DETERMINING FERTILIZER AND LIME RATES FOR MAXIMUM PROFITABILITY

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SUMMARY

Technical or production efficiency is not sufficient for farmers and ranchers who plan to survive in an open-market agricultural economy. Producers must also ensure that their operations are economically efficient.

Decision making aimed at profit maximization is an important element of long-term business survival. Profit maximization generally occurs at output levels which are less than maximum in agricultural production systems. Producers who can evaluate input and output decisions on the basis of changes in receipts and changes in costs, and who produce that output for which these changes are equal, are producing at the profit maximizing level.

Field research results of fertilizing and liming forage and grain crops commonly produced in East Texas are subjected to economic analysis. Profit maximization levels of input use were estimated and compared to input rates for maximum production.

In many cases, such as applying Potassium (K) on Coastal bermudagrass, limestone on ryegrass, and Phosphorus (P) on Hard red winter wheat, the profit maximizing level of input use is very close to input use for maximum production. However, in some scenarios evaluated, differences between these two levels of use were more dramatic. Results were affected by initial soil conditions, fertilizer and lime prices, and the value of forage or grain being produced.

INTRODUCTION

Producers of high quality forages constantly labor over deciding upon fertilizer and lime rates that will result in maximum profitability. These decisions are complicated since producers face unique situations in terms of available production resources such as soils, rainfall, and temperature, in addition to financial resources such as available capital or credit for operating expenses.

Profit is the key factor that hangs in the balance as farmers make management decisions. One key to business success is careful economic analysis of input/output relationships so that inputs will be used at levels as close to the point of profit maximization as possible.

Three economic principles provide guidance to managers as decisions about levels of resource use are made. First, input use should be increased as long as the value of added output, or income, is greater than added cost of additional units of input. For example, additional fertilizer should be applied as long as each dollar expended generates at least one dollar in income. This implies that the point at which profits are maximized is where added income just offsets additional costs.

Second, inputs should be substituted, one for another, as long as costs are decreased with the level of production remaining constant. Producers selecting efficient fertilizer mixes, deciding upon lime products, or choosing feeding programs for cow herds should closely consider this second principle.

Third, agricultural producers generally face diminished marginal returns as additional levels of inputs are used. For example, yield increases expected from applying the first 50 lb of nitrogen to bermudagrass pastures are anticipated to be greater than increased yields attributed to a second 50 lb application shortly thereafter. Figure 1 illustrates this type of production response. The implications surrounding this third principle are that producers should target profit maximization levels of input use rather than maximum production, even though there may not always be large differences between the two levels.

PROCEDURES

Results of previous agronomic studies were used to develop economic analyses of fertilizer and lime applications on Coastal bermudagrass, ryegrass, and HRW wheat in East Texas. Field trials were conducted under the direction of Dr. Vince Haby, Texas Agricultural Experiment Station, Overton and Dr. Leon Young, Stephen F. Austin State University, Nacogdoches. Details concerning experimental design, soil analyses, and other research results can be obtained from either of these individuals.

The aforementioned economic principles were considered in evaluating the economic feasibility of applying fertilizers and other soil amendments in the regions studied. The level of application corresponding to the point of maximum profits was estimated for each experiment evaluated.

Fertilizer and lime application recommendations based on profit maximization result from comparing marginal factor cost (MFC) with marginal value product (MVP). MFC is merely an economic term for "added cost" of using an additional unit of an input. For example, the added cost of applying an additional unit of fertilizer per acre (say an additional 100 lbs per acre).

MVP is the "added return" generated by increased output resulting from using additional unit of an input. For example, the increased revenue from selling additional hay produced when an additional 100 lbs of fertilizer per acre was applied.

A fundamental principle of farm management is that the profit maximizing level of input use occurs when MVP equals MFC. Should MVP be greater than MFC, then the added value of forage production is greater than the added costs from using the next unit of fertilizer. Hence, it makes economic sense to add the next unit of fertilizer as long as MVP exceeds MFC. By adding more fertilizer, total profits are increased. If the situation were reversed, it would make economic sense to decrease fertilizer use, permitting profits to increase.

MFC and MVP estimates were based on current (1989) average prices and costs provided by industry representatives. Custom rates were used to prevent assumptions about equipment components and operating costs. Livestock forage consumption and rates of gain were supplied by a computerized simulation program developed by research animal scientists.

RESULTS

With profit maximization, the goal of the farm manager is to find the level of inputs (and hence outputs) that maximizes the difference between revenues and costs. One could accomplish this task by calculating the difference between total income and total cost. Figures 2 and 3 illustrate these two values from experiments which included applying K at various rates on Coastal bermudagrass (Leonard, 1986). However, this method has two disadvantages. First, it conceals the marginal effects of changes in the input level. Second, it takes more time to find the new optimum input level if the price of either the input or output changes. Therefore, the preferred method of estimating the profit maximizing level of an input is to equate MVP and MFC.

Three examples of economic applications to forage production situations are presented. Statistical analysis of field research resulted in estimating a production function with a maximum yield at 304 lbs K/ac. However, the profit maximizing level of use, determined by equating MFC with MVP, was estimated to be about 295 lb K/ac when it cost $11 for 50 lbs of K with hay selling for $50/ton (Figure 4).

The profit maximizing level of K is directly related to the prices of K and hay. This level decreases as the price of hay decreases or as the price of K decreases. It is important to remember that these recommendations and calculations are based on holding all other factors of production at constant levels.

Annual ryegrass is a very important cool season forage crop in East Texas. The practice of applying limestone to overcome acid soil infertility common to this region has been well documented by many researchers including Hillard (1989) whose results were used for economic analysis. Results of research indicated that ryegrass yields more than doubled with the addition of 1 ton lime/ac on soil with an initial pH of 4.5 (Figure 5).

It is interesting to note that limestone was applied in 1983, so that yields were effected by the result of residual lime in the soil. This likely accounted for a portion of higher yields at higher lime rates while yields at lower rates dropped off substantially in 1987.

The economic returns from liming ryegrass under these experimental conditions were impressive. An economic value for the additional ryegrass produced as a result of liming was estimated with the aid of a computerized animal nutrition and gain model. The assumption for the economic evaluations was that ryegrass would be grazed by 450 lb stocker animals and that lime cost $24/ac spread.

Results indicated that there were economic benefits to applying more than 1.5 tons lime/ac as MVP remained above MFC (Figure 6). The profit maximizing point was not readily calculated as it was beyond the range of the experimental data. However, it appears to be near 2 tons lime/ac under these conditions.

Lime, nitrogen (N), and K are all important soil amendments for maintenance of high quality Coastal bermudagrass pastures in East Texas. Making recommendations of application rates based on economics can be confusing when interactions between nutrients are considered. Varying application rates of other soil amendments may or may not have an affect on the optimum economic level of limestone.

Research results present six different scenarios for economic analysis (Leonard, 1986). Only one, where 249 lb K/ac and 250 lb N/ac were applied, resulted in a profit maximizing level at 2 tons lime/ac (Figure 7). All three cases with 500 lb N applied/ac resulted in an economic optimum level of lime at 1.6 tons/ac (Figure 8).

Hard red winter (HRW) wheat is important to East Texas both for its ability to produce forage for grazing as well as grain for commercial sale. The final two cases, analyzed independent of each other with all other factors held constant, are phosphorous (in the form of phosphate fertilizer) and limestone applications on HRW wheat. Initial soil conditions included a pH of 5.3 and soil test P level of 3.0 ppm.

Production responses of HRW wheat to P represented typical diminishing returns to input use (Figure 9). Maximum production occurred at a fertilizer phosphorus rate of about 100 lbs/ac. The profit maximizing rate was only slightly less at nearly 98 lbs/ac (Figure 10).

HRW wheat also exhibited typical diminishing returns to lime application on the soils described above. Maximum production occurred at a rate of 1 ton lime/ac while the profit maximizing level was estimated to be close to 1.6 tons lime/ac (Figures 11 and 12).

REFERENCES

Hillard, J. B. 1989. Coastal bermudagrass and Marshall ryegrass response to surface-applied kunestibe and phosphorus on an acid, sandy East Texas soil. Ph.D. Thesis, Texas Agricultural Experiment Station, Texas A&M University, Overton.

Leonard, A. T. 1986. The effects of lime and K on Coastal bermudagrass yield and nutrient concentrations at two N rates. M.S. Thesis, Stephen F. Austin State University, Nacogdoches.

Figure 1. Example of Diminishing Returns to Use of an Input

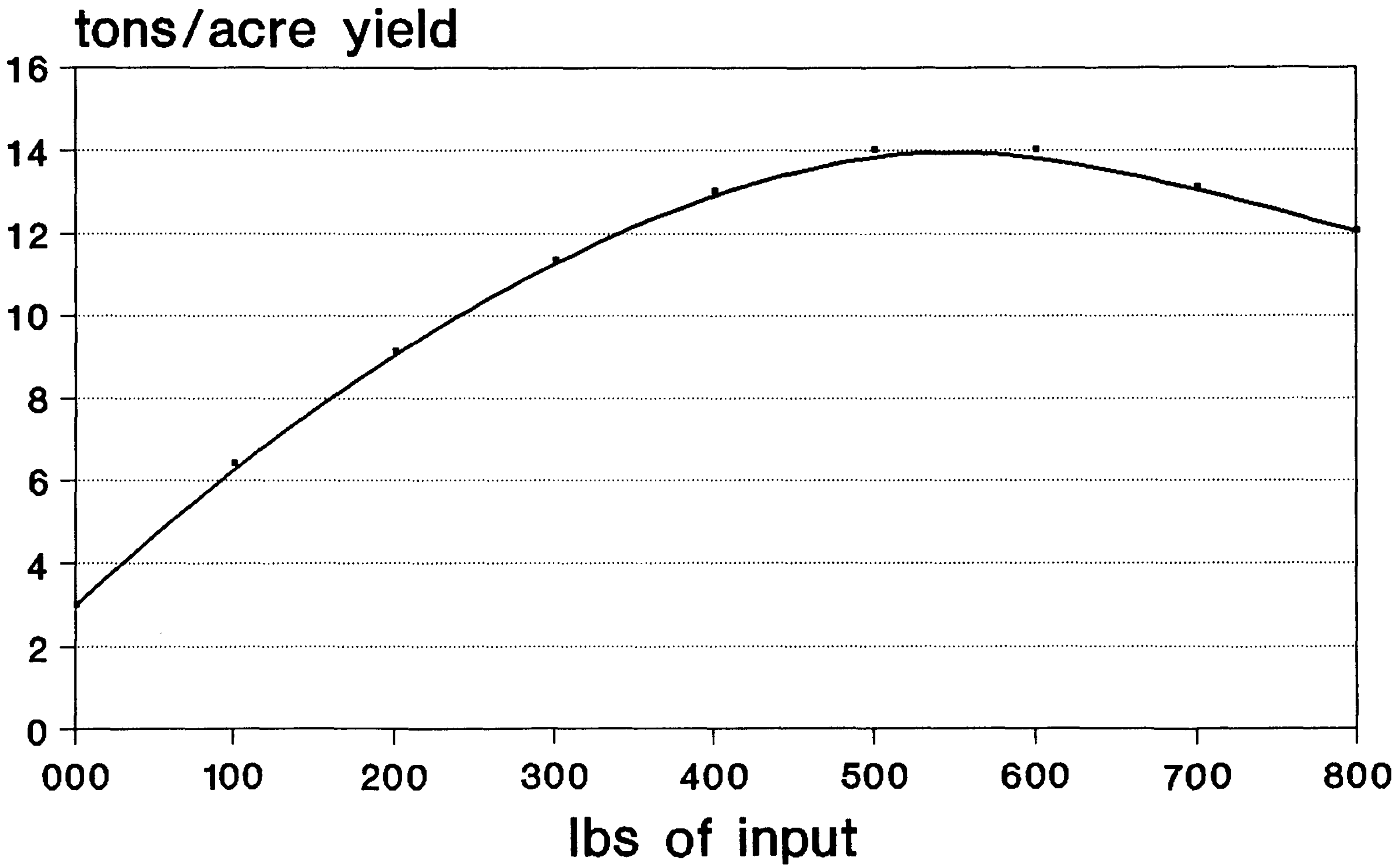
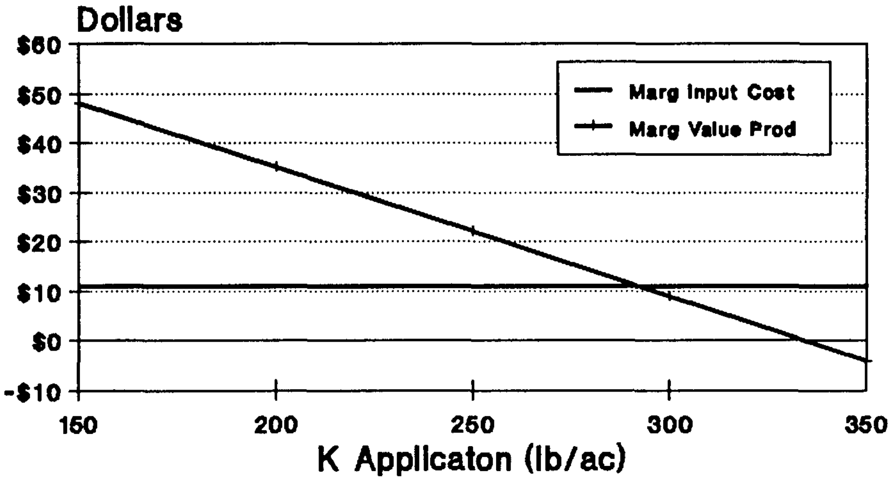
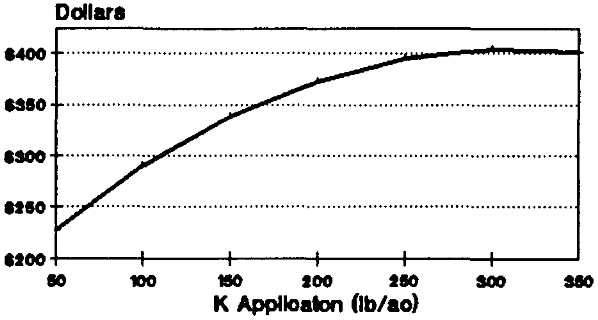


Figure 4. Determining Profit Maximizing Rate of K Applied to Coastal



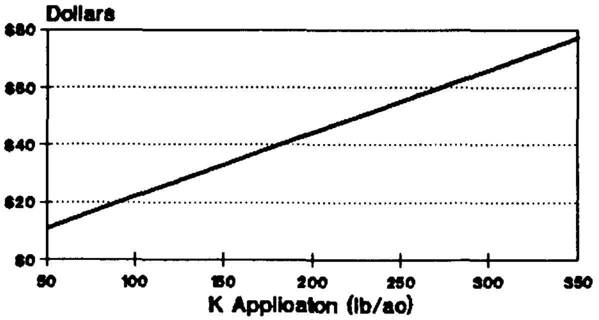
1.6 tons lime/ac; $50/T hay; 250 lb N/ac
$.22/lb K; Darco sandy loam; Nacogdoches
Stephen F. Austin State Univ.

Figure 2. Income from Coastal Hay Resulting from K Fertilization



1.6 tons lime/ac; $50/T hay; 250 lb N/ac
Darco sandy loam; Nacogdoches Co;
Stephen F. Austin State Univ.

Figure 3. Total Cost of K Applied to Coastal Hay



1.6 tons lime/ac; $.22/lb K; 250 lb N/ac
Darco sandy loam; Nacogdoches Co.
Stephen F. Austin State Univ.

Figure 5. Production Response, Applying Lime to Ryegrass with pH 4.5 Soil in 1983

Lime Rate (lb/ac)	1986 Yield (lb/ac)	1987 Yield (lb/ac)
0	3233	551
1000	5148	1220
2000	6503	2494
3000	7298	7371

112 lb P/ac; Lilbert Loamy Fine Sand; TAES, Overton

Figure 6. Determining Profit Maximizing Level, Lime Applied to Ryegrass, pH 4.5 Soil

Lime Appl. (lb/ac)	1986 MFC	1986 MVP
0-1000	$12	$186
1000-2000	$12	$132
2000-3000	$12	$77

112 lb P/ac; Lilbert loamy fine sand; TAES, Overton

Figure 7. Profit Maximizing Rates of Lime Applied to Coastal with 250 lb N/ac

K (lb/ac)	Lime Rates (tons/ac)
125	*1* 1.6 2 4 8
249	1 1.6 *2* 4 8
373	*1* 1.6 2 4 8

Sandy Loam; $60/T hay; $24/T Lime; Nacogdoches; SFA

Figure 8. Profit Maximizing Rates of Lime Applied to Coastal with 500 lb N/ac

K (lb/ac)	Lime (tons/ac)
125	1 *1.6* 2 4 8
249	1 *1.6* 2 4 8
373	*1* *1.6* 2 4 8

Sandy loam; $60/T hay; $24/T lime; Nacogdoches; SFA

Figure 9. HRW Wheat Yield Response to Phosphate Fertilizer with .5 ton Lime/ac

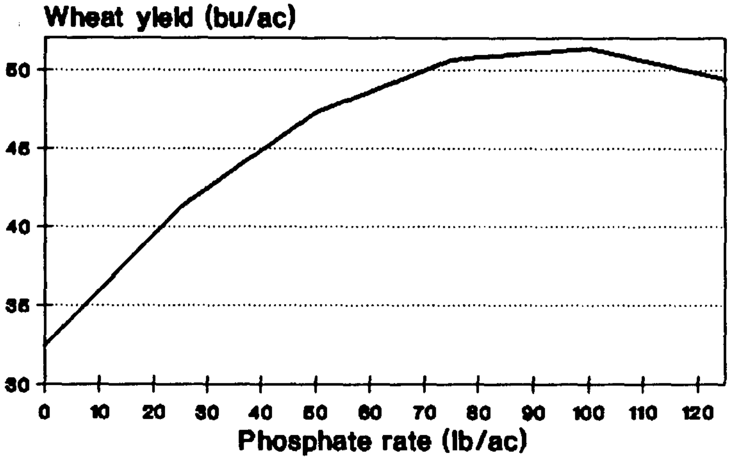
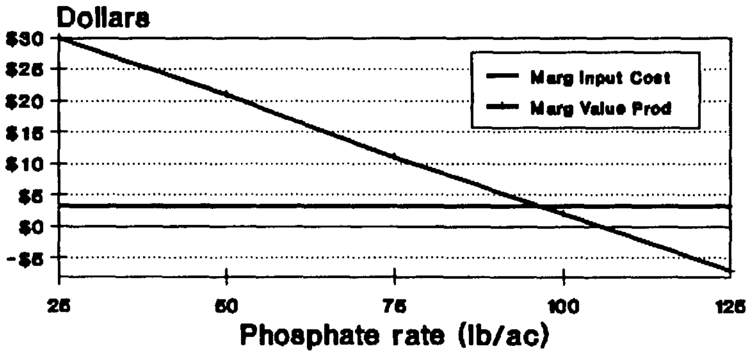
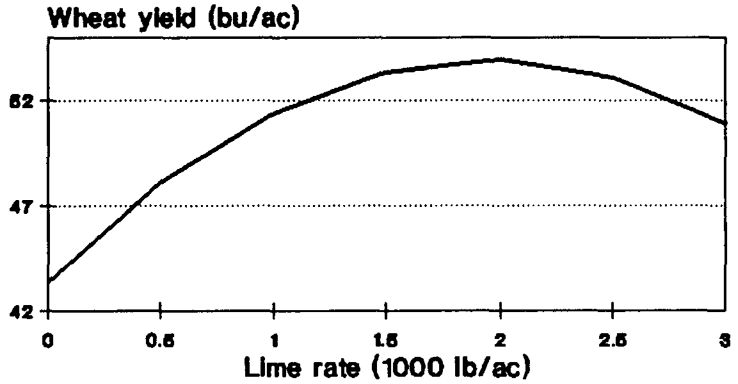


Figure 10. Profit Maximizing Level of Phosphate Applied to HRW Wheat with $.28/lb Phosphate and $3.50/bu Wheat



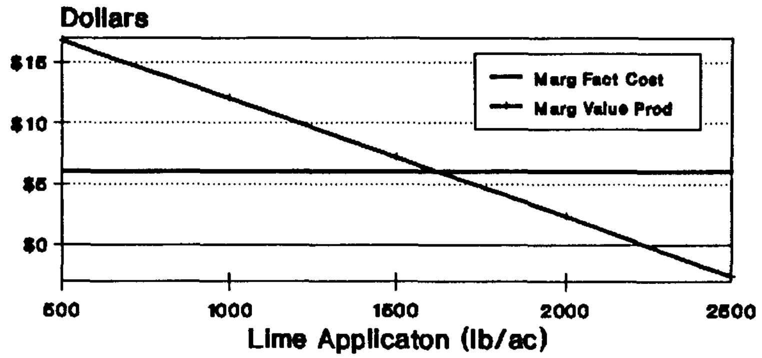
1000 lb lime/ac; initial pH 5.3;
3.0 ppm P; Burleson heavy clay;
Red River Co.

Figure 11. HRW Wheat Yield Response to Limestone Applications with 94 lb Phosphate/ac



Burleson heavy clay; Red River Co.
Initial pH 5.3; 3.0 ppm P

Figure 12. Profit Maximizing Level of Lime Applied to HRW Wheat with $24/T Lime and $3.50/bu Wheat



94 lb phosphate/ac; Initial pH 5.3
Burleson heavy clay; P 3.0 ppm;
Red River Co.