An Example of the Development of Microcomputer Technology for Crop Production Decisions

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In late 1979 the author learned of an effort to develop computer software for refining crop production management decisions. This effort was underway in Montana through 1982 when it was published as FLEXCROP: A Dryland Systems Model (2). The people developing this model were willing to share the concept with staff of the Cooperative Extension Service at North Dakota State University, who modified the concept some and presented their version, called CROPPAK (3), to Extension field staff in 1981.

During the 1981 growing season the ability of the CROPPAK software to predict harvested wheat yields using seeding time inputs was tested. The test was conducted on recrop sites at Minot and Williston Branch Experiment Stations. The variables tested were:

1. Extimated stored soil water at seeding time
2. Expected average growing season precipitation
3. Weed control
4. Disease control
5. Nitrogen fertilization
6. Variety selection

Disease control did not affect yield performance at these sites. As a result, the yield comparisons presented are an average of the two disease control treatments.

The ability of the model to predict final wheat yield averaged 93 percent accuracy for variety performance; 96 percent accuracy for fertilizer use, and 89 percent accuracy for weed control. The variety, nitrogen fertilizer and weed control results for the sites are given in Table 1.

CROPPAK predicted Solar should yield 15 percent more than Coteau at Williston. The yields obtained showed that Solar yielded 11.5 percent more than Coteau. Thus 15.0 − 11.5 = 3.5 percent less yield than projected.

At Minot, CROPPAK predicted Cando would out-yield Vic by 2 percent. Actual yields obtained were 34.3 bushels per acre for Cando and 33.8 for Vic. Thus Cando out yielded Vic by 1.5 percent.

The CROPPAK model did quite well in 1981 predicting harvest yields using seeding time inputs. Remember that these inputs were used several months before harvest. The Williston site was seeded on 4/24/81 and harvested on 8/12/81. The Minot site was seeded on 5/13/81 and harvested on 8/27/81. Weed infestation counts were made on 5/27/81 at Williston, and 5/28/81 at Minot. The expected yield reductions due to weed infestation were based in equations contained in Montana's FLEXCROP model (2).

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Table 1. 1981 CROPPAK Model Test

	Location/Variety Williston	
Subroutine	**Coteau**	**Solar**
	(bushels per acre)	
Variety		
Predicted	28.0	32.3
Obtained	29.6	33.0
% error	− 5.7	− 2.2
Fertilizer		
Predicted	29.4	33.9
Obtained	29.6	33.0
% error	− 0.7	+ 2.7
Weed Control		
Predicted	15.1	16.8
Obtained	13.0	15.6
% error	+ 13.9	+ 7.1

	Location/Variety Minot	
Subroutine	**Coteau**	**Solar**
	(bushels per acre)	
Variety		
Predicted	30.6	31.2
Obtained	33.8	34.3
% error	− 10.5	− 9.9
Fertilizer		
Predicted	31.7	32.3
Obtained	33.8	34.3
% error	− 6.6	− 6.2
Weed Control		
Predicted	26.4	26.8
Obtained	27.7	31.8
% error	− 4.9	− 18.7

These results led to further efforts to study microcomputer use and crop production software jointly financed by the Cooperative Extension Service and CENEX.

The goal of the Cooperative Extension Service was to have a plant science specialist capable of using available research data in computer programs to assist producers and agribusiness firms in development of crop production decisions involving combinations of inputs and have the capability of illustrating the effect of those input decisions on potential yield and probable economic results. The software needs expressed by CENEX included, "Another priority is a chemical or herbicide type program where we can put in major weeds, crop, soil type, pH, etc., and come up with the best combinations of chemicals for that particular field."

One of many ideas discussed about the feasibility of computer technology being used was to custom-blend fertilizer materials based on soil parameters as the applicator traveled a producer's field. This idea has now emerged, as evidenced by exerpts from a news release from Bader Rutter and Associates.

"The latest use of the computer—in this case, a microprocessor—is in blending and applying dry fertilizer right in the field, changing rates and blends as soil types in the field change.

"Developed by Soil Teq Inc. (STI) of Waconia, Minn., this process of custom blending fertilizers in the field is knows as the SOILECTION SYSTEM.

"STI begins with infrared color photographs of the area, each covering one square mile. Color changes, varying from light to dark, highlight changes in soil type or properties. Various soil types, depending on moisture and organic matter, appear as different colors on an infrared photo.

"For instance, in an infrared photo of a field the heavy, high organic matter soils will appear as dark colors; the sandy, low organic oils as light colors.

"This infrared photograph is then enhanced, using computer analysis, to produce a digitized soil map. This map uses colors to more clearly define different soil types in the field.

"From this digitized soil map, agronomists can sample and test different soil types, and make recommendations for the most ecnomical fertilizer mix to use. The digitized soil map can be re-used because soil types change slowly, except in severly eroded fields.

"The digitized map is stored on a computer PROM—or programmable read-only memory. This PROM, about an inch in size, is inserted in a microprocessor that sits in the cab of the application vehicle.

"The map is then displayed on a 15-inch computer monitor, which is also mounted in the cab. As the applicator moves about the field, its location flashes on the map displayed on the monitor. Currently this is done by setting up radio repeaters in the field that send signals to the microprocessor.

"Information that had been gathered about soil types and different fertilizer needs in the field has already been entered on the computer. As the applicator passes over different soil types, the microprocessor sends a signal to each of six fertilizer bins in the bed of the truck.

"The signal controls a hydraulic valve that operates starwheels at the bottom of each fertilizer bin, dispensing the right amount and blend of fertilizer required by the soil. Every time the soil type changes, the fertilizer blend changes.

"The net result is that the farmer fertilizes the soil, not the field. That should allow farmers to get more return for their dollar by increasing the efficiency of their farm management."

Information prepared by Dr. Dean Fairchild, manager of agri-production services for CENEX, gives some of the background that led to the production of the applicator. It also points out some of their future plants for this computer technology being used to refine crop production input decisions.

Says Fairchild, "Soil type information is important to farmers in the following crop production decisions: drainage; irrigation; crop suitability; yield goal determination; fertilizer rates, timing and placement; herbicide, rates and type; tillage; populations or stand and erosion.

"Efforts were started in 1983 to soil sample and adjust fertilizer rates by soil type, properties and yield goal. Initial research included flying infrared photography on various fields in western Minnesota and northeast North Dakota. Using these photos, soil survey maps, and computer digitalized maps, agronomists soil sampled various fields by "soil type." As a point of clarification, the use of the term "soil type" may not be correct in the true professional sense. Soil properties are identified by the sampling and photos that generally relate to soil type.

"Examples of soil nutrient variability by soil samples are shown in Table 2.

"Because of these soil nutrient differences within fields, farmers could obtain better yields and more efficiently put on fertilizer and chemical inputs if rates could be adjusted for these soil differences.

"The following example from a western Minnesota field shows these differences (Table 3). Yield goal, fertilizer rates and Bladex rates have been changed to reflect soil properties. In this example, using current fertilizer prices and corn at $2.50 per bushel, this farmer would have a net gain of $16 per acre by treating each soil separately.

"With these results, CENEX joined with an infrared photography company and manufacturing firm to form Soil Teq, Inc. (S.T.I.). S.T.I. has developed and patented a machine that will accept soil information and adjust rates and grades as the unit moves through the field.

Table 2. Soil Sample Results from Various Field Locations.

Sample Identification	Texture	pH	OM%	lbs/A NO_3-N	lbs/A P	lbs/A K	ppm Zn
	Soil Test Results						
1. Dark Soil- 9 acres	CL	7.4	3.6	41	36	359	1.0
Medium Soil-23 acres	L	7.1	2.9	32	34	277	0.5
Light Soil- 2 acres	SL	7.6	2.3	21	15	267	0.3
2. Dark Soil-40 acres	CL	6.9	3.4	92	41	427	3.0
Medium Soil-12 acres	CL	7.1	2.0	84	29	378	2.6
Light Soil- 1 acre	CL	7.9	1.3	20	14	298	1.5
3. Dark Soil-29 acres	SiL	7.9	4.4	20	10	246	0.8
Medium Soil-29 acres	SiL	7.9	2.8	12	15	277	1.0
Light Soil- 8 acres	L	8.3	1.2	5	9	253	0.3
4. Dark Soil-16 acres	M	7.3	10.7	—	57	280	2.8
Medium Soil-10 acres	L	7.6	3.9	—	90	432	2.2
Light Soil- 8 acres	SL	6.9	1.7	—	34	294	0.6

Table 3. Fertilizer-Chemical Inputs Matched to Soils.

Nutrient	Heavy	Soil Type Medium	Light
Yield goal (bu/A)	140	125	80
Texture	SiCL	L	SL
% O.M.	4.2	3.3	1.5
P lbs/A	29	20	11
K lbs/A	243	170	165
Zn ppm	.8	.4	.3
Acres	72	68	17
Fertilizer recommendation lbs/A	150 + 65 + 75	125 + 80 + 90 + 10Zn	75 + 40 + 40 + 10Zn
Bladex recommendation qts/A	4	3	2

"This machine includes a computer in the cab that allows for entering recommendations by soil needs. A cathode ray tube (CRT) continuously displays the field-soil image to the driver. Navigation systems are included to pinpoint the truck's location in relationship to soils.

"As soil conditions in the field change, the microprocessor sends signals to boxes at the back of the vehicle. The signal controls starwheels at the bottom of six fertilizer bins. The starwheels spin faster or slower creating the various rates needed. These materials are blended "on the go" and spread. This machine was tested in Minnesota last fall and this spring. Additional tests were conducted in Arizona during the winter of 1984-85.

"Testing of the machine will continue with four to five units in the field during the fall of 1985.

"Future plans are to expand the use of farmer soil maps on not only fertilizer applicators but on sprayers and planters for population control.

"The key to future success of this program will be the development of soil map data base for each farmer's field. This will be done by using Soil Conservation Service (SCS) maps, infrared photos and soil sampling."

This project is an example of how Extension and agribusiness can cooperate to develop technology that can help producers make production decisions. The challenge for the future is to develop needed software, based on local research wherever possible. Some of the local data still need to be collected but researchers in several disciplines already have past and present research data which could be programmed into computer software.

REFERENCES

1. Brun, Lynn J., "Spring Wheat-Evapotranspiration Response at Fargo in 1985," Department of Soil Science Research Report, No. 17, Agricultural Experiment Station, North Dakota State University, October, 1985.
2. Halvorson, A.D. and P.O. Kresge, "FLEXCROP: A Dryland Cropping Systems Model," U.S. Department of Agriculture Production Research Report No. 180, 1982.
3. Leholm, Arlen and E.H. Vasey, "CROPPAK", a short run crop enterprise analysis program available on AGNET - A Management Tool for Agriculture, Cooperative Extension Service, North Dakota State University, June, 1983.