Programmable Calculators and Their Application to Feeding and Management of Dairy Cattle[1]

J. G. LINN[2] and P. L. SPIKE
Iowa State University
Ames 50011

ABSTRACT

The programmable calculator offers high-speed numerical analyses at a relatively low cost. Laborious and complicated calculations in ration formulation and other dairy-management decisions can be simplified greatly. Most dairy producers, however, have neither the time nor background for developing calculator programs. The Iowa State University Cooperative Extension Service has developed a subscription service to supply programs to persons involved in agricultural decisions. Also, the solid-state module has been developed to store programs permanently inside the calculator. The programmable calculator offers an aid in the day-to-day management decisions by agricultural producers, but extension personnel also find it time-saving and a useful educational tool.

INTRODUCTION

During the last decade, handheld calculators have developed from a simple adding machine into a sophisticated tool for complex numerical calculations. A recent development is the programmable calculator. This paper will describe what programmable calculators are, discuss their advantages and disadvantages, and explain how the Iowa State University Cooperative Extension Service has applied the Texas Instrument Model 59[3] to feeding and managing dairy cattle.

PROGRAMMABLE CALCULATORS

Handheld programmable calculators can perform all the functions of less sophisticated calculators and also store variables in memories for use in prewritten programs. The programs are a series of instructions or mathematical equations which the programmable calculator can remember and then execute in the desired sequence. The programmable calculator is similar to larger computers in that it can be programmed to decide which series of calculations should be performed first. The decision-making process generally is centered around the calculator's capability to determine differences in the relative magnitude of two numbers (i.e., Is X greater than Y?). Thus, different calculations can be performed, depending upon previous calculations or information.

Programs for the programmable calculators are not written in a computer language but represent the key sequence needed to perform the same calculations on a nonprogrammable calculator. Once a program has been entered into the calculator's memory, a series of calculations can be repeated an indefinite number of times by using new variables. Also, some programmable calculators have the capability of recording programs or data on magnetic cards for future use. The Texas Instrument model 59 and the Hewlett Packard model 97[3] are two calculators capable of storing programs on magnetic cards. Thus, the often long and tedious procedure of entering program steps before each use is eliminated. Programs can be recorded from the calculator by passing a magnetic card or cards through a slot in the programmable calculator. Once recorded, the program can be reentered into the programmable calculator at any time by inserting the card through the calculator. The capability of recording programs is important because the greatest gain in efficiency occurs when the calculator can "remember" how to perform a long series of calculations, thus allowing users to concentrate more on interpreting results of

Received August 20, 1979.

[1] Journal Paper No. J-9567 of the Iowa Agriculture and Home Economics Experiment Station, Ames. Project No. 1053.

[2] Present address: Department of Animal Science, University of Minnesota, St. Paul 55101.

[3] Mention of a commercial product or firm is for clarity of description only and does not constitute endorsement by Iowa State University and cooperating units or agencies nor recommendation over other products that may be similarly suitable.

outputs rather than on program entry. Also, many different programs can be entered into memory with ease.

Some programmable calculators, such as the Texas Instruments TI-58 and TI-59, can use preprogrammed modules. These modules are approximately 1 cm thick and 2 cm square and fit into the back of the calculator. The internal solid-state modules contain permanently stored programs that are accessible directly through the keyboard. One module contains approximately 5000 program instructions and, depending upon program length, can replace from 10 to 25 magnetic cards. The module has the advantage in that it eliminates the initial entering of programs. Two disadvantages are that module programs cannot be changed or altered and modules must be produced in large quantities to minimize cost.

Most programmable calculators can print selected material. Some have a built-in printing units whereas others, such as the TI-59, have optionally attachable printers. The TI-59 calculator can print alphabetical characters, but this requires considerable program memory. Printers are most benefical in writing or entering programs because users can retrace entry steps quickly and conveniently.

ADVANTAGES AND DISADVANTAGES

The programmable calculator has several advantages relative to other types of computer hardware:

1. A large mathematical capacity can be obtained for a low cost ($300 or less). Simple problems can be solved more conveniently and at a lower cost on a programmable calculator than with large computers.

2. Programmable calculators are completely portable.

3. Programmable calculators are similar in appearance to common handheld calculators. Thus, the psychological barrier sometimes encountered with use of full-size computers is reduced.

4. Programmable calculators allow for instant turn around time with system interaction. They are complete units, requiring no long distance hookups as with portable terminals to computers.

5. Programmable calculators can be operated when it is convenient and timely in any location.

6. Because of relatively easy programming, programmable calculator users can modify existing programs or develop new ones to fit their own needs.

Programmable calculators also have disadvantages that limit application:

1. Limited amounts of data can be stored at any one time. In the TI-59, memory capacity is limited to 100 values or less and a maximum of 960 steps in any one program.

2. The programmable calculator printers have limited alphabetical capability and do not allow for extensive self-interpretable output. Thus, printouts must either be accompanied by a written explanation or transferred to a more self-explanatory form.

3. Because programmable calculators are relatively inexpensive and may be purchased in a variety of stores, limited assistance is available for operation and programming. Many first time users have found this very frustrating and subsequent discouragement for future use.

PROGRAM DEVELOPMENT AND IMPLEMENTATION

The development and distribution of software (programs) for owners of programmable calculators has been limited, especially for agriculturally related programs. Some of the earliest application of programmable calculators and program development in agriculture was made by the Iowa State University Cooperative Extension Service. Previously users had to develop their own programs or rely on calculator companies to supply them. As interest in programmable calculators grew, the need for a program exchange between extension personnel became evident. Concurrently, as calculators gained more exposure through extension meetings, agribusinessmen and agricultural producers began purchasing calculators and identifying program needs.

The Iowa State program library is an accumulation of programs written for the TI-59 programmable calculator. Agribusiness personnel, along with agricultural producers, have been instrumental in identifying areas where programs are needed. Once a program need has been identified, the program is written and followed by field testing. After the program passes testing and is approved, it is made available on a subscription basis. Subscribers receive a notebook containing all previously

written programs and are updated with new programs as they become available. Notification of any existing program changes also is included. At present, 61 programs relating to animal science, farm management, and agronomy are included in the library. Animal science programs are primarily in the area of livestock nutrition, emphasis on ration formulation and analysis, and performance indexes for beef and swine. The farm management programs are concerned primarily with budgeting, investment, and livestock and crop marketing analysis. More than 1300 Iowa State University libraries have been distributed in 40 states and 12 foreign countries. Cornell University also has a similar subscription service for programmable calculator programs.

Each Iowa State library program contains a statement of its objective, inputs and outputs, documentation of data used in calculations, and an example problem. A listing of program steps and how the program, once entered, can be recorded on a magnetic card for future use also is included. Magnetic cards containing the programs are not distributed because cards recorded on one calculator cannot always be read by another, even of the same model.

McGrann and Edwards (1), after an early survey of library subscribers, described some problems encountered among 140 users of the programmable calculator (Table 1). The most frequent difficulty was recording programs on magnetic cards and (or) the reading of cards into the calculator. Some of the problems can be traced to mechanical failure of calculators themselves, but user program entering probably was the major problem. Having an attachable printer for the calculator tended to reduce recording and use problems, especially in entering program steps and recording on magnetic cards.

Forty-four percent of survey respondents had either written new programs or modified library programs to fit their own situations. In as much as writing or modifying programs requires more knowledge than just entering and recording prewritten programs, these users tended to have less operational problems in recording and using library programs than did those who only used library programs. Experience of the Iowa State extension staff has been that a 2 to 3 h training session on calculator operation has been sufficient to overcome most user operational problems.

Sixty-nine percent of the survey respondents indicated that having programs stored internally in the calculator, such as with program modules, would help eliminate some of the problems encountered. Thus a Texas Instrument–Iowa State University agricultural module was developed to eliminate the reading of magnetic cards.

Extension and agribusiness personnel along with livestock producers identified 16 programs to include in a module. The programs are primarily library programs on livestock nutrition (analyzing and formulating rations), analysis of livestock marketing, and land investment and general livestock management programs. During the first 4 mo, approximately 800 modules have been distributed.

APPLICATIONS OF THE PROGRAMMABLE CALCULATOR

The programmable calculator should be considered as a supplement to, and not a substitute for, larger computers. The calculator can be taken directly onto the farm and used to help solve simple management problems at low cost. Rations can be formulated and management decisions made for individual situations quickly and accurately. Many agribusiness firms have found a one-on-one situation with instant individualized answers to help improve sales.

Extension personnel can use programmable calculators to help solve individual management problems and as an educational tool. In consulting with dairymen, ration deficiencies can be determined and new rations formulated in a short time. Farm management programs can be used to quickly and accurately determine individualized answers to complicated budgeting questions. In preparing for extension meetings, the programmable calculator can be used to speed preparation of materials, particularly when a series of rations or cost analyses are to be used.

The Iowa State dairy ration balancing program was designed to answer the following questions in relation to the amount and quality of forage fed: 1) What percentage of crude protein, calcium, and phosphorus is needed in the grain mixture? 2) How much grain should be fed at various amounts of milk production? 3) How much protein supplementation is needed at various amounts of milk production?

TABLE 1. Problems encountered with programmable calculators.

Type of problem	Number[a]	Percent[a]
No. problems	50	36
Mechanical problem, charger, or printer	18	13
Incorrect results after all program steps entered	13	9
Problems recording program steps on magnetic cards and (or) reading recorded cards into calculator	42	30
Interpretation problems with information entered or stored in calculator	15	11
Problems interpreting significance of program answers	15	11

[a]Some respondents indicated more than one problem.

Such programs can be used to help individual dairymen with their ration-formulation problems and also can be used as educational aids during meetings. For example, a dairyman may not understand a net energy deficiency of 10 Mcal for cows in early lactation. Indicating a requirement of 38 lb of concentrate when only 25 lb are fed, however, clearly illustrates an energy deficiency for the cow. The effects of improving forage quality on reducing grain recommendations can quickly be shown by changing a few forage input variables. In addition, audience interest is stimulated by the use of a new gimmick or gadget.

The limitations relating to the instruments' capability have been explained already. It must be remembered, however, that the programmable calculator outputs are only as accurate as the inputs. If errors are made in data entry, erroneous recommendations can be given. Likewise, if data sources for programs are not documented, the validity of these programs should be questioned. Interpretation of output also requires a person with knowledge and experience in that area. As more programmable calculators come into use in ration formulations, are all users going to be qualified nutritionists? Not thoroughly understanding or misinterpreting outputs may be more harmful than the original problem. The principal limitations of the programmable calculator as a sophisticated yet simple tool in aiding agricultural decisions occurs with the users. The education of the user to properly input information, followed by correctly interpreting and applying the outputs, should be the primary goal for extension personnel. Developing and writing new programs should be a tool used in the extension educational process.

FUTURE

Programmable calculators are just one phase of the rapidly developing electronic technology for dairy management. Therefore, their future is uncertain. If present use is any indication, acceptance of and the capabilities of programmable calculators will increase. The limiting aspect of programmable calculator use is and will continue to be program development. Currently, most dairy programs are concerned with either formulating or analyzing rations. Experiences at Iowa State with beef and swine indicate that the most popular and widely used programs concern economical decisions on marketing based upon management inputs. Similar programs for day-to-day management decisions will be most useful to dairy producers. Such programs relating to economical decisions concerning cow culling, mastitis losses, values and costs of replacement animals, semen pricing, and many others need to be developed. In addition, specific discipline programs in areas such as engineering concerning waste management, housing, and ventilation will be of benefit to extension and agribusiness personnel. Because of limited data storage, programmable calculators cannot do the genetic evaluations and formulation of least-cost rations currently done in large computers. Likewise, Dairy Herd Improvement records cannot be kept on programmable calculators. Because of this, programmable calculators will not compete with computers but will compli-

ment them as a convenient low-cost analytical tool for field use.

SUMMARY

Experiences with the programmable calculator at Iowa State University indicate that it has useful application in agricultural management decisions. The calculator's low-cost analytical capacity, ease of programming, and sufficient capacity to provide valuable information for many agricultural decisions make it a valuable tool for extension workers in meeting preparation and individual problem consultations. Livestock producers and agribusiness personnel also find the calculator to be of great assistance in their day-to-day decision-making processes.

REFERENCES

1 McGrann, J. M., and W. E. Edwards, 1979. Application of the programmable calculator to extension agricultural management programs. North Cent. J. Agric. Econ. (In press).