

Table 1. Fertilizer Application Management Comparison.

Management	Yield Goal (bu/acre)	Recommendation (lbs/acre)	Nitrogen Applied (lbs/acre)
Human Expert Preseason	150	20	20
Human Expert Fertigations	150	132	132 (152 total)
Cropflex Preseason	150	101	20
Cropflex Midseason	156	92	92 (112 total)

The human expert recommended more frequent and larger irrigations on average (ten

applications, 1.77 inches per application) as compared with Cropflex management which recommended seven applications averaging 1.64 inches per application, Figure 1.

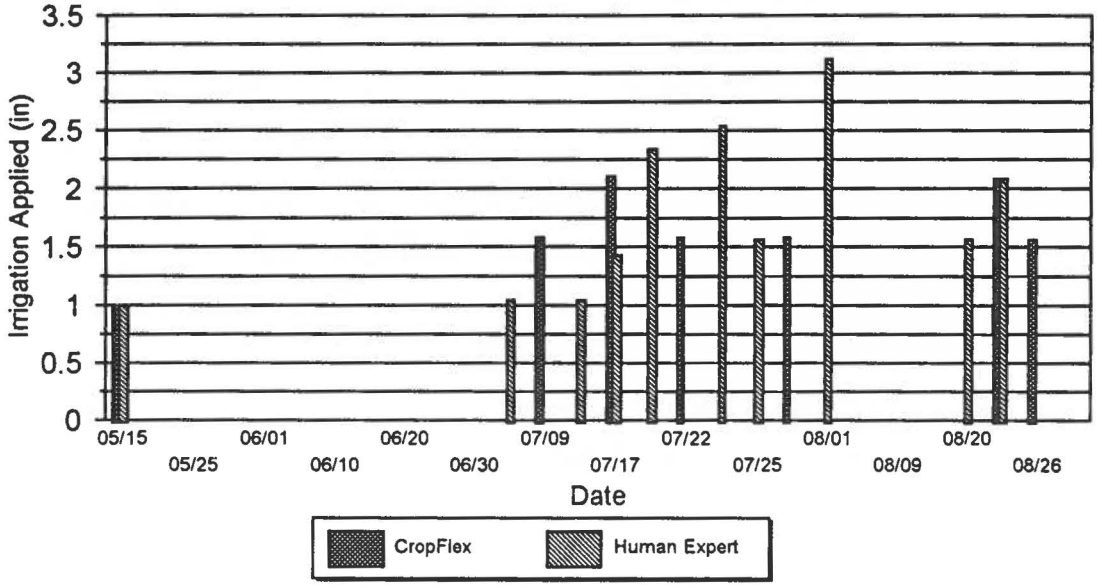

Figure 1. Irrigation Schedule.

The human expert applied a total of 17.7 inches of irrigation which is 6 inches more water than applied by Cropflex management (11.5 in), Table 2. This resulted in increased deep percolation by the human expert's management (4.2 inches) by more than 2 inches over Cropflex management (1.9 inches) as calculated by the Cropflex end-of-season leaching consultation.

Table 2. Total Irrigation Water Applied and Seasonal Evapotranspiration Comparison.

Management	Evapotranspiration (in)	Rain (in)	Irrigation (in)	Deep Percolation (in)
Cropflex	22.4	9.75	11.5	1.9
Human Expert	22.4	9.75	17.7	4.2

Prior to planting and after harvest, soil samples were taken to a ten foot depth and analyzed in one foot increments to monitor nitrate movement through the soil profile, Figures 2 & 3.

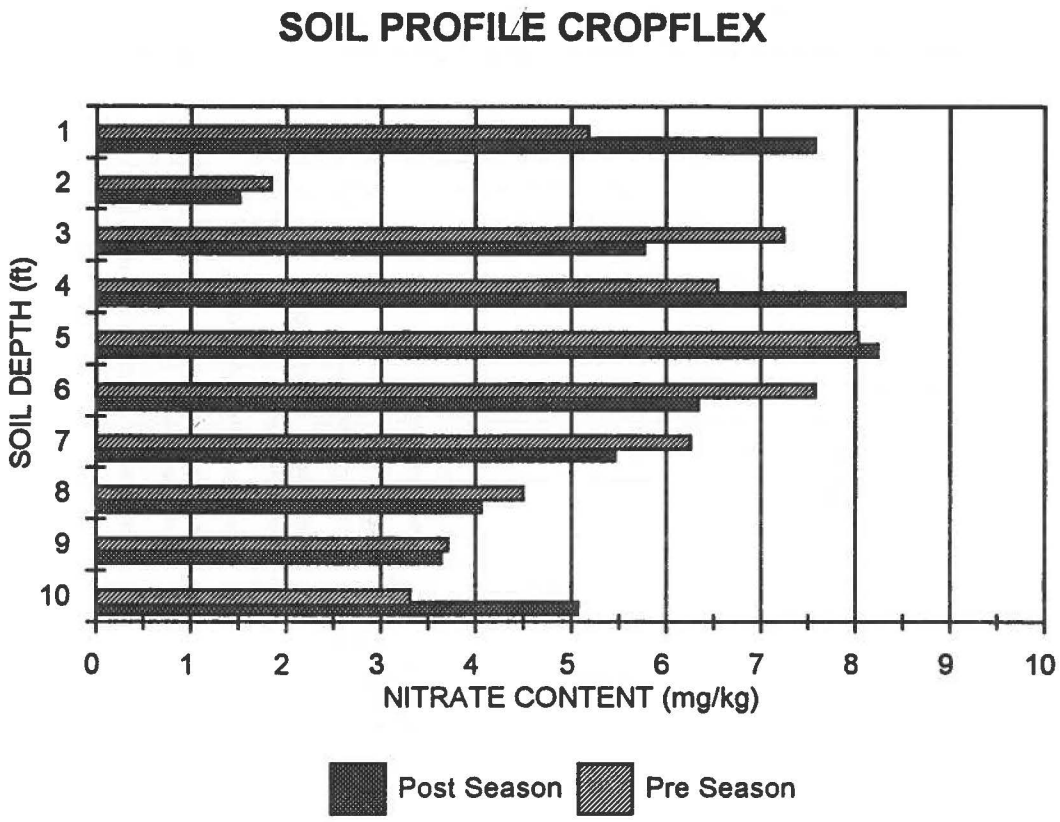

Figure 2. Cropflex Soil Nitrate Profile.

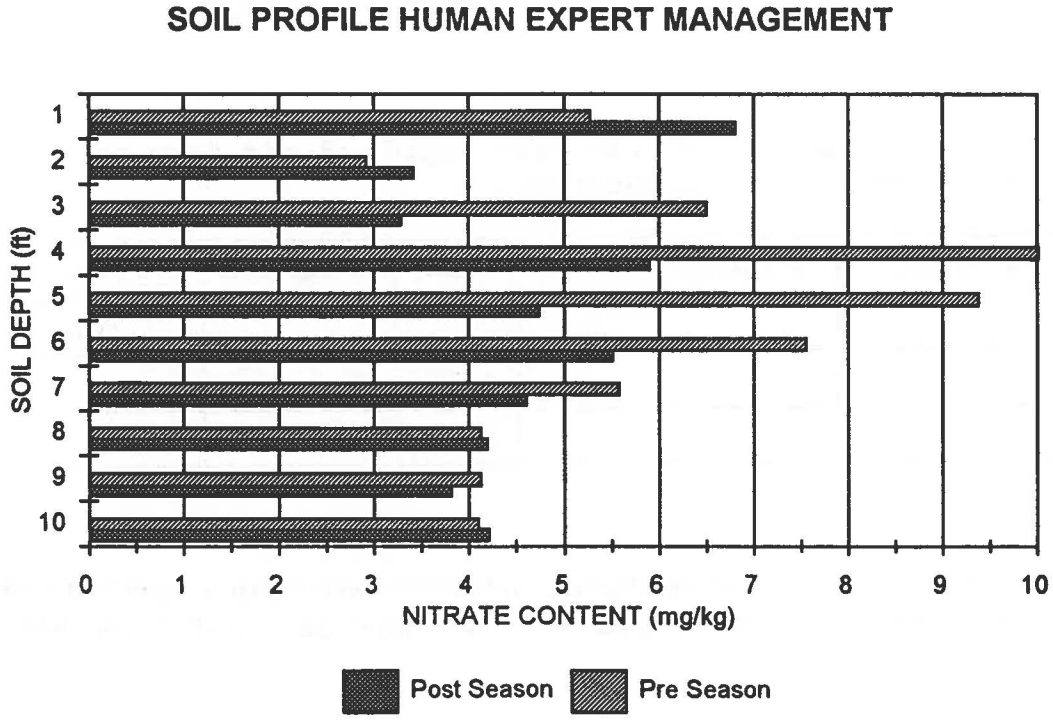

Figure 3. Human Expert Management Soil Nitrate Profile.

A general trend was observed where Cropflex managed plots leached smaller amounts of nitrates out of the soil profile (ten feet) and retained larger amounts of nitrates in the crop root zone (48 inches) when compared with plots managed by the human expert, Table 3. Despite this trend the differences are not statistically significant due to the variability of the plots and the large standard deviation of the measured levels of nitrates in the soil.

Table 3: Soil Nitrate Movement.

Management	Residual Root Zone Nitrate (48 inches) (lbs/acre) (90% CI)	Nitrate Leached Past Soil Profile (10 ft.) (lbs/acre) (90% CI)
Cropflex	83.8 (+ or - 17.9)	2.1 (+ or - 21.7)
Human Expert	69.4 (+ or - 31.6)	28.0 (+ or - 21.8)

Field observations during the season yielded no visible difference between the Cropflex and human expert managed plots and no signs of stress due to insufficient water or nutrients were observed.

Table 4. Final Yield Comparison.

Management	Average Yield (bu/acre)	Maximum Yield (bu/acre)	Minimum Yield (bu/acre)
Cropflex	123.1	140.8	96.2
Human Expert	122.5	134.4	103.7

The average final yields of both Cropflex and human expert management showed no significant difference at 123.1 bu/acre and 122.5 bu/acre, respectively, Table 4.

Discussion:

The two primary criteria set forth for Cropflex management were that it minimizes nitrate leaching potential while maintaining or increasing crop yield. The objective of this field test was to determine if Cropflex management meets these criteria.

The field test produced indications that Cropflex reduced nitrate leaching potential when compared with the human expert management. Cropflex management reduced the nitrate leaching potential by recommending smaller amounts of nitrogen fertilizer to be applied as compared to expert management. These smaller nitrogen applications reduce the amount of nitrogen available for leaching.

Cropflex also recommended less irrigation water be applied as compared to the amounts of irrigation applied by the human expert. The smaller amount of irrigation water applied reduced the potential for deep percolation past the maximum root zone.

The comparison of soil nitrate profiles taken prior to planting and after harvest showed a trend of increased leaching under human expert management when compared with Cropflex managed plots. However, these results were not statistically significant due to the high degree of variability and large standard deviations observed in the soil nitrate measurements.

The Cropflex managed plots average yield was equal to that of human expert managed plots. This therefore meets the second criterion set forth for Cropflex, that is, maintaining or increasing yield.