CROPROD: A crop management computer model for undergraduate agronomy courses

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ABSTRACT

A crop management computer model was used as an exercise in a sophomore-level crop production course at the University of Nebraska-Lincoln. The model contains data for corn (Zea mays L.), grain sorghum (Sorghum bicolor L. Moench), soybean (Glycine max L. Merr.), and winter wheat (Triticum aestivum L. Thell.). Students are asked to input management decisions on fertilizer, lime, herbicide, variety, seeding rate, row spacing, planting date, and irrigation, if applicable. Decisions are based on soil and weed conditions supplied by the student or derived from the program. The model is described briefly, and student reactions to it are discussed. Student evaluations indicate the model is a valuable learning tool.

Additional index words: Computer-assisted learning, Computer simulation model, Crop production, Simulation.

Several studies have shown a need for increased student experience in field and laboratory exercise in addition to, or in place of, traditional lecture and laboratory methods of teaching (2, 6, 7). This practical experience is especially beneficial to students with non-farm backgrounds (4, 5, 10).

An excellent way to give students experience with problems and decisions involving agriculture is through the use of computer simulation models (1, 3, 8, 9, 11). These simulations give the student rapid feedback without the time and expense involved with actual crops or animals, and with the additional advantage of rapidly repeated experiences.

The purpose of this paper is to describe CROPROD, a crop management computer model used in Agronomy 204, Field Crop Production, a sophomore-level course at the University of Nebraska-Lincoln.

METHODS

Field Crop Production is a 3-credit-hour course consisting of 3 h of lecture per week and no laboratory. Approximately 80 to 100 students enroll in the course each semester. Most students in the course are sophomores and juniors with a few freshmen and seniors. About 90% of all students have direct farm experience. About midway through the semester the students are required to complete an exercise using CROPROD, a computer program on the AGNET System. AGNET is a regional computer network based at the Institute of Agriculture and Natural Resources in the University of Nebraska-Lincoln. It utilizes an IBM 370-3031 computer that is accessed using terminals connected to the mainframe computer by telephone. Terminals have been placed at several locations on campus for student use.

Students are required to run the model at least 10 times for each crop and change at least five variables with each crop.
Planting date, amount of stored soil water, and anticipation, rotary hoeing, variety, seeding rate, row spacing, crop, the program asks the student to enter management gram then asks which crop the student wants. For each weeds present (broadleaf or grasses, or both). The program is provided if the user chooses, followed by a screen format, while the FORTRAN version is designed for use with a video screen and utilizes a split drive. Both versions give identical results but differ slightly in input/output formats. The BASIC version is also utilized some AGNET subroutines to simplify the interaction between student and computer. The model also utilizes some AGNET subroutines to simplify the interaction between student and computer. The model has also been written in BASIC (Applesoft) and presently will run on any Apple II microcomputer with one disk drive. Both versions give identical results but differ slightly in input/output formats. The BASIC version is designed for use with a video screen and utilizes a split screen format, while the FORTRAN version is designed for output to a printer and does not repeat some output such as a list of input variables as often. Also, the BASIC version does not record the student’s use of the program.

The reactions of 105 students enrolled in the course during Fall semester, 1983, were tabulated. Evaluation information was divided between students with farm experience and those with none.

**HOW CROPROD WORKS**

Two versions of CROPROD are available. The version on AGNET is written in FORTRAN language and also utilizes some AGNET subroutines to simplify the interaction between student and computer. The model has also been written in BASIC (Applesoft) and presently will run on any Apple II microcomputer with one disk drive. Both versions give identical results but differ slightly in input/output formats. The BASIC version is designed for use with a video screen and utilizes a split screen format, while the FORTRAN version is designed for output to a printer and does not repeat some output such as a list of input variables as often. Also, the BASIC version does not record the student's use of the program.

There are four crops in the model & corn (*Zea mays* L.), grain sorghum (*Sorghum bicolor* L. Moench.), soybean (*Glycine max* L. Merr.), and winter wheat (*Triticum aestivum* L. Thell.). The data for the corn model are from research in south central Nebraska, and the data for sorghum and soybean are from eastern Nebraska. The data for winter wheat are from western Nebraska.

Figure 1 shows an abbreviated flow diagram for the model. When the program begins, a description of the program is provided if the user chooses, followed by a request for the student’s first name. It then asks if the student wants to use his/her own soil and weed conditions. If not, the program will randomly assign a set of soil conditions including soil pH, soil nutrient levels, and soil organic matter content, and general groups of weeds present (broadleaf or grasses, or both). The program then asks which crop the student wants. For each crop, the program asks the student to enter management decisions on fertilizer and lime rates, herbicide selection, rotary hoeing, variety, seeding rate, row spacing, planting date, amount of stored soil water, and anticipated growing season rainfall. For all crops but wheat, the student is also asked whether the crop will be irrigated. If the crop will be irrigated, the type of irrigation and the amount of irrigation water will be requested. For wheat, the student will be asked whether the fallow method will be stubble mulch (residues maintained) or black (no residues maintained).

CROPROD is designed to be “user-friendly,” which means it can be used by someone with little or no computer experience. Requests for input are checked by subroutines that prevent program termination due to operator error. All interactive requests that are not completely explanatory are accompanied with “help” messages that the student can access by typing “help.” These messages further explain what information is needed and the entry format to be used. Limits are placed on all inputs to ensure that student responses are realistic and within the scope of the model. If an entry exceeds the limits, the program gives the limits for that question and asks the student to enter the information again.

After all inputs are received, the program reports the yield and shows the fraction of the possible yield attained from each management factor (Fn). The model then gives an abbreviated economic analysis. The student is asked if he/she wants to enter fixed production costs or not, the program supplies an average number. The student is then asked to enter the anticipated price of the crop, and the program reports the gross income, expenses, and profit per acre. Input expenses for herbicide, seed, lime, fertilizer, and irrigation are included.

The program then asks whether the student wants to change a variable, restart and enter all inputs for the crop, run the model determining yield and economics, or stop with option to go to another crop. If the student changes a variable, these options are repeated. If the student asks the stop the current crop model, the program asks whether he or she wants to change the soil and weed information and what crop is now wanted. The student can also exist the program at this point.

Yield is calculated by assuming that each of the inputs or factors is a direct function of the yield as shown in Table 1. If no inputs are limiting, the potential yield (Yp) will equal the maximum yield (Ymax) where Ymax = 225 bushels per acre for corn, 180 for grain sorghum, 70 for soybean, and 60 for winter wheat. Potential yield is calculated using the following equation:

**Table 1. Yield equations used in CROPROD†**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Ymax</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>F6</th>
<th>F7</th>
<th>F8</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Yp = 225 × IC + WC + SC + DC + PK + RC + VC</td>
<td>RC = Total water correction</td>
<td>SC = Seeding rate correction</td>
<td>YLD = Yp × NC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>Yp = 180 × IC + WC + SC + DC + PK + RC + VC</td>
<td>YLD = Yp × NC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>Yp = 70 × NC + WC + SC + DC + PK + LC + VC</td>
<td>SPC = Row spacing correction</td>
<td>YLD = Yp × RC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>Yp = 60 × NC + WC + SC + DC + PK + RC + VC</td>
<td>Vc = Variety correction</td>
<td>SPc = YLD = Yp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† Ymax = Maximum crop yield, Yp = Yield crop potential, VLD = Final crop yield, SPC = Row spacing correction, VC = Variety correction.
START

MODEL DESCRIPTION?

YES

PRINT DESCRIPTION.

NO

ASK FOR FIRST NAME. READ INPUT.

OWN SOIL AND WEED INFORMATION?

YES

ASK FOR SOIL AND WEED DATA. READ INPUT.

NO

RANDOMLY ASSIGN SOIL AND WEED DATA. READ INPUT.

ASK WHICH CROP USER WANTS. READ INPUT.

ASK FOR RATES OF N, P, K, AND LIME. READ INPUT.

IS CROP IRRIGATED?

YES

ASK FOR TYPE OF IRRIGATION. READ INPUT.

ASK FOR INCHES OF STORED SOIL WATER, GROWING SEASON RAINFALL, AND IRRIGATION WATER. READ INPUT.

ASK FOR HERBICIDE. READ INPUT.

IS CROP ROTARY HOED?

YES

SET FLAG. ADD COST.

NO

ASK FOR VARIETY. READ INPUT.

ASK FOR SEEDING RATE AND ROW SPACING. READ INPUT.

ASK FOR PLANTING DATE. READ INPUT.

CALCULATE FACTORS AFFECTING YIELD. \( F_1 \ldots F_N \)

CALCULATE CROP YIELD.

PRINT CROP YIELD AND YIELD FACTORS.

OWN COST OF PRODUCTION?

YES

SET PRODUCTION COSTS.

NO

ASK FOR PRODUCTION COSTS. READ INPUT.

ASK FOR CROP SELLING PRICE. READ INPUT.

CALCULATE CROP INCOME, COSTS AND PROFIT. PRINT RESULTS.

PRINT INPUT VARIABLES.

ASK IF USER WANTS TO RESTART, CHANGE A VARIABLE, CALCULATE YIELD, OR STOP. READ INPUT.

RESTART?

YES

NO

CHANGE A VARIABLE?

YES

ASK WHICH VARIABLE TO CHANGE. READ INPUT.

ASK FOR NEW INPUT ON VARIABLE.

CALCULATE YIELD?

NO

STOP?

YES

NO

ANOTHER CROP?

YES

CHANGE SOIL AND WEED INFORMATION?

NO

STOP

Fig. 1. Flow diagram for CROPROD.
\[ Y_p = Y_{max} \times F_1 \times F_2 \ldots \times F_n \]

where \( F_1 \) through \( F_n \) are the inputs supplied by the student. Each factor (\( F_n \)) is calculated as a decimal fraction of the possible attainable yield based on that input. In some cases, certain factors such as nitrogen in corn and sorghum, and water in soybean are calculated after initial yield potential is determined. Many factors interact with each other and changing one factor may affect another factor. Factors which are not included in the yield equation either have an indirect effect on the yield or only affect crop costs. For instance, rotary hoeing may change effectiveness of weed control that is measured by the herbicide correction factor.

RESULTS

Of the 105 students surveyed regarding the exercise, 98 had direct experience in crop production and 7 did not. The responses of students to questions regarding the exercise were divided by farm experience and are reported in Table 2. When asked if the exercise was worthwhile, 102 students agreed or strongly agreed. None of the non-farm students disagreed with the statement. When asked if the exercise increased their understanding of the factors affecting crop production, 101 students agreed or strongly agreed. Again the non-farm students were unanimous in agreement. When asked if the exercise made the material presented in lecture more meaningful, 99 students agreed or strongly agreed, and all but one non-farm student agreed. The enthusiasm for the exercise is similar to that reported earlier for SOYBEANPROD (11) which has been incorporated into the CROPROD model. Although only required to run the model 10 times for each crop, computer records show that many students become fascinated with seeing how high they can increase yields and run the model for each crop as many as 50 times. Students have also reported instances of competing with each other for highest yield.

SUMMARY

A computer simulation model can be an effective learning tool, giving students rapid feedback to management decisions and allowing them to experiment and make mistakes without penalty. Student response to CROPROD is positive, and all students, whether farm or non-farm, apparently benefit from its use.

<table>
<thead>
<tr>
<th>Question/Type of student</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The CROPROD computer exercise was worthwhile.</td>
<td>All students</td>
<td>38</td>
<td>64</td>
<td>2</td>
</tr>
<tr>
<td>Farm</td>
<td>34</td>
<td>61</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Non-farm</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The computer exercise increased my understanding of the factors affecting crop production.</td>
<td>All students</td>
<td>24</td>
<td>73</td>
<td>5</td>
</tr>
<tr>
<td>Farm</td>
<td>20</td>
<td>70</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Non-farm</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The computer exercise made material presented in lecture more meaningful.</td>
<td>All students</td>
<td>24</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>Farm</td>
<td>20</td>
<td>73</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Non-farm</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

CROPROD is considered by the author to be public domain and printed copies of either the BASIC or FORTRAN version can be obtained free by writing the author. The BASIC version can also be obtained free by sending a 13.34 cm (5½ in) microcomputer diskette to the author at the address listed with this paper.

REFERENCES