SOIL FERTILITY AND ITS RELATIONSHIP TO CROP PRODUCTION COST IN NO-TILLAGE SYSTEMS

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The rapidly increasing cost of crop production is forcing an interest in practices that reduce or eliminate specific cost variables normally associated with crop production. Some practices which have been shown to be beneficial in reducing production cost are reduced tillage, double cropping, and crop rotations. Reduced tillage operations decrease operating costs such as fuel and labor, however, added cost of special herbicides may offset this advantage if an effective weed control management system is not utilized. Double cropping systems help decrease fixed costs by spreading cost associated with taxes, land rent, and equipment over exceptionally long growing seasons rather than over a few months during the spring and summer. Double cropping winter legumes with summer annuals such as corn and sorghum may substantially reduce the amount of nitrogen (N) required for summer crop production. Crop rotations are effective in eliminating special weed problems and can be a big advantage in fertilizer utilization, especially if leguminous/non-leguminous systems are used.

Other methods used to cut production cost include reductions in fertilizer usage, plant populations, and herbicide usage. Excessive reduction in any of these and similar essential items may reduce crop yield below an economical level and actually increase rather than decrease production cost.

The purpose of this paper is to report results from some of the fertility/tillage research studies conducted in central and north Georgia during the past three years and relate these management practices to production costs. The reader should be aware that the prices quoted may vary among seasons and locations. Cost figures were valid at the time and location at which the research was conducted, but may not be valid for other locations or future purchases. Most of the studies cited in this paper have not been completed and rates of fertilizer or herbicides used should not be interpreted as a recommendation.

Value of maintaining optimum phosphorus levels for double-cropped, no-tillage wheat and soybeans

Wheat and no-tillage soybeans have been double-cropped on a Cecil soil with various P levels for the past two years. Treatments were a one time application of P_2O_5 applied in the fall of 1977. Applied P, cost of P, soil P levels, soybean and wheat yields are listed in Table 1. There is no doubt that the $15/acre cost of applying 130 lbs/acre of P_2O_5 in the fall of 1977 was a sound economical investment. This application increased net returns over the two year period by approximately $95/acre for wheat and $90/acre for soybean. There was, however, a more economical return than illustrated by yield alone, especially with no-tillage soybean production. In both

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years, soybeans grown on the low P soil failed to develop a closed canopy which resulted in extreme but unnecessary weed pressure. To effectively control weeds in the low P plots, soybeans had to be post directed twice in both years with contact herbicides which added $12/acre/year to the production cost of the lower yielding soybeans.

Table 1. Applied P_2O_5, cost of applied P, soil P levels, and yield of double cropped no-tillage soybean and wheat.

Applied P_2O_5	cost/ acre	Soil P level		Yields			
				Wheat		Soybean	
		1978	1979	1978	1979	1978	1979
lbs/acre	$	-lbs/acre-		---------bu/acre----------			
0	0	10	9	32	20	34	36
130	15	20	19	46	35	40	43
260	30	56	32	40	39	45	45
520	60	96	100	35	38	46	46
780	90	200	168	29	38	46	47

Applying large applications of P every three of four years instead of recommended annual rates will reduce total application cost but may be detrimental to wheat yields. Early season wheat growth and winter survival increased as applied P increased in both years, but in 1978 wheat grain yield decreased when applied P_2O_5 rates were greater than 260 lbs/acre (Table 1). The 1977/1978 growing season was favorable for glume blotch infectians; the infection along with lodginq was related to excessive P, applications (Table 2). In order to avoid possible problems associated with excessive P, fertilizer application rates should always be based on soil test recommendations.

Table 2. Lodging and glume blotch infection of wheat in 1978 as affected by applied P_2O_5.

Applied P_2O_5	Lodging		Glume blotch infection
	6 April	4 June	
lbs/acre	%		
0	0	0	29
130	30	35	47
260	40	64	70
520	53	77	73
780	65	95	84

Data in Table 2 was collected by B.M. Cunfer, Dept. of Plant Pathology, Georgia Station, Experiment, GA.

Time and method of P fertilization for double-cropped wheat and soybeans

Phosphorus mobility in soils is restricted and losses through leaching are generally not encountered. The restricted mobility and non-leaching characteristics of the phosphate ions will permit advanced applications of P fertilizers. In double-cropping systems, once a year applicatons instead of fertilization for each crop can cut production cost. However, as previously pointed out, over-fertilization with P can decrease wheat yield and, in addition, P fertilizers can be converted to a form that is not readily available for plant uptake which may be a disadvantage to applying P several months in advance of planting, especially on low P soils. In continuous no-tillage systems, P fertilizers may accumulate at or near the soil surface and could possibly result in P deficient subsurface soils.

A major study was established in the Georgia Piedmont on a Cecil sandy loam soil in the fall of 1977 to investigate the effects of time and methods of P application on wheat and soybean yields. Treatments consisted of times of application (fall only, spring only, and fall plus spring); methods of application (incorporated and unincorporated); and P_2O_5 rates (0, 65, 130, and 260 lbs/acre/year). Method of application is also a form of tillage and no-tillage, since phosphorus was incorporated by turning and disking immediately after application.

In 1978, there was a response to applied P (Table 3) but no differences in methods of application. Maximum yield was obtained with the 65 lb/acre/year P_2O_5 application which cost approximately $7.50/acre. This $7.50/acre/year investment resulted in an increased gross return of $3l/acre for wheat and $90/acre for soybeans. With adequate P_2O_5 applications (65 lbs/acre/year), preemergence residual herbicides applied prior to planting soybeans were effective in supressing weed growth. Postemergence herbicide applications in the unincorporated, no-tillage plots and cultivation in the incorporated, conventional tillage plots were not required. The no-tillage system at the optimum P level resulted in an approximate $10/acre savings in total production cost over the conventional tillage system; however, in the conventional tillage system, a more economical preemergence herbicide program could probably have been utilized which would have helped equalize the production cost between the tillage systems. The biggest advantage for no-tillage would have been in time saved during land preparation. When soybeans were grown at the low fertility level (no applied P_2O_5), cost of the postemergence herbicides required for effective weed control was much greater than cultivation cost for the conventional tillage system.

In 1979, wheat yield for the conventional tillage, incorporated P treatments averaged 10 bu/acre higher than yield from the no-tillage system. The yield difference could not be equalized with the cheaper no-tillage production system. Lower wheat yield with the no-tillage system was a result of a poorer stand than with the conventional tillage system.

Soybean yield was lower in 1979 than 1978 but the response to applied P was similar in both years. The conventional tilled beans averaged 35 bu/acre and the no-tillage beans averaged 40 bu/acre. The soybean yield increase with no-tillage equalized the loss obtained with no-tillage wheat, but the most economfcal practice was with the conventional tilled wheat and no-tilled soybeans.

Table 3. Yield of wheat and soybeans in 1978 as affected by applied phosphorus

Applied P_2O_5	Yield: Wheat	Yield: Soybean
lbs/acre/year	bu/acre	
0	39[1/]	34
65	48	46
130	46	47
260	46	45

[1/] Yields are averaged over two methods of application and three times of application.

Nitrogen fertilizer for grain sorghum when no-tilled into crimson clover

When winter crops are planted for the sole purpose of providing a no-tillage mulch, a winter legume may be an economical choice for the winter cover crop. Legumes will generally provide an adequate mulch so that the advantages of no-tillage can be realized and in addition, they may also provide an adequate quantity of N for the summer crop. The cost of seeding these legumes cost $20 to $25/acre, which is approximately equal to the price of 100 pounds of N. In the Southern Piedmont of Georgia, crimson clover will mature in mid-to-late May which is an ideal time for planting grain sorghum. Allowing these legumes to mature each year will eliminate the cost of reseeding each fall, thereby providing an exceptionally low cost N source and no-till mulch.

A major study was established in the Southern Piedmont of Georgia in 1977 to evaluate crimson clover as a partial or complete source of N for grain sorghum production. The grain sorghum was no-tilled into self-seeded, mature crimson clover. Nitrogen was applied to the grain sorghum at rates of 0, 13, 27, 40, 80, and 120 lbs/acre. There was no response to applied N, therefore only 3 rates are shown in Table 4. The nitrogen plots were split into two application periods (at planting and 30 days after planting), but time of application did not influence yield. The N produced by the clover reduced production cost of grain sorghum approximately $20/acre/year. It is noteworthy that the 2-year average grain sorghum yield was 100 bu/A where the sole source of N was the legume. Since the clover reseeded itself each year, there was no cost for clover establishment except for the initial seeding.

Additional treatments included removing the clover tissue at maturity for hay and no-tilling sorghum into the clover stubble. This did not effect re-establishment of clover the following fall or influence grain sorghum yield relative to applied N. However, an additional consideration relates to replacing P and K removed in the clover which can be an added cost factor. Phosphorus and K removed in the clover tissue averaged 14 and 138 lbs/acre, respectively. Replacement cost would be approximately $8/acre for P and $21/acre for K. The value and need for the clover hay may easily overcome this additional cost.

Table 4. Yield of grain sorghum no-tilled into mature crimson clover as affected by applied nitrogen

Applied nitrogen	Year 1978	1979
lbs/acre	——— bu/acre	———
0	94	106
40	90	112
120	96	110

Choice of double cropping systems may help decrease fertilizer cost

In many no-tillage systems, continuous grain crops are grown on the soil throughout the year. Stubble and unused materials from each crop remains on the soil surface as a no-tillage mulch for the following crop. Two compatable cropping systems are wheat double cropped with soybeans and wheat double cropped with grain sorghum. When wheat follows soybeans, N application to wheat can be reduced resulting in a substantial savings in N fertilizer cost. Yield from a N fertilizer wheat study following no-tillage grain sorghum and no-tillage soybeans are listed in Table 5. Nitrogen fertilizer required for maximum wheat yield was 60 lbs/acre when planted behind soybeans and 100 lbs/acre when planted behind grain sorghum. Considering possible weed, disease, insect, and nematode problems, a good management system would not include continuous double cropped wheat and soybeans for several years on the same soil. However, when wheat follows soybeans in the overall cropping system, the cost saving advantage with reduced N fertilizer should be utilized.

Table 5. Effect of fall and winter N applications on yield of wheat following soybeans or grain sorghum.

	Summer crop and N applied at planting (lbs/acre)					
February	Soybeans			Sorghum		
applied N	0	20	40	0	20	40
lbs/acre	———	wheat yield, bu/acre	———			
0	31	40	41	4	12	24
20	47	45	58	14	28	29
40	48	46	52	21	39	39
60	50	54	55	34	45	51
80	51	48	51	50	52	55

Source and method of nitrogen fertilization for no-tillage corn

Many agricultural specialists have suggested that no-tillage corn requires more N than conventional tillage corn. These suggestions are partially erroneous. The amount of N required for a specific variety to produce top yields is the same regardless of production practice. If more N is lost from the soil or is immobilized in one system than another, then more N fertilizer may be required in the higher loss system to supply the plant with sufficient quantities of N to produce maximum yield.

Unfortunately, some of the cheaper N fertilizers are more susceptible to losses through ammonia volatilization than the more expensive ones. These losses are often accelerated with surface applications in no-tillage systems. An example of nitrogen sources that are susceptible to N losses through ammonia volatilization is urea and urea containing compounds such as 28, 30, and 32% N solutions. Climatic and soil conditions that determine the potential for ammonia volatilization are numerous and whether or not losses will occur in any particular system are difficult to predict.

Surface applications of N solutions in no-tillage systems, which is a common practice, can be risky. In some years N losses will be insignificant, but in others, losses may be severe due to factors such as inadequate moisture, high soil pH and/or high temperatures. In no-tillage systems it may be best to use ammonium nitrate which is not very susceptible to N losses through ammonia volatilization. However, if the price difference between ammonium nitrate (19% liquid or 34% solid) and the various urea-ammonium nitrate solutions is substantial, it may be more economical to use the solutions. Even under maximum loss conditions, from solutions seldom reach 25% of the amount applied. It may be more economical to apply a high rate of the N solution if the price of solid ammonium nitrate is 15% or greater than solution costs (based on cost per pound of actual N).

A comparison between solid ammonium nitrate and 32% N solutions in no-tillage corn production indicated there was no difference between the two sources in 1978 but a difference in favor of NH_4NO_3 in 1979 (Table 6.) Due to the many factors that may influence losses of urea-N from the soil, it is difficult to predict in advance when it would be safe to surface apply urea-N compounds to the surface of no-tilled soils.

Table 6. No-tilled corn yield as affected by nitrogen sources

	Year and nitrogen source			
	1978		1979	
Applied nitrogen	Ammonium[1] nitrate	Nitrogen[2] solution	Ammonium nitrate	Nitrogen solution
lbs/acre	grain yield, bu/acre			
80	137	133	132	110
160	144	149	155	147
240	165	161	172	157

[1] 34% solid amnonium nitrate

[2] 32% urea - ammonium nitrate solution

Starter fertilizer for early planted no-tillage grain sorghum

When soils are cool, sorghum is a slow growing plant. This slow growth will increase susceptibility to insect and disease damage, and in season when preemergence herbicide activity is poor, weeds may grow as fast as the sorghum plant. This equal weed growth may prevent satisfactory application of post directed herbicides.

In ratooning systems, the initial seeding must be planted in relatively cool soils during late winter or early spring so that the second crop will mature before a killing frost occurs in late fall. In 1977 and 1978, early no-till planted sorghum on some of the University of Georgia's experimental stations grew much slower than did early planted conventional-tilled sorghum. In 1979, a study was designed to investigate the possible use of starter fertilizers to increase growth rate of early planted no-tillage sorghum. Results of test conducted at Plains and Griffin, Georgia (Table 7) indicate that there may be an economical advantage in using these fertilizers. Growth rates during the first two months after planting were almost twice as great when starter fertilizer was applied than when it was not applied. In addition, plants receiving starter fertilizer matured 7 to 14 days earlier than those not receiving starter fertilizer. When averaged over N rates the use of starter fertilizer increased net returns $14/acre at Plains and $25/acre at Griffin.

Table 7. Yield of early planted sorghum as affected by N and starter fertilizers at Plains and Griffin, GA, 1979

Sidedress[2/] N	Location and starter fertilizer,[1/] lbs/acre			
	Plains		Griffin	
	0	80	0	80
lbs/acre	sorghum yield, bu/acre			
0	22	32	39	54
40	31	41	64	79
80	39	45	70	88
120	42	47	68	88

[1/] The sorghum was planted in an in-row subsoiler. The starter fertilizer (DAP or 18-46-0) was applied in the subsoil tract at planting.

[2/] Nitrogen was applied four weeks after planting

If soil test values are medium to high in P and/or K, the total amount of these fertilziers needed may be applied as a starter application; thereby, eliminating costly fertilzier application. However, high concentration of fertilizers should not be placed in contact with the seed or banded directly beneath the seed.

Conclusion

Methods to reduce production cost or at least slow down the rate of increase must be developed and utilized. Properly managed no-tillage and double cropping systems appear to be excellent methods for reducing cost. Fertilizer cost increased during the past year and will probably continue to increase. A reduction in fertilizer use is tempting but as pointed out in this paper, an over-reduction in fertilizer use can actually increase production cost. Cost associated with fertilizer use may be reduced through proper application method, source selection, and crop rotations. Regardless of production practice, tillage system, or crop rotation, the most economical method for determining fertilizer application rate is through soil testing. When irrigation systems are utilized, plant analysis should be used, along with a soil testing, to determine the most economical fertilizer rates.