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Research Division Report 147

March 1973

Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

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Introduction

No-tillage corn production has gained rapid acceptance in Virginia. In 1971, an estimated[2] 130,000 acres were planted, representing approximately 20% of the corn acreage in the state. This change has occurred largely since 1967 when probably fewer than 1,000 acres were planted. In view of the many economic and ecological advantages offered by no-tillage corn, continued expansion is expected. Research on the various practices connected with the method is essential to promote its widest use.

One aspect of no-tillage production research not previously reported is crop rotation. Experiments on the subject were conducted at Blacksburg, Orange, and Charlotte Court House during 1964-1970. Economic interpretation of the crop yields obtained in the different rotations is not attempted, but instead the yields themselves are presented to serve as a base for determining the most profitable rotations on a given farm. The research was planned to provide answers to important questions such as the effect of soil tillage on comparative yields of continuous corn and corn rotated with other crops, as well as the effect of corn tillage methods on succeeding crops.

The purpose of this report is to show the crop yields obtained with different rotations when the corn component was tilled and non-tilled.

Procedure

The experiments were conducted at Blacksburg on Frederick silt loam, at Orange on Davidson clay loam, and at Charlotte Court House on Cecil clay loam. Lime was applied to maintain soil pH at 5.5 to 6.5 and plant nutrients averaging 168, 59, and 111 pounds per acre of N, P, and K, respectively, were applied to each corn crop. When conventional tillage corn was grown, the sod or cover crop was turn-plowed, disked and harrowed, before planting. When no-tillage corn was grown, the sod or cover crop was killed with chemical herbicides and the corn planted with the least soil disturbance necessary to place the seed into the soil. The corn varieties used were short season, adapted hybrids.

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[2]From Virginia Soil Fertility Association Newsletter.

The crop rotations tested at the three locations are shown in the tables of results. At Blacksburg and Orange there were one-, two-and three-year rotations, and at Charlotte Court House there were one and three year rotations. All crops were grown at each location each year. Summer rainfall at each location is shown in Table 9.

There were four replications of each treatment, in a randomized block design, at Orange and Charlotte Court House. At Blacksburg, the one-year rotation plots were separated from those that tested two- and three-year experiments. Therefore, statistical comparison of yields from the one-versus two-or three-year rotations cannot be made. However, since all the plots were in close proximity and without important soil differences, we can be confident that large yield differences are meaningful.

Results

Crop Rotation for No-Tillage Corn Not Necessary

Corn grown every year on the same land by the no-tillage method produced equally as well as growing at two- or three-year intervals. This result is shown at Blacksburg, Orange, and Charlotte Court House in Tables 1, 2, and 3, respectively. There were no significant differences in yield between continuous (corn every year) and rotated corn at Orange or Charlotte Court House and probably not at Blacksburg, although differences at the latter location could not be statistically evaluated, as previously noted. In Tables 1, 2, and 3, continuous corn is shown as the one-year rotation, the rotation aspect arising from the fact that a cover crop of rye for mulch was grown each winter between the summer corn crops.

In contrast to no-tillage culture, rotation probably increased conventionally tilled corn yields significantly at Blacksburg. There was no effect at Orange, and this factor was not tested at Charlotte Court House. At both Blacksburg and Orange, the two- and three-year rotations yielded equally well. Improvement in soil structure was likely responsible for the yield increase on the Frederick soil at Blacksburg, since plowing is a structure destroying operation, and grass culture is a structure building process. The longer rotations, then, tend to rebuild the structure destroyed by plowing. The Davidson soil at Orange has excellent inherent structure, so rotation would be less influential on corn yields at that location.

Double Cropped Corn Yields Lower

Double cropped corn yield averaged 48 percent of single crop yield at Orange and 56 percent at Charlotte Court House. It was not tested at Blacksburg. As seen in Tables 2 and 3, there were wide yearly fluctuations of corn yields when double cropped, primarily reflecting the variations in summer rainfall. The

uncertainty of adequate summer moisture imparts an unusual degree of risk to double cropping corn in Virginia.

Two-Year Grain Rotations at Blacksburg and Orange

A rotation designed for grain production without the necessity of seeding sod or cover crops was tested at Blacksburg during the 1966-1970 period. Corn and wheat were grown on alternate years and wheat stubble was left on the soil to serve as winter cover and mulch for the succeeding no-tillage corn crop. Conventional tillage (wheat stubble plowed under in spring) was tested for comparison. Corn yields, shown in Table 4, were comparable to those made with other rotations, when the same tillage method was used. No-tillage yielded significantly more than conventional tillage. Wheat yields were slightly lower where wheat followed no-tillage corn than where wheat followed conventionally tilled corn, but the difference was not significant. Observations during the course of the experiment indicated that it was more difficult to prepare a satisfactory seedbed for small grain after no-tillage corn, than after conventionally tilled corn.

At Orange, corn yields, shown in Table 2, were equal to those in either one-year or three-year rotations. Small grain yields, shown in Table 5, were comparable whether they followed no-tillage or conventionally tilled corn.

Small Grain Following Corn in Three-Year Rotation at Orange

Wheat and barley seeded after no-tillage corn tended to yield slightly lower at Orange than when seeded after conventionally tilled corn, as shown in Table 6, although the average difference was not statistically significant. The difference was probably caused by a slightly inferior seedbed resulting from discing no-tillage corn soil, as opposed to discing conventionally tilled corn soil. There were observations, however, both at Orange and at Blacksburg, that herbicide residues were apparently sometimes more detrimental following no-tillage corn as compared to conventionally tilled corn.

Hay Yields in Three-Year Rotations

Hay yields, composed of mixed orchard grass and red clover, that followed no-tillage and conventionally tilled corn were equal at Blacksburg, as shown in Table 7, and at Orange, as shown in Table 8.

Discussion

It seems clear that rotation is not important for no-tillage corn in Virginia. If, as was done in these experiments, a suitable

mulch is provided, weeds are controlled, and fertilization is adequate, continuous corn (corn every year) will yield equally well as that grown less frequently. No advantage was gained by rotating no-tillage corn with other crops at any of the three locations. Judging by Blacksburg's results, conventionally tilled corn, on the other hand, benefits from rotation. Apparently, improvement in soil structure and tilth, resulting from crop rotation, was responsible for the benefit. No-tillage corn rotated with small grain yielded equally well as that rotated with grass and clover sod at both Blacksburg and Orange. It appears that a suitable mulch, from whatever source, makes no-tillage corn successful, at least on a short term basis.

Summary

Crop rotation was found to be unimportant in determining the yield of no-tillage corn. Neither the length of the rotation nor the crops with which corn was alternated affected the yield. Thus, the no-tillage method makes possible the most intensive corn production that can be realized. The mulch cover apparently protects the soil enough to preserve the necessary soil aggregation and tilth. Conventionally tilled corn, on the other hand, benefitted when rotated with other crops.

Double cropped corn yields (planted in stubble of small grain after harvest) averaged 51% of corn planted at normal dates in the spring.

Yields of small grain crops that followed no-tillage corn were slightly lower than those that followed conventionally tilled corn, although the differences were not statistically significant.

Grass and clover hay yields were not different whether they were in rotation with no-tillage corn or in rotation with conventionally tilled corn.

Table 1. Corn yields with two types of tillage in one, two, and three-year rotations at Blacksburg.

Length of Rotation	Conventional Tillage								No-Tillage							
	1964	1965	1966	1967	1968	1969	1970	Average	1964	1965	1966	1967	1968	1969	1970	Average
	hundred weight per acre															
1 year[1/]	53.0	46.2[4/]	63.3	42.4	60.4	55.7	72.6	56.2[5/]	67.7	54.3[4/]	67.2	70.7	75.0	86.3	80.9	71.7[5/]
2 year[2/]	57.6	80.0	62.3	54.4	77.5	52.3	81.6	66.5[6/]	68.0	85.9	54.1	72.9	80.5	69.9	84.9	73.7[7/]
3 year[3/]	57.0	84.1	55.0	53.0	79.8	57.8	88.8	67.9[6/]	70.7	91.2	54.1	77.0	85.9	71.5	85.2	76.5[7/]

1/ Corn each year with a winter cover crop of rye.

2/ Corn, and grass and clover, on alternate years.

3/ Corn, and grass and clover, and grass and clover, on consecutive years.

4/ Corn in the one year rotation replanted due to armyworm damage. Yield not comparable in 1965 to two or three year rotations because no armyworm damage occurred and they were not replanted.

5/ Statistical comparison to yields in two or three year rotations was not possible.

6/ No significant difference in average yield.

7/ No significant difference in acreage yield.

Table 2. Corn yields, in tilled and non-tilled culture, in one, two, and three year rotations at Orange.

Length of Rotation	Conventional Tillage							No-Tillage						
	1965	1966	1967	1968	1969	1970	Average	1965	1966	1967	1968	1969	1970	Average
	hundred weight per acre													
1 year[1]	64.3	43.4	88.1	52.6	71.1	70.6	65.0[5]	65.7	48.9	106.4	69.3	76.7	75.9	73.8[6]
2 year[2]	69.0	35.6	98.0	57.2	71.1	65.7	66.1[5]	55.7	37.8	112.6	72.0	74.0	69.8	70.3[6]
3 year[3]	57.2	39.8	103.9	49.6	77.7	68.9	66.2[5]	64.8	40.9	97.1	70.6	77.1	73.8	70.7[6]
Double Cropped[4]	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	57.7[7]	25.4[8]	48.8[8]	25.2[8]	39.2

[1] Corn each year, with a winter cover crop of rye

[2] Corn, and small grain on alternate years.

[3] Corn, small grain, and grass and clover on consecutive years

[4] Corn planted without tillage in small grain stubble immediately following harvest.

[5] No significant difference in average yield.

[6] No significant difference in average yield.

[7] Small grain stubble was from wheat.

[8] Small grain stubble was from barley.

Table 3. Corn yields, in tilled and non-tilled culture, in one and three year rotations at Charlotte Court House.

Length of Rotation	Conventional Tillage					No-Tillage				
	1967	1968	1969	1970	Average	1967	1968	1969	1970	Average
	hundred weight per acre									
1 year[1/]	55.3	36.5	32.5	43.4	41.9	80.5	54.6	38.8	58.9	58.2[6/]
3 year[2/]	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	76.0	67.7	38.2	Not	60.6[6/]
Double[3/] Cropped	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	59.1[4/]	9.6[5/]	29.2[5/]	Not Tested	28.9

[1/] Corn eacn year, with a winter cover crop of rye.

[2/] Corn, small grain, and grass and clover, on consecutive years.

[3/] Corn planted without tillage in small grain stubble immediately following harvest.

[4/] Small grain was wheat.

[5/] Small grain was barley.

[6/] No significant difference in average yield.

Table 4. Corn and wheat yields, in tilled and non-tilled soil, in an experimental two year grain rotation[1/] at Blacksburg.

Crop	Conventional Tillage						No-Tillage					
	1966	1967	1968	1969	1970	Average	1966	1967	1968	1969	1970	Average
	hundred weight per acre											
Corn [1/]	58.4	40.2	79.1	51.8	86.2	63.2 [2/]	61.4	65.9	82.5	67.0	87.7	72.9 [2/]
Wheat [1/]	24.6	---	26.8	33.0	9.1	23.3 [3/]	27.6	---	21.4	26.8	6.1	20.4 [3/]

[1/] Corn was spring planted without tillage in small grain stubble left undisturbed from the previous summer. Wheat was planted after discing corn land where corn had been removed as silage.

[2/] Average no-tillage corn yield significantly higher than conventional tillage at the 5% level.

[3/] No significant difference in average wheat yield.

Table 5. Small grain yields, following tilled and non-tilled corn in two year rotation, at Orange.

Year	After Conventionally Tilled Corn	After No-Tillage Corn
	hundred weight/acre	
1965	21.9 [1/]	22.1 [1/]
1966	20.4 [1/]	20.8 [1/]
1967	31.2 [1/]	34.6 [1/]
1968	34.8 [2/]	32.5 [2/]
1969	31.9 [2/]	33.3 [2/]
1970	25.4 [2/]	26.2 [2/]
Average	27.6 [3/]	28.3 [3/]

[1/] Wheat.

[2/] Barley.

[3/] No significant difference in average yield.

Table 6. Small grain yields, following tilled and non-tilled corn in three-year rotation[1/], at Orange.

Year	After Conventionally Tilled Corn	After No-Tillage Corn
	hundred weight/acre	
1965	22.8 [2/]	24.0 [2/]
1966	20.6 [2/]	21.5 [2/]
1967	37.1 [2/]	33.0 [2/]
1968	23.3 [2/]	10.0 [2/]
1969	31.3 [2/]	35.2 [2/]
1970	25.9 [2/]	26.8 [2/]
Average	26.8 [3/]	25.1 [3/]

[1/] Corn, small grain, grass and clover, on consecutive years.

[2/] Wheat.

[3/] Barley.

Table 7. Grass and clover hay yields in the third year of the three year rotations at Blacksburg.

Year	Conventional Tillage	No-Tillage
	—— hundred weight/acre, 12% H_2O ——	
1964	68.5	57.8
1965	54.9	49.2
1966	57.2	78.1
1967	47.2	52.9
1968	64.6	54.0
1969	31.4	30.9
1970	52.6	60.7
Average	53.8 1/	54.8 1/

1/ No significant difference in average yield.

Table 8. Grass and clover hay yields, in three year rotation in which corn is tilled and non-tilled, at Orange.

Year	After Conventionally Tilled Corn	After No-Tillage Corn
	hundred weight/acre, 12% H_2O	
1965	53.6	45.6
1966	71.5	70.0
1967	60.9	79.6
1968	86.0	81.5
1969	47.8	34.9
1970	50.9	58.8
Average	61.8[1/]	61.7[1/]

[1/] No significant difference in average yield.

Table 9. April - September, inclusive, precipitation at experimental locations in appropriate years.*

Year	April	May	June	July	August	September	Total
	inches						
				Blacksburg			
1964	4.00	2.09	1.31	4.43	4.38	3.03	19.24
1965	3.14	2.60	3.38	5.08	3.13	2.93	20.26
1966	2.65	3.15	0.39	4.94	4.61	5.09	20.83
1967	2.28	4.13	2.34	2.93	5.75	2.23	19.66
1968	3.88	3.45	3.22	2.38	3.73	1.18	17.84
1969	2.10	0.92	3.92	2.55	4.25	5.35	19.09
1970	3.32	2.09	3.80	7.25	5.44	2.78	24.68
				Orange			
1965	2.62	3.48	1.72	2.96	4.80	2.19	17.77
1966	3.31	6.02	2.74	3.13	0.88	10.72	26.80
1967	1.07	3.51	1.21	6.50	8.58	1.70	22.57
1968	1.50	4.34	4.23	3.62	5.96	2.01	21.66
1969	1.28	2.09	4.19	5.69	4.63	4.22	22.10
1970	3.89	3.43	1.27	6.03	1.30	1.59	17.51
				Charlotte Court House			
1967	1.41	3.94	3.46	2.38	6.44	0.90	18.53
1968	1.67	4.45	4.35	3.94	2.26	0.83	17.50
1969	1.52	2.18	2.91	3.84	3.10	2.77	16.32
1970	3.75	2.58	1.73	5.06	4.33	2.07	19.52

*Information taken from C. W. Crockett, Climatological Summaries for Selected Stations in Virginia, Bulletin 53, Water Resources Research Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.