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Chapter 11

Organizing Fertilizer Input-Output Data in Farm Planning

FERTILIZER is a major cost item on north Georgia farms. Using general fertilizer recommendations, this item amounts to 40 to 60 percent of the cash cost and 20 to 35 percent of the total cost of corn production. Correctly then, farmers are interested in using fertilizer to gain maximum profits. Most farmers in Georgia know that they must use fertilizer efficiently if they are to make a reasonable profit from farming. Many have compared the 10 to 20 bushels of corn per acre obtained from land not fertilized with the 50 to 100 bushels of corn obtained on land that is well fertilized. Many also know that yields from 100 to 150 bushels per acre are possible on some of the best land, if larger amounts of fertilizer are used and recommended management practices are followed.

Steps in Decisions

From these and other production possibilities, the farmer must somehow make decisions as to which practices and fertilizer quantities are best for his particular situation. There is considerable information concerning the logic involved in the process of making rational decisions but there is limited information on how different farmers actually do make decisions (3, 4, 5, 7, 8). The first step in actual decision-making is that of observation. Some knowledge of possible fertilizer responses is obtained from personal experience, observation, and discussion of the problem with other farmers. While these kinds of observations do not give complete information, evidence (1, 2, 9, 12) suggests that this is the extent of information obtained by many farmers. Aside from the farmer's own experience and his observation of other farmers in the area, information may be obtained from the various agricultural agencies, magazines, newspapers, radio, commercial organizations, and college bulletins.

How does a farmer analyze the information he obtains? Here, too, research information is limited. Certainly much of the information he obtains is, or seems to be, conflicting. One neighbor may be convinced that 250 pounds of fertilizer per acre is the right amount on corn at planting time, while another is equally convinced that 700 pounds is needed. One article in a farm magazine may infer increasing returns;

another, decreasing returns in using fertilizer. Yet farmers somehow resolve these differences and come to a decision.

Response and Economic Use by Soil Type

Most farmers know that the response to fertilizer varies with the type of soil. Crops on some soils are not able to use large amounts of fertilizer efficiently. Good bottom soils without serious erosion, poor structure, or drainage and drought hazards give better response to fertilizer than soils with limitations other than fertility. This relationship is illustrated in figure 11.1 for a Talladega soil area, a Hayesville soil, and a Transylvania soil. When corn is worth $1.50 per bushel and nitrogen costs 15 cents per pound, only 40 or 50 pounds of nitrogen can be used economically on the Talladega soil by the farmer with ample funds.[1] On the Transylvania silt loam, however, an application of over 90 pounds is economical.

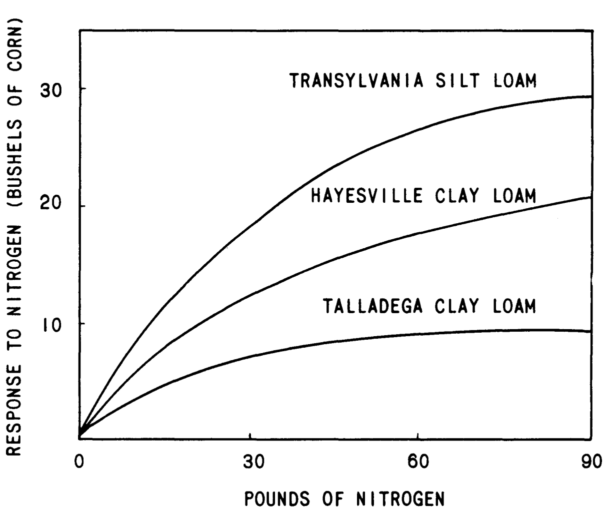

Fig. 11.1 — Corn yield response to nigrogen for three soil types. Source: Adapted from Ga. Exp. Sta. Bul. 264 (response estimated for Talladega clay loam).

Response to fertilizer also varies with the fertility level of a particular soil type. This situation is illustrated in figure 11.2 and table 11.1, for Hayesville clay loam of low, medium, and high fertility.[2] Using 60 pounds of P_2O_5 and 60 pounds K_2O and assumed prices of 15 cents per

[1] Expressions such as "most economical rate" or "most profitable rate" for farmers with unlimited capital denote that application which would result in highest net return per acre (where marginal cost equals marginal revenue).

[2] Quadratic square-root equations were computed for the yield data which included three consecutive crop seasons. Since the experiment did not include over 90 pounds of nitrogen, prediction beyond that level was impossible. Also there are some doubts about the reliability of the curve fitting for the medium fertility soil because of the limited range of the data.

TABLE 11.1. Corn Yield Response to Nitrogen on Hayesville Clay Loam When 60 Pounds P_2O_5 and 60 Pounds K_2O Are Applied per Acre

Nitrogen	Total Yield	Additional Corn from 10 Lbs. Nitrogen	Value Additional Corn $1.50 per Bu.	Cost Additional 10 Lbs. Nitrogen 15¢ Lb.
(Pounds)	(Bushels)		(Dollars)	
		Low Fertility		
0	12.4	-	-	-
10	26.5	14.1	21.15	1.50
20	31.0	4.5	6.78	1.50
30	34.0	3.0	4.42	1.50
40	36.1	2.1	3.20	1.50
50	37.7	1.6	2.42	1.50
60	39.0	1.2	1.86	1.50
70	40.0	1.0	1.43	1.50
80	40.7	.7	1.11	1.50
90	41.2	.6	.83	1.50
100	41.6	.4	.61	1.50
		Medium Fertility		
0	53.6	-	-	-
10	59.6	6.0	8.96	1.50
20	62.8	3.2	4.85	1.50
30	65.6	2.8	4.17	1.50
40	68.1	2.6	3.82	1.50
50	70.5	2.4	3.60	1.50
60	72.8	2.3	3.44	1.50
70	75.1	2.2	3.32	1.50
80	77.2	2.2	3.23	1.50
90	79.3	2.1	3.15	1.50
100	81.4	2.1	3.08	1.50
		High Fertility		
0	71.2	-	-	-
10	76.3	5.1	7.63	1.50
20	78.4	2.2	3.30	1.50
30	80.2	1.8	2.58	1.50
40	81.6	1.5	2.22	1.50
50	83.0	1.3	1.98	1.50
60	84.2	1.2	1.82	1.50
70	85.3	1.1	1.68	1.50
80	86.4	1.1	1.58	1.50
90	87.4	1.0	1.50	1.50
100	88.3	1.0	1.43	1.50

Source: Woodworth, R. C., and Brooks, O. L., Economics of fertilizer use on north Georgia farms, unpub. ms., Dept. Agr. Econ., University of Georgia, Athens, Ga.

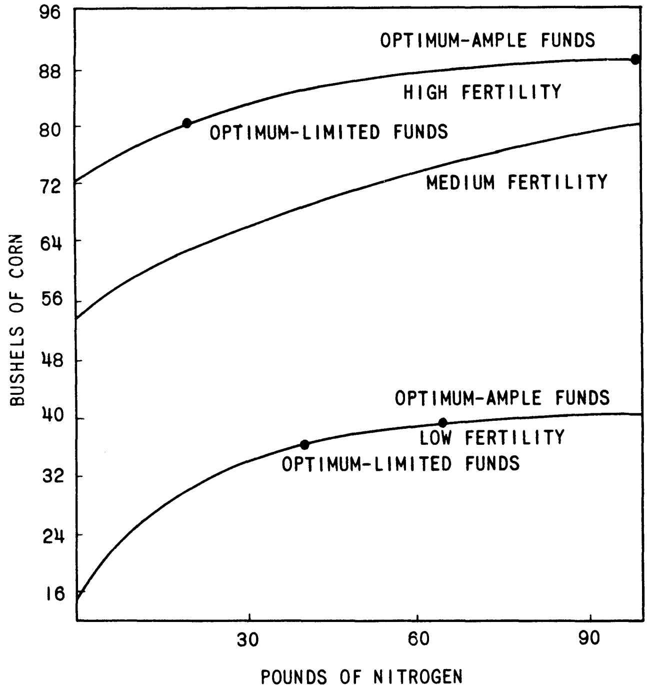

Fig. 11.2 — Corn yield response from nitrogen for three fertility situations on Hayesville clay loam. Source: Woodworth, R. C., and Brooks, O. L., Economics of fertilizer use on north Georgia farms. Unpubl. ms., Dept. Agr. Econ., University of Georgia, Athens.

pound of nitrogen and $1.50 per bushel of corn, 65 pounds of nitrogen is most profitable for the farmer with ample funds on low fertility land. For the medium fertility soil, the profitable level is apparently well over 90 pounds of nitrogen. For the high fertility soil, the profitable level is slightly over 90 pounds.

Using Fertilizer Under Limited Capital

Economic logic suggests that a farmer attempting to make the best use of limited resources should spend funds as follows: Use fertilizer until a point is reached where a greater return can be obtained by investment elsewhere in the business. Hence, the "right" amount of fertilizer to apply is less for a farmer short of capital, with many alternative productive investment opportunities, than for a farmer with ample capital. The farmer short on capital has great investment and consumption uses relative to his funds. Unfortunately, very little information is available to enable the farm operator to make wise decisions on the most efficient use of his limited capital. Should he apply three-fourths

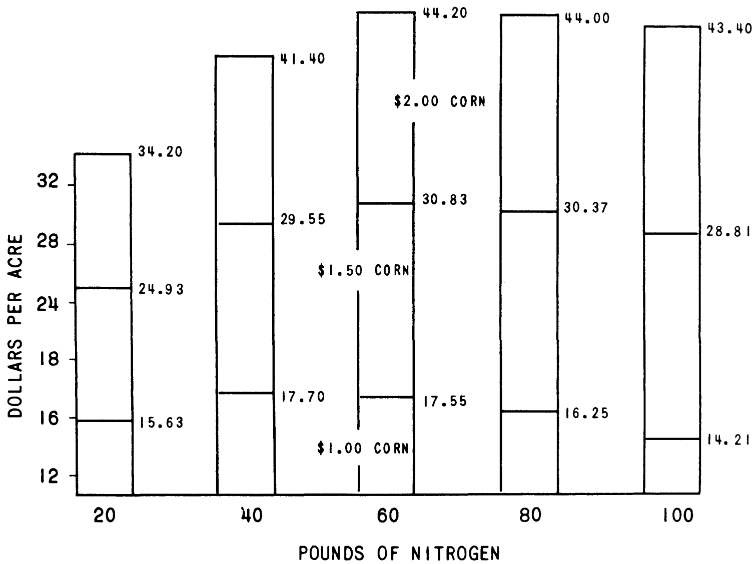

Fig. 11.3 — Returns above nitrogen cost from the use of nitrogen for corn on low fertility Hayesville clay loam. Source: Woodworth, R. C. and Brooks, O. L. Efficient use of fertilizer on north Georgia farms. Unpubl. ms., Dept. Agr. Econ., University of Georgia, Athens.

of the recommended fertilizer and purchase an extra brood sow or cow? or would some other division of investments increase his net farm income?

Using the illustration shown in figure 11.2 for a situation where a farmer has limited capital and needs a 2-dollar return for each dollar invested in nitrogen fertilizer, he should apply 40 pounds on the low fertility soil, or 25 pounds less than if he had ample funds; he should apply 20 pounds on the high fertility Hayesville clay loam, 80 pounds less than if he had ample funds.

Alternative price expectations cause the optimum nitrogen application to vary. On the low fertility land, corn priced at $2 would specify use of about 70 pounds of nitrogen; corn priced at $1 would specify 50 pounds. On the highly fertile land, over 100 pounds of nitrogen would have been economical with $2 corn; 36 pounds would be optimum for $1 corn. The graph in figure 11.3 shows returns above nitrogen costs on low fertility Hayesville clay loam when nitrogen is 15 cents and corn priced at $1.00, $1.50, and $2.00. In this case, 60 pounds of nitrogen would not miss maximum returns by enough to be termed important by many individuals, regardless of historical price relationships.

The situation is quite different for the farmer with limited capital, however. When the price of corn is low, he can apply 30 pounds of

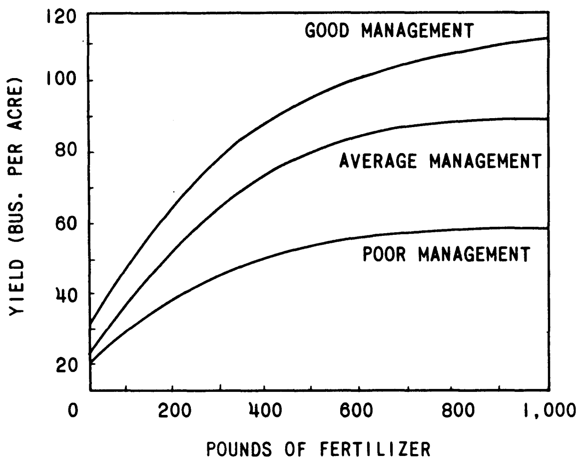

Fig. 11.4 — Effect of management on response to fertilizer. Source: Virginia Farm Economics, No. 141, Feb. 1955, p. 17.

nitrogen and sacrifice little income, compared with using 60 pounds. But when corn prices are high relative to nitrogen, he loses much more by not using 60 pounds. With $2.00 corn, he loses $4.20 per acre by not investing another $4.50; with $1.20 corn, he loses about $3.00; and with $1.00 corn he loses about 50 cents.

Management Levels and Risk

The extent to which general management levels are important in determining economic use of fertilizer has been explored by Plaxico and Loope (11) at Virginia. In their investigations (see figure 11.4), a superior manager with unlimited capital could use 800 pounds of fertilizer per acre under stated conditions; a poor manager could use only 500 pounds. Intangible as management measures are, fertilizer is apparently more productive under superior management which includes efficiency in timeliness of operations, choice of varieties, and other recommended cultural practices. Increased use of fertilizer is most effective on many farms only if improved cultural practices are used at the same time. Management considerations also involve adjustments to risk.

Risk Considerations

Very little information is available to show the farmer how much risk is involved in alternative fertilizer investments. Yet this, too, is part of the judgment a farmer undertakes when he decides how much fertilizer to use. The farmer short of capital is more likely to use less fertilizer because a one-in-ten chance of a $50 loss would be more serious than for a farmer with ample capital. Since many farmers borrow money for fertilizer, these risks must be considered in relation to "staying in the business."

Some indication of risk due to differences in seasons is shown in figure 11.5 for low fertility Hayesville clay loam. In two of the three years involved, 1947 and 1948, over 90 pounds of nitrogen would have been profitable for the farmer with ample funds. The other year, 1946, turned out to be a dry growing season. For this year, only about 35 pounds of nitrogen would have been economical. This situation is clearly recognized by many farmers. They would like to know the nature of risks involved in fertilizer use (see discussion in Chapter 1). In the absence of reliable information tailored to their needs, many farmers perhaps discount expected returns too severely.

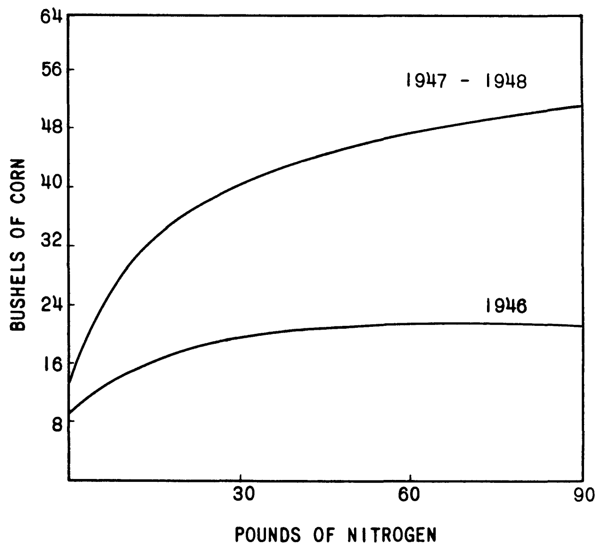

Fig. 11.5 — Corn yield response from nitrogen on low fertility Hayesville clay loam for different years. Source: Ga. Exp. Sta. Bul. 264.

Organizing Information for Planning

How can fertilizer input-output data be organized for greatest efficiency in farm planning? There is no one answer for all areas and all uses. Generally, fertilizer input-output data are needed for: (a) agricultural workers and farmers to illustrate economic principles in fertilizer use; (b) agricultural workers and farmers to assist in making specific decisions; (c) budgeting or linear programming in whole-farm planning; (d) other micro- or macro-economic analyses dealing with resource allocation in agriculture.

If greater progress is to be made with the "hard-to-reach" farmers, who do not come regularly to agricultural workers for help, more and better basic input-output estimates are needed. One should start with a particular farmer's situation in terms of resources, interests, and abilities. The farmer will have to be provided with the know-how to determine the consequences of various courses of action. He may need to solve his own problems so that he can make future decisions without assistance. This type of educational approach places heavy demands on research in various subject matter fields.

In teaching farmers some of the basic principles of fertilizer application, this approach is used. The farmer is informed that an investment in fertilizer is similar to any other investment. He is asked: "If you invest $2, how much can you expect to get back? How much risk is involved? If the farmer can invest $2 profitably after considering returns from other investments, why not invest a second $2, a third $2, and so forth?" The farmer is shown that the major difference between investing in fertilizer and in a savings account is that the rate of return for each additional $2 spent for fertilizer and the risk of loss will depend very definitely on how many 2-dollar units are invested.

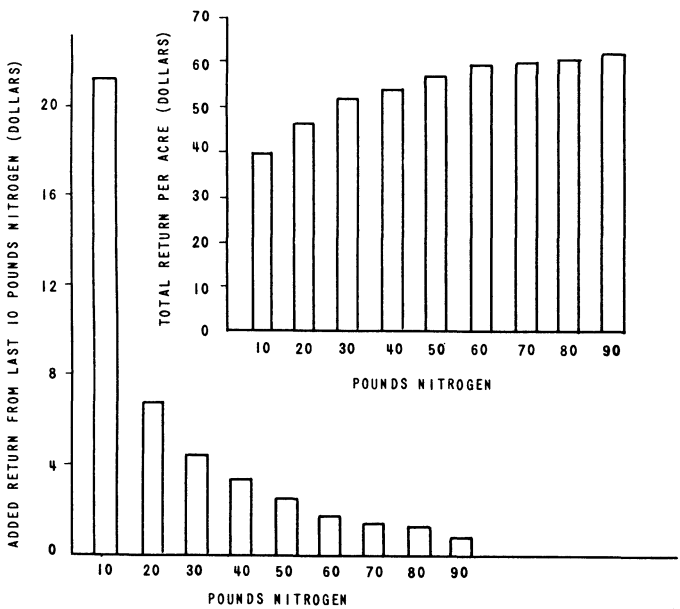

Fig. 11.6 — Returns from the use of nitrogen on corn for low fertility Hayesville clay loam. Source: Woodworth, R. C., and Brooks, O. L. Efficient use of fertilizer on north Georgia farms. Unpubl. ms., Dept. Agr. Econ., University of Georgia, Athens.

While research work along this line is conducted informally, it is felt that a large proportion of farmers can be effectively reached with this sort of logic. There is evidence of its effectiveness, because the typical response is, "But how can I tell when another $2 will not be profitable?" A chart such as that of figure 11.6 is highly effective in illustrating economic principles for farmers or agricultural workers.

Whole-Farm Business

Research and educational programs designed to promote agricultural development must deal with the whole-farm business as well as the parts that make up the whole. Acceptance of whole-farm planning techniques hinges on confidence in the integral parts. In linear programming, as in budgeting, the assumptions, the inputs and outputs, must be accepted as realistic if the conclusions are to be accepted and put into use. For use on specific farms, specific fertilizer input-output data are needed which will be realistic for the particular situation.

With the introduction of refined techniques of estimating input-output relationships under experimental conditions (6), and with an increasing need for these farm planning guides, greater attention should be given to problems of inference. A primary consideration is to determine the population of soil conditions for which particular estimates apply. How does one make the best use of limited research funds when attempting to provide information on different soils? Intensive and refined research conducted on a particular soil experiment provides maximum information for that particular field; but it provides only limited inference for other conditions. However, plot research funds usually are not sufficient to provide data from all soil-mapping unit conditions found in a particular area.

If a technique could be developed which would allow interpolation between soils and plot applications in predicting yield, experiments could have a greater range of applicability to different soils. From this standpoint, the logical starting point in assembling fertilizer input-output data would seem to be in the area of soil classification. Since traditional classification schemes were designed for other specific functions (such as erosion control or similarity in physical properties), additional considerations need to be given to schemes which are based directly on crop response. One such scheme was developed by Osgood (10) in Mississippi. Preliminary investigations in Georgia using a similar concept have indicated the possible usefulness and need for further research on ways and means of organizing soil mapping units for efficiency in farm planning.

Use of Plot Information for Farm Planning

The work in Mississippi indicated that, for a particular crop, soils could be arrayed according to ability to supply moisture (other variables may be associated with moisture), and this array could be used advantageously to specify soil differences in organizing and presenting input-output data for farm planning. The conceptual framework for this scheme is illustrated in figure 11.7 for corn and cotton. In this arrangement, the dependent variable is the array of soils from wet bottom and well-drained bottom to the good terrace and upland soils and to the poorer upland soils with erosion or drought hazards. "Benchmark" soil-mapping units can then be selected at strategic intervals across the range of soil conditions.

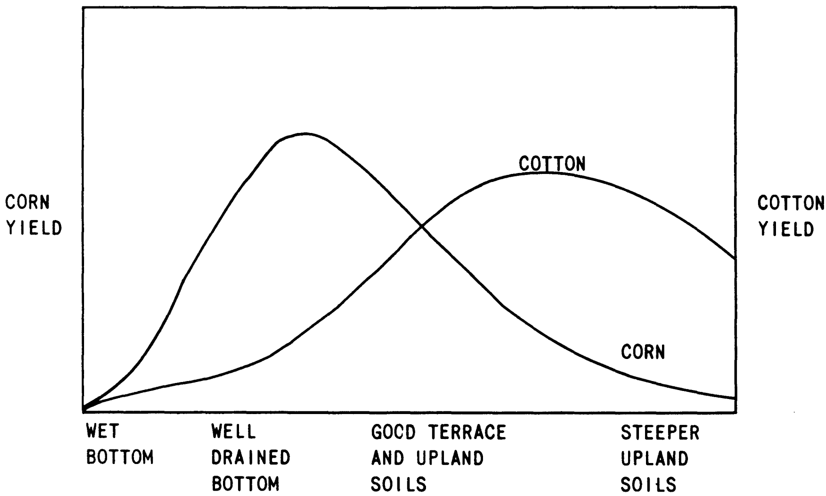

Fig. 11.7 — Relationship between different soils and yield of cotton and corn when fertilizer and other production factors are used in "optimum" amounts.

If this or a similar scheme would allow prediction of the effect of different soils on yield with a desired degree of reliability, research dollars would provide more information. Each plot experiment could be placed geographically to provide maximum efficiency in predicting results for a variety of soil conditions. One could interpolate between areas for soils where specific research has not been conducted.

Three major problems exist in making inferences to farms from experimental plots. First, present knowledge of soil differences is not sufficient to allow refined estimates of reliability for this scheme in predicting yield. Still, these differences may not be of sufficient magnitude to be important. For preliminary testing of this procedure for local soil conditions in Georgia, (a) soil mapping units were rated for suitability to produce specific crops, (b) mapping units were combined with similar ratings, and (c) these groups of soils were arrayed according to the "model" illustrated in figure 11.7. The results are presented in table 11.2 and are sufficiently encouraging to warrant further development.

TABLE 11.2. Soil Characteristics – Fred Nichols' Farm of 160.6 Acres in Catoosa County

Soil Series and Types	Lindside Silt Loam	Huntington	Pope	Dewey-Decatur	Clarksville	Clarksville	Decatur	Clarksville	Colbert
Topographic position	Wet bottom	Bottom	Draw	Upland	Upland	Upland	Upland	Upland	Upland
Slope	0-2	2-6	2-6	2-6	2-6	6-10	10-15	10-15	10-15
Acres	32.0	5.6	19.5	9.2	5.8	19.0	19.8	44.2	5.5
Drainage, surface	Poor	Good	Fair	Good	Good	Good	Good	Good	Poor
Entire profile	Poor	Good	Fair	Good	Good	Good	Good	Good	Poor
Erosion hazard	None	None	Slight	Slight	Slight	Moderate	Mod.-Severe	Mod.-Severe	Moderate
Drought hazard	Slight	Slight	Moderate	Moderate	Moderate	Moderate	Severe	Severe	Severe
Suitability for:[b]									
Corn	Fair[a]	Excellent	Very good	Very good	Good	Good	Fair	Fair	Very poor
Small grain	Poor	Excellent	Very good	Excellent	Very good	Good	Good	Fair	Very poor
Alfalfa	Not suited	Poor	Excellent	Very good	Very good	Very good	Good	Good	Very poor
Temporary pasture	Fair	Excellent	Excellent	Excellent	Very good	Good	Good	Good	Poor
Grass – Ladino	Excellent	Excellent	Excellent	Excellent	Excellent	Very good	Very good	Good	Fair
Cotton	Very poor	Poor	Fair	Very good	Good	Good	Fair	Fair	Poor

[a]Water hazard, assumes adequate control.
[b]Assumes adequate erosion control.

Source: Woodworth, R. C.; Perkins, H. F.; McIntyre, O. L., Dept. of Agr. Econ., Dept. Agron., University of Georgia, and Soil Scientist, SCS., respectively.

A second problem concerning inferences for farm planning purposes from experimental plot experiments is that of differences in management practices. If responses to fertilizer, when all factors but management are held constant, could be arrayed for a population of farm operators, presumably responses obtained on an experiment station would fall in the upper quartile of these; inferences drawn from the experiment would involve increasing error as applied to average and below-average managers (see fig. 11.4). Here survey data and soil-testing histories may be used to fill gaps in knowledge. Perhaps plot experiments and check-row data on case-study farms also can be an aid.

A third inference problem is associated with most current fertilizer input-output data. It stems from a lack of knowledge about the dynamic effects of fertilizer on soil fertility over a period of time. It also is mentioned in Chapter 1. Information of the effects of time on responses is needed if economic analyses are to be applied with a desired degree of confidence. Information is needed on economical rates of fertilizer application for a return in one crop year, two crop years, or three crop years to fit particular "time horizon" attitudes of farm operators in different capital positions.

TABLE 11.3. Response to Fertilizer Corn on Hayesville Clay Loam, Georgia, 6-10% Slope, Soil Test P_2O_5 Low, K_2O Medium

Fertilizer per Acre[a]			Range[b]	Average	Dry Year	Favorable Year	Years in 100 Yield Would be as Much or More Than (Bu. per acre)			
N	P	K	Bus./Acre	Bus./Acre	Bus./Acre	Bus./Acre	40	60	80	100
X	X	X	X-X	40	X	X	X	X	X	X
X	X	X	X-X	50	X	X	X	X	X	X
X	X	X	X-X	60	X	X	X	X	X	X
X	X	X	X-X	70	X	X	X	X	X	X
X	X	X	X-X	80	X	X	X	X	X	X
X	X	X	X-X	85	X	X	X	X	X	X

[a]Most efficient fertilizer combination to produce given yield for specific or average price ratios.
[b]Range in long-time average yield to reflect variations in management.

Table 11.3 indicates some of the basic types of information which are needed for farm planning. First, the data should refer to particular soil and fertility conditions. Second, alternative levels of fertilizer application should be indicated to assist in making decisions for particular capital situations and goals. Third, ranges of outcomes in expected long-time average yields (first and third quartile of a population of farm yields) are needed to assist in making judgments for management differences on particular farms. Fourth, expected yields for favorable and unfavorable seasons are needed. Fifth, a measure of relative frequency of expected given yields over time with average management should be included.

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