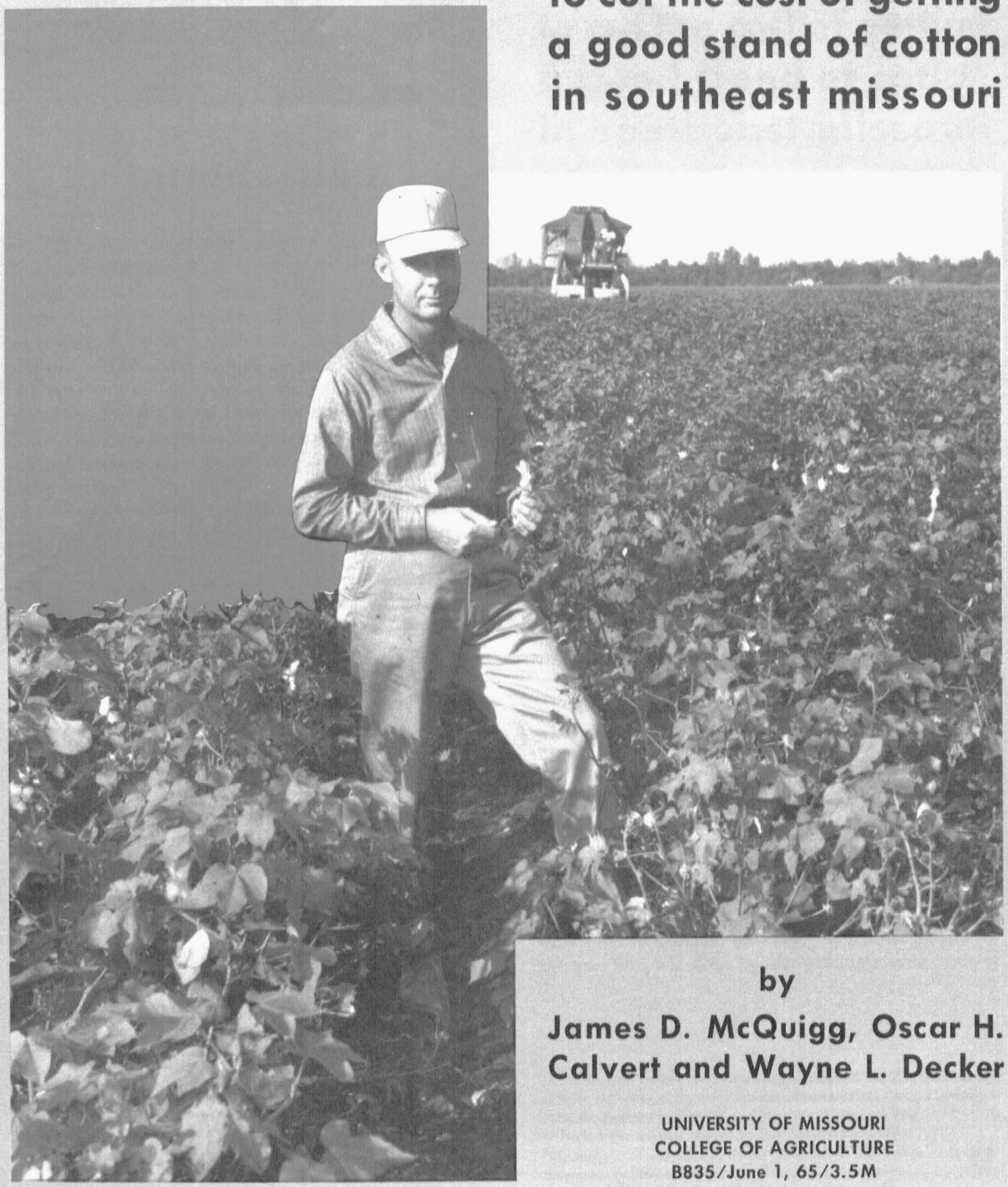
Using Weather Information

to cut the cost of getting a good stand of cotton in southeast missouri



by

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Introduction

The choice of planting dates is one key decision a producer of cotton must make. If he is impatient and plants on the first decent-looking day in early spring, often the seeds will not germinate and it will be necessary to replant. If he waits until late in the planting season, the soil will be warm enough for good germination, but the crop will be late through the rest of the season. In the northern Mississippi Delta, including Southeast Missouri, the growing season is relatively short. There are several advantages to getting the cotton crop off to an early start.

How can a farmer get his cotton planted as early as possible and at the same time lower the risk of having to replant? An answer to this question comes from two experimental projects at the University of Missouri. The first experiment was conducted in the Field Crops Department growth chambers[2], where soil temperature conditions can be controlled. The second experiment was conducted in the University of Missouri Computer Center,. where daily soil temperature records for eleven years were analyzed.

Results of the Growth Chamber Experiments

The first ten days following cotton planting are very important. If cotton plants have emerged in sufficient numbers and are growing vigorously by the end of that time, the chance for early damage by various plant diseases is much less than would be true where emergence was delayed beyond ten days. The growth chamber controls were set to provide 12-hour "days" during which the lights were on and temperatures rose to specified levels, and 12-hour "nights", during which the lights were off and temperatures dropped to certain levels, much as happens under natural conditions in the spring of the year. By moving the pots in which the seeds were planted from chamber to chamber, it was possible to simulate runs of warm and cold periods. (Fig. 1 shows some typical plantings from this experiment).

One of the conclusions reached at the end of this experiment that has practical use in the management of cotton planting is this:

If soil temperature at planting depth remains below 68°F for more than six of the days in the ten-day period beginning with planting, an unacceptable number of cotton seeds will germinate and emerge. If similar conditions are experienced under field conditions, replanting probably would be necessary.

Results of the Computer Experiment

Computer facilities at the University of Missouri were used to simulate the choice of planting dates for cotton. This was done by first placing eleven years of

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[1]U. S. Weather Bureau, State Climatologist, Missouri and Research Associate in Soils, University of Missouri; Assistant Professor Field Crops, University of Missouri; Professor of Climatology, University of Missouri, Respectively. (This research is the result of projects in Soils 281 and Field Crops 322)

[2]McQuigg, J. D. and Calvert, O. H., "Influence of Soil Temperature on the Emergence and Initial Growth of Upland Cotton", submitted to Agricultural Meteorology for publication.

FIGURE 1: RESPONSE OF COTTON SEED GERMINATION AND EMERGENCE TO SOIL TEMPERATURES FOR THE TWELVE DAYS FOLLOWING PLANTING (This photo was taken 12 days following planting. Each pot was kept in a different growth chamber, with temperatures ranging from those experienced in the early spring to those in the midst of the main cotton planting season in the Upper Mississippi Delta.)

daily soil temperature and precipitation observations in the memory of the computer, then proceeding with a series of questions as outlined in the flow chart in Figure 2.

The question in Step I, "Is the soil dry enough to allow operation of planting machinery?" was answered by checking the precipitation amounts for the preceding two days. If both days had received less than .20 inches of rain, the answer was "yes". In actual practice, this question would be answered by taking a look at the field that was to be planted.

April 15 was considered the first possible planting date, so in the computer experiment this was the earliest date that the question in Step I was asked.

In Step II the question was, "Was the observed soil temperature at least 68°F yesterday afternoon?" This was answered in the computer experiment by checking the value which had been placed in the memory for "yesterday". In actual practice, a cotton farmer could obtain this information either from his own soil thermometer, or by listening to the broadcasts of this information from a local radio station during planting season.

The question in Step III "Is the five-day forecast favorable?" was answered by having the computer make "forecasts" for five-day periods. This was done by first having the computer check the observed values which were in the memory for the desired five-day period. It was possible to issue perfect "forecasts", or to produce forecasts with a desired level of accuracy, by having the computer deliberately generate errors. It would have been just as easy in the computer experiment to produce ten-day forecasts too, since this is the length of the critical period for cotton beginning on the date of planting. The five-day forecast period for the computer experiment was chosen because this is the longest period covered by forecasts actually issued by the Weather Bureau. These can be interpreted during the cotton planting season as either "favorable" or "not favorable" as will be shown. Five-day forecasts that had been issued for southeast Missouri for several cotton planting seasons were studied, to see if they could be used to identify periods when soil temperatures would remain below 68°F long enough to interfere with cotton seed germination and emergence. The results of this study are shown in Table I.

Four things are apparent from examination of the data in Table I.

1. If the soil temperature "yesterday afternoon" was observed to be below 68°F, and the five-day forecast is for near or below normal temperatures, it is highly likely that there will be more than 6 unfavorable days for cotton emergence in the ten-day period following the date of issuance of the forecast.
2. If the soil temperature was observed to be 68°F or more "yesterday", and the five-day forecast is for near or above normal temperatures, probably there will be enough favorable days for cotton germination in the ten-day period following the date of issuance of the forecast.

ILLUSTRATION OF STEPS IN COTTON PLANTING DECISION MODEL

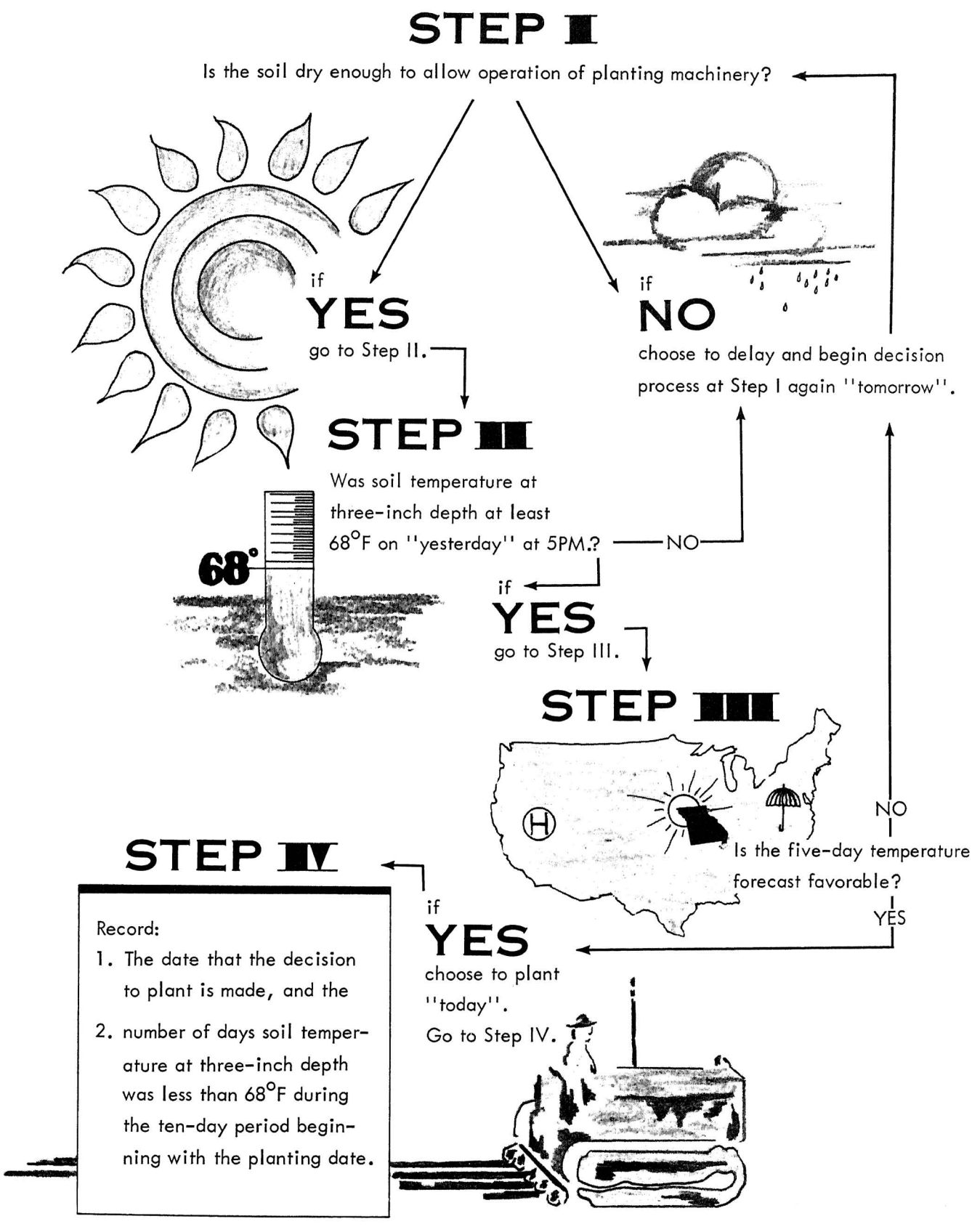

FIGURE 2

TABLE I

RELATIONSHIP BETWEEN FIVE DAY FORECASTS ISSUED FOR MISSOURI BOOTHEEL DURING APRIL 21-MAY 9, 1956-1963 AND NUMBER OF DAYS WITH SOIL TEMPERATURE BELOW 68°F IN TEN DAY PERIOD FOLLOWING THE DATE OF ISSUANCE OF THE FORECAST

	Average Number of Days with Soil Temperature Less Than 68°F When:	
Five Day Temperature Forecast	Soil temperature is less than 68°F on day before forecast	Soil temperature is 68°F or more on day before forecast
More than 2 degrees above normal	3 FAVORABLE	3
Within two degrees of normal	7	2
More than 2 degrees below normal	7 UNFAVORABLE	5

3. If soil temperature was less than 68°F "yesterday afternoon", and the five-day forecast is calling for temperatures to be more than two degrees above normal, there is a fairly good chance for acceptable germination.
4. If soil temperature was above 68°F yesterday afternoon, but the five-day forecast is for temperatures to average more than two degrees below normal, the odds are not favorable for acceptable germination.

In the first application of the computer model, Steps II and III were omitted. Using only Step I, this procedure resembles the management of cotton planting by a farmer who chose to ignore current and forecast weather information by planting on the first day the soil was dry enough to allow operation of machinery after April 15.

In the second application of the computer model, Step III was omitted. This procedure resembles the management of cotton planting by a farmer who chose to ignore weather forecasts but who did consider observed soil temperatures when making his decisions.

The computer was instructed to record the date that was chosen for planting each of the eleven years, and the number of days the soil temperature at planting depth remained below 68°F in the ten-day period beginning with planting date. In each instance, if there were more than six such days in the ten-day period, it was assumed that replanting would be necessary. The cost of replanting cotton is estimated at $5.00 per acre, based on figures presented in a recent study by Justus[3].

Figure 3 shows the results of the first two applications of the computer model. This can be used to illustrate the following points:

It is possible to reduce greatly the average annual costs of obtaining an acceptable stand of cotton in Southeast Missouri by paying attention to observed soil temperatures. Consideration of this simple, easily-available information will reduce the average annual cost per acre by about $2.50 if planting is accomplished by May 1. After early May, soil temperatures are almost always above the minimum levels, so that it is not as necessary to consider this factor for late plantings.

In the third application of the model, all three steps shown in Figure 2 were used. This simulated the decision process of a cotton producer who waited until the soil was dry enough, until he had had one day with soil temperature at least 68°F at planting depth, and who knew that the five-day forecast of temperature was "favorable". The computer was first instructed to issue perfect temperature forecasts. This resulted in later average planting dates, but replanting was not necessary. (See

[3]Justus, F. E. Jr., "Costs and Returns of Producing Cotton in Missouri", University of Missouri, *Ag. Exp., Sta., B790, 1963.*

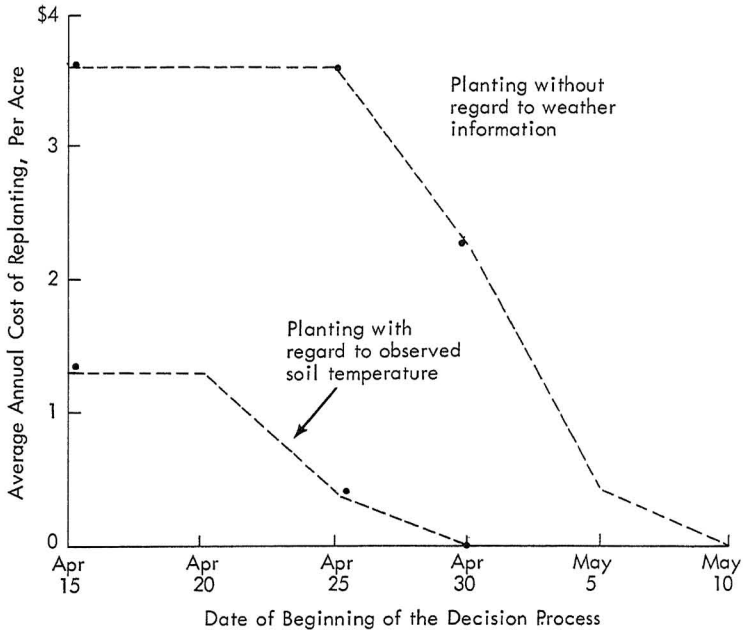

FIGURE 3

AVERAGE ANNUAL COST OF REPLANTING COTTON AS COMPUTED FROM REPEATED APPLICATIONS OF SIMULATION MODEL.

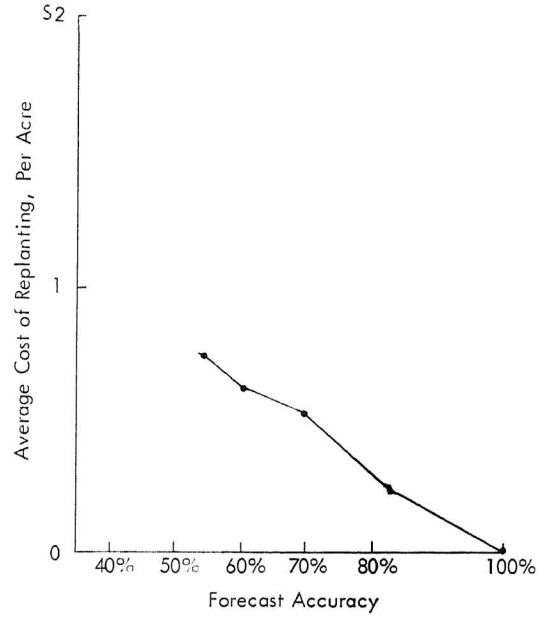

FIGURE 4

RELATIONSHIP BETWEEN FORECAST ACCURACY AND AVERAGE COST OF REPLANTING COTTON IN THE MISSOURI BOOTHEEL.
(Decision process beginning April 15)

Table II) There were some planting dates as early as April 21 in this application.

No responsible meteorologist would claim the ability to make consistently perfect forecasts. There always will be times when it is not possible to anticipate every change in weather patterns. The next applications of the model were accomplished by having the computer first check over the observed temperature values for a particular five-day period, and then deliberately making a certain number of wrong forecasts[4]. The percentage of correct forecasts was varied from 50 to 100. With the decision process beginning in each case on April 15, the average annaul cost of replanting one acre of cotton decreased as the accuracy of the forecasts increased.

Figure 4 shows the relationship between the average

[4]For example, if the computer is to make "forecasts" of soil temperature of about 80 percent accuracy, the following procedure would be followed. First, the computer would check over the soil temperatures for the desired five-day period (which had been placed in the memory of the computer.) There are two possibilities here. Either all of the soil temperatures will be at least 68°F, (favorable) or at least one of the days will have a soil temperature below 68°F (unfavorable). Next, the computer will choose a two-digit random number. If this random number happens to be on the range 00 through 79, the "forecast" will agree with the observed soil temperature. If the random number is on the range 80-99, the "forecast" deliberately will be made wrong, or just the opposite of the observed pattern. Five-day forecasts were made in this model because that is the practical limit of operational forecast capability at this time.

TABLE II

SUMMARY TABLE

	Using No Weather Information	Using Only Observed Data	Using Observed and Forecast Data			
			Forecasts 70% Right	Forecasts 80% Right	Forecasts 90% Right	Forecasts 100% Right
Average Planting Date	April 17	May 2	May 6	May 9	May 10	May 18
Average Annual Cost of Replanting Per Acre	$3.63	$1.36	$0.60	$0.28	$0.15	$0.00

annual cost of replanting and the accuracy of the five-day forecast of temperature (as taken from the results of the computer experiment). A reasonable practical level of forecast accuracy would lie somewhere on the range of 75 to 85 percent. Use of the five-day forecasts that the Weather Bureau issues, plus consideration of the observed soil temperature at planting depth in a decision-making pattern like the one shown in Figure 2, can greatly reduce the likelihood of having to replant cotton in Southeast Missouri, to the point that the expected cost of replanting would be only $0.25 to $0.40 per acre. It is true that this system will result in delaying planting until mid-May in some years, but it also identifies the years when it is safe to plant in April, too. Table II provides a summary which allows comparison of the three methods of decision-making which were used in the computer experiment.

Summary

In summary, planting cotton in Southeast Missouri without regard to either observed or forecast weather information in April will result in average annual costs of replanting near $3.60 per acre. Use of a decision-making procedure that takes into account the observed soil temperature each day will reduce this average cost to near $1.25 per acre. Consideration of both observed and forecast temperatures will cut this average annual cost to about $0.40 per acre. Thus, the cotton farmer who uses all available weather information can save an average of a little over $3.00 per acre per year. If only half of the cotton acreage in Southeast Missouri were planted using this system of decision-making, the total saving would be nearly $500,000 per year.

References

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