Time Study of Parallel Terraces

Dwight D. Smith
Member ASAE

Parallel terraces, obtained by smoothing out the curves and eliminating point rows, reduce farming time over conventional terraces and may improve farmer acceptance of contour farming

A STUDY of terrace system improvement was started at the Midwest Claypan Experiment Farm, McCredie, Mo., in 1951. A portion of the study involved reconstruction of three conventionally terraced fields to systems of parallel terraces. It was believed that the successful adaptation of parallel terraces to the Midwest claypan soils would eliminate the two chief objections of farmers to terracing—crooked lines and point rows. Time records of the farming operations have been secured during the years 1954 and 1955, from these fields and also from a similarly farmed field of conventional terraces.

Description of Terraces and Fields

The soil of the fields is Mexico silt loam, typical of 10 million acres of Midwest claypan soils. Slopes are under 6 percent in steepness and 400 to 800 ft in length. The general fertility level without treatment is medium to low.

The type of terraces selected for application was a series of alternate ridge and channel types as required for parallel lines, similar to those suggested by Arnold (1)* in 1941. They were planned first on a contour map with 2-ft contour intervals (2). Cuts and fills were made to a final grade of either 0.40 or 0.50-ft drop per 100 ft of length. Variation in grade from level to one percent, as advanced at that time by Jacobson (3) for the more open soils of western Iowa, were not considered desirable for this claypan soil. The particular fields available for the study limited the terrace length to 900 ft or less. Spacing was increased about 25 percent over recommendations at that time and in most cases adjusted to multiples of four corn rows.

The third or fourth terrace on a slope was selected as the key terrace. Curves were smoothed by a bulldozer so that the new terrace could be followed readily by a corn picker and trailing wagon. Little cutting or filling was required on the key terrace. Lines above and below were staked by use of a device mounted on the front of a tractor. The tractor traveled the line of the key or subsequently staked terrace. This device is shown in Fig. 1. It consists of a steel tape fastened to the front center of the tractor and kept perpendicular to the line of travel by lining the tight tape with a pointer on a wood frame mounted on the front of the tractor.

Profile levels were run along the staked lines to determine the amount of cuts and fills and if necessary any needed adjustment of the key terrace line. Cuts on the parallel terraces varied in depths from 0 to 30 in. Excess soil was moved to the adjacent drainage way crossed by the terrace line. On one of the fields it was possible for all five terraces to be parallel with cuts limited to 20 in or less. On the other two fields the land slope flattened toward the outlet side of the field. This required that the lower terrace spacing be widened toward the outlet end to prevent the cut depth from exceeding 30 in. The cut material was used to broaden the fill at the point where the terrace spacing narrowed to provide for easy crossing of the terrace ridge and thus eliminate the need for point rows.

Point-Row Area Reduction

Construction of parallel terraces on these fields reduced materially the area in point rows. Figs. 2 and 3 show the original and also the reconstructed parallel terrace lines for two fields. Point-row areas were reduced from 30 to 7 percent of the total area of the three fields by paralleling of the terraces. Data by fields are shown in Table 1. The table also contains data from three parallel terrace fields (4) on the Midway Farm operated by the agricultural engineering department of the University of Missouri. Point-row areas with conventional terraces on these fields also averaged 30 percent of the total. Paralleling of the terraces reduced the point-row areas to an average of 12 percent. The Midway Farm terraces were longer than those at McCredie, which with a somewhat shallower maximum cut accounts for the smaller reduction in point-row areas. But for the six fields on the two soil areas over 70 percent of the point-row areas were eliminated by paralleling.

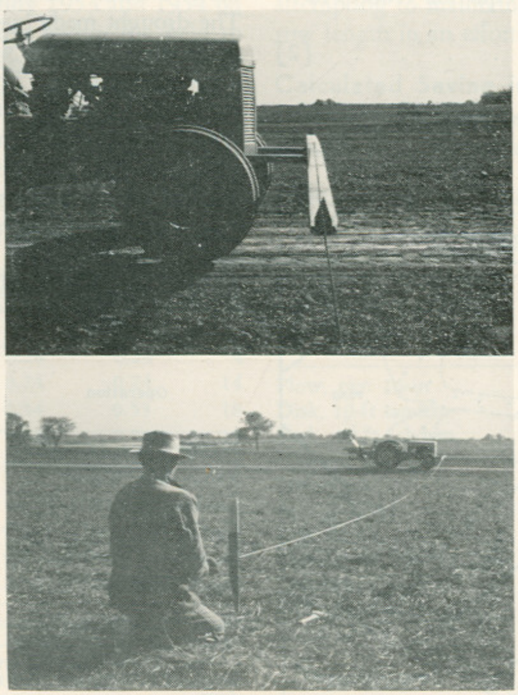

Fig. 1 An attachment consisting of a steel tape for measuring distance to stakes for parallel terrace lines. Tractor travels along the line of the previously staked terrace line

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The author—Dwight D. Smith—is agricultural engineer (SWC, ARS), U.S. Department of Agriculture, and research associate, agricultural engineering department, University of Missouri.

*Numbers in parentheses refer to the appended references.

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TABLE 1. REDUCTION OF POINT-ROW AREAS ON THREE FIELDS OF MEXICO SILT LOAM SOIL WITH LAND SLOPE OF 1 TO 5 PERCENT AND ON THREE FIELDS OF SEYMOUR SILT LOAM WITH LAND SLOPES OF 3 to 6 PERCENT.

Location and field	Number of terraces	Conventional terraces (Area) Total Acres	Point row Acres	%	Parallel terraces (Area) Total Acres	Point row Acres	%
McCredie							
2	2	5.37	2.19	41	4.65	.65	14
3	4	7.14	1.75	25	7.84	0	0
4	4	8.01	2.20	27	6.65	.62	9
	10	20.52	6.14	30	19.14	1.27	9
Midway(*)							
A	5	6.70	2.14	32	6.59	.71	11
E	2	5.10	1.44	28	5.10	.64	13
B	2	6.08	1.71	28	6.01	.75	12
	9	17.88	5.29	30	17.70	2.10	12

(*)From M.S. thesis of L. D. Meyer, agricultural engineering department, University of Missouri.

The Production Equation

An equation relating area, row length and width, time for and number of turns, and speed of travel can be written that will cover farming operations on both conventional and parallel terraces, as follows:

$$R=\frac{WNL}{8.25\ NL/S+43{,}560\ t\ (N-1)} \quad [1]$$

where R=production in acres per hour
W=row or cut width of implement in feet
L=average row length in feet
N=total number of rows or cut widths per terrace interval
S=speed in miles per hour
t=time per complete turn in hours.

If the number of turns is considered equal to the number of cut widths instead of one less the equation reduces to

$$R=\frac{SWL}{8.25\ L+43{,}560\ t\ S} \quad [2]$$

$$S=\frac{8.25\ RL}{WL-43{,}560\ t\ R} \quad [3]$$

$$L=\frac{43{,}560\ A}{} \quad [4]$$

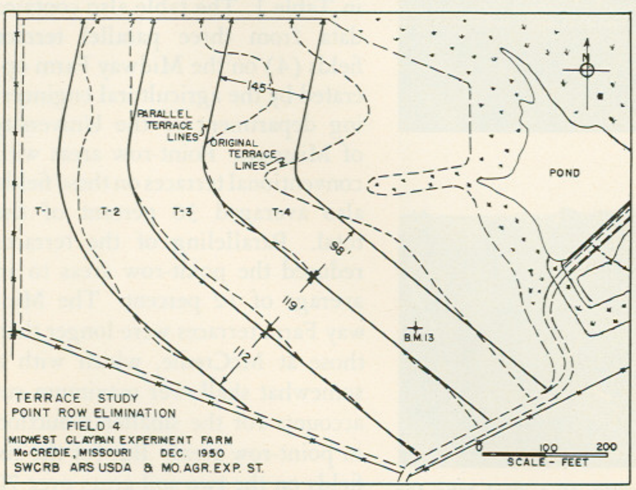

Fig. 2 A 10-acre field of parallel terraces on the Midwest Claypan Experiment Farm, McCredie, Mo., showing the original terrace lines in broken lines. Maximum cut depth on terrace T-4 was 30-in.

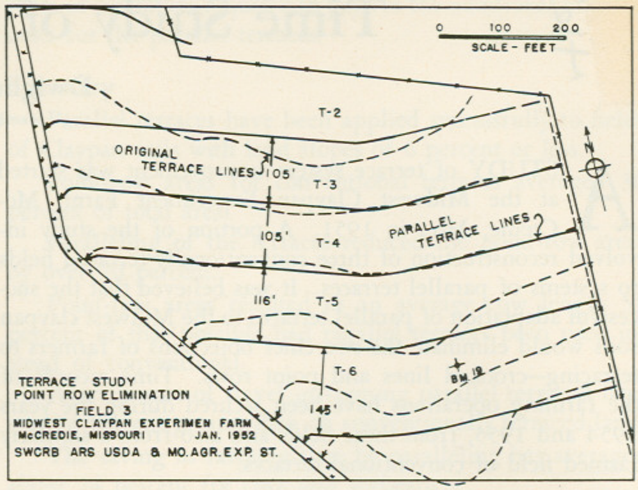

Fig. 3 A 12-acre field of parallel terraces on the same farm. The 20-in maximum cut was on terrace T-2

The area in acres *(A)* and the number of cut widths per terrace interval *(N)* can be secured from a scale map of the area. By knowing the total time required for a specific operation over a complete terrace interval and the average time of turning measured with a stop watch, solution of the equation for the average effective speed is possible. For areas on which production rates *(R)* are not known they can be calculated by assuming a value of S for use in equation [2].

Saving in Production Time

Production time data was secured during 1954 for corn both on a field of parallel terraces and a field of conventional terraces. The data indicated a reduction of 28 percent in operating time for planting, cultivating and shredding stalks. Data on plowing is not reported since plowing of the two fields was at different times and moisture contents. The drought made husking corn unnecessary. During 1955 when all operations were included, the saving in time averaged 17 percent. The data are shown in Tables 2 and 3. Adjusted values for the fields with parallel terraces are used in the comparisons. This was done by use of equations [2] and [3]. It was necessary since the widths of the parallel terrace fields was such that the average row length was less than the average row length would have been if

TABLE 2. PRODUCTION TIME AND PERCENT SAVING BY PARALLEL TERRACES IN PRODUCTION OF CORN DURING 1954

Operation	Production time per acre Conventional Measured* Hours	Parallel Measured† Hours	Parallel Adjusted‡ Hours	Saving in time Percent
Planting, two 42-in rows	0.56	0.51	0.48	14
Rotary hoe, 2-row	0.34	0.26	0.24	29
Cultivation (1st), 2-row	0.81	0.41	0.38	53
Cultivation (2nd), 2-row	0.42§	—	—	–
Cultivation (3rd), 2-row	0.51	0.48	0.45	12
Shred stalks, 2-row	0.53	0.45	0.42	21
Total hours	2.75§	2.11	1.97	28

*Average row length, 579 ft. If terraces had been parallel, row length would have been 1033 ft. Area consisted of second and third terrace on slope.

†Average row length, 641 ft. Point rows at bottom and top of field.

‡Data from field in second column adjusted to comparable row length (1033 ft) for field in first column.

§Second cultivation time omitted from total.

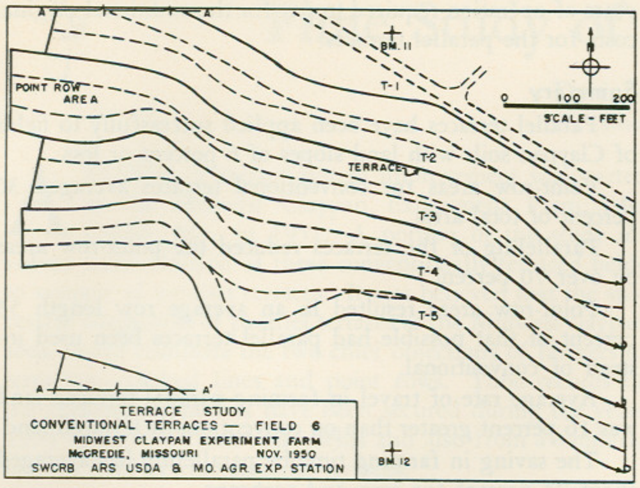

Fig. 4 Point rows between terraces amounted to 20 percent of the total area of this 10.5-acre field of conventional terraces

parallel terraces had been applied to the field with the conventional terraces. Fig. 4 shows the field with the conventional terraces. Row length and other data for the four lower terraces on the field are as follows:

- Average area per interval, 2.25 acres
- Average low length, 555 ft
- Average row length, if parallel, 1048 ft
- Average row length, percent of parallel, 53 percent
- Point-row area, percent of total, 20 percent
- Value of t, 0.008 hr for all fields and operations, except husking, which averaged 0.0061 hr.

The average row length of 555 ft is 25 ft longer than obtained by equation [4]. This difference represents the overlap resulting from planting of the point rows. The tendency to overlap in planting point rows is indicated by stand and harvesting data secured during 1953 and 1954 on the conventional terrace field. Turning within the field to cultivate point rows generally has been considered to result in a reduction of stand and yield at these areas. The data secured did not indicate that there was a significant difference

TABLE 3. PRODUCTION TIME AND PERCENT SAVING BY PARALLEL TERRACES IN PRODUCTION OF CORN, 1955

Operation	Production time per acre: Conventional Measured*	Parallel Measured†	Parallel Adjusted‡	Saving in time
	Hours	Hours	Hours	Percent
Plowing, two 16-in	1.15	0.92	0.88	23
Disking, 10-ft tandem	0.25	0.24	0.24	4
Disking, 10-ft tandem	0.28	0.24	0.24	14
Planting, two 40-in rows	0.65	0.54	0.53	18
Cultivation (1st) 2-row	0.59	0.51	0.50	17
Cultivation (2nd) 2-row	0.37	0.35	0.34	8
Cultivation (3rd) 2-row	0.41§	—	—	—
Husking, 1 row‖	1.64	1.32	1.28	22
Shred stalks, 2-row	0.40	0.38	0.37	8
Total	5.33§	4.50	4.38	18

*Average row length, 555 ft. If terraces had been parallel row length would have been 1048. Area consisted of second, third, fourth and fifth terraces on slope.

†Average row length, 839 ft. Area consisted of second, third and fourth terraces on slope.

‡Data from field in second column adjusted to comparable row length (1048 ft) for field in first column.

§Third cultivation time omitted from total.

‖Down corn required husking one direction.

TABLE 4. FINAL STAND OF CORN AND CROP YIELD ON STANDARD TERRACE AREAS WHERE POINT-ROW TURNING OCCURRED AND ON ADJACENT AREAS OF SAME TERRACES WHERE THERE WAS NO TURNING

Year	Pairs of samples	Stalks per acre: Point-row turning	Stalks per acre: No turning	Yield per acre: Point-row turning	Yield per acre: No turning
1953	2	10,200	8,600	54.5 bu	47.4 bu
1954	6	10,200	10,800	1.06 tons*	1.03 tons*

*Tons dry matter in fodder. Differences are not significant.

in either stand or yield where point-row turning occurred over adjacent areas where there was no turning. Apparently the overlap in planting resulted in a sufficiently greater original stand such that stalks killed by turning did not reduce the stand at harvest or the yield to below that of the adjacent areas. These data are shown in Table 4.

Speed Reduced on Short Rows

The speed or rate of travel was not predetermined for the different operations. The operator's only instructions were to keep a record of starting and stopping time and to exclude any abnormal stoppage such as that caused by mechanical failure of the implement or tractor. In 1954 the same operator covered both conventional and parallel terrace areas. This was not possible during 1955. Also in 1955 the tractor was equipped with a speedometer. The effective speed for each operation during both years was calculated by equation [3]. All values are tabulated in Table 5.

The tendency to reduce tractor speed on short rows has been observed for several years. Turning is most always at low speeds. If the distance of travel is short, the operator frequently does not open the throttle as when he has a long row to plow or cultivate. This was evident during 1954 when the same operator worked on both areas, but with a tractor not equipped with a speedometer. The more narrow ratio for 1955 data may have resulted from the operator attempting to maintain the rated tractor speed regardless of row length in an effort to speed operations.

Calculated Saving in Time—Soybeans

Production time records were secured from a field of parallel terraces planted to soybeans during 1955. These

TABLE 5. AVERAGE SPEED OF OPERATION CALCULATED FROM MEASURED PRODUCTION RATES AND OPERATING SPEED EQUATION [3]

Operation	Calculated speed per hour: Corn, 1954 Conventional	Corn, 1954 Parallel	Corn, 1955 Conventional	Corn, 1955 Parallel	Soy beans, 1955 Parallel
	Miles	Miles	Miles	Miles	Miles
Plow, two 16-in	—	—	3.39	4.06	2.54
Disk, 10-ft tandem	—	—	3.45	3.45	3.01
Disk, 10-ft tandem	—	—	2.98	3.45	3.82
Harrow, 2-section	—	—	—	—	5.00
Plant†	2.50	2.70	2.23	2.57	2.53
Rotary Hoe†	4.80	6.30	—	—	—
Cultivation (1st)†	1.65	3.53	2.49	2.75	4.15
Cultivation (2nd)†	3.57	—	4.03	4.25	—
Cultivation (3rd)†	2.83	2.91	4.75	—	—
Husking, 1-row	—	—	3.66	4.39	—
Shred stalks†	2.71	3.16	4.11	3.87	—
Average	2.90	3.72	3.29	3.60	—
Ratio of $\frac{S\ \text{(conventional)}}{S\ \text{(parallel)}}$		0.75*		0.91	

*Both years together ratio is 0.86. †Two-row equipment.

TABLE 6. PRODUCTION TIME AND PERCENT SAVING BY PARALLEL TERRACES IN PRODUCTION OF SOYBEANS 1955

Operation	Production time per acre Conventional Calculated*	Parallel Measured†	Saving in time
	Hours	Hours	Percent
Plowing, two 16-in	1.79	1.23	31
Disking, 10-ft tandem	0.42	0.32	24
Disking, 10-ft tandem	0.35	0.27	23
Harrow, 2-section (10-ft)	0.29	0.22	24
Planting, two 40-in rows	0.72	0.57	21
Cultivate, 2-row	0.49	0.37	24
Total	4.06	2.98	27

*Calculated by use of equation [2] assuming speeds 0.86 of those listed in the last column of Table 5 and a row length 0.53 of that from the field with parallel terraces.

†Average for five terraces with a total area of 9.7 acres and an average row length of 690 ft.

data are shown in Table 6.

The rate for conventional terraces was calculated using equation [2] and assuming speeds for conventional terrace operation as 0.86 of those for the parallel terrace field. Theoretically this ratio should increase to unity as the operating speed decreases to the average speed during turning. The plotting of the ratios for the individual operations against speed suggests this trend. There was not, however, sufficient data for establishing a true trend line so a simple average was used. The length of row was also assumed as 53 percent of the length with parallel terraces, the same as determined for the conventional terrace field in corn.

These data while somewhat of a preliminary nature support the theory that operating time can be reduced materially by paralleling of terraces. With data on cost of layout and construction an estimate could be made of the number of years of operation required to pay for the additional original costs for the parallel terraces.

Summary

Parallel terraces have been applied successfully to fields of Claypan soils with land slopes of 6 percent or less.

Point-row areas for conventional terraces averaged 30 percent of total area.

Paralleling of the terraces reduced the point-row areas by over 70 percent.

Point-row areas resulted in an average row length 53 percent of that possible had parallel terraces been used instead of conventional.

Average rate of travel in farming parallel terraced land was 16 percent greater than on conventionally terraced land.

The saving in farming time by paralleling has averaged about 24 percent for corn and soybeans.

Equations, expressing the relationship of area, row length and width, time for and number of turns, and speed of travel applicable to both conventional and parallel systems are presented.

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