AN ENGINEERING BASED, ECONOMIC ANALYSIS OF TILLAGE OPTIONS FOR PEANUT

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INTRODUCTION

Farmers need simpler, less expensive systems for tillage and other farm operations. Peanut, cotton, corn, and soybean produced in rotations in the Southeast Coastal Plain traditionally have required separate tillage systems. Ownership and upkeep of a variety of implements used on only one part of the farm have reduced overall farm income. Managing as many as 18 trips over a field creates a labor nightmare in a labor-short market.

Modern conservation tillage methods were introduced to provide more effective control of soil erosion than expensive and difficult to maintain field structures such as terraces, diversions and waterways. All conservation tillage practices seek to maintain partial cover through the management of crop residues and living vegetation. Depending on soil type they may also seek to loosen topsoil or disrupt hard pans. Adoption of conservation tillage often involves purchase of new types of implements, changes in tractor sizes, and changes in timing of labor use.

Any decision regarding changes in tillage practice must include bottom-line considerations. While the change may be initiated to adopt conservation tillage, control hard-pan development, or control persistent weeds, the selection among implement types, sizes, and features should be guided by potential economic returns to land and management. The new practices should maintain or improve profitability or simplify management by reducing labor and equipment.

Tillage comparisons conducted on farms and experimental plots have often included economic analyses. These analyses provide good comparisons of the primary tillage changes, but they seldom include evaluation of these tillage options in view of how these changes fit into the entire season management of the cropping enterprise or the entire farm enterprise. Field studies usually include four or fewer direct comparisons and are limited to one brand or type of tillage implement, to available tractor sizes, and to planting date, growing season and other cultural practices.

A new effort was begun to systematically analyze tillage options. Several goals were identified for this analysis: to calculate the energy and field time requirements for all tractor/implement practices used during a growing season; to calculate variable and fixed costs associated with each operation and with the entire crop enterprise; to determine how often selected tillage and other field operations will be delayed by inclement weather; to determine how planting schedules, affected by tractor/implement selection and weather will influence harvest schedules and crop yield; to allow partial assignment of fixed costs for each implement to a crop enterprise based on its shared use with other crop enterprises on a farm. A computer program (EVTOPS) was written and a data base of tractors and implements assembled to accomplish these goals. The program provided the means to screen many options and do sensitivity evaluations. The purpose is report is to describe the methodology used in the analysis and to discuss some of the results from the analysis of three tillage options for peanut.

METHODOLOGY

Program Development

Implement Data Base. To provide the greatest flexibility, an external data base was assembled containing purchase price and specifications that affect power. labor, and operating costs. For tractors and self-propelled equipment, purchase price (NAEDA, 1993, and survey of dealers in the Tifton, Ga., area), horsepower and weight (specified by manufacturers), and repair and maintenance factors (ASAE D497, 1990) were included. For tillage and other implements specifications included effective treatment width or number of crop rows treated, weight, PTO power requirement, average draft force created by the implement under average operating conditions in sandy loam soils, field operation efficiency. minimum and maximum operating speeds, purchase price (survey of dealers in the Tifton, Ga., area) and

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repair and maintenance factors. Where they were not available from manufacturers, engineering specifications were computed from ASAE D497 (1990) for comparable implements. Draft force for multi-component tillage implements were computed from a sum of forces for individual components, such as coulters, chisels, and various disks. In addition to the complete implements in the data base, individual components were added to allow the user to try out potential new equipment configurations. Each tractor and implement also included an percent assignment to the crop being assessed. For peanut, diggers and combines were assigned 100% of the time to the crop, but tractors, sprayers, and tillage implements could be shared with other enterprises on the farm to distribute fixed costs more appropriately.

In addition to the implement data base, a default data base was constructed for acres to be planted, average slope of the fields, unit prices for fuel, oil, labor, and commodity, and interest rate on capital. Finally, a default scenario data base was constructed. A scenario was a sequence of field operations to be used in the production of the crop. Scenarios are comparisons for which engineering and economic analyses are desired. They may consist of nearly identical series of field operations where only one tractor or implement is being varied, or they may be completely different systems of production, such as, comparisons between moldboard plow based production with nine field operations versus conservation tillage based system with just four operations.

Each operation in a scenario is a separate pass over the field. When, for example, subsoilling, row cultivation, planting, fertilizer application are accomplished in a single pass it is one operation. Conversely, each pass with a disk harrow was a separate operation. For each operation, an implement from the equipment data base, a maximum number of hours per day for the operation, and preferred date or dates were specified. For most operations the preferred date was the date on which the operation would begin unless delayed by inclement weather, poor soil conditions, or incomplete prior operations in the scenario. For cultivation, a period of delay could also be specified so that cultivation would be delayed a fixed number of days after planting or after previous cultivation. For planting, four dates were supplied: the earliest possible date to begin planting assuming soil temperature was high enough; the planned or normal planting date; the date by which planting must begin even if not all field areas are prepared; and the last date on which planting could be done. The latter two dates involved abandoning some of the planting intentions in order to obtain an acceptable yield. They were not used unless weather delays or inadequate equipment was specified for the intended acreage. For harvest (digging), the planned date will be the maturity date for that portion of the field as predicted from the planting date and intervening weather, but a must-start-harvest date and must-stop-harvest date can be specified to prevent late delivery to the market.

Engineering calculations. The procedures followed methods outlined in Parmar et al. (1991) and were used to calculate hours required for each operation. Hours required are field size divided by implement speed and width. Implement speed was calculated from power requirements of the implements selected and available power of the tractor selected. Power for PTO and draft force were supplied in the equipment data base. Rolling resistance force was computed for tractors and wheeled implements from weights for tractor or implement plus mean contents of sprayers, fertilizer spreaders, etc., and average land slope using methods outlined by Hunt (1989). If the calculated speed fell below the minimum speed for operation, the tractor was too small and a higher powered tractor was required. If the speed exceeded the maximum operating speed, then the speed was limited to that maximum.

Economic Analyses. Once hours required for each operation were known, costs could be computed. Fuel and oil costs were calculated from tractor horsepower, operating hours and fuel costs as outlined by Hunt (1989). Labor was calculated from operating hours and labor costs. Repair and maintenance for each implement and tractor were based on purchase price and repair factors supplied in the equipment data base. Computation followed ASAE EP496 (1990). Annual fixed costs were computed from supplied interest rate and purchase price using capital consumption equations of Hunt (1979). These assumed a 10-year life of machinery, salvage value of 10% of purchase price, and tax, shelter, and insurance costs equal to 2% of the purchase price. When equipment, such as tractors, was shared over operations, fixed costs for each operation were prorated over shared operations based on hours required for each. Unshared items, such as peanut diggers, had all fixed costs assigned to that operation.

Crop and Weather Interactions An important component of the analysis of tillage options is the affect of changed practices on timeliness of operations. If an alternative practice requires more time, it increases the likelihood that inclement weather will delay operations. When the delayed operation is planting or harvest, yield can be affected. To determine how tillage scenarios interact with weather and crop yield, the PNUTGRO model was run for 25 years (1973 to 1992) of weather from the Tifton, Ga., region. When soil in the upper 15 in. had water content above field capacity, the field was too wet and all field operations were suspended. Other delays were caused by rainy days and by very cold (average air temperature below 40 F or maximum below 45 F). Additionally, planting was delayed if soil temperatures during the three days before scheduled planting were below 70 F. Digging was forced by the first freeze because vines would be killed in late maturing peanuts. All weather affected delays were recorded and continuation of the delayed field operation scheduled to resume as soon as weather or soil conditions permitted.

When planting operations began the portion of the field planted on a given day was handled as a cell for which a maturity [digging) date and yield were computed for each year using the PNUTGRO model and that year's weather. Planting that extended over many days, particularly when delayed by rain, created fields that had uneven maturity and yield. Three days before peanuts matured in the first cell, harvest was started. As each day's harvest was complete a yield was computed for that harvested area from the composite of cells harvested that day. Early and late harvests for each crop reduced yield as described by Parmar et al. (1991). A composite seasonal yield was computed and average yield and economic return calculated for the 25 years of weather. These long term average minimized biases in tillage options caused by conducting tests in exceptional years.

Analysis of Peanut Tiilage Options

In the example shown here, the engineering based, economic analyses EVTOPS was run for three common tillage systems: slot planting (strict no-till), row-till (conservation tillage including in-row subsoil and row cultivation), and moldboard plow (conventional). Operations included digging and combining in all cases. early spring herbicide application for the first two systems, and rototilling and field cultivation in the moldboard plow scenario. For the conservation tillage a 155 hp tractor was required to pull the integral, 6-row, subsoiller/planter. The 6-row. no-till planter and the 2-row moldboard plow and rototiller could be operated with a 100 hp tractor. In the cases examined here, all equipment was assumed to be 100% dedicated to the peanut crop enterprise.

RESULTS AND DISCUSSION

Initial runs show that costs are highly affected by the tillage and tractor required. Table 1 summarizes operations, field time required, and costs for the three scenarios for a 320 acre peanut field. The moldboard plowing required the greatest field time and, hence, had the highest labor costs. The total fixed costs for the moldboard plow scenario was the same as for the slot planting system since the same 100 hp tractor was charged against this enterprise. but the more expensive 155 hp tractor added substantially to the tractor fixed cost. The tractor variable cost is largely dependent upon time, but the higher power requirements adds additional fuel cost with the large tractor, and the repair and maintenance costs are affected by the purchase price. The implement fixed costs were highest for the conservation tillage because the subsoiller/row tilllplanter was more expensive than the 6-row planter used in the slot planting and moldboard plow systems. Implement fixed costs are for the entire season since most are used only in one operation per year.

The yields predicted for these three scenarios were similar, approximately 3200 lb/acre pod yield, since we selected large enough tractors to plant and harvest in a short time. If we switched the conservation tillage equipment to 2-row to allow use of the 100 hp tractor, then the longer planting season caused lower yields with conservation till. Over 25 years of weather for the Tifton. Georgia, area, the average number of delayed field days was 7.0 for the moldboard plow, 4.0 for the slot planting and 4.6 for the conservation tillage. Delays would be greater with larger field areas and for locations with a less favorable spring or fall weather.

EVTOPS can help identify tillage options that can lower overall costs and not reduce potential yields due to planting delays. The program cannot determine the yield response to the tillage itself. however. In this example, slot planting was the least expensive tillage scenario, $192/acre

Table 1. Fixed and variable costs, time required for operations and labor costs for three tillage systems. All tractor and equipment costs are assigned to this 320 acre enterprise.

Operation	Time Used	Tractor Fixed	Tractor Variable	Implement Fixed	Implement Variable	Labor Costs
	hours	----------Dollars/acre				----------
		Slot planting - 320 acre - 100 hp tractor				
Herbicide	34.7	3.10	1.07	1.42	0.25	0.65
Plant	35.3	3.15	1.17	11.14	1.43	0.66
Dig/Invert	61.2	5.45	1.88	6.95	0.65	1.15
Combine	169.3	15.10	5.21	11.34	3.12	3.17
Total	300.5	26.80	9.25	30.85	5.52	5.64
		Conservation till - 320 acre - 155 hp tractor				
Herbicide	34.7	3.60	1.61	1.42	0.25	0.65
Subsoil/plant	118.1	12.23	5.51	25.52	10.96	2.21
Dig/Invert	61.2	6.70	2.85	6.95	0.65	1.15
Combine	169.3	17.54	7.90	11.34	3.12	3.17
Total	383.3	40.07	17.89	45.23	14.98	7.18
		Moldboard plow - 320 acre - 100 hp tractor				
Disk	29.6	1.27	0.91	5.67	0.27	0.55
Disk	29.6	1.27	0.91	0.00	0.27	0.55
Plow	148.8	6.36	4.58	3.97	2.44	2.79
Rototill	103.6	2.58	3.47	1.05	0.32	1.94
Plant	25.2	1.08	0.77	8.10	0.74	0.47
Cultivate	29.6	1.27	0.91	2.83	0.11	0.55
Cultivate	29.6	1.27	0.91	0.00	0.11	0.55
Dig/Invert	61.2	2.62	1.84	6.95	0.65	1.15
Combine	169.3	8.95	5.18	11.34	3.12	3.17
Total	626.5	26.80	19.28	39.92	8.04	11.74

compared with $308 for conservation and $261 for moldboard. However, in soils that have hard pans the loss in yields may offset part of these cost savings. Field trials will be needed to verify yield effects. The costs, space, and time requirements for field tillage studies precludes use of large numbers of variables in long-term studies. Evaluation of Tillage Options (EVTOPS) enables a screening method for planning and evaluation a large number of tillage options.

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