Corn Production and Profitability as Influenced by Tillage, Winter Cover, and Nitrogen Fertilizer

S.L. Ott* and S.M. Dabney[1]

Introduction

Reducing soil erosion and increasing profits are two goals of farmers and agronomists alike. Two possible methods for achieving these goals simultaneously are no-till planting and using a winter legume cover crop. This paper compares the corn yields and profits of using different combinations of no-till planting and winter legumes cover crops with those from a conventional tillage system.

Methodology

Thirty six combinations of tillageicover crop treatments and nitrogen (N) fertilizer rates in producing corn *(Zea mays* L.) in Louisiana were tested. The thirty six combinations arose from three tillage options, two cover crops, and six N fertilizer rates. The three tillage options were conventional tillage, no-till with paraplow, and no-till without paraplow. Subterranean clover *(Trifolium subterraneum)* and no planted cover crop (fallow) are the two possible winter covers. Each of the six tillage/cover crop treatments received six rates of nitrogen fertilizer: 0, 36, 71, 107, 143, or 178 pounds of actual N per acre. The experiment occurred at the Ben Hur Farm, Baton Rouge, LA during the 1986 and 1987 growing seasons.

The six tillage/cover crop treatments differed in the type and timing of machinery operations. Table l lists the machinery operations and when they occurred. In Louisiana, conventional tillage for corn consists of three diskings plus some type of subsoiling. In our study, the paraplow was used for subsoiling.

The conventional tillage/fallow treatment began with paraplowing and disking in the fall. The following spring two diskings were made and the corn was planted. For weed control, atrazine (2 lb. a.i./A) and alachlor (3 Ib. a.i./A) were applied soon after planting, followed by mechanical cultivation. A month after planting, liquid nitrogen fertilizer was

[1]S.L.Ott, Dept. of Agricultural Economics, Georgia Experiment Station. Griffin. GA 30223-1797 and S.M. Dabney. USDA-ARS National Sedimentation Laboratory. P.O. Box I 157.Oxford. MS 386.55. *Corresponding author.

Table 1. The Timing of Machinery Operations for Six Tillage/Cover Crop Treatments in Louisiana.

Operation	Month of operation	Machine size	Tractor size (hp)	Tillage/Cover Crop Treatment: Conv. Tillage-fallow	Conv. Tillage-clover	No-till fallow	No-till clover	Paraplow fallow	Paraplow clover
				number of operations					
Paraplow	Nov[a]	4-shank	I43	1	1			1	1
Disk	Nov	20 It	143	1	1				
Drill clover	Nov	12 ft	93		1				
No-till drill clover	Nov	12 fl	93				1		1
Disk	Mar	20 tt	I43						
Spray (herbicide)	Mar	30 ft	93						
Plant Corn	Mar	6-row	I43						
No-till plant corn	Mar	6-row	I43			1	1	1	1
Spray (herbicide)	Mar	30 ft	93	1	1				
Spray (fertilizer)	Apr	30 ft	93	1	1				
Spray (fertilizer and herbicide)	Apr	30 fl	93			1	1	1	1
Combine	Aug	6-row		1	I	1	I	I	I
Truck	Aug	5-Ion		0.4	0.4	0.4	0.4	0.4	0.4

a. First year only.

Table 2. Per Acre Corn Production Costs — Six Tillage/Cover Crop Treatments, 1989.

Input	Unit	Price $	Conventional Tillage: Fallow	Conventional Tillage: Clover	No-till: Fallow	No-till: Clover	Paraplow: Fallow	Paraplow: Clover
			$/A					
Corn seed	thou.	0.90	25.20	25.20	25.20	25.20	25.20	25.20
Clover seed	lb	1.50		22.50		22.50		22.50
lnoculant	bag	2.75		0.83		0.83		0.83
Nitrogen	lb	0.21	a	a	a	a	a	a
Phosphate	lb	0.24	9.60	9.60	9.60	9.60	9.60	9.60
Potash	lb	0.14	5.60	5.60	5.60	5.60	5.60	5.60
Paraquat	lb a.i.	20.73			7.77		7.77	
Glyphosate	lb. a.i.	21.25				21.25		21.25
2-4D	lb a.i.	2.73				1.37		1.37
Atrazine	lb a.i.	2.95	4.90	4.90	4.90	4.90	4.90	4.90
Alachlor	lb a.i.	5.50	16.50	16.50	16.50	16.50	16.50	16.50
Linuron	lb a.i.	14.74			14.74	14.74	14.74	14.74
Crop oil	gallon	8.14			1.63	1.63	1.63	1.63
Surfactant	gallon	11.60			5.22	5.22	5.22	5.22
Labor	hour	5.00	8.50	9.50	5.50	6.50	7.50	8.50
Diesel fuel	gallon	0.76	6.23	7.07	2.96	3.80	5.40	6.31
Gasoline	gallon	1.00	1.20	1.20	1.20	1.20	1.20	1.20
Equip. repairs	dollars	1.00	16.89	18.49	13.39	15.37	16.06	18.03
Drying changes	bu	0.18	b	b	b	b	b	b
Interest charges'	dollars	0.10	3.55	5.57	4.03	6.65	4.58	7.19
Total operating cost[d]			98.17	126.96	118.24	162.86	125.90	170.57
Machinery costs			32.56	35.60	25.27	29.03	30.73	34.49
Total costs			130.73	162.56	143.51	191.89	156.63	205.06

a. Varies (0, 36, 71, 107, or 178 Ib/A.
b. Is a function of corn yield.
c. Excluding any interest charges on nitrogen fertilizer.
d. Excludes nitrogen costs and drying charges.

applied. Corn harvest occurred in August.

The conventional tillage/clover treatment differed from the conventional tillageifallow treatment by the planting of clover in the fall. After the fall disking, clover seed was drilled at a rate of 15 lb./A. The spring diskings were enough to control the clover. For both conventional tillage treatments, paraplowing occurred only once at the beginning of the experiment in the fall of 1985.

The no-tillifallow treatment started with a bum-down application of paraquat (0.375 Ib. a.i./A) followed 7 days later with atrazine (2 lb. a.i/A.) and alachlor (3 lb. a.i./A.) After another 7 day wait, the corn was no-till planted. A month later, liquid nitrogen fertilizer and linuron (1 lb. a.i./A) were applied.

Substituting clover for fallow, the no-tilliclover treatment required the no-till drilling of clover seed at 15 lb/a. Paraquat is not very effective in controlling (killing) subterranean clover (Dabney and Griffin, 1987). To control clover, glyphosate (1 lb a.i/A) and 2-4 D (0.5 lb a.i./A) replaced paraquat. The rest of the inputs did not differ from the no-tillifallow treatment. Note that this study uses the subterranean clover cultivar 'Woogenellup' which is easier to control than 'Mt. Barker' (Dabney and Griffin, 1987).

Both paraplow treatments were simply no-till with paraplowing the first fall. The second year, there were no differences in machinery operations between the paraplow and no-till treatments.

Significant yield differences among the different tillage/cover crop treatments were calculated using paired t-tests. To compare relative profitability of each tillage/cover crop treatment, crop budgets were developed using 1989 Louisiana enterprise budget information (Paxton and Lavergne, 1989; Lavergne and Paxton, 1989). Profits for each tillage/cover crop treatment and N rate combination were calculated using average experiment yields, corn price of $2.84/bu, and the crop budgets from Table 2. Using a 2% real discount rate, profits from the second year were added to the first year's profits. Relative profitability for each tillage/cover crop treatment was then based on total discounted profits. For this analysis profits represented a return to management, risk, and land.

Table 3. Mean Corn Yields (bu/A), Ben Hur Farms, Baton Rouge, LA, 1986-1987

	N Fertilizer Rate (lb/A)						
Tillage/cover crop	0	36	71	107	143	178	Mean
Year	bu/A						
Conv. Tillage/Fallow							
1986	73.7	108.8	114.9	123.8	128.7	138.8	114.8
1987	31.2	65.6	98.5	116.3	132.4	109.2	92.2
Average	52.5	87.2	106.7	120.1	130.6	124.0	103.5
Conv. Tillage/Clover							
1986	120.4	139.4	134.6	115.1	141.2	157.9	134.8
1987	82.5	85.9	101.3	142.1	132.2	102.0	107.7
Average	101.5	112.7	118.0	128.6	136.7	130.0	121.2
No-Till/Fallow							
1986	55.2	94.9	96.3	120.4	123.0	141.7	105.3
1987	36.8	76.0	93.4	82.7	63.1	76.4	71.4
Average	46.0	85.5	94.9	101.6	93.1	109.1	88.3
No-Till/Clover							
1986	90.0	98.6	100.3	109.9	124.4	145.0	111.4
1987	99.9	88.6	106.2	116.9	75.2	93.2	96.7
Average	95.0	93.6	103.3	113.4	99.8	119.1	104.0
Paraplow/Fallow							
1986	64.5	110.0	131.0	117.5	117.4	96.6	106.2
1987	30.1	59.6	89.8	93.5	107.4	87.7	78.0
Average	47.3	84.8	110.4	105.5	112.4	92.2	92.1
Paraplow/Clover							
1986	103.2	125.7	121.5	110.7	115.8	147.5	120.7
1987	91.9	125.1	97.5	99.6	134.9	81.0	105.0
Average	97.6	125.4	109.5	105.2	125.4	114.3	112.9

The difference between average yields that are significant at the 10% confidence level as determined by the paired t-test are:

Conv. tillage/fallow — conv. tillage/clover
Conv. tillage/fallow — no-till/fallow
Conv. tillage/fallow — paraplow/fallow
Conv. tillage/clover — no-till/fallow
Conv. tillage/clover — paraplow/fallow
Conv. tillage/clover — no-till/clovcr
No-till/fallow — no-till/clover
No-till/fallow — paraplow/clovcr
Paraplow/fallow — paraplow/clovcr

Agronomic Results

Table 3 reports the mean corn yields. Conventional tillage produced superior corn yields. The highest two-year average yields for both fallow and clover cover crops occurred with conventional tillage. The top two-year average corn yield of 137 buia occurred using 143 lbiA N following clover as a cover crop. For corn following fallow, the optimal N rate was also 143 lbiA producing a two-year average yield of I31 bu/A. The superiority of conventional tillage yields was also demonstrated by comparing yield differences at each N fertilizer rate within cover crop treatments. For fallow. conventional tillage is superior to no-tilling with and without paraplowing and for clover conventional tillage is superior to no-till without paraplow, all at the 10% confidence level.

Paraplowing increased yields relative to regular no-till for both fallow and clover cover crops. However, the differences were not significant.

Clover as the cover crop treatment produced significantly (at the 10% confidence level) higher average corn yields than fallow for all three tillage treatments. The yield advantage though decreased as the N rate increased. For some years within a tillage treatment, the maximum corn yield following clover occurred at a N rate equal to or greater than that which produced the maximum corn yield following fallow. Thus. clover should not be viewed strictly as a nitrogen fertilizer substitue. It can act as a yield enhancer as well.

In comparing the two years, we find that the yields for all tillage/cover crop treatments were lower the second year. One explanation for the lower yields is the excess rainfall that occurred during tasseling.

Economic Results

Conventional tillageifallow at the 143 lb/A N rate generated the greatest profit over the two years, Table 4. The extra yield from using a clover cover crop for the conventional tillage system was not enough to cover its establishment cost. The price of clover seed, $1.50/1b, is relatively high in 1989 due to supply shortages. Clover seed prices would have to drop to $0.46 lb before it would be economical to plant clover in a conventional tillage system. A price drop of two-thirds is highly unlikely though.

For no-till. paraplowing increased profits. With fallow as the cover crop, paraplowing increased profits over the two year period by almost $40/A. With the clover cover crop, the profit increase was almost $80/A. Paraplowing also decreased optimal N fetilirer levels. For both types of cover crops. optimal N fertilizer for no-till without paraplowing is 178 lb/A. With paraplowing, the optimal N rate decreases to 71 lb/A following fallow and 36 lb/A following clover.

As with conventional tillage, the use of clover as cover crop was uneconomical for both no-till paraplow and regular no-till. Contributing to subterranean clover's uneconomical position was the extra herbicide cost of $20/a required to kill it. If no additional herbicide costs were required, then using clover would become profitable with paraplowing.

Given the high chemical cost of killing subterranean clov-

Table 4. Annual and Total Discounted Profits as a Function of Tillage, Cover Crop and N Rate.

	N Fertilizer Rate (lb/A)					
Tillage/Cover Crop	0	36	71	107	143	178
	$/A					
Cow. Tillage/Fallow						
Year 1	65.30	149.64	158.28	174.14	179.36	98.64
Year 2	-34.05	47.84	127.77	167.31	202.31	133.01
Discounted total'	31.93	196.52	283.49	338.10	371.62	328.99
Conv. Tillage/Clover						
Year 1	157.71	198.64	178.26	118.58	180.20	217.20
Year 2	70.01	70.02	102.90	204.11	169.95	82.02
Discounted total	226.32	267.26	279.10	318.61	346.75	297.40
No-till/Fallow						
Year 1	3.31	101.11	97.23	153.53	152.63	194.78
Year 2	-45.63	50.84	89.52	53.24	-6.71	21.08
Discounted total	-41.41	150.93	184.96	205.70	146.05	215.44
No-Till/Clover						
Year 1	47.52	62.58	59.51	77.23	107.99	155.19
Year 2	73.85	35.98	75.20	95.85	-22.88	17.40
Discounted total	119.89	97.84	133.21	171.16	85.57	172.24
Paraplow/Fallow						
Year 1	14.94	128.16	176.43	132.70	124.62	61.70
Year 2	-63.45	7.21	79.94	81.97	111.13	51.14
Discounted total	-47.24	135.23	254.77	213.03	233.53	111.82
Paraplow/Clover						
Year 1	69.46	121.50	102.73	66.19	71.95	148.68
Year 2	52.57	133.07	52.06	49.83	135.92	-15.05
Discounted total	120.98	251.91	153.75	115.02	205.15	133.93

1. Discounted total = year 1 + (0.98 x year 2).

er (mowing is not effective) (Dabney and Griffin, 1987), other winter legumes should be evaluated. Hairy vetch *(Vicia villosa)* and crimson clover *(Trifolium incarnatum)* have increased profits for no-till corn grown in Georgia (Franklin, Ott, and Hargrove, 1989). Hairy vetch and crimson clover are easier to control than subterranean clover by either chemicals or mowing (Dabney and Griffin, 1987).

Summary and Conclusions

At least in the short-run, tillage pays. Conventional tillage with paraplow is superior to no-till with or without paraplow. Conventional tillage farmers concerned about soil erosion can plant a legume cover crop like subterranean clover which helps reduce soil erosion with minimal sacrifice in profits. Finally, the cost of killing the legume cover crop can be as important as the cost of planting it when determining legume cover crop profitability.

References

Dahney, S.M. and J.L. Griffin. 1987. Efficacy of hurndown herbicides on winter legume cover crops. p. 122-124. In J.F. Power (ed.) The role of legumes in conservation tillage systems. Soil Conservation Society of America. Ankenv. IA.

Elton. E.J. and M.J. Gruber. 1987. Modern portfolio theory and investment analysis. 3rd. ed. John Wiley & Sons, New York, NY.

Franklin, R.L., S.L. Ott, and W.L. Hargrove. 1989. The economics of using legume cover crops as sources of nitrogen in corn production. Division of Agricultural Economics, University of Georgia, Faculty Series 89-11. 20p.

Lavergne, D.R. and K.W. Paxton. 1989. Projected costs andreturnscotton, soybeans. corn, milo and wheat, Red River and central areas, Louisiana, 1989. Louisiana Exp. Stn. A.E.A. Information Series No. 71

Paxton, K.W. and D.R. Lavergne. 1989. Projected costs and returns — cotton, soybeans. corn, milo and wheat, northeast Louisiana, 1989. Louisiana Exp. Stn. A.E.A. Information Series No. 70.