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CROP AND TILLAGE EFFECTS ON RESIDUE COVER

This report covers a two-year study on crop residue. It was carried out by Frans Wessels under the direction of Dr. Don McCool at USDA-ARS, Washington State University.

Crop and Tillage Effects on Residue Cover

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Introduction

The USDA-ARS at Pullman, WA started on a multidisciplinary project in the fall of 1985. The title of the project is "An Integrated Pest Management System for Crop Production in the Northwest Wheat Region", abbreviated as IPM. Disciplines involved in this project are weed science, soil science, agricultural engineering, plant pathology, entomology, agricultural economics and predictive modeling. The main purpose is to assess the interaction of two 3-year crop rotations, two tillage systems and three levels of weed management with weeds, diseases and insects, nutrient uptake and utilization, and soil erosion for maximum economic crop production.

This report concerns the part of the IPM project that assesses the interaction between crop management and soil erosion protection, more specifically, the effect of type of crop and tillage on residue cover. Residue cover is an important factor in protecting the soil against water erosion. Even when the soil is frozen and runoff occurs over thawing soils, residue cover can protect the soil from excessive rates of erosion.

The residue project was initiated during the first year (1985) of the IPM study, but an early winter hampered data collection. A report of the second year (1986) of the project was prepared in 1987. This report will give the results of the third year (1987) and will compare these results with those of the second year.

Experimental Procedure

The plot area is located approximately 5.1 km northwest of Pullman, WA on land leased from a cooperator. The soil on the site is a Palouse silt loam. For the six years previous to the IPM project, the land was farmed in no-till seeded small grains.

The IPM experiment is divided into 12 main plots with four replicates. The size of the plots (45.7 m long x 36.6 m wide) is such that nearly normal tillage depth and speed can be achieved. The main plots are divided into three subplots (12.2 m wide), each with a different weed management level.

The main plots are randomized by combinations of tillage (minimum and conventional) and two 3-year crop rotations. One rotation is winter wheat, winter wheat, spring wheat; the other is winter wheat, spring barley, spring peas. Minimum tillage involves chisel plowing (after winter wheat and spring barley) or no-till seeding if there is not a heavy residue left from the previous crop (after spring wheat and spring peas). Conventional tillage involves moldboard plowing (after winter wheat, spring wheat and spring barley) or tandem disking (after spring peas). After primary tillage, secondary tillage is used during the fall for the winter wheat plots (except for the no-till plots) and during the spring for the other plots. Secondary tillage was intended to consist of two field cultivations followed by seeding with a double disk drill. However, in the fall of 1987, dry soil conditions caused the primary tillage to leave large clods. For those plots being seeded to winter wheat a heavy disk harrow replaced the field cultivator as the first operation after primary tillage. Some main plots were flailed after harvest. These were primarily minimum tilled plots where residue was anticipated to

interfere with the seeding operation. The crops and tillage operations for each plot in 1987/88 are given in Table 1.

In order to determine the effect of crops and specific tillage operations on residue cover, before and after each tillage and seeding operation photographic color slides were taken. A frame (78 x 96 cm) was used to border the area to be photographed. This frame was moved diagonally over each subplot and pictures were taken from a step ladder in order to include the entire frame in one picture, under an almost perpendicular angle. On sunny days it was necessary to use a sun shade to block the direct sunlight on the ground as this makes analyzing the slides very difficult.

The slides were analyzed by projecting them on a back lighted slide projector screen with a grid of 45 squares measuring 2.0 x 2.0 cm taped to the screen. To determine the percentage residue cover, dots placed at the upper right corners of each intersection were inspected to determine whether or not the dot hit residue cover on the slide. The number of hits divided by 0.45 gives the residue cover percentage.

Analytical Procedure

The number of hits counted on each slide is stored in a computer file. This file is used as input for the fortran program MEAN. This program transforms the numbers into percentages and calculates the average values per main plot, weed management level and replication. The program MEAN is almost the same as the program used in the first year of the IPM project. A few adaptations have been made to make it possible to use a variable number of slides per plot.

Several statistical values, including the standard deviation, are calculated with the SAS program MEANS. The same adaptations as in the program MEAN are used for this program. The fortran program ENDRES is used to calculate the residue cover changes after each tillage operation.

All these programs are on the CMS system at WSU. The figures in this report are made with ATAPLOT on an HP 1000.

Results and Discussion

In this chapter the results of the third year (1987) will be discussed, after which the results of the second (1986) and third year (1987) will be compared.

1987 DATA:

The residue cover after harvest (Table 2) was highest for winter wheat (91.8%) followed by spring barley (85.0%) and spring wheat (84.2%). Spring peas (59.7%) clearly leave less residue on the surface after harvest than do small grains. This is due to the different properties of the spring pea plants. Pea residues are also less uniformly distributed after harvest. The cover percentages for the minimum tilled plots were slightly higher than for the conventionally tilled plots.

the before operation residue, although the amounts before and after the field cultivation were quite low.

Data from the second field cultivation in the spring of 1988 are presented in Table 10. The data are quite variable. This operation left 84.8% of the original residue on the surface of the minimum tilled plots and 89.9% on the conventional tilled plots. No significant trends are apparent.

Residue cover changes from seeding are presented in Table 11. Minimum till plots 2 and 5 were seeded with a heavy double disk no-till drill. The operation left about 75% of the residue on the soil surface. The drills used on the remainder of the plots left fairly consistent residue quantities, except for the conventional tilled spring barley and spring peas where, at least visually, residue was returned to the surface.

Residue cover changes for plots left rough-tilled over winter are about the same for the winter wheat and the spring barley plots (Table 12). On the minimum tilled plots the percentage of original residue left on the surface is higher (88.9% for winter wheat, 92.3% for spring barley) than on the conventional tilled plots (71.1% and 66.9%). The mean visual disappearance was much greater for conventional tillage (30.3%) than for minimum tillage (10.0%). This may be real or it may be caused by soil splash or darkening of the low quantities of residue on the conventional tilled plots.

The residue cover data after all operations (Table 11) show that the residue cover was highest for the no-till plots (66.0% for the spring wheat plots and 46.2% for the spring pea plots). There was much more residue left on the surface of the plots that were plowed with a chisel plow (27.1% for winter wheat, 15.0% for spring barley) than on those plowed with a moldboard plow (4.0% for winter wheat, 1.7% for spring barley and 3.9% for spring wheat). On the spring pea plots which were disked twice the residue cover after all the operations was 9.9%. These data also show that winter wheat and spring wheat left more residue on the surface than spring barley after all operations. Of the minimum tilled plots, those left rough tilled over winter and seeded to spring crops had much less residue after seeding than those seeded in the fall. In general, spring tillage when the soil is near field capacity and residues have weathered over winter buries more residue than fall operations. Quantities of residue on the conventionally tilled plots were quite small in all cases.

Figures 1 through 12 show the residue cover remaining after each operation on each plot. Only three of the rotation and tillage treatments left sufficient residue after seeding to meet the 30% residue criterion generally specified before a treatment can be classified as conservation tillage by the Soil Conservation Service. However, all of the minimum tillage plots, 1 through 6, had more than 30% residue cover over the critical winter period. None of the conventionally tilled plots, 7 through 12, had sufficient residue, even over winter, to qualify as conservation tillage. If sufficient roughness were left by the moldboard plow, those left rough tilled over the winter would still have reasonable protection. Surface roughness was not a part of this study.

COMPARISON OF 1986 AND 1987 DATA:

The residue cover after harvest (Table 13) was a little lower for the small grains in 1987. During 1986, all the small grain plots were flailed, while only the minimum tilled winter wheat and all spring wheat plots were flailed in 1987. The photos were taken after flailing in both years. The cover on the spring pea plots was much less for 1986.

The cover changes due to primary tillage operations (Table 14) are about equal for both years, except for the conventional tilled spring barley and spring pea plots. For these plots the percentage of the original cover after the operation is almost twice as high for 1987. The reason for the difference on the spring pea plots can probably be attributed to the fact that the top soil was wetter in 1986. In September 1986, 0.84 inches of rain fell before the disking operation, while in September 1987 no rain fell.

Residue cover changes over winter for rough tilled stubble are given in Table 15. There was slightly more after winter residue in 1987/88 as compared to 1986/87 for both winter wheat and spring barley stubble. Based on visual criteria alone, about 81% of the before winter residue was seen in the spring of 1987 and about 80% in the spring of 1988. Differences in the portion of original cover between minimum and conventional tillage were larger in the 1987/88 data than in the 1986/87 data. As expected, large differences in cover are seen between minimum and conventional tillage.

Because of use of a disk harrow rather than a field cultivator as the next operation after primary tillage in the fall of 1987, direct comparisons of secondary tillage operations are limited. Direct comparisons are further hampered by the fact that in 1986/87 it was not possible to take photos after each operation; but rather after a combination of operations. Thus, the direct comparisons that can be made are limited to the first field cultivation in the spring, the second field cultivation and seeding in the spring, and the seeding operation.

The first spring field cultivation left more residue in 1986/87 as compared to 1987/88, both for winter wheat and spring barley residue (Table 16). The difference was small for winter wheat residue but substantial for spring barley residue. The reasons for this are unknown. The quantities of residue left after the winter were similar in each year (Table 15). More winter wheat residue was left where minimum tillage had been used but the results were mixed in the case of spring barley.

Data from the combination of the second field cultivation and seeding are presented in Table 17. More of the original residue remained on the surface in 1987/88 with the exception of minimum tilled winter wheat stubble. The larger values are compatible with the dry soil conditions in 1987/88. The reason the minimum tillage results are similar is not known.

Table 18 contains data on the portion of before operation cover left after seeding. In general, more of the residue was left in 1987/88 as compared to 1986/87. There was a marked difference in results for no-till seeding into spring pea stubble as well as into spring wheat stubble. However, conventional seeding into spring wheat residue in 1987/88 showed a doubling of the portion of the residue left by this operation.

The residue cover remaining after all operations is given in Table 19. The results are quite similar except for minimum tilled spring wheat residue and both tillages of spring peas. The different results for spring wheat may be related to the different soil moisture conditions in the fall of each year when these tillage operations were carried out. For these soils, tillage implements generally bury less residue under extremely dry conditions. The difference in spring pea residues is a result of the same effect. There was more residue after harvest in 1986/87, but the tillage operations buried less residue in 1987/88.

The standard deviations after each operation are about equal for both years. This means that the range of the results, after each operation, for each crop are about the same for both years.

Summary

A two-year study on the effect of crop rotation, weed management and tillage on residue cover has been completed and the data summarized. Soils receiving conventional tillage are exposed to a much greater risk of erosion than soils receiving minimum tillage. Conventional tillage left less residue on the surface over the winter erosion season (2 to 11% cover) than general SCS recommendations. Minimum tillage left more residue on the surface (36 to 66% cover) which results in better protection against erosion. When the soil was fall tilled for spring crops, decomposition and other factors reduced the visible residue cover of small grain by about 20% (range of 8 to 33%).

The effect of specific tillage operations was as follows: The moldboard plow left from 4 to 11% of the original small grain residue on the soil surface; the average was about 9%. The chisel plow left from 40 to 50% of the original residue on the soil surface, with an average of about 47%. The tandem disk left from 14 to 25% of the original residue on the soil surface, with an average of 20%. The field cultivator left from 46 to 87% of the original residue on the soil surface, with an average of 71%. The heavy double disk no-till drill left from 41 to 78% of the original residue on the soil surface; the average was 63%.

The results of using a given implement appeared to be influenced by soil moisture. The effect seemed to be more pronounced for the secondary implements.

The residue data for winter wheat and spring wheat did not differ greatly. Barley left less residue on the surface than wheat, but more than peas.

The weed management levels had little influence on the standard deviation; only spring peas showed higher variance in the results per weed management level.

TABLE 1. CROPS AND TILLAGE OPERATIONS, 1987/88

Main Plot	Prev. Crop	Succ. Crop	Tillage	Operations
1[1]	WW	SW	Minimum	Flail, CP[2], FC[3], FC, Drill
2	SW	WW	No-till	Flail, No-till drill, Roll
3	WW	WW	Minimum	Flail, CP, Disk[4], FC, Drill
4[1]	SB	SP	Minimum	CP, FC, FC, Drill
5	SP	WW	No-till	No-till drill, Roll
6[1]	WW	SB	Minimum	Flail, CP, FC, FC, Drill
7[1]	WW	SW	Convent.	MP[5], FC, FC, Drill
8	SW	WW	Convent.	Flail, MP, Disk, FC, Drill
9	WW	WW	Convent.	MP, Disk, FC, Drill
10[1]	SB	SP	Convent.	MP, FC, FC, Drill
11	SP	WW	Convent.	Disk, Disk, FC, Drill/Harrow
12[1]	WW	SB	Convent.	MP, FC, FC, Drill

1 Left rough tilled over winter
2 CP = Chisel plow
3 FC = Field cultivator
4 Disk = Tandem disk harrow
5 MP = Moldboard plow

TABLE 2. RESIDUE COVER AFTER HARVEST, 1987

Main Plot	Tillage	Previous Crop	Residue Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1*	Minimum	WW	91.97	4.18	75.6	100.0
2*	No-till	SW	85.12	9.14	66.7	97.8
3*	Minimum	WW	92.16	3.51	82.2	97.8
4	Minimum	SB	87.84	7.75	60.0	97.8
5	No-till	SP	63.86	19.94	11.1	95.6
6*	Minimum	WW	93.78	2.87	86.7	97.8
7	Convent.	WW	91.24	4.58	80.0	97.8
8*	Convent.	SW	87.34	11.80	48.9	97.8
9	Convent.	WW	88.97	5.57	71.1	95.6
10	Convent.	SB	82.17	11.52	55.6	97.8
11	Convent.	SP	55.43	21.69	4.4	95.6
12	Convent.	WW	91.74	4.44	77.8	97.8

* Flailed before these data collected.

TABLE 3. RESIDUE COVER CHANGES FROM FLAILING, 1987

Main Plot	Residue Cover (%)	Portion of Original Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1	91.97	98.80	3.99	84.4	97.8
2	No Data				
3	No Data				
6	No data				
8	87.34	104.96	8.02	57.8	100.0

TABLE 4. RESIDUE COVER PERCENTAGES AFTER HARVEST PER REPLICATION

Crop:	REP1 (%)	REP2 (%)	REP3 (%)	REP4 (%)
Winter wheat	92.35	93.10	91.65	91.33
Spring wheat	86.17	87.66	80.37	84.69
Spring barley	88.03	84.82	85.43	81.74
Spring peas	70.61	46.85	58.08	63.03

TABLE 5. RESIDUE COVER PERCENTAGES AFTER HARVEST PER WEED MANAGEMENT LEVEL

Weed Management Level	Residue Cover WW (%)	SW (%)	SB (%)	SP (%)
Minimum	92.01	85.30	83.06	64.12
Moderate	91.95	83.22	86.77	57.08
Optimum	92.18	83.39	85.19	57.73

TABLE 6. RESIDUE COVER CHANGES FROM PRIMARY TILLAGE, 1987

Main Plot & Operation	Prev. Crop	Residue Cover after Operation (%)	Portion of Orig. Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1* chisel	WW	35.93	38.60	12.51	6.7	75.6
2* no-till	SW	NA	-----	-----	-----	-----
3* chisel	WW	44.63	48.43	14.98	8.9	80.0
4 chisel	SB	37.16	42.30	13.84	8.9	64.4
5 no-till	SP	NA	-----	-----	-----	-----
6* chisel	WW	50.13	53.45	16.79	4.4	88.9
7 moldboard	WW	11.22	12.30	8.07	0.0	40.0
8* moldboard	SW	6.02	7.24	5.03	0.0	15.6
9 moldboard	WW	6.85	7.70	4.89	0.0	20.0
10 moldboard	SB	7.16	8.71	3.95	0.0	17.8
11 disk	SP	13.76	24.82	9.07	0.0	40.0
12 moldboard	WW	11.73	12.79	9.73	0.0	44.4

* Flailed

TABLE 7. RESIDUE COVER CHANGES FROM DISK HARROW AFTER PRIMARY TILLAGE, FALL 1987

Main Plot	Prev. Crop	Residue Cover (%)	Portion of Original Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1	WW	NA	-----	-----	-----	-----
2	SW	NA	-----	-----	-----	-----
3	WW	41.48	92.94	14.76	17.8	77.8
4	SB	NA	-----	-----	-----	-----
5	SP	NA	-----	-----	-----	-----
6	WW	NA	-----	-----	-----	-----
7	WW	NA	-----	-----	-----	-----
8	SW	3.77	62.62	4.03	0.0	13.3
9	WW	3.64	53.14	2.73	0.0	8.9
10	SB	NA	-----	-----	-----	-----
11	SP	10.75	78.12	6.07	2.2	22.2
12	WW	NA	-----	-----	-----	-----

TABLE 8. RESIDUE COVER CHANGES FROM FIELD CULTIVATION AFTER DISKING, FALL 1987

Main Plot	Prev. Crop	Residue Cover (%)	Portion of Original Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1	WW	NA	-----	-----	-----	-----
2	SW	NA	-----	-----	-----	-----
3	WW	43.17	104.07	16.99	13.3	82.2
4	SB	NA	-----	-----	-----	-----
5	SP	NA	-----	-----	-----	-----
6	WW	NA	-----	-----	-----	-----
7	WW	NA	-----	-----	-----	-----
8	SW	4.10	108.75	3.78	0.0	15.6
9	WW	3.38	92.86	2.74	0.0	8.9
10	SB	NA	-----	-----	-----	-----
11	SP	9.63	89.58	8.96	0.0	55.6
12	WW	NA	-----	-----	-----	-----

TABLE 9. RESIDUE COVER CHANGES FROM FIRST FIELD CULTIVATION, SPRING 1988

Main Plot	Prev. Crop	Residue Cover (%)	Portion of Original Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1	WW	25.68	78.08	13.12	2.2	64.4
2	SW	NA	-----	-----	-----	-----
3	WW	NA	-----	-----	-----	-----
4	SB	17.90	52.20	10.12	2.2	48.9
5	SP	NA	-----	-----	-----	-----
6	WW	36.97	85.50	15.49	4.4	75.6
7	WW	4.91	58.94	4.93	0.0	20.0
8	SW	NA	-----	-----	-----	-----
9	WW	NA	-----	-----	-----	-----
10	SB	2.21	46.14	2.71	0.0	11.1
11	SP	NA	-----	-----	-----	-----
12	WW	6.41	80.33	5.23	0.0	24.4

TABLE 10. RESIDUE COVER CHANGES FROM SECOND FIELD CULTIVATION SPRING 1988

Main Plot	Prev. Crop	Residue Cover (%)	Portion of Original Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1	WW	19.57	76.21	11.19	2.2	48.9
2	SW	NA	-----	-----	-----	-----
3	WW	NA	-----	-----	-----	-----
4	SB	16.98	94.86	8.77	2.2	44.4
5	SP	NA	-----	-----	-----	-----
6	WW	30.80	83.31	15.12	6.7	71.1
7	WW	4.97	101.22	4.84	0.0	20.0
8	SW	NA	-----	-----	-----	-----
9	WW	NA	-----	-----	-----	-----
10	SB	1.70	76.92	2.11	0.0	8.9
11	SP	NA	-----	-----	-----	-----
12	WW	5.87	91.58	4.34	0.0	20.0

TABLE 11. RESIDUE COVER CHANGES FROM SEEDING, 1987

Main Plot	Prev. Crop	Residue Cover (%)	Portion of Original Cover (%)	Standard Deviation (%)	Min. Value (%)	Max. Value (%)
1[1,2]	WW	17.02	86.97	8.00	2.2	33.3
2[1]	SW	65.98	77.51	14.09	31.1	93.3
3[1]	WW	39.04	90.43	15.41	11.1	77.8
4[2]	SB	14.97	88.16	7.88	2.2	33.3
5	SP	46.23	72.39	20.33	0.0	82.2
6[1,2]	WW	25.11	81.53	13.11	2.2	57.8
7[2]	WW	4.43	89.13	4.43	0.0	22.2
8	SW	3.94	96.10	4.16	0.0	17.8
9	WW	2.64	78.11	2.04	0.0	6.7
10[2]	SB	1.74	102.35	2.17	0.0	8.9
11	SP	9.87	102.49	6.08	2.2	22.2
12[2]	WW	5.05	86.03	4.89	0.0	31.1

[1] Flailed after harvest
[2] Rough tilled over winter

TABLE 12. RESIDUE COVER CHANGES OVER WINTER, 1987/88

Main Plot	Prev. Crop	Residue Cover (%)	Portion of Original Cover (%)	Visual Disapp. (%)	Stand. Dev. (%)	Min. Value (%)	Max. Value (%)
1	WW	32.89	91.54	8.46	13.52	11.1	66.7
2	SW	-----	-----	-----	-----	-----	-----
3	WW	-----	-----	-----	-----	-----	-----
4	SB	34.29	92.28	7.72	15.53	11.1	75.6
5	SP	-----	-----	-----	-----	-----	-----
6	WW	43.24	86.26	13.74	13.44	15.6	71.1
7	WW	8.34	74.24	25.76	5.26	0.0	26.7
8	SW	-----	-----	-----	-----	-----	-----
9	WW	-----	-----	-----	-----	-----	-----
10	SB	4.79	66.90	33.10	4.33	0.0	22.2
11	SP	-----	-----	-----	-----	-----	-----
12	WW	7.98	68.03	31.97	5.32	0.0	24.4

TABLE 13. AVERAGE COVER PERCENTAGE AFTER HARVEST PER CROP

Tillage	WW (%)	SW (%)	SB (%)	SP (%)
1986				
Minimum	98.6*	92.7*	94.7*	82.5
Conventional	91.6*	89.7*	90.6*	71.7
Average	94.1	91.2	92.6	77.1
1987				
Minimum	92.6*	85.1*	87.8	63.9
Conventional	90.7	87.3*	82.2	55.4
Average	91.6	84.2	85.0	59.7

* Flailed before these data collected

TABLE 14. PORTION OF ORIGINAL COVER LEFT AFTER PRIMARY TILLAGE

Operation	WW (%)	SW (%)	SB (%)	SP (%)	AVG. (%)
1986					
Chisel	49.7	-----	40.2	-----	47.3
Moldboard	10.2	7.0	4.5	-----	8.4
Disk	-----	-----	-----	13.6	13.6
1987					
Chisel	48.0	-----	42.3	-----	46.6
Moldboard	10.9	6.9	8.7	-----	9.7
Disk	-----	-----	-----	24.8	24.8

TABLE 15. RESIDUE COVER CHANGES OVER WINTER

Tillage	WW Residue Cover (%)	WW Portion of Original Cover (%)	SB Residue Cover (%)	SB Portion of Original Cover (%)
1986/87				
Minimum	33.6	81.1	27.9	73.5
Conventional	5.8	82.3	3.5	86.2
Average		81.7		79.9
1987/88				
Minimum	38.1	88.9	34.3	92.3
Conventional	8.2	71.1	4.8	66.9
Average		80.0		79.6

TABLE 16. PORTION OF ORIGINAL COVER LEFT AFTER FIRST FIELD CULTIVATION IN THE SPRING

Tillage	WW (%)	SW (%)	SB (%)	SP (%)
1986/87				
Minimum	87.4	-----	71.9	-----
Conventional	77.6	-----	80.6	-----
Average	82.5	-----	76.3	-----
1987/88				
Minimum	81.8	-----	52.2	-----
Conventional	69.6	-----	46.1	-----
Average	75.7	-----	49.2	-----

TABLE 17. PORTION OF ORIGINAL COVER LEFT AFTER SECOND FIELD CULTIVATION AND SEEDING

Tillage	WW[1] (%)	SW[2] (%)	SB[1] (%)	SP[2] (%)
1986/87				
Minimum	67.1	-----	65.6	-----
Conventional	52.3	67.2	37.8	28.4
Average	59.7	-----	51.7	-----
1987/88				
Tillage	WW	SW	SB	SP
Minimum	67.1	-----	83.6	-----
Conventional	84.5	104.5	78.7	91.8
Average	75.8	-----	81.2	-----

[1] Spring operations
[2] Fall operations

TABLE 18. PORTION OF ORIGINAL COVER LEFT AFTER SEEDING

Tillage	WW[1] (%)	SW[2] (%)	SB[1] (%)	SP[2] (%)
1986/87				
Minimum	85.1	60.8	-----	41.3
Conventional	74.7	47.0	-----	-----
Average	79.9	58.9	-----	41.3
1987/88				
Minimum	90.4	77.5	88.2	72.4
Conventional	78.1	96.1	102.4	102.5
Average	84.3	96.3	95.3	87.4

[1] Spring operation
[2] Fall operation

TABLE 19. RESIDUE COVER AFTER ALL OPERATIONS

Tillage	WW (%)	SW (%)	SB (%)	SP (%)
1986/87				
Minimum	26.7	56.3	13.2	34.2
Conventional	4.4	3.1	1.1	2.5
1987/88				
Minimum	27.1	66.0	15.0	46.2
Conventional	4.0	3.9	1.7	9.9

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Fig 1: PLOT 1 MINIMUM TILLAGE

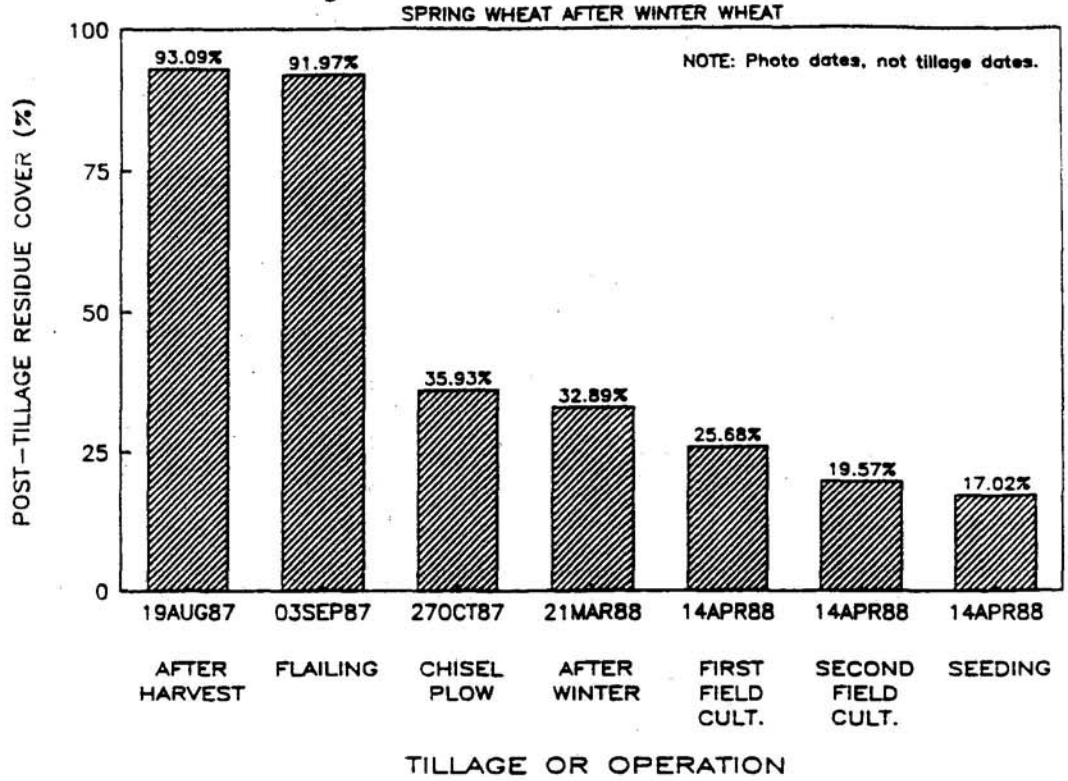

Fig 2: PLOT 2 MINIMUM TILLAGE

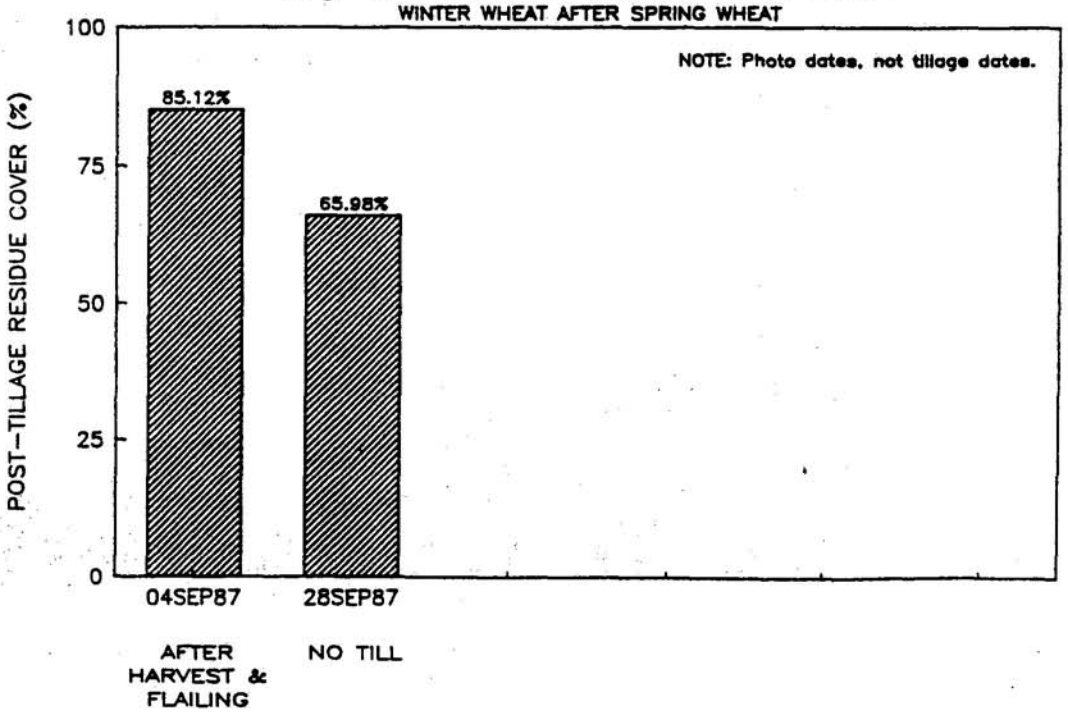

Fig 3: PLOT 3 MINIMUM TILLAGE

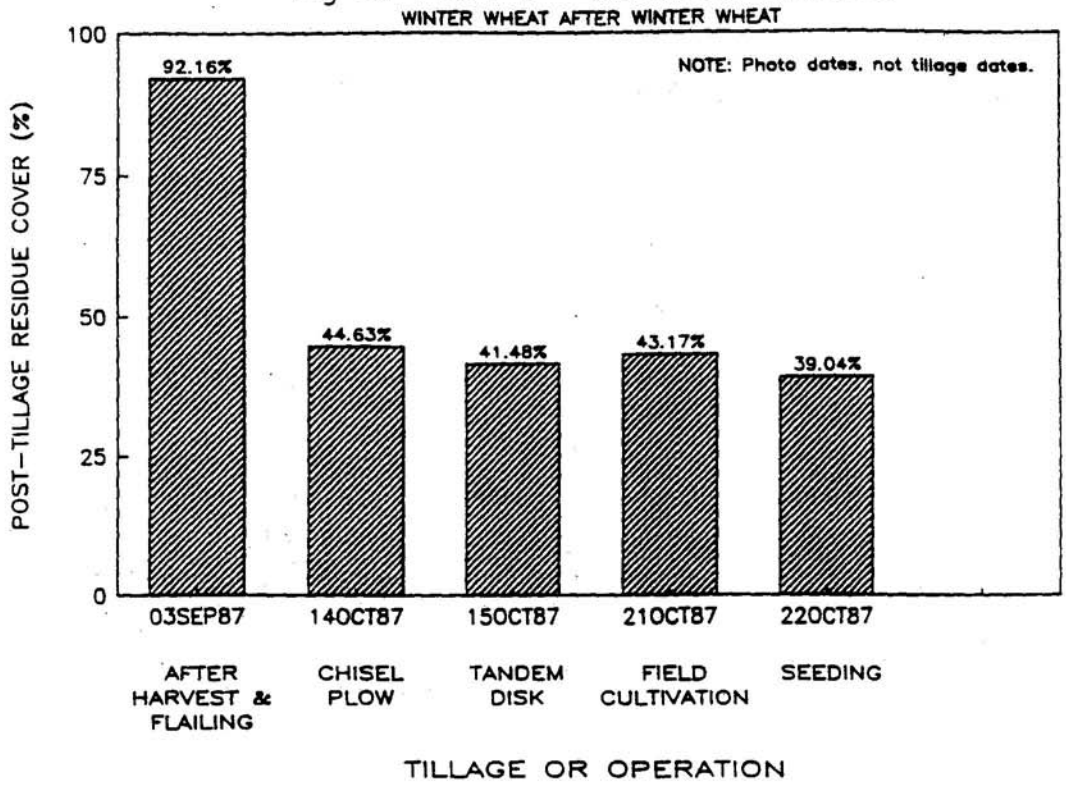

Fig 4: PLOT 4 MINIMUM TILLAGE

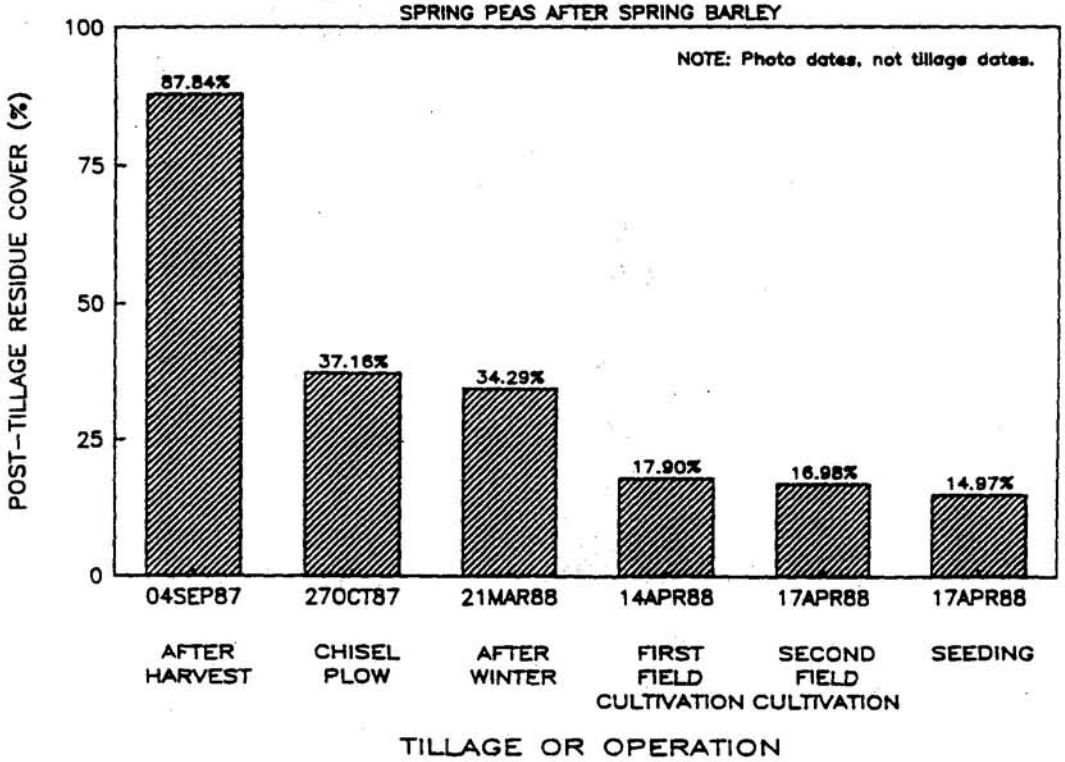

Fig 5: PLOT 5 MINIMUM TILLAGE

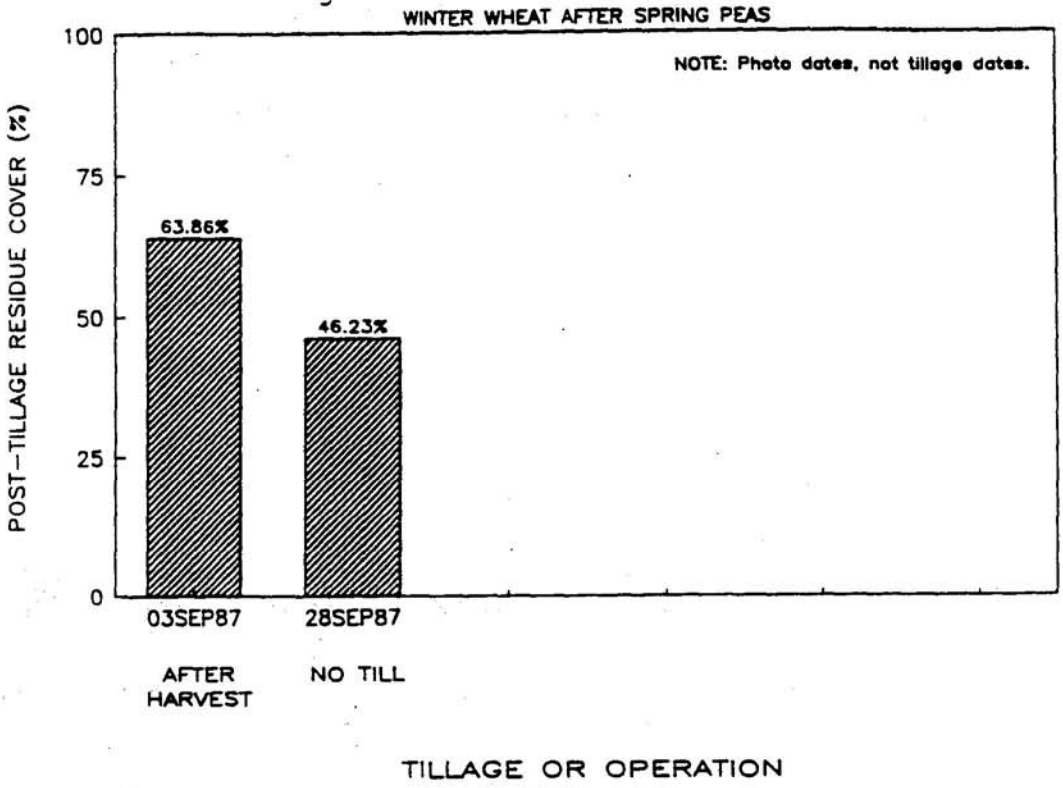

Fig 6: PLOT 6 MINIMUM TILLAGE

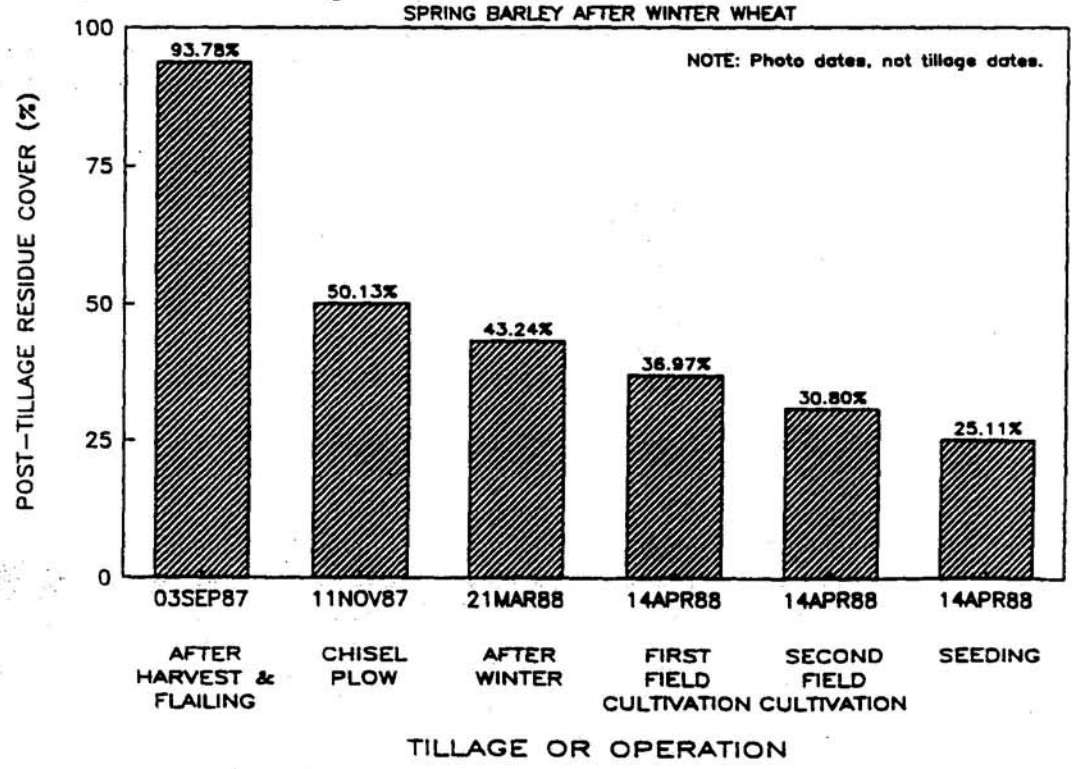

Fig 7: PLOT 7 CONVENTIONAL TILLAGE

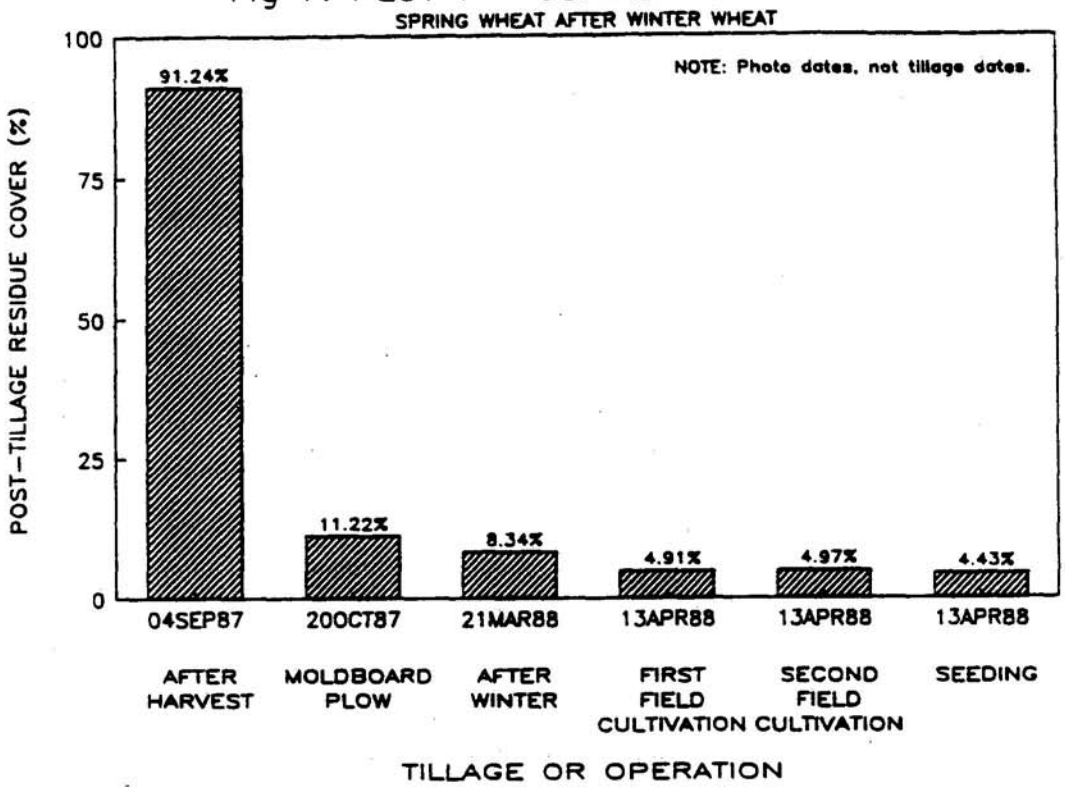

Fig 8: PLOT 8 CONVENTIONAL TILLAGE

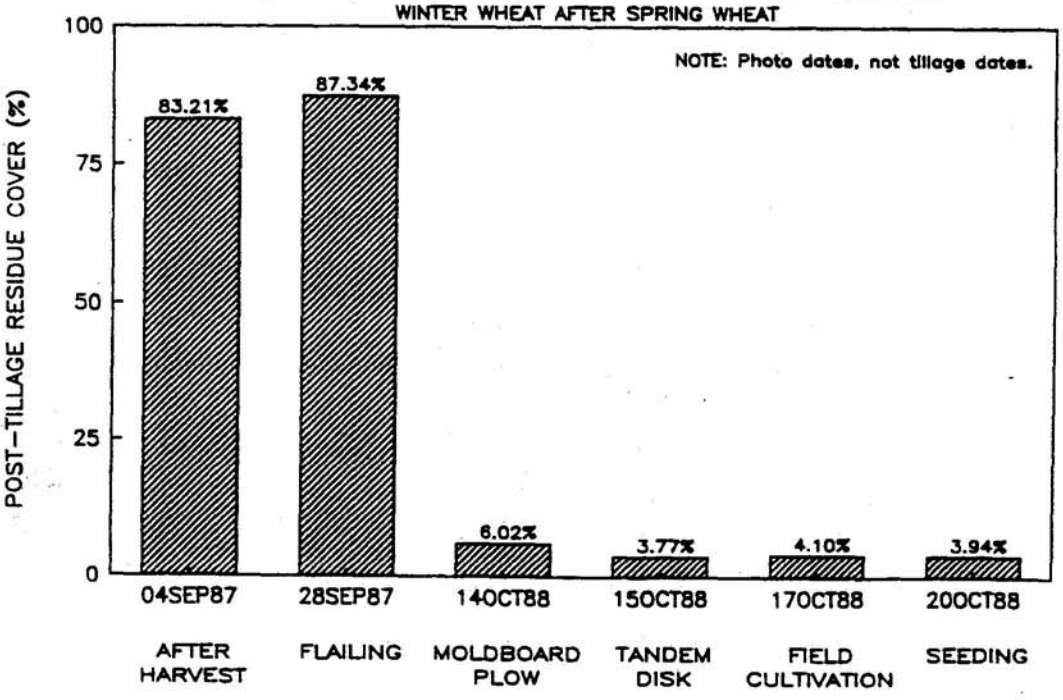

Fig 9: PLOT 9 CONVENTIONAL TILLAGE

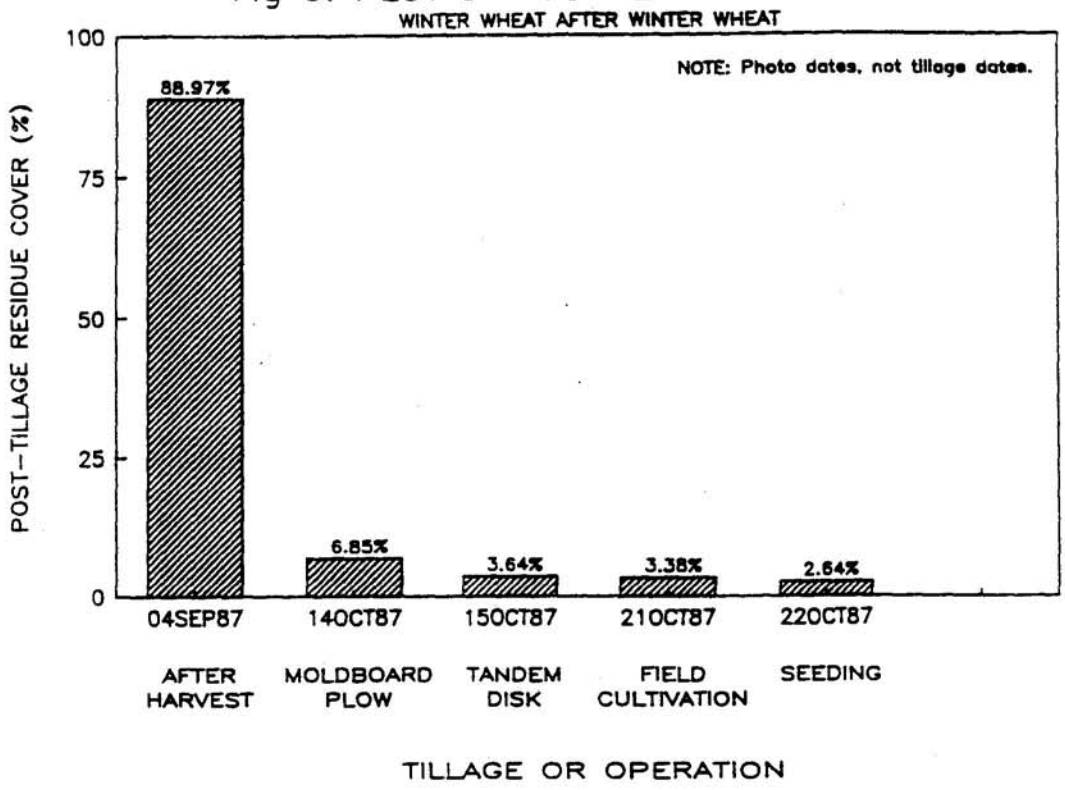

Fig 10: PLOT 10 CONVENTIONAL TILLAGE

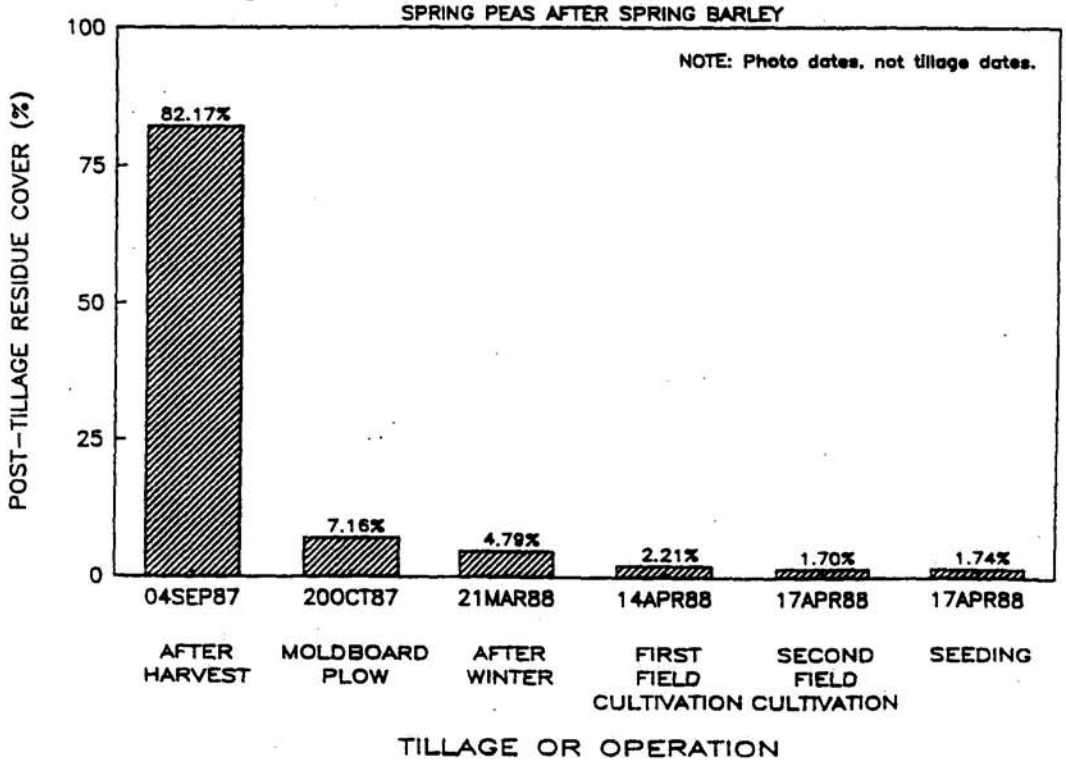

Fig 11: PLOT 11 CONVENTIONAL TILLAGE

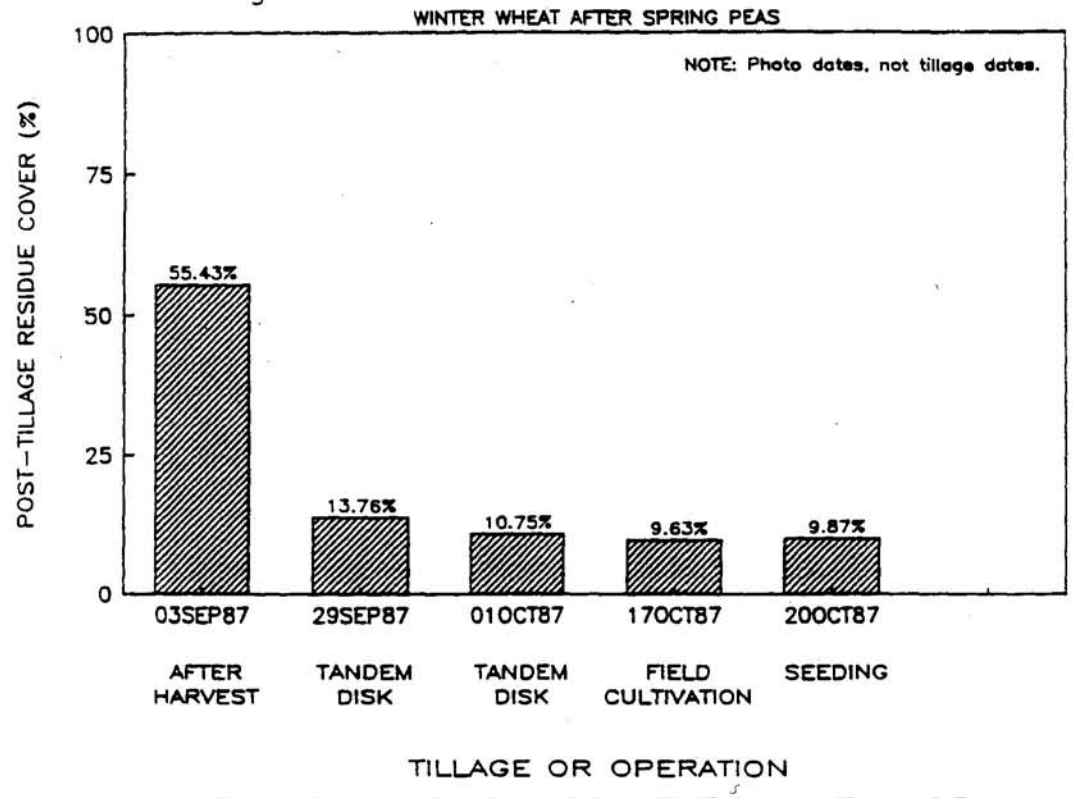

Fig 12: PLOT 12 CONVENTIONAL TILLAGE