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IMPACTS OF ALTERNATIVE TILLAGE,

FERTILIZATION, AND HERBICIDE APPLICATION METHODS

ON CORN PRODUCTION COSTS AND RETURNS

by

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ABSTRACT

The impacts on actual corn production costs and returns were analyzed. Tillage, fertilization,a nd herbicide alternatives are reported. Both stubble and ridge till planting had lower costs per bushel and higher returns per acre than conventional tillage. Banding of fertilizer and, to a lesser extent, manure management had lower costs per bushel and higher returns per acre than broadcast application of fertilizer. Manure applications increased both diesel fuel use and time required per acre. Since corn yields by herbicide application method varied in the same order as the cash rent cost (a proxy for land quality), the differences between application method may be due to both factors. These observations were from one year and a few farms so should be interpreted with caution; more data is being collected in 1990.

*Olson is an Assistant Professor, Department of Agricultural and Applied Economics, University of Minnesota, Twin Cities. Weber is the coordinator of the project and a farmer from Sanborn, Minnesota.

IMPACTS OF ALTERNATIVE TILLAGE,
FERTILIZATION, AND HERBICIDE APPLICATION METHODS
ON CORN PRODUCTION COSTS AND RETURNS[1]

by

Kent Olson and Craig Weber[2]

The farmers of the Southwestern Minnesota Farm Business Management Association are concerned about the future--just like their neighbors in Minnesota and the rest of the nation. Their concern is over the future profitability of farming, the quality of their lives, the quality of their physical environment, the quality of their communities, and the productivity of their land for future generations. This concern created a desire to know more about the on-farm effects of alternative production methods. This desire for knowledge led to the development and subsequent funding of a grant to study the on-farm effects of sustainable agriculture.[3]

In 1989, the first year of the project, fourteen farms were monitored. The farms were members of the Association and, thus, had both whole-farm and enterprise records. In addition, the project coordinator

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[1]Presented at "Extending Sustainable Systems," a training conference sponsored by the Minnesota Department of Agriculture, The Farm Business Management Association, and the Minnesota Extension Service at the Sunwood Inn, St. Cloud, Minnesota, May 10, 1990.

[2]Olson is an Assistant Professor, Department of Agricultural and Applied Economics, University of Minnesota, Twin Cities. Weber is the coordinator of the project and a farmer from Sanborn, Minnesota.

[3]This was a project of the Southwest Minnesota Farm Business Management Association through its Sustainable Agriculture Committee. The cosponsor was the Department of Agriculture and Applied Economics, University of Minnesota, St. Paul. The funding was from the Agriculture Utilization Research Institute Energy Savings Program of the Greater Minnesota Corporation.

visited these farms and gathered information not normally collected on input amounts and operations and equipment used. The practices monitored included alternative methods of tillage, fertilization, and herbicide application.

This paper summarizes the major observations noted in analyzing the corn production practices on 12 of these farms in 1989. Because the data are from one year and from a small number of farms, no statistical tests were performed on the data. The project will continue to monitor these farms, gather more data on these and other practices in corn and soybean production in 1990.

One of the problems of on-farm research is that all factors are not controlled. So we do not know if differences are due to the treatments or due to other factors. To avoid some of this confusion, the costs of the production practices are calculated using typical rates charged by custom operators. This removes the differences due to differences in machinery complements such as age and maintenance level. To remove the impact of differences in marketing ability, standard prices for inputs and for corn are used in estimating the enterprise budgets. Differences may still be due to management and location, but these "standardized" costs and returns allow a more accurate comparison of practices between farms. As more data are gathered, these effects will be separated more clearly.[4] Having standardized as much as possible, differences in corn production are noted in the next three sections for different tillage, fertilization, and herbicide application methods. These preliminary comparisons are made on the basis of yields, costs, returns, and resource use.

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[4]The data for each field are listed in the appendix.

TILLAGE PRACTICES

There were three tillage methods with enough observations in 1989 to make some preliminary comparisons. The three methods were conventional, stubble planted (also called slot-till or no-till), and ridge till. Conventional tillage fields were plowed by a moldboard or chisel plow and/or had two or more spring tillage treatments. Stubble planted fields were planted in soybean stubble from the previous year with no fall or spring tillage work. Ridge till fields were planted on top of permanent ridges. The only tillage performed on ridge till land is the cultivation between the ridges during the growing season. In 1989, the project monitored 8 fields of each tillage method. These fields were on 6 farms for conventional tillage, 3 farms for stubble planting, and 4 farms for ridge till.

The average corn yield in fields with conventional tillage were slightly higher than the average stubble or ridge till yields (Figure 1). However, differences in land quality need to be considered before yield differences are attributed to tillage methods. As a proxy for a measure of land quality, cash rent per acre was used. The fields with stubble planting had the highest average cash rent ($78 per acre) and the ridge till fields the lowest ($71) (Figure 2). Since the ranking of yields is not the same as the ranking of land values, we concluded that the differences in yield were due to factors other than just land quality.

Figure 1. Average yields by tillage method

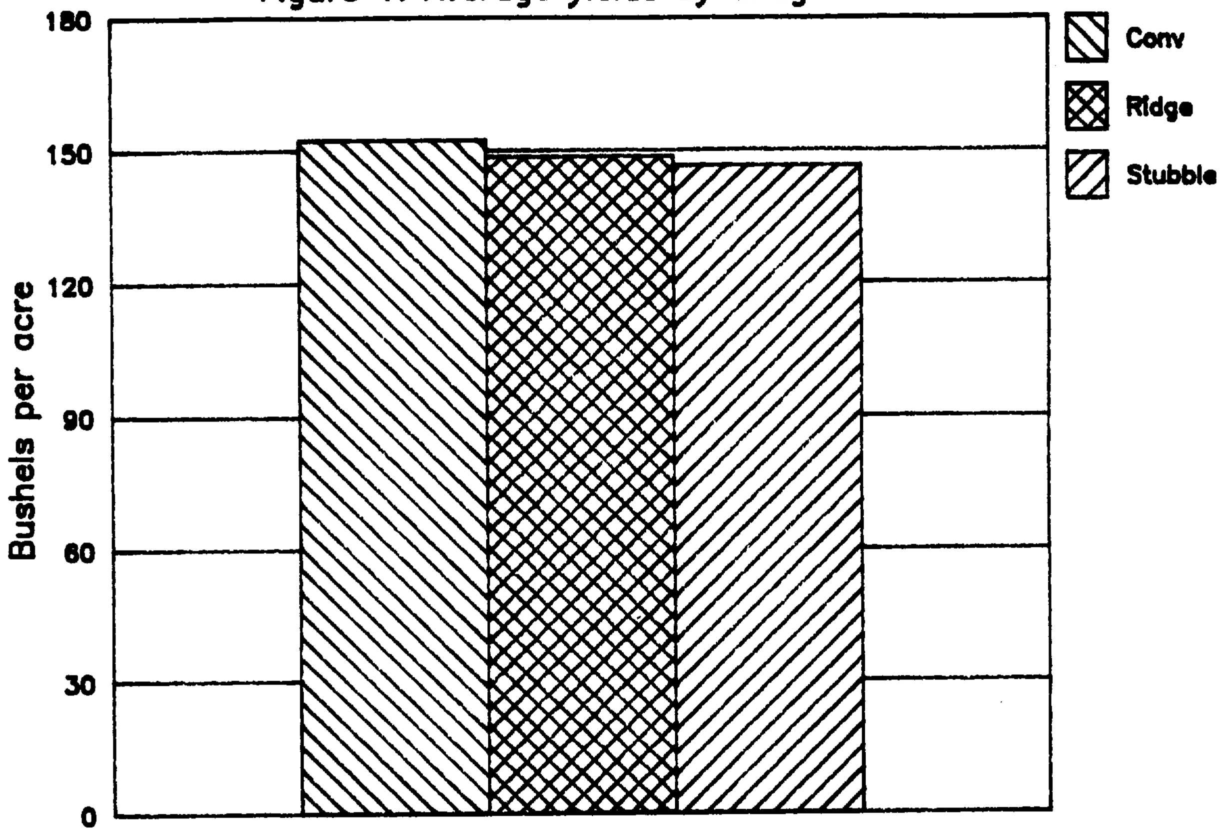
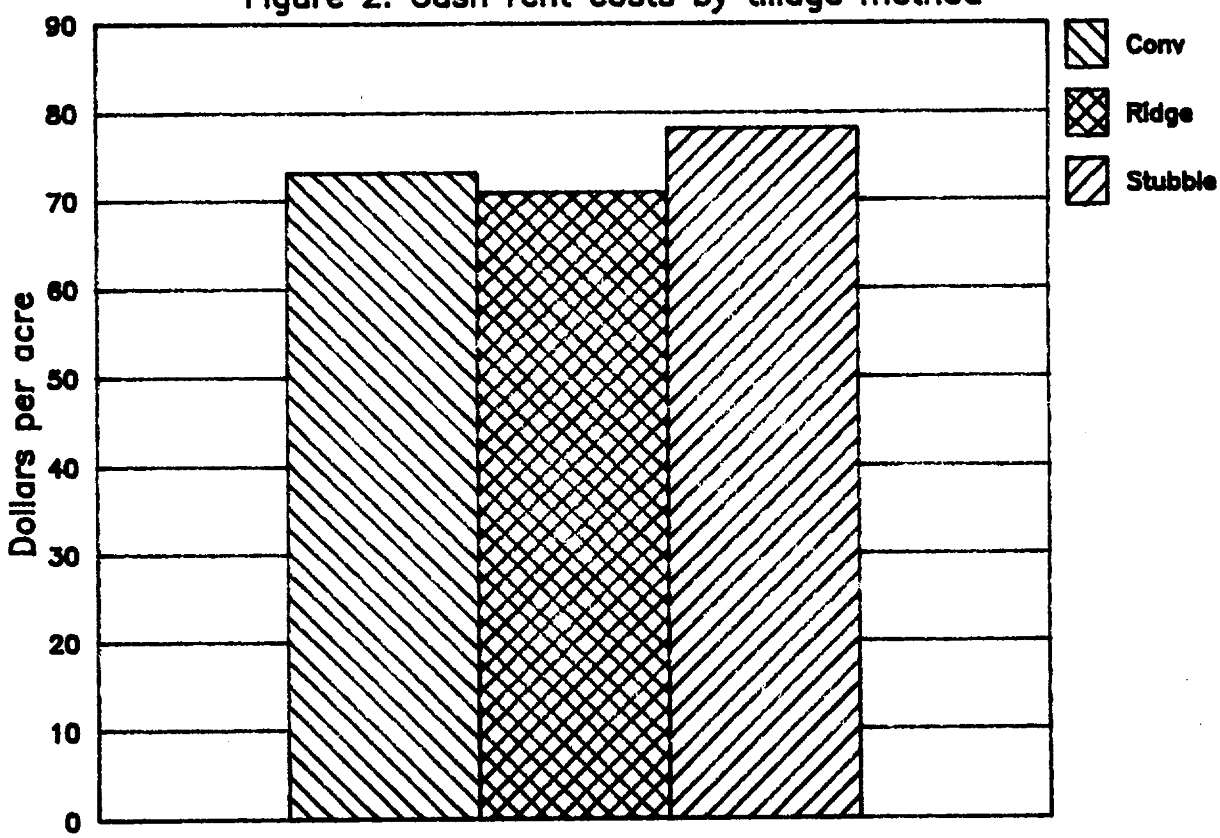


Figure 2. Cash rent costs by tillage method



Production costs[5] for stubble planted corn were the lowest of the three tillage methods studied with an average of $118 per acre (Figure 3). Ridge till had an average cost of $135 per acre and conventional tillage had an average of $147 per acre. Machinery costs for stubble planted corn ($57) were almost $20 less per acre than the other two methods (Figure 4).

[5]Production costs include typical custom rates for machinery (and the associated labor) and seed, fertilizer, and herbicide costs, but do not include land costs or interest costs.

Figure 3. Production costs per acre (no land)

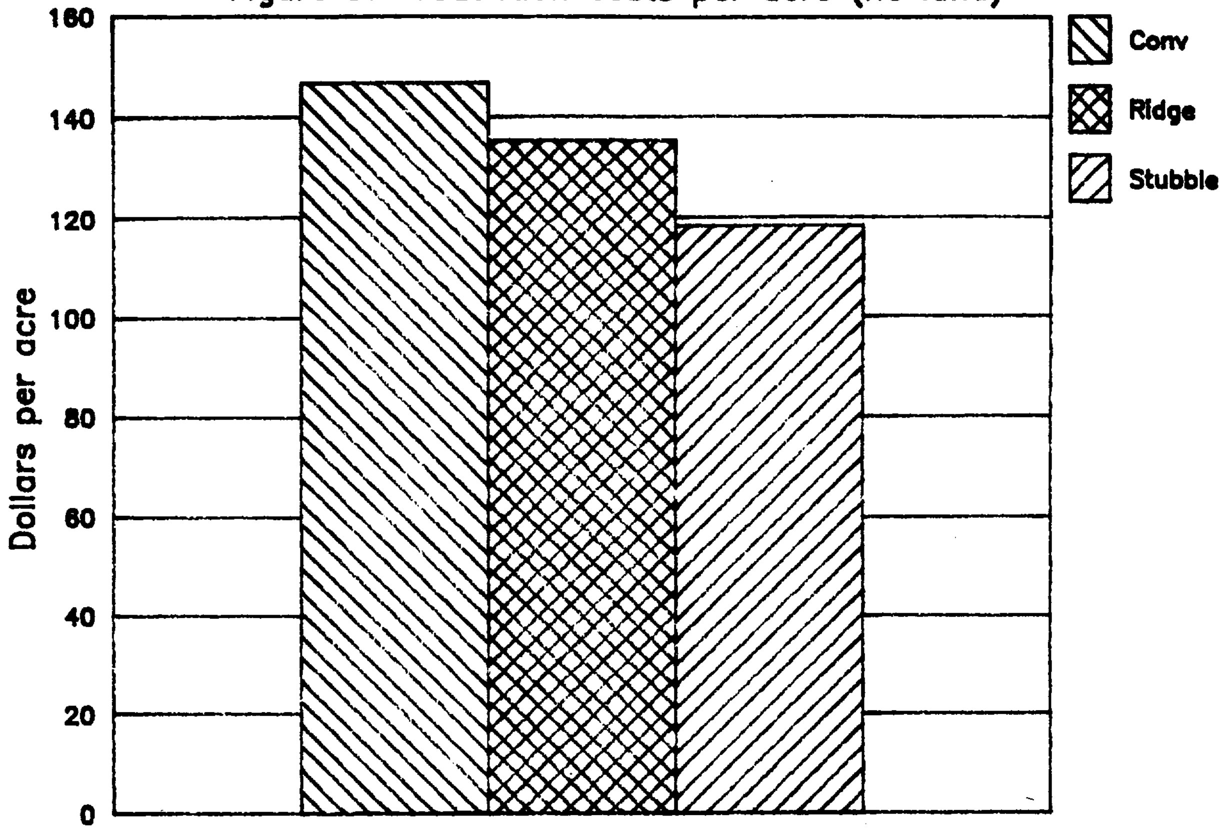
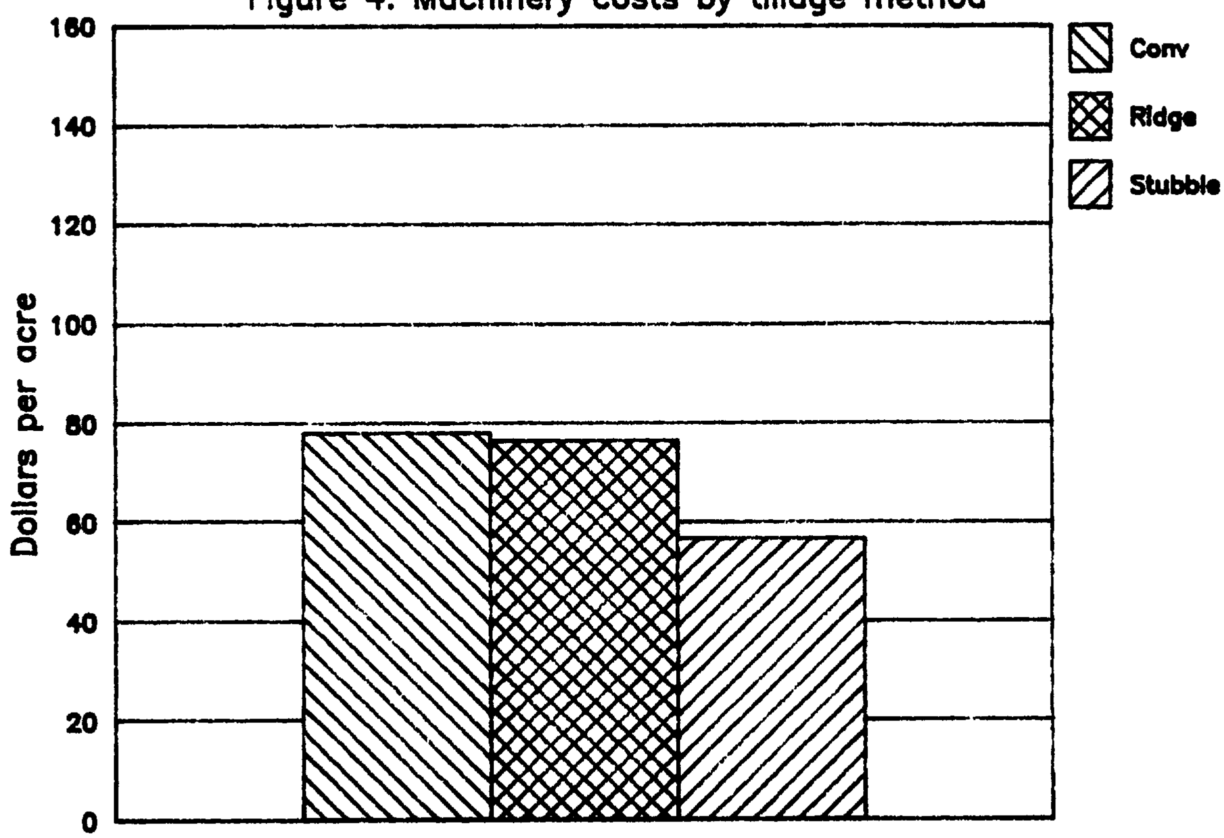


Figure 4. Machinery costs by tillage method



Another comparison of interest is the total cost (including land) per bushel. In the corn fields monitored in this project, stubble planted corn had the lowest standardized costs at $1.35 per bushel (Figure 5), ridge till corn had an average cost of $1.39 and conventional tillage $1.50. Thus, based on this one year of data, stubble planted and ridge till corn had costs per bushel which were very close if not equal to each other and both had costs which were lower than conventional tillage costs.

The stubble planted fields have the highest average net return ($111 per acre) followed by ridge till ($106) and conventional ($100; Figure 6). This is the reverse order of the average yields. These net returns are the returns to unpaid labor, management, other unallocated overhead costs, and risk; that is, the cost of these resources have not been subtracted. Machinery costs for repairs, fuel, interest, depreciation, and machinery labor are accounted for in the charge for custom operations. Land costs are captured in the cash rent cost. Using a 5 year average corn yield for each farm instead of their 1989 yields still leaves stubble planted fields with the highest net return but gives conventional tillage a higher estimated return than ridge till planting.

Figure 5. Total costs per bushel (with land)

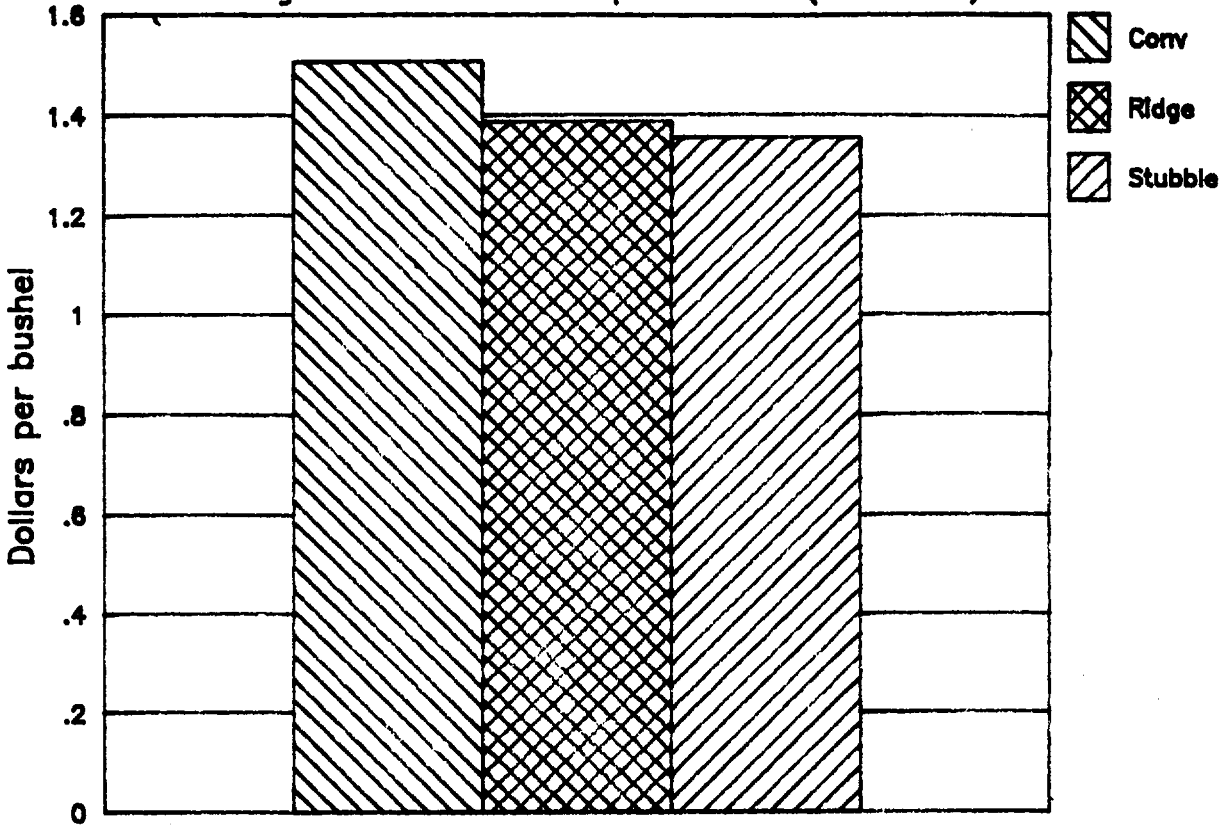
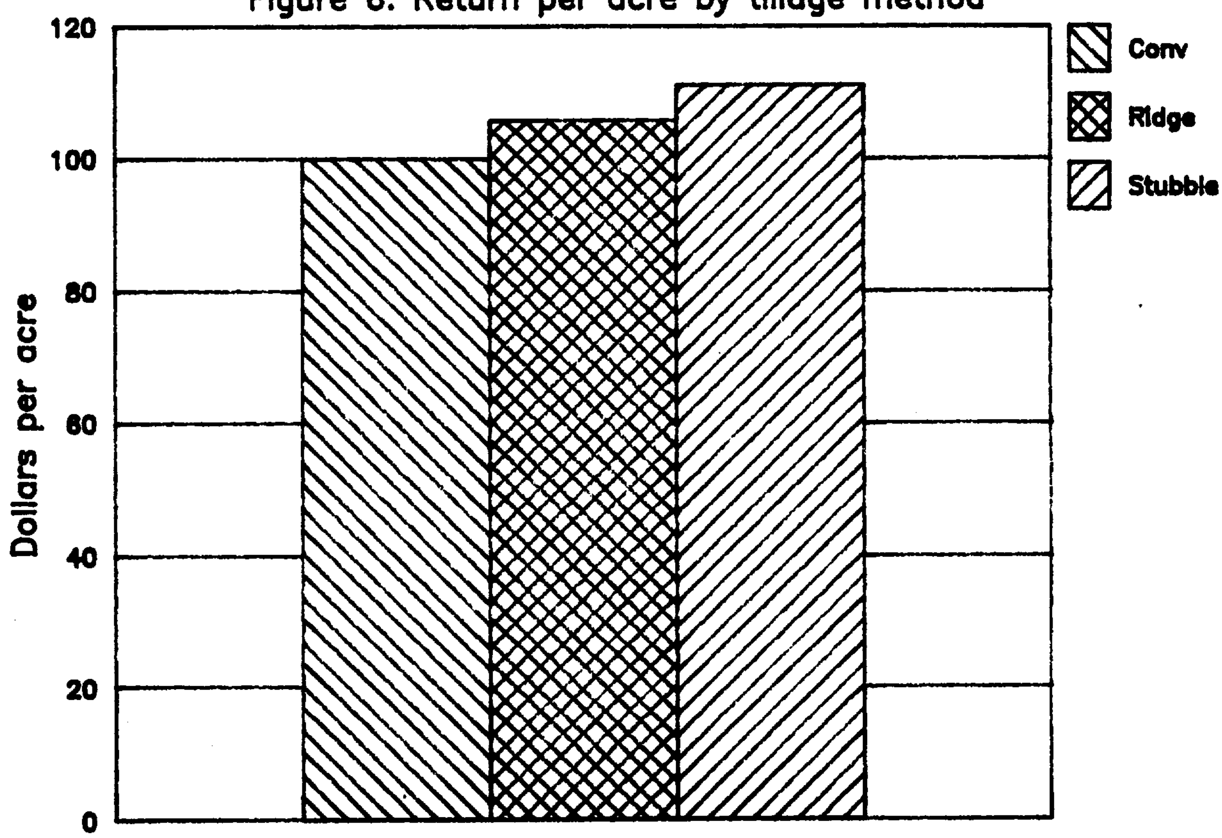


Figure 6. Return per acre by tillage method



One of the goals within sustainable agriculture is to reduce the use of herbicides and processed fertilizers. In this project those fields with ridge till averaged $11 in herbicide costs per acre compared to stubble planted at $13 and conventional tillage at $18. Due to the tillage method, ridge till and stubble planted fields received only pre- or post-emergence herbicides. Fertilizer costs were only slightly different. Conventional tillage fields had the lowest average fertilizer cost per acre, $17; ridge till, $18; and stubble planted, $19. The stubble planted fields received no manure while some of the other fields did receive manure.

Reducing fuel use is another goal of sustainable agriculture. Stubble planting is substantially lower than both ridge till and conventional tillage (Figure 7). Stubble planted corn used 5.2 gallons of diesel fuel per acre compared to 7.7 and 7.9 gallons for ridge till and conventional tillage, respectively.

There were substantial differences in the amount of time required per acre. Stubble planting required 54 minutes per acre (Figure 8). Ridge till required 82 minutes and conventional tillage, 96 minutes. Part of this difference may be due to the lack of manure handling on the stubble planted acres. Translating the returns per acre into returns per hour by those time requirements also shows stubble planting to yield a higher return for labor. Stubble planting is estimated to return $124 per hour while ridge till is estimated to return $77 per hour and conventional tillage $62. Thus, from this first year of data, the stubble planting method appears to not only take less labor and thus free that labor for other uses; stubble planting also provides a larger return per hour.

Figure 7. Diesel fuel use by tillage method

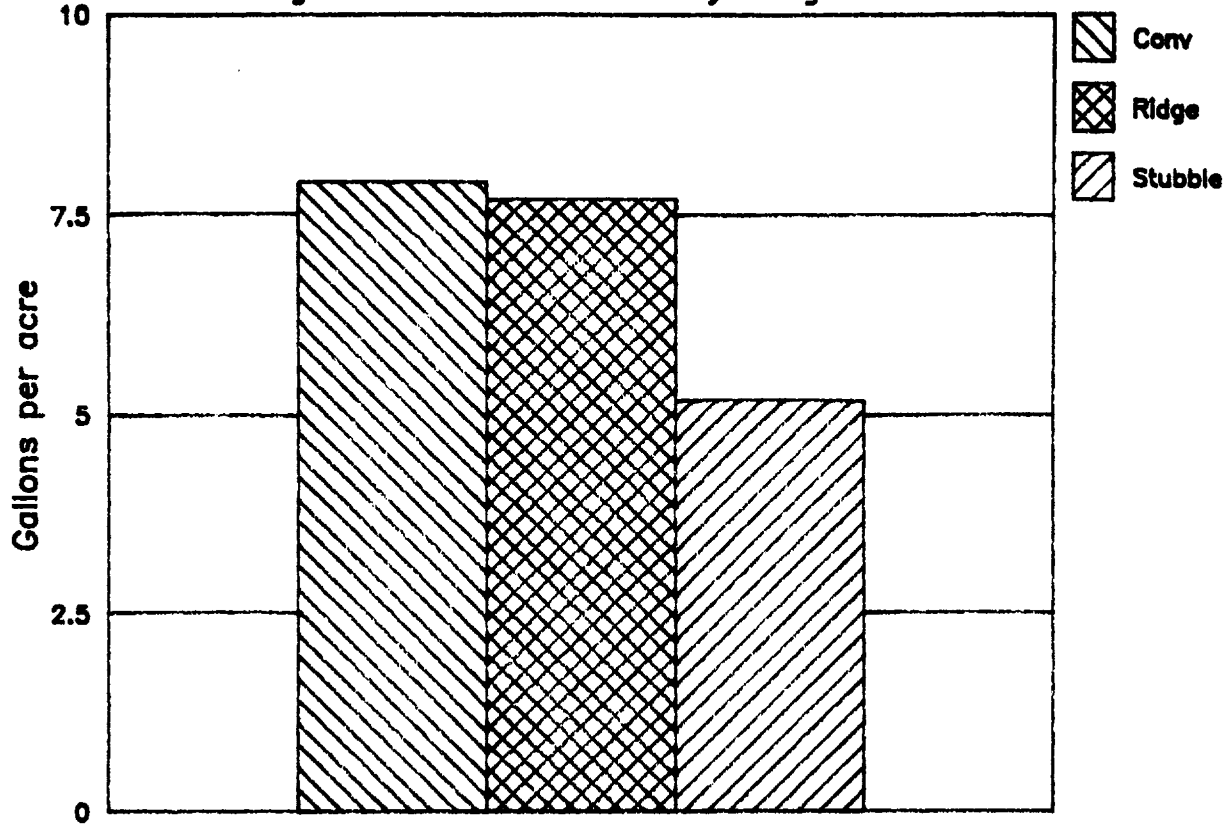
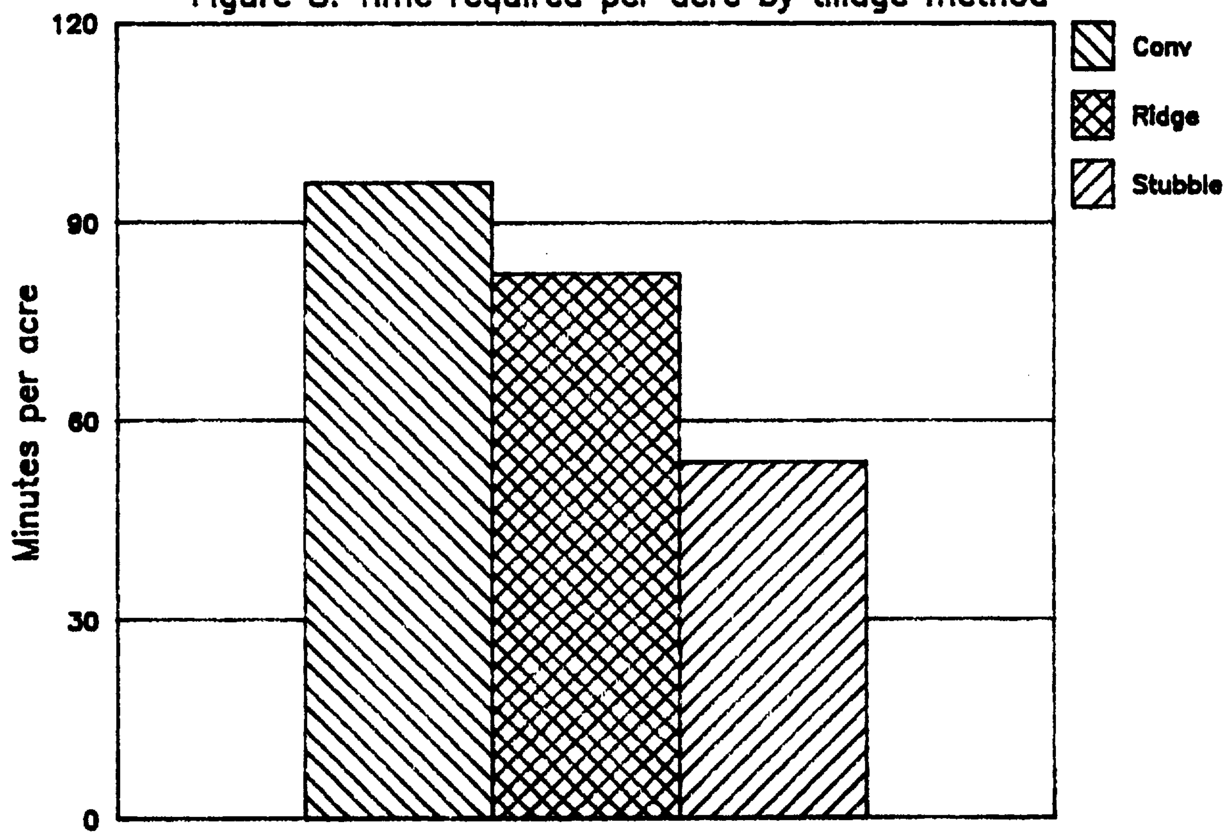


Figure 8. Time required per acre by tillage method



FERTILIZATION METHODS

There were three methods of fertilization of corn which had sufficient observations to report here: broadcast, banded, and manure management. Broadcast fertilizer was applied and incorporated later. Banded fertilizer had fertilizer injected into the soil in bands either in the row or to the side of the row either at planting time or at a separate treatment time, generally in the fall. These fields include only those fields which used banding as the only method of fertilizer application. Those fields classified as manure management may have also received a starter fertilizer but manure was the main source of applied nutrients. There were 8 fields on 5 farms which received broadcast fertilizer; 7 fields on 2 farms with banded fertilizer; and 11 fields on 6 farms which received manure.

Average yields of the three methods were very similar (Figure 9). Banded fertilizer averaged 151 bushels; manure, 150; and broadcast fields, 145. Compared to the cash rent cost (Figure 10) of the land (as a proxy for land quality), the banded fields would be expected to have the highest yields and the manured fields, the lowest. Since the yields did not meet these land quality expectations, we can assume that other factors are more important in the final yield determination.

Figure 9. Average yields by fertilization method

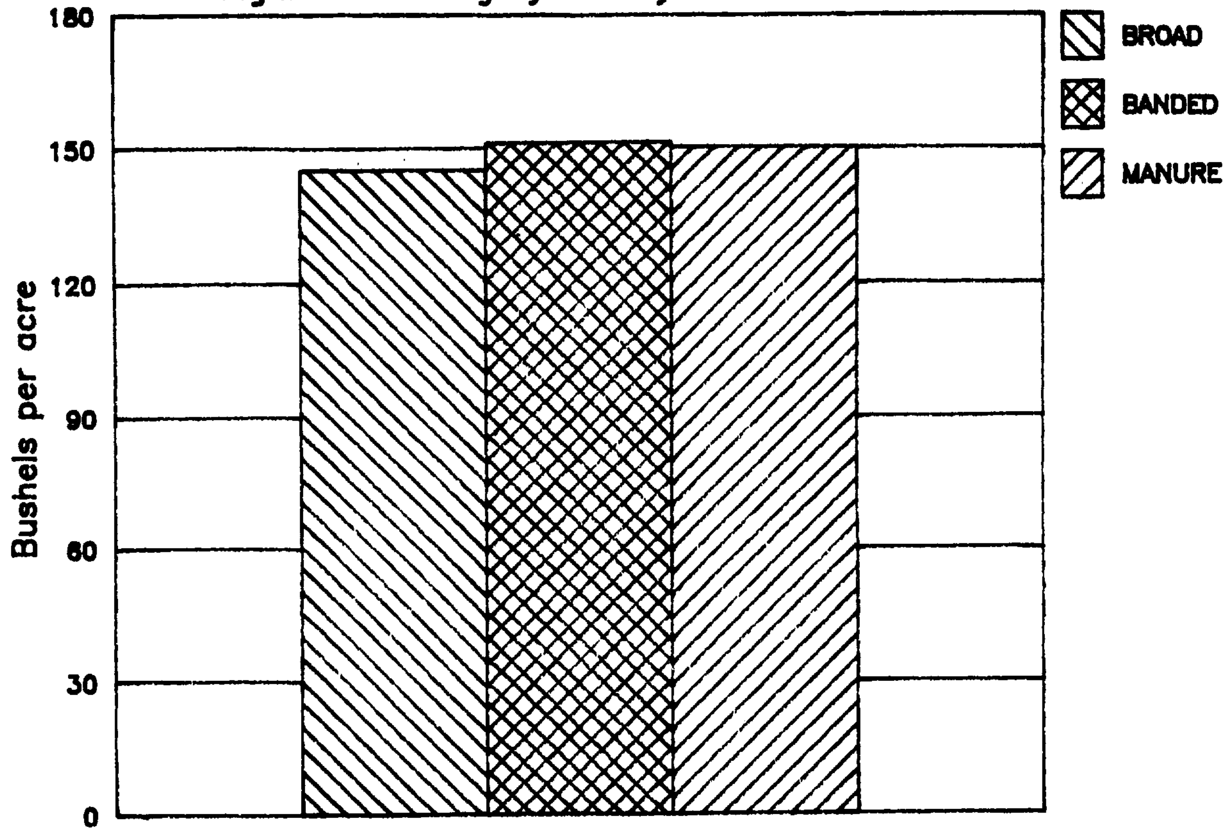
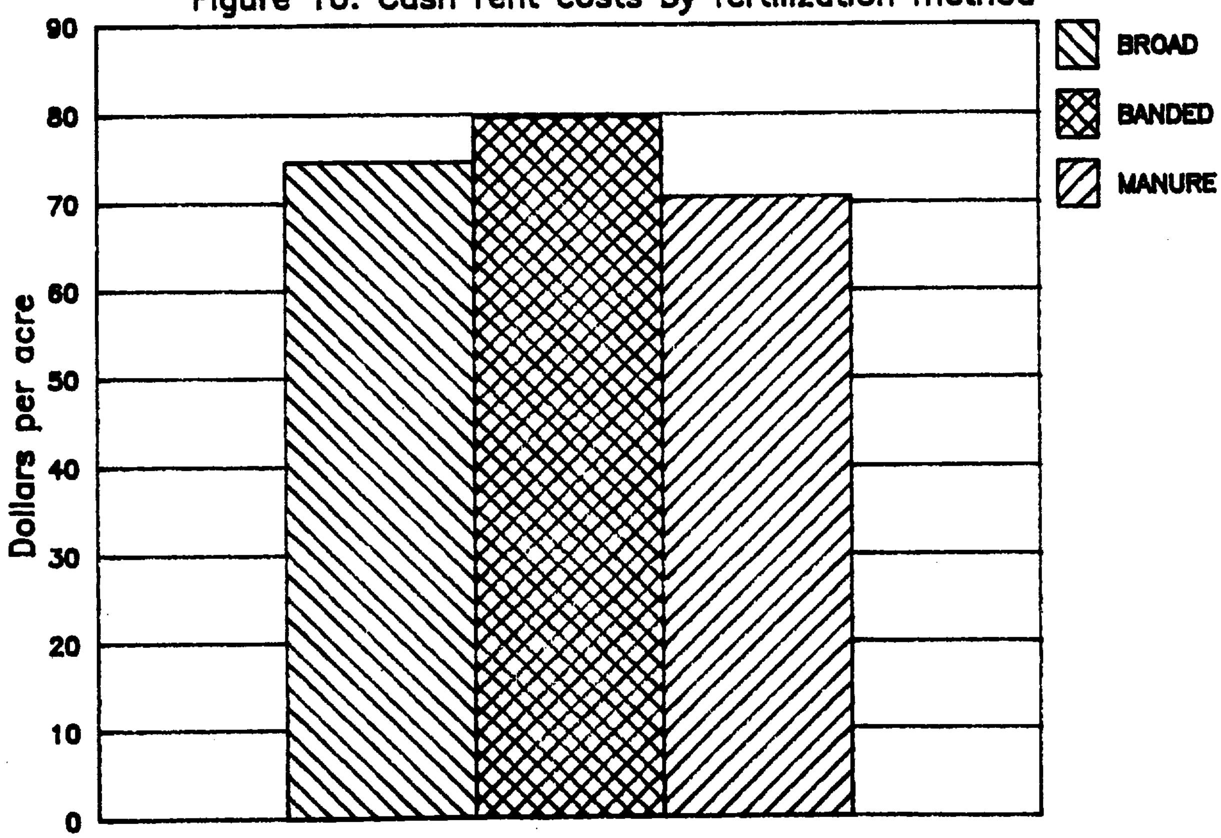


Figure 10. Cash rent costs by fertilization method



Banded fertilizer fields had an average production cost (without land costs) of $121 per acre (Figure 11). Broadcast and manured fields have production costs of $137 and $140 per acre, respectively. Costs for fertilizer ranged from $28 per acre for broadcast fertilizer, to $20 for banded, to $9 for manured fields (Figure 12).

Figure 11. Production costs per acre (no land)

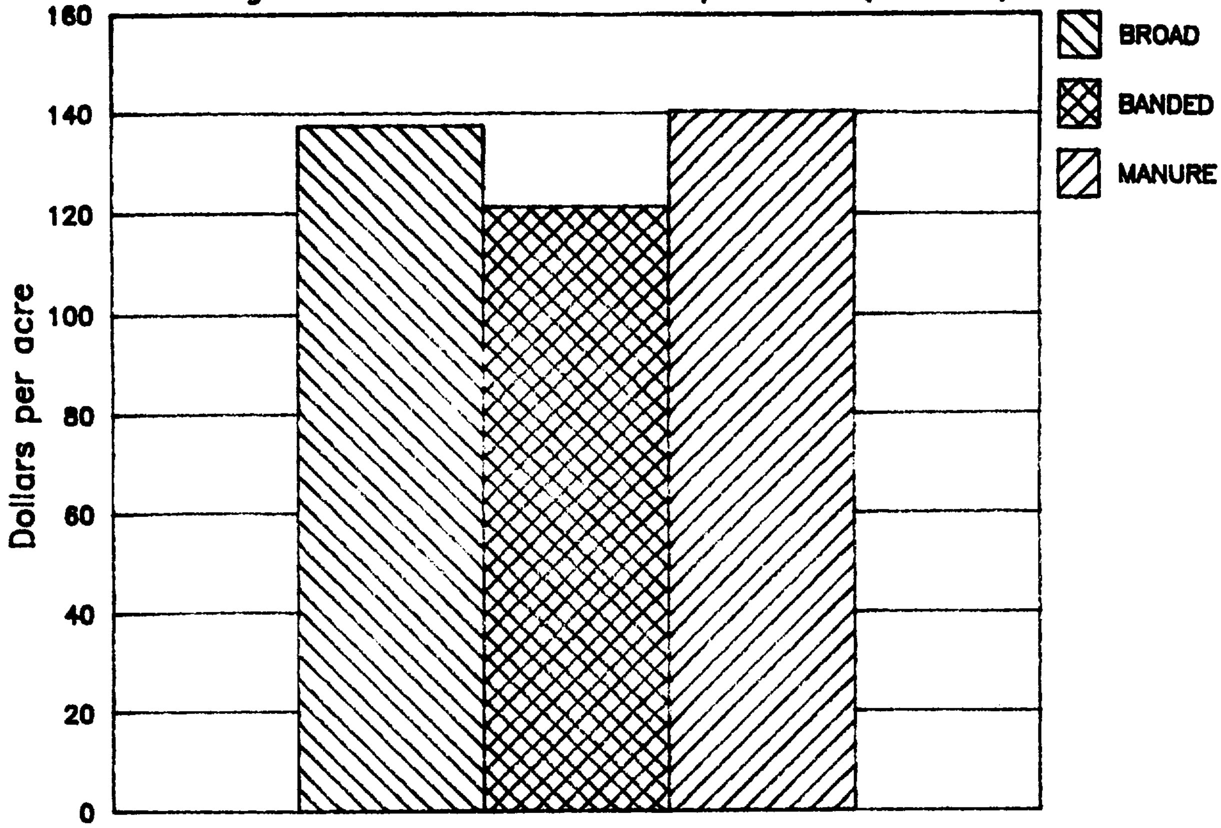
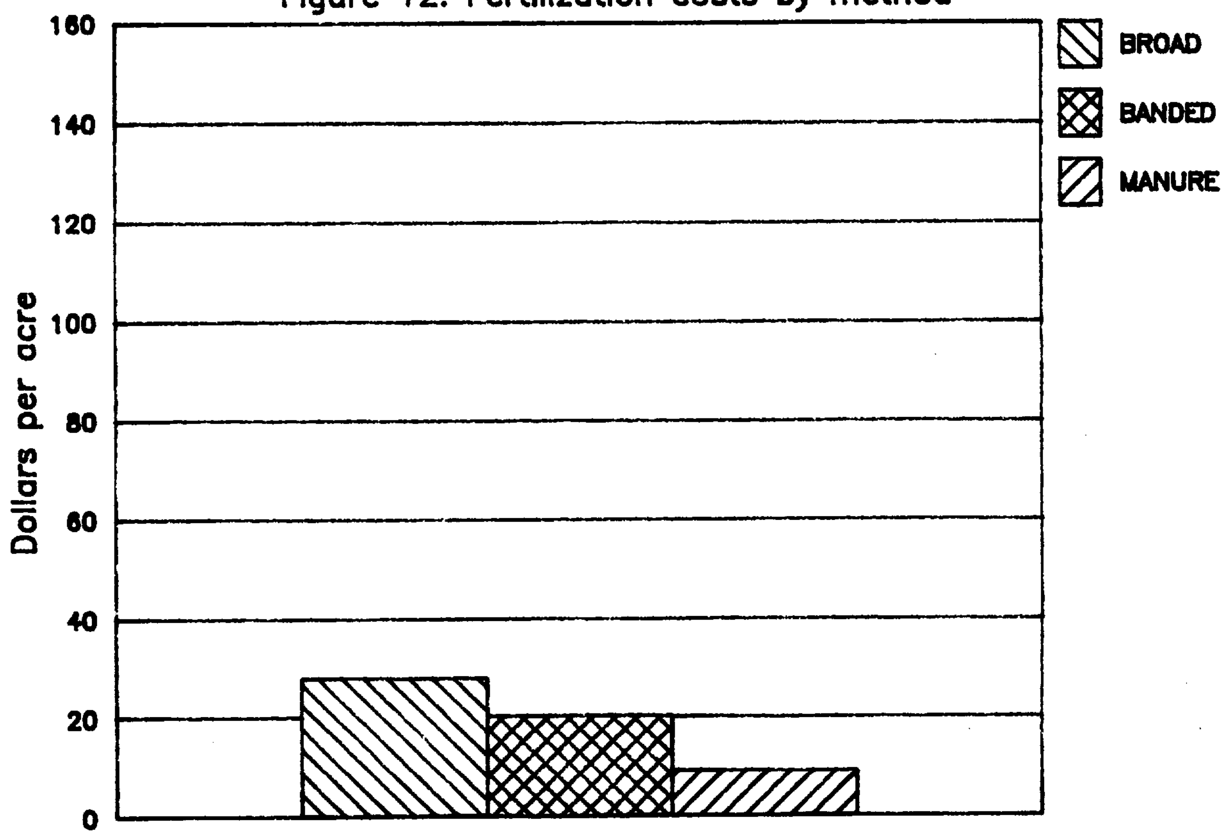


Figure 12. Fertilization costs by method



On a per bushel basis, the total costs (including land) were estimated to be highest for broadcast fields ($1.52) and lowest for banded fields ($1.34, Figure 13).

The differences in costs and the slight differences in yields resulted in differences in net returns per acre (Figure 14). Banded fields were estimated to have the highest average returns at $116. Manured fields had an estimated return of $104 and broadcast, $93 per acre. When each farm's 5-year average yield was used instead of the 1989 yield, average net returns were lower for all tillage systems but the average banded field still had a higher net return than broadcast and manured fields.

Figure 13. Total costs per bushel (with land)

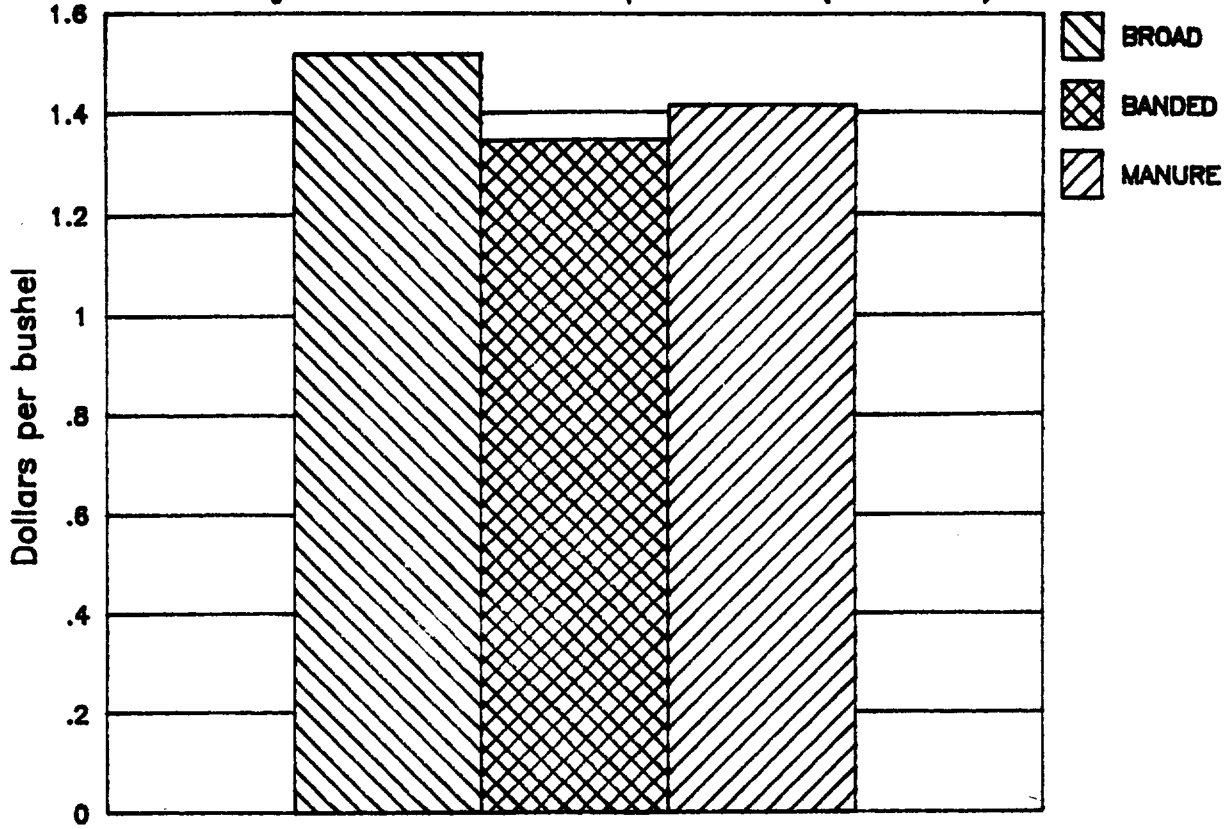
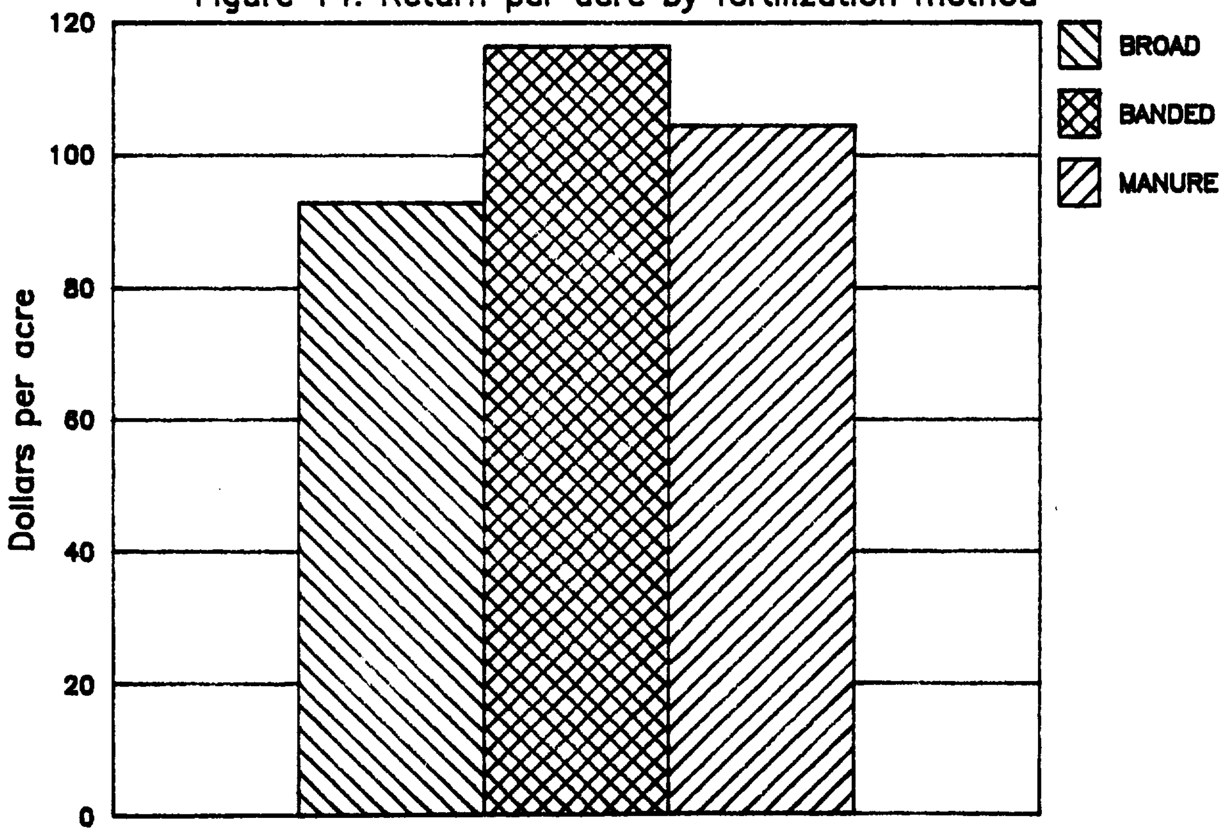


Figure 14. Return per acre by fertilization method



The lower fertilizer cost for manured fields was balanced by higher costs for herbicides, machinery, fuel use, and labor requirements. Average herbicide costs per acre were highest for manured fields ($16 per acre). Herbicide costs for banded fertilizer fields were $12 and for broadcast fields, $15 per acre. Average machinery costs were $83 per acre for manured fields, which was $13 higher than the costs for banded fields and $12 higher than broadcast. As would be expected due to the manure hauling, the manured fields had the highest diesel fuel usage (Figure 15) and labor requirements (Figure 16). The higher requirements for the manured fields are due to the increased operations needed to spread the manure. In terms of return per hour, banded was the highest, partially because these fields did not have manure applications, which imposed higher labor requirements.

Figure 15. Diesel fuel use by fertilization method

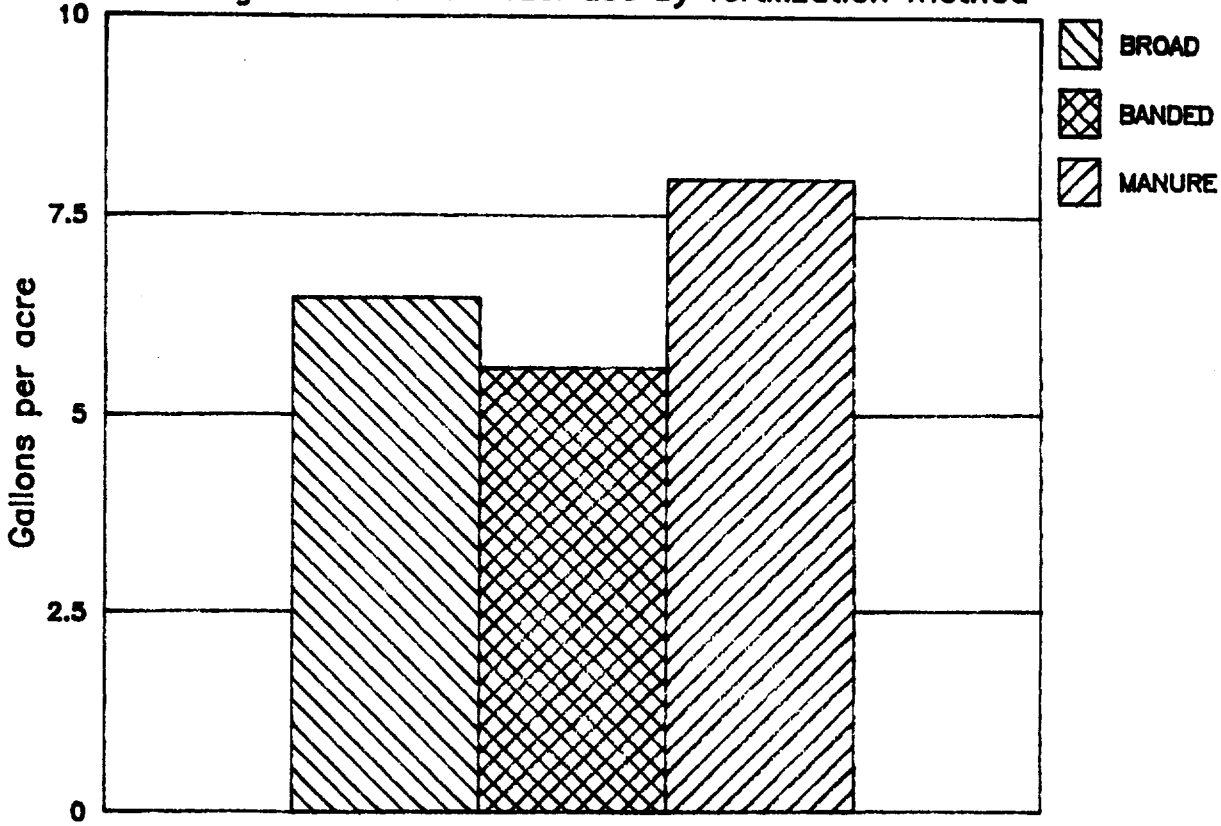
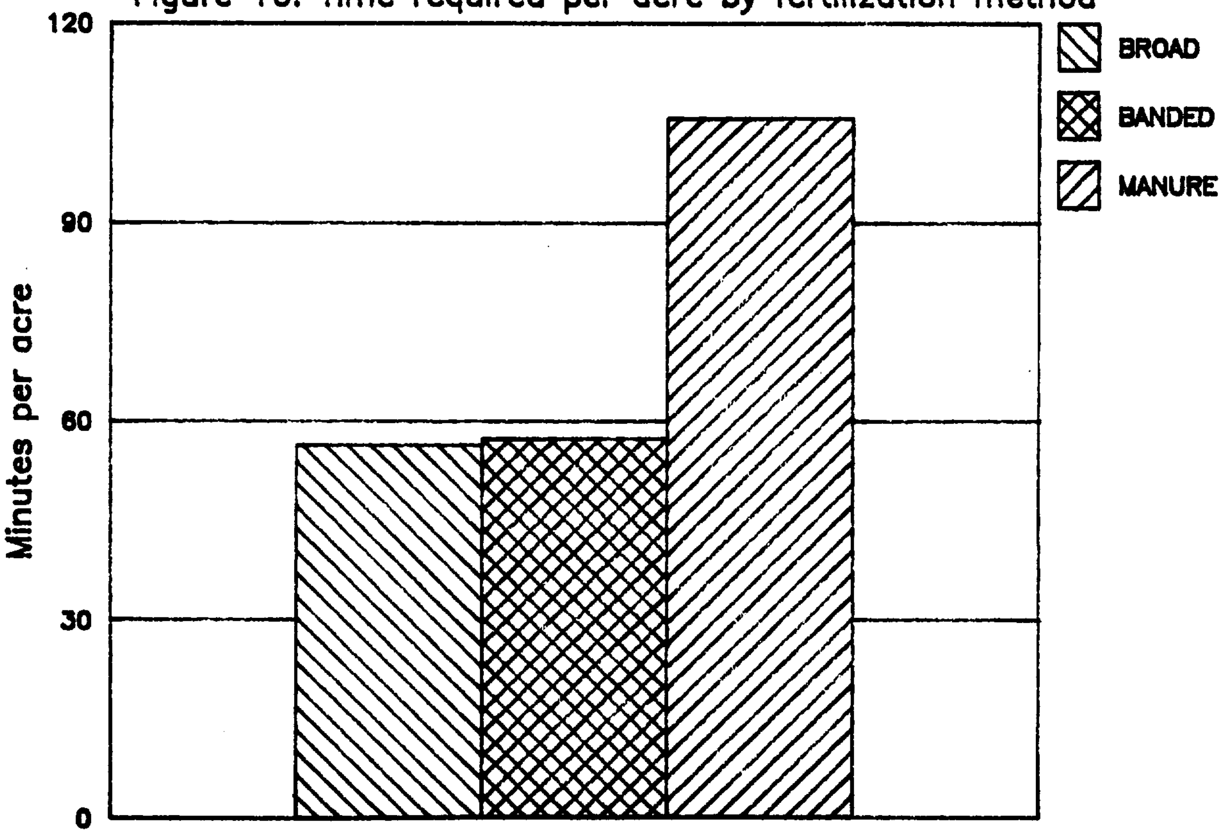


Figure 16. Time required per acre by fertilization method



HERBICIDE APPLICATION METHODS

The final set of comparisons made in this paper are between three herbicide application methods: preplant incorporated, pre-emergence, and post-emergence. The pre-plant incorporated herbicide was the main method of weed control on these fields although a banded pre-emergence or post-emergence herbicide may have been used also. The pre-emergence herbicide was the main treatment on these fields at planting time. The pre-emergence herbicide may have been banded and a post-emergence herbicide may have been applied also. For the post-emerge fields, this was the only weed control treatment; some pre-emergence herbicides were banded. There were 5 fields on 4 farms which had the herbicide preplant incorporated; 12 fields on 7 farms which used pre-emergence herbicides; and 6 fields on 5 farms which used post-emergence herbicides.

Average yields were the highest for post-emergence fields, 155 bushels; pre-emergence fields had an average yield of 151 bushels; and pre-plant incorporated fields, 149 bushels (Figure 17). The differences in yield between treatment methods may be due to differences in land quality. The average of cash rent costs have the same pattern between treatment methods (Figure 18) as the average yields do. Thus, any differences between methods will have to be interpreted as potentially due to land quality as well as the treatment method.

Figure 17. Average yields by herbicide app. method

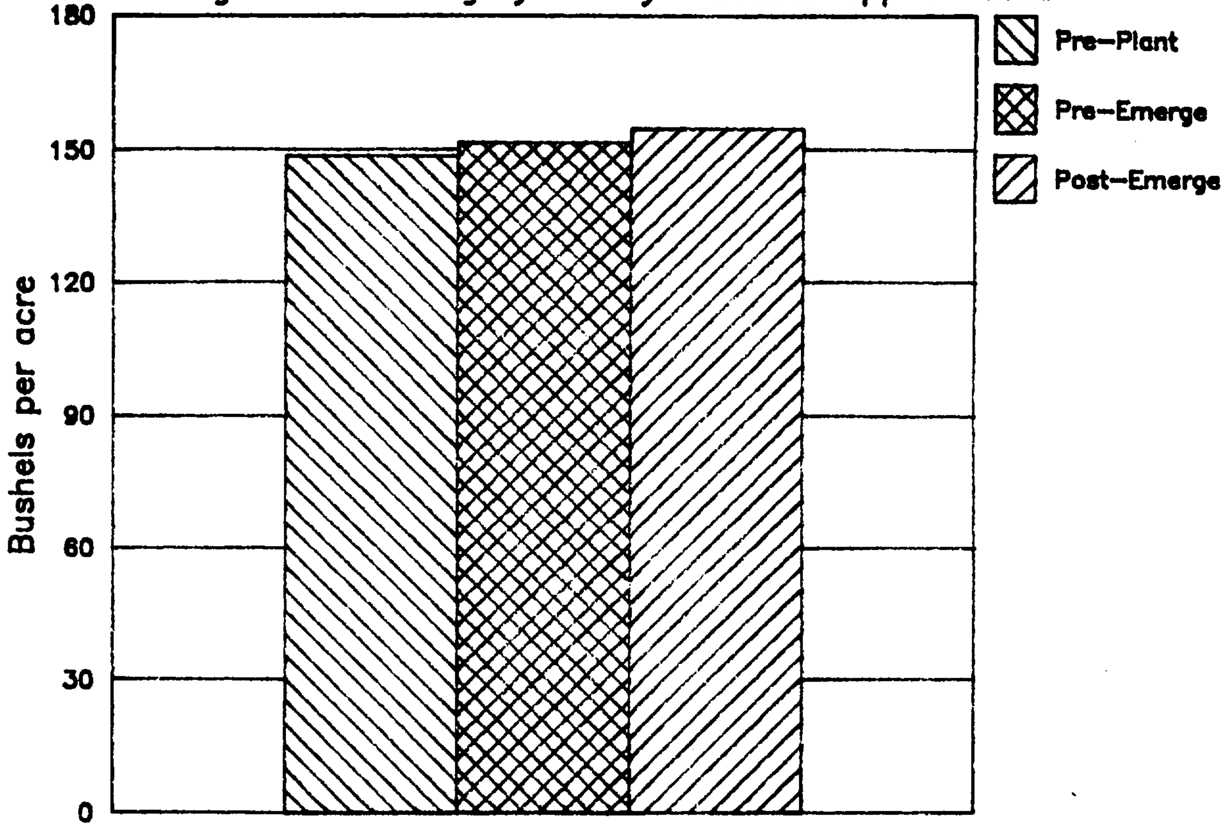
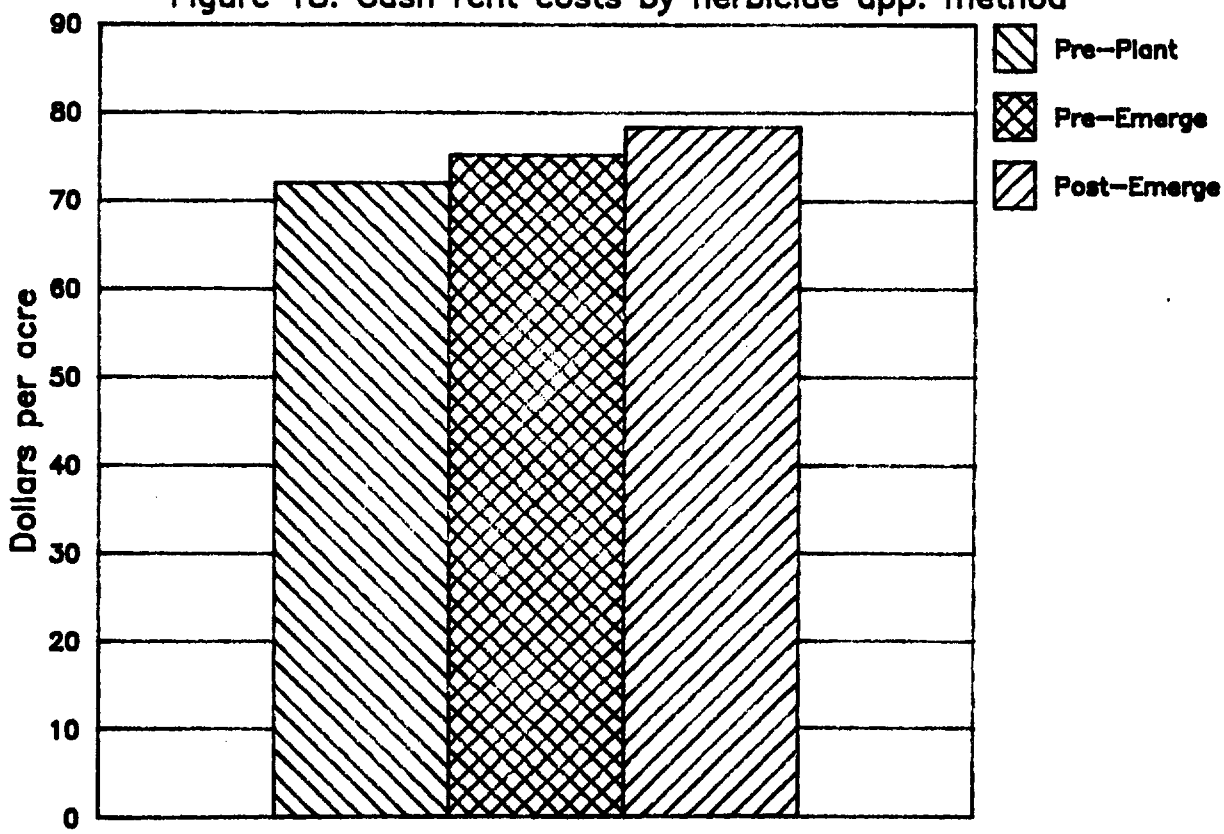


Figure 18. Cash rent costs by herbicide app. method



Fields treated with pre-plant herbicides had the highest average standardized costs per acre, not including land costs ($155; Figure 19). Pre-emerge fields had average costs of $134 per acre; post-emerge fields, $129 per acre. Herbicide costs were highest for the pre-plant incorporated application ($26 per acre); herbicide costs were $15 for pre-emerge and $12 for post-emerge (Figure 20).

Figure 19. Production costs per acre (no land)

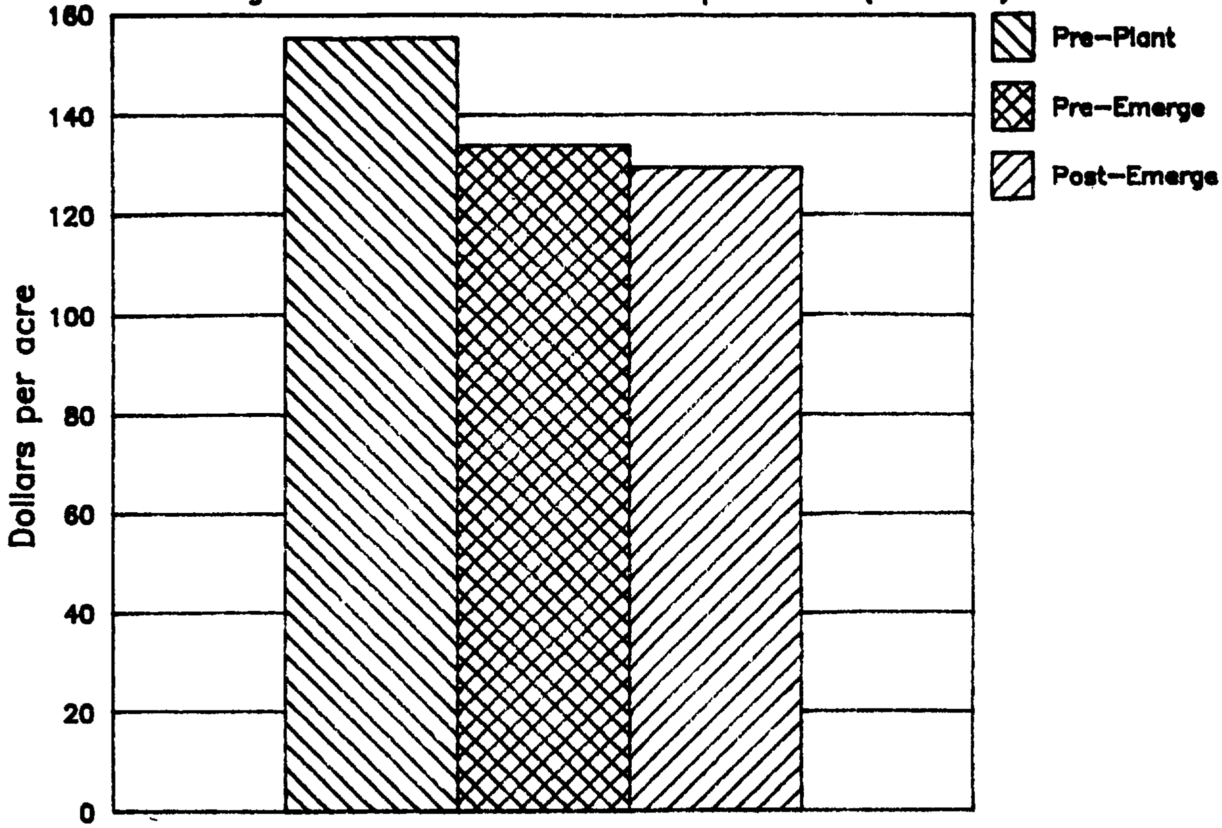
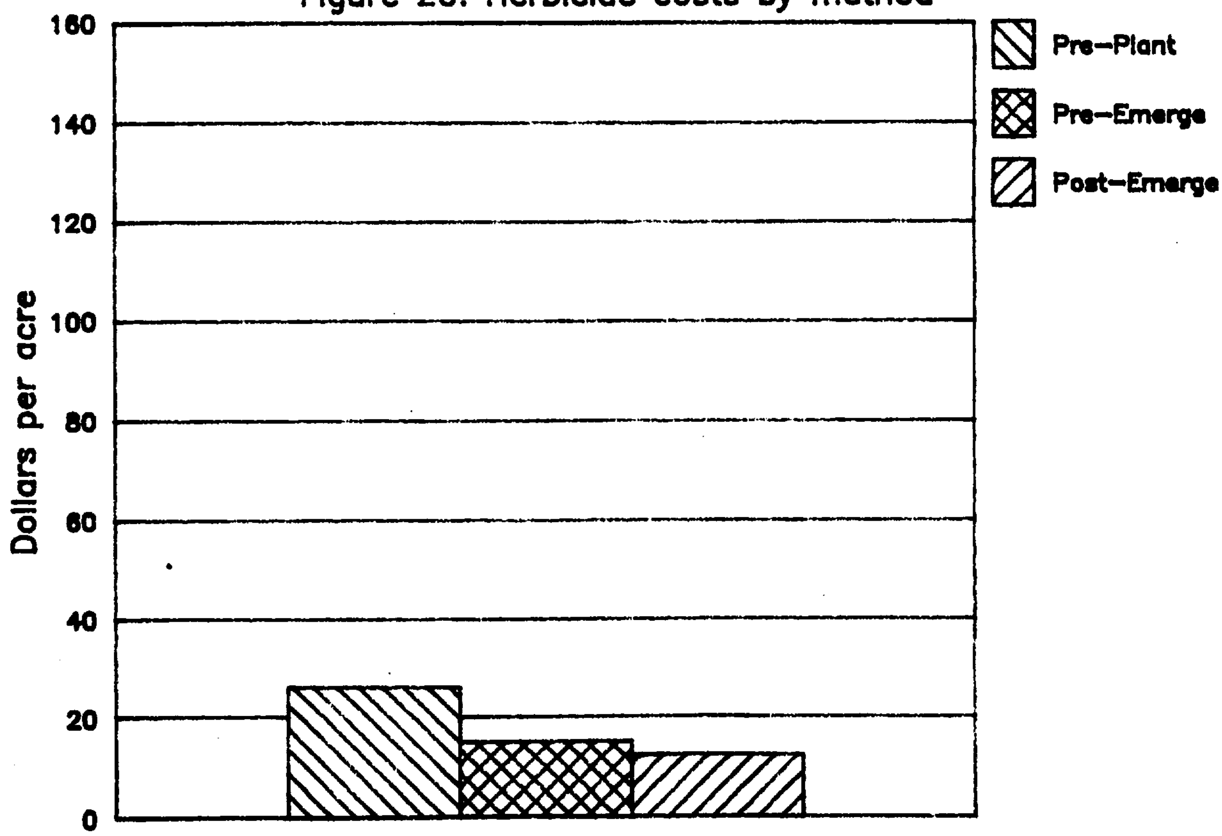


Figure 20. Herbicide costs by method



The average total cost per bushel for the pre-plant incorporated fields was $1.62; for pre-emerge, $1.38; and for post-emerge, $1.37 (Figure 21). And, as expected from this yield and cost information, pre-plant incorporated fields also stand out as having the lowest net return per acre ($85), with post-emerge having a higher return ($117) than pre-emerge ($109) (Figure 22). Using each farm's 5-year average yields does not change the ranking of net returns per acre by application method.

Figure 21. Total costs per bushel (with land)

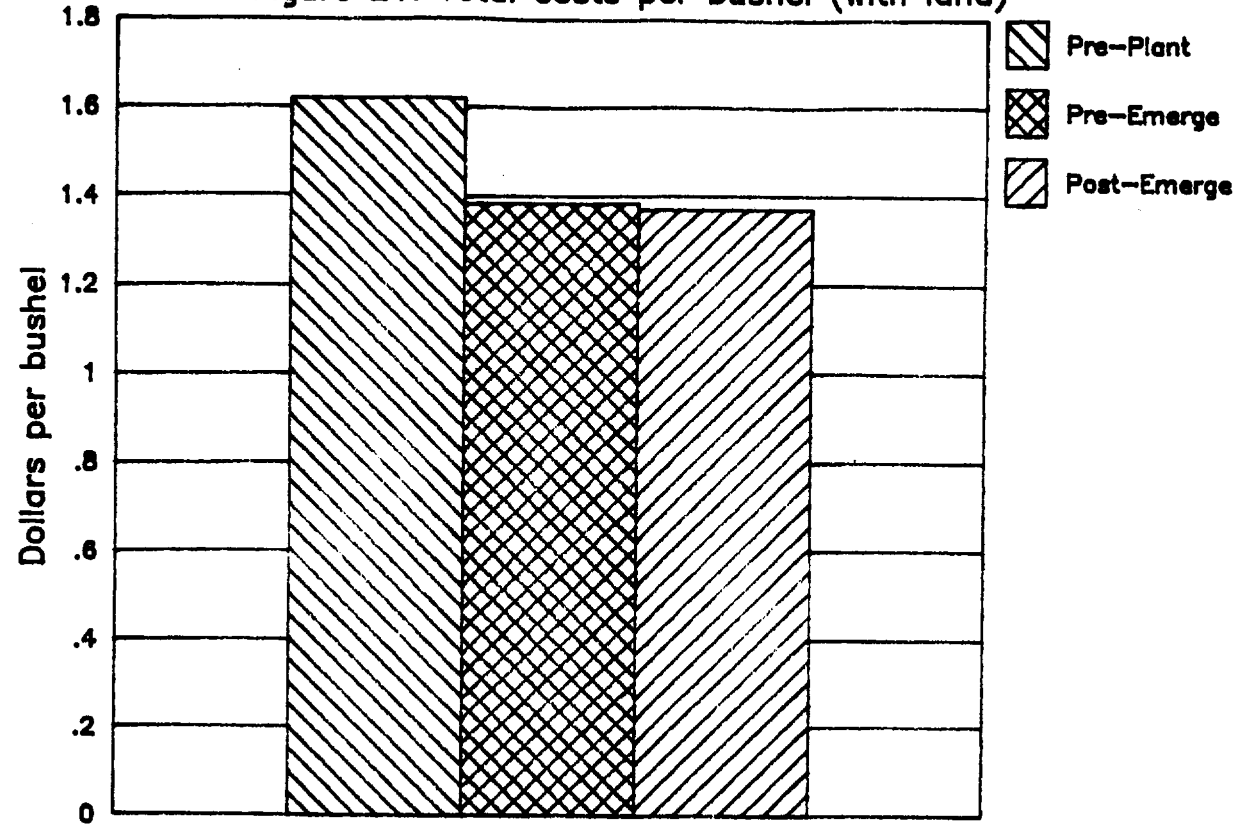
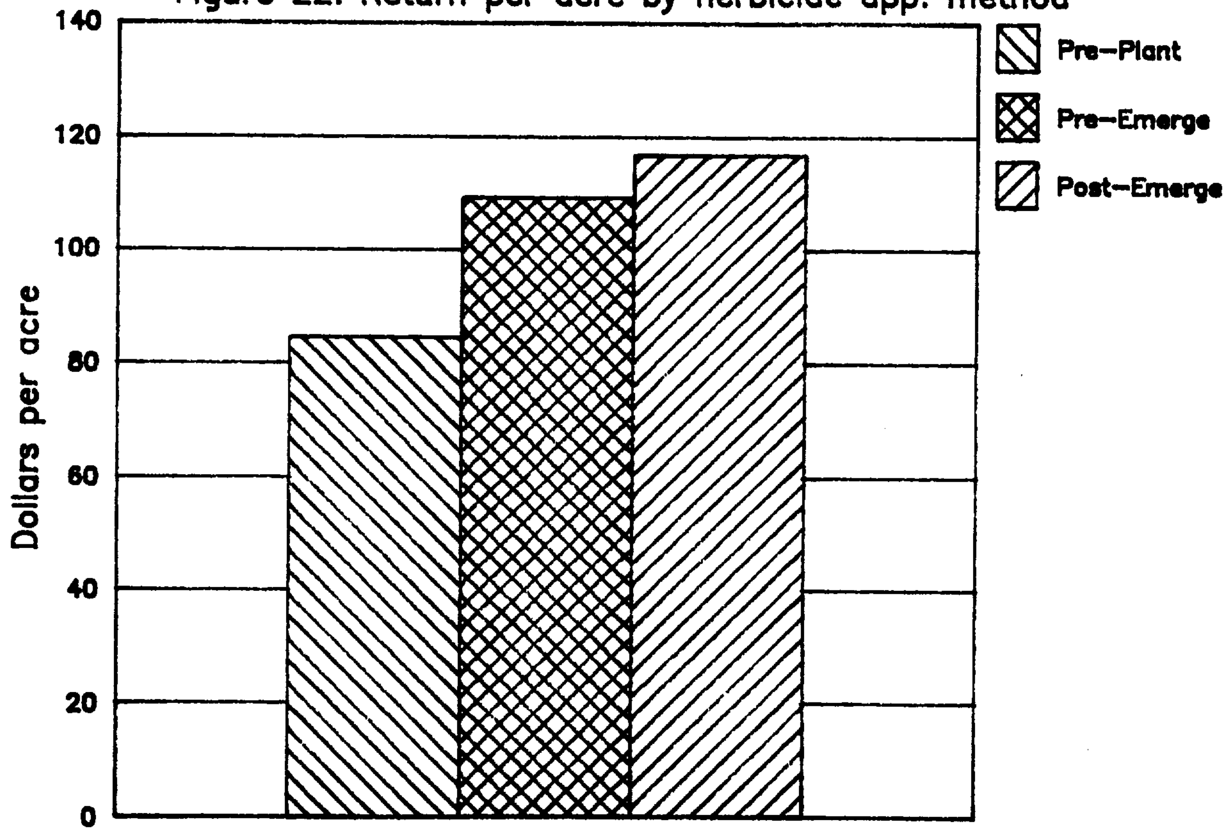


Figure 22. Return per acre by herbicide app. method



Pre-emerge and post-emerge fields had lower average machinery costs per acre than the pre-plant fields. A similar pattern was evident in fuel usage (Figure 23). Preplant incorporation was also found to require more labor per acre (Figure 24), but this may be due to the time required for manure handling.

Figure 23. Diesel fuel use by herbicide app. method

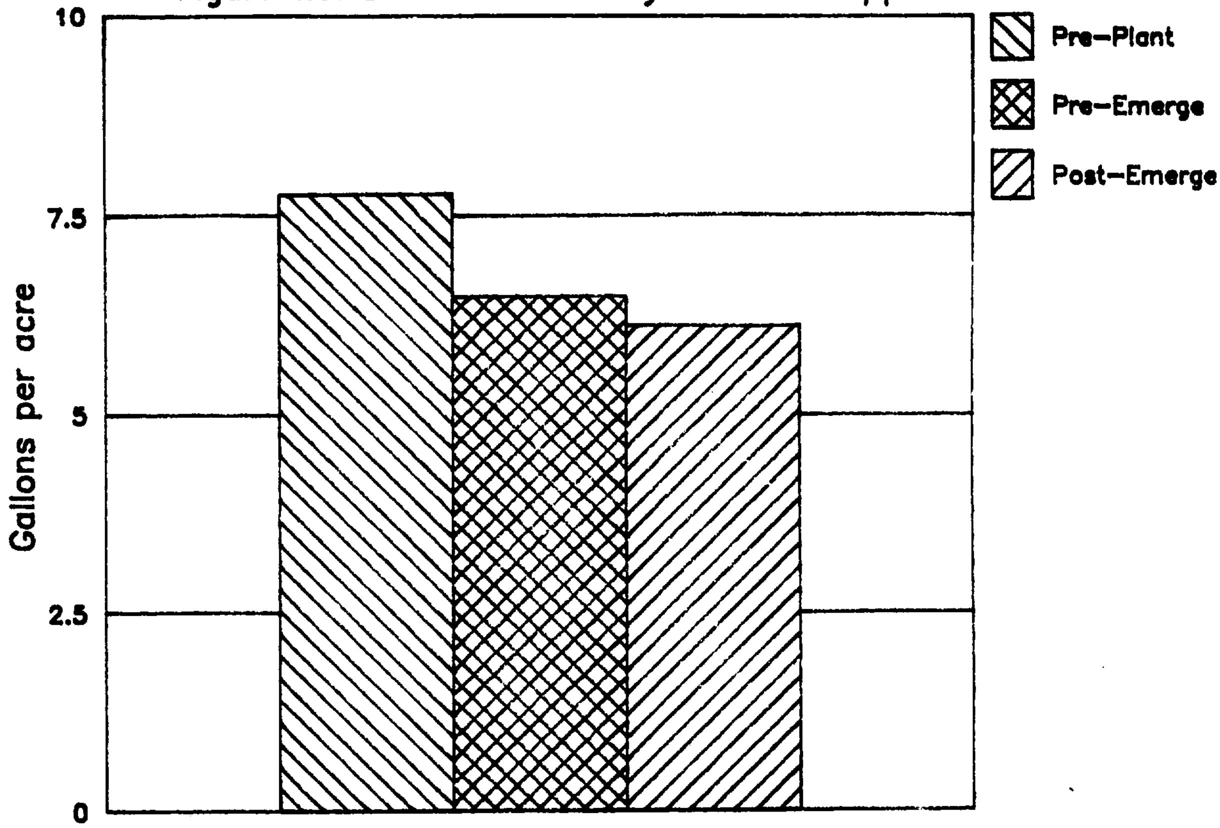
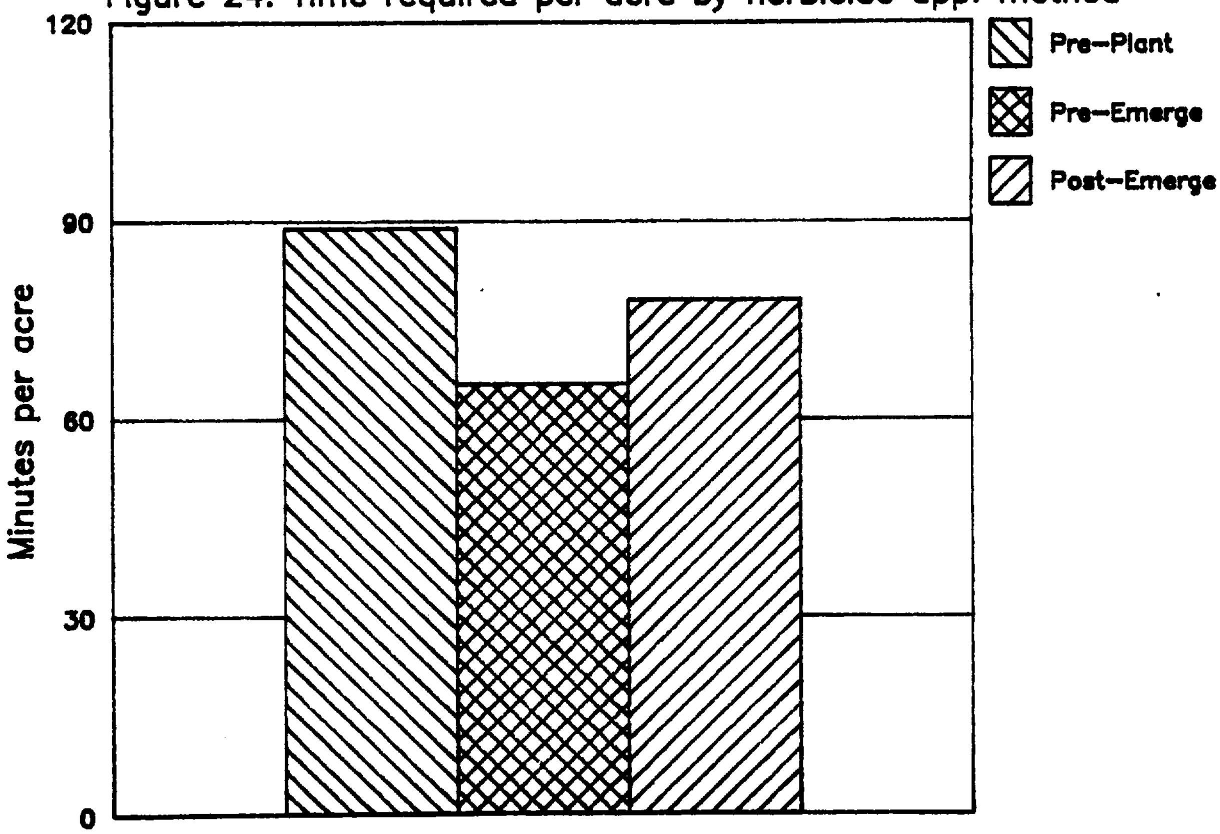


Figure 24. Time required per acre by herbicide app. method



CONCLUDING REMARKS

As a parting reminder, these observations are from only one year and a few farms. So they need to be viewed as potential areas to study, not as definitive answers. However, each farmer needs to make his or her own decisions. And, in light of criticism that we at the University keep our data closed until it is published and that we care about significance only at high levels, we present this data to you for your information.

If I was a farmer who was using the conventional methods described in this paper, I would start to do some serious thinking about how I farm. Both stubble and ridge till planting had lower costs than conventional tillage. Coupling that lower cost with the reduction in erosion and other benefits of the reduced tillage methods, would make me look very seriously at these two options. But I also understand that rotating the primary tillage method may be needed to maintain proper nutrient mix in the soil. The observations on fertilization costs make banding look very good especially if there is a chance to reduce applied fertilizer levels. Environmental benefits would result from such a change also. Since the land quality varies directly with yield in the herbicide application methods, I am not as certain about what to think about the differences between herbicide methods. But there is enough information to study the idea that preplant incorporation may not be desirable for both farm profit and the environment.

Appendix Table: Individual farm data on corn from Southwest Minnesota Sustainable Agriculture Project in 1989.

Farm	Tillage	Fertilizer	Herbicide	Yield	Price	Gross Return	Mach	Seed	Fert	Herb	Costs w/o land	Land	Total Costs	Total Net Return	5 year Yield	5 Year Net Return	hours per acre	diesel (gal/ac)
	-------- Comparison	--------																
1	ridge	broadcast	pre	166.0	2.10	348.60	64.94	27.50	43.20	13.37	153.61	82.00	235.61	112.99	159.40	67.96	.8	6.4
1	ridge	manure	pre	157.1	2.10	329.91	86.98	27.50	11.21	20.24	149.63	82.00	231.63	98.28	159.40	15.19	1.5	9.3
2	ridge	band	pre	164.3	2.10	345.03	68.76	26.60	31.18	16.40	147.13	78.00	225.13	119.90	145.28	13.12	.8	7.3
3	reduced	broadcast	post	164.9	2.10	346.29	62.15	27.00	24.66	9.75	127.09	80.00	207.09	139.20	129.50	94.56	1.0	5.7
4	ridge	manure	pre	156.9	2.10	329.49	78.85	30.20	23.69	13.82	150.57	65.00	215.57	113.92	108.90	42.36	1.4	7.4
4	ridge	manure	pre	157.7	2.10	331.17	92.00	30.20	23.69	13.82	163.87	65.00	228.87	102.30	108.90	70.24	1.8	9.4
5	conv	manure	post	174.0	2.10	365.40	91.44	24.75	7.70	5.64	132.32	75.00	207.32	158.08	151.80	30.18	2.2	7.3
5	conv	manure	ppi	171.0	2.10	359.10	91.44	24.75	7.70	13.86	149.22	75.00	224.22	134.88	151.80	63.86	2.2	7.3
6	slot	band	post	168.0	2.10	352.80	58.24	24.90	19.53	4.50	110.08	80.00	190.08	162.72	123.00	61.93	1.0	5.3
6	slot	band	pre	165.5	2.10	347.55	58.24	24.90	19.53	10.51	116.37	80.00	196.37	151.18	123.00	111.46	1.0	5.3
6	slot	band	pre	165.5	2.10	347.55	59.52	24.90	19.53	19.95	127.53	80.00	207.53	140.02	123.00	64.86	1.0	5.3
6	slot	band	post	129.6	2.10	272.16	58.24	24.90	17.60	4.50	108.06	80.00	188.06	84.10	123.00	33.13	1.0	5.3
6	slot	band	pre	133.1	2.10	279.51	58.24	24.90	17.60	10.51	114.35	80.00	194.35	85.16	123.00	103.11	1.0	5.3
6	slot	band	pre	132.0	2.10	277.20	59.52	24.90	17.60	19.95	125.51	80.00	205.51	71.69	123.00	57.85	1.0	5.4
7	conv	manure	org	139.5	2.10	292.95	98.86	25.00	3.28	.00	129.57	70.00	199.57	93.38	107.80	86.15	2.2	10.5
8	conv	manure	ppi	181.0	2.10	380.10	80.64	30.00	6.86	64.68	187.76	75.00	262.76	117.34	140.90	63.95	1.9	8.0
8	reduced	manure	post	128.0	2.10	268.80	71.80	30.00	6.86	40.61	163.04	75.00	238.04	30.76	140.90	17.83	1.6	6.5
9	conv	broadcast	post	162.5	2.10	341.25	65.07	26.26	30.38	9.93	135.44	80.00	215.44	125.81	133.00	49.55	1.1	6.6
10	conv	broadcast	ppi	163.5	2.10	343.35	60.61	28.50	24.85	18.47	149.82	80.00	229.82	113.53	141.80	26.81	1.2	7.8
10	stubble	broadcast	pre	146.0	2.10	306.60	50.07	28.50	20.05	28.59	131.63	80.00	211.63	94.97	141.80	-.18	.7	4.5
11	stubble	broadcast	pre	131.4	2.10	275.94	51.40	26.00	22.66	8.56	111.83	65.00	176.83	99.11	107.80	36.66	.6	5.1
11	conv	broadcast	ppi	141.0	2.10	296.10	65.14	26.00	32.31	18.47	146.19	65.00	211.19	84.91	107.80	52.79	1.0	7.7
11	conv	broadcast	ppi	86.0	2.10	180.60	71.20	26.00	26.26	16.14	143.55	65.00	208.55	-27.95	107.80	.00	1.2	8.0
12	ridge	manure	pre	142.0	2.10	298.20	73.39	24.00	5.45	6.55	111.88	65.00	176.88	121.32	98.60	50.77	1.6	7.3
12	ridge	manure	org	126.5	2.10	265.65	73.39	24.00	5.45	.35	105.40	65.00	170.40	95.25	98.60	79.96	1.6	7.3
12	ridge	manure	org	117.7	2.10	247.17	73.39	24.00	.00	.35	99.70	65.00	164.70	82.47	98.60	99.13	1.6	7.3
AVERAGES				148.87	2.10	312.63	70.14	26.39	18.03	14.98	134.28	74.31	208.58	104.05	126.09	53.59	1.3	6.86

Abbreviations used:

conv: conventional tillage
ridge: ridge till planting
stubble: stubble planting
reduced: reduced tillage

broadcast: broadcast fertilizer
banded: banded fertilizer
manure: manure management

ppi: pre-plant incorporated herbicides
pre-emerge: pre-emerge applied herbicides
post-emerge: post-emerge applied herbicides
org: organic weed control; no herbicides used

NB: Due to only two farms, the information on reduced tillage and organic alternatives are not reported separately in the body of the paper.