Experiences with Vertical Mulching[1]

HELMUT KOHNKE
Agronomy Department
Purdue University, Lafayette, Indiana 47907

Abstract

The placing of plant residues or other loose material in vertical slits in the soil is called vertical mulching. The purpose is to allow surface waters to enter the soil quickly, so that runoff and erosion are reduced and the plants better supplied with water. Experiments in Tippecanoe County, Indiana, conducted over 14 years, did not result in pronounced runoff reduction nor in corn yield increases. While the principle of vertical mulching is sound, several factors counteract the advantages. Consequently the method can not be recommended for situations of land use, soil, and climate similar to the ones of these experiments.

Definition and Purpose

The placing of plant residues or other loose material in vertical slits into the soil has been called vertical mulching. The purpose of this operation is to allow surface water to enter the soil quickly. If this is achieved, runoff rates and amounts are reduced as is erosion, water is well distributed through a greater depth and is not lost as much by evaporation as where this practice is not used. To what extent benefits can be derived from vertical mulching will be discussed in this paper.

Development of the Idea

For a number of years in the 1950's experiments were conducted at Purdue University with subsoil fertilization. This is the application of fertilizer in vertical slits in the subsoil. The purpose of placing fertilizer in the subsoil is twofold: to induce deeper penetration of crop roots so that there is more water at the disposal of the plants, and secondly that these roots help to keep the slits open that have been cut through the subsoil. The success of subsoil fertilization has been erratic as far as yield increases are concerned. Numerous tests have shown that most of the slits closed up completely after one or two seasons. There was no pronounced effect on rate and amount of surface runoff.

It was therefore suggested by Spain (4) to keep the subsoil slits open with plant residues. Beginning in 1955 tests were conducted with this technique at Purdue University (2, 3, 5) and elsewhere (1, 8). Specialized equipment was prepared for the purpose. After some preliminary work, research was started in 1956 on the Purdue Throckmorton Farm to determine what effect vertical mulching has on runoff, soil conditions, and crop yields. These experiments are discussed in this paper. Laboratory studies on the effect of vertical

[1] Journal Paper No. 4244, Purdue University Agricultural Experiment Station.

mulching on water movement into the soil were conducted by Swartzendruber (6, 7).

Experimental

Since there had been no previous experience with vertical mulching, it was found necessary to modify the experimental design and methods from time to time. While this makes a strictly statistical evaluation impossible, it has resulted in the greatest amount of information.

The experiment was conducted on 15 small watersheds of the Purdue University Throckmorton Farm with the purpose of studying not only the effect of vertical mulching on soil and crop but also on runoff.

The watersheds vary in size from 2 to 3 acres and in average slope from 2 to 5%. The soils are silt loams of prairie-timber intergrade, derived from a thin loess layer over calcareous glacial till. In general they are well drained and had been well fertilized for at least 15 years before the experiments began.

From 1956 to 1965 the land use was corn-corn-oats seeded to grass and clover. The subsoil treatments were: Subsoil fertilization, vertical mulching and no subsoil treatment.

The subsoiling was done every 3 years to a depth of 20 inches with an application of approximately 50+50+50 (N, P_2O_5, K_2O) per acre in the subsoil. The spacing was about 4.5 feet apart.

Vertical mulching was done on the contour, 16 to 20 inches deep and with a spacing of 80 inches. This was changed to 160 inches in 1957 and to 340 inches in 1967.

No fertilizer was applied in the vertical mulch grooves to avoid rapid bacterial decomposition which might shorten the period of effectiveness of the residues. During the first years the grooves were left open only until spring when the entire area was tilled. Since 1962 both vertical mulching and tillage was in straight rows and the grooves were left open. Oats were replaced by corn in 1966 resulting in identical land use on all watersheds every year. This was done both to eliminate a variable in the experiment and to provide for more crop residue to fill the vertical mulch grooves.

Originally vertical mulching was done by the combination of a forage chopper and a subsoiler that had been modified to keep the slot open until the crop residues were blown in immediately behind the subsoil chisel. A commercial company developed a vertical mulcher which has been used since 1963. This machine picks up corn stover or other crop residue, macerates this material and blows it into a trench opened up by a chisel.

A gasoline engine is mounted on the vertical mulcher to provide the power for the chopper and blower. Since the machine is very heavy and opens up a deep and wide trench it requires a tractor of more than normal power, a condition which restricts the usefulness of this technique. The loosened soil forms a ridge on both sides of the trench and hinders the entry of surface water into the groove. Therefore in 1966 wings were attached to the subsoiler to spread out this soil.

Experiences

Vertical mulching—as any subsoiling—has to be done when the subsoil is only slightly moist to avoid puddling. Consequently under Indiana conditions, it is done in late summer or fall.

Green plant material shrinks and decomposes too fast in the soil to be of much value for vertical mulching. Mature, dry plant material is preferable because it maintains porosity longer. Corn stover proved to be the most useful choice. Corn dries up toward the end of October. At best, this leaves only a short time when vertical mulching can be done successfully, since subsoils are usually wet by December.

While it was recognized that the best results with vertical mulching can be obtained where the channels stay open to the surface, in the first years (until 1961) these channels were closed by cultivation just prior to planting corn. The channels were placed on the contour while the planting was done in straight rows. This system was changed in 1962 by putting both the vertical mulching and the corn in straight and parallel rows. This made it necessary to allow for some extra space between the channels and the first row of corn, to avoid filling up the groove with soil during tillage and cultivation.

Originally (1956-1964) a rotation of corn, corn, oats with an intercrop was used, but it became obvious that the oat stubble together with the grass and legume intercrop did not provide sufficient bulk to fill the vertical mulch channels. For one year (1965) a sorghum-sudan-grass hybrid ("Sudex") was tried, again with unsatisfactory results. Consequently, we changed to continuous corn. A shorter season hybrid was used for the third year, the one preceding vertical mulching in the fall to allow more time for this operation. At 16 foot spacing and 2 pounds of stover per running foot, 5,400 pounds of stover are needed per acre. The amount actually available seldom exceeded 3,200 pounds/acre. Besides, the machine cannot pick up all of the stover from the ground. It was resorted to importing stover from other fields, a rather cumbersome undertaking. To avoid this extra labor, beginning in 1967, the vertical mulch channels were separated by eight instead of four corn rows. This supplied sufficient material to fill the channels but required windrowing the stover with a side delivery rake. Of course it has the disadvantage of having fewer channels per acre.

In order not to disturb the vertical mulch channels by cultivation of the corn a space of 32 inch width was allowed for it. This reduces the area that can be used effectively for growing of corn. Depending on the number of corn rows between channels and on the width of the corn rows this reduction may be between 16 and 9% of the total area. Quite obviously this is not a net loss in productive capacity since moisture, nutrients and light are available to the corn bordering the channels in greater amounts than in the ordinary stand.

One of the problems encountered with vertical mulching is the control of weeds over the channels. Mechanical control is difficult because the soil stirred up by a cultivator cannot be permitted to fall into the grooves. Besides in ordinary practice there is no cultivator shovel that would reach the channel since it is three feet away from the nearest corn row. For the same reason use of herbicide requires special equipment. Experience has shown that in most years, in spite of an attempt of herbicide treatment, weed control was inadequate.

Results

Runoff

During much of the time of this experiment the runoff recording equipment was inadequate. From the beginning until 1966 dextrin coated wooden rods inside of perforated steel tubes were used as peak stage recorders. These rods were placed in the center of the flume at the outlet of the watershed. In theory the yellow colored dextrin was dissolved and removed by the water, leaving the rod yellow above the high-water mark. Actually this line was seldom very clear. This method also does not give information about the amount of runoff. Finally in 1967 sufficient funds became available to procure mechanical water stage recorders for most of the watersheds. Records from these instruments and the peak stage recorders as well as observations in the field during rain storms have shown that generally runoff rates and amounts from the vertically mulched areas were lower than from the untreated areas. The differences however were not large and in a few cases the results were reversed. It must be understood that the techniques of vertical mulching has changed during the life of the experiment and that a satisfactory method was achieved only in the last years. The trend has been toward more effective control of runoff toward the end of the period.

Soil Moisture

Consistently in spring and early summer more moisture was found in the soil immediately adjoining the channels than in untreated soil. During the summer and fall no such differences were found to exist, probably because of the greater use of water by the roots of corn and weeds near and in the channels.

Structure

Soil on the side of the channel was found consistently to have a higher aggregation index than soil 20 inches away from the groove. A study in 1965 showed that the aeration capacity in the groove at 10 inches depth averaged 20.2% while untreated soil had only 8.4%.

A thorough investigation in 1969 revealed that the effective half life of the vertical mulch groove is about 3 years (Fig. 1). As the organic residues in the groove are decomposed the soil closes up and after 5 or 6 years no difference in aeration porosity could be detected.

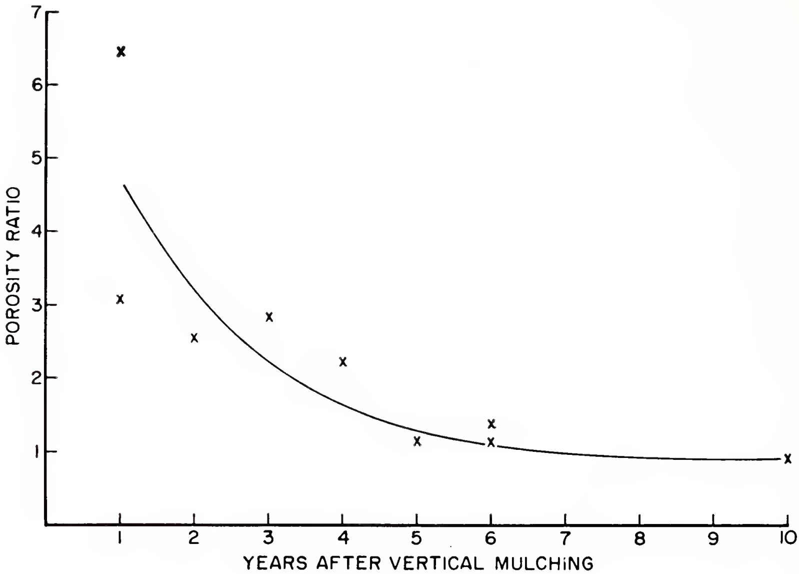

FIGURE 1. *Change of aeration porosity with time in vertical mulch channels (25-30 cm). Porosity ratio = aeration porosity in vertical mulch channels/aeration porosity in untreated soil.*

Organic Matter

Table 1 shows the amounts of organic matter in the grooves at various depths and various times after application. It is obvious that there is a considerable increase of organic matter compared to the untreated areas. A year after application the organic matter content was found to be between two and five times as high as in untreated soil. Even after 10 years there was 1.5 times as much organic matter in the grooves (Fig. 2).

Plant Nutrients

No determinations of nitrogen were made but it can be assumed that it performed somewhat parallel to organic matter. The increase of phosphate compared to untreated soil was phenomenal. Also, potassium was much higher in the grooves than in the untreated soil. But pH, calcium content and magnesium content were hardly affected by vertical mulching (Table 2). The data in Table 2 represent results from nine different vertical mulch areas that were sampled in 1969. Since the data were rather consistent in spite of the age of the treatments and the depths of sampling (25-30 cm and 35-40 cm) only averages are presented.

TABLE 1. *Increase of organic matter content of subsoil due to vertical mulching.*

Years after vertical mulching	25-30 cm depth Organic Matter %			35-40 cm depth Organic Matter %		
	Channel	Untreated	Ratio	Channel	Untreated	Ratio
1	2.35	1.01	2.33	1.07	0.69	1.55
1	7.60	1.68	4.52	3.80	1.05	3.62
2	2.15	0.93	2.32	6.50	0.77	8.44
3	4.93	1.26	3.91	3.57	0.89	4.01
3	3.38	1.59	2.15	5.55	1.03	5.39
4	2.54	0.92	2.76	4.20	0.78	5.38
5	1.75	1.01	1.73	2.60	0.58	4.48
6	3.45	1.56	2.21	2.03	0.98	2.07
6	1.82	1.47	1.24	1.18	1.07	1.10
10	2.03	1.39	1.46	1.83	0.94	1.95
Average	3.20	1.28	2.5	3.24	0.88	3.7

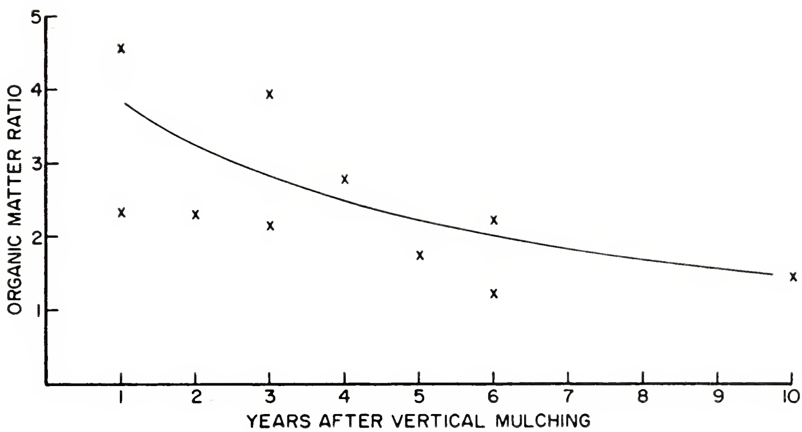

FIGURE 2. *Organic matter content ratio in the subsoil (25-30 cm). Organic matter ratio = organic matter % in vertical mulch channels/organic matter % in untreated soil.*

TABLE 2. *Soil fertility components in vertical mulch groove and in untreated soil.*

	Vertical Mulch Groove	Untreated
Available P	26.4 ppm	1.6 ppm
Available K	192 "	111 "
Exchangeable Ca	1530 "	1660 "
Exchangeable Mg	330 "	370 "
Organic Matter	2.95 %	1.04 %
pH	6.1	5.8

Crop Growth

For a number of years it was found that the stand of corn plants in the rows adjacent to the vertical mulch channels was slightly smaller than in the rest of the field due probably to soil clods that interfered with planting. This was partially compensated by larger ears. This situation was overcome in 1966 with the installation of wings on the subsoiler which smoothed out the soil thrown out on both sides of the groove.

Yields varied greatly from year to year. Yields per unit length of row in the vertical mulched watersheds and in the check watersheds did not vary significantly over the years, with a slight advantage in favor of the vertical mulched areas. However, due to the fact that from 9 to 16% of the area was used for the vertical mulch channels, the net yield per acre was slightly lower for the vertical mulched watersheds.

Corn roots appeared to concentrate in the vertical mulch channels; however, no quantitative measurements were made.

Conclusions and Suggestions

While the principle of vertical mulching, *i.e.*, permitting the surface water to enter the soil through large openings maintained by organic residues, appears very promising, in actual practice no great benefits have been evident under the conditions of these experiments.

Runoff was neither reduced materially nor were the yields increased. Part of this can be explained by faulty techniques used because of inexperience and lack of the proper implements. The value of vertical mulching is to open up tight soil. Actually the soil of the Throckmorton Farm, where the experimental watersheds are located, is fairly pervious and sufficiently aggregated to permit a satisfactory rate of infiltration. An inherent fault of vertical mulching is that most of the crop residue is removed from the surface and cannot serve to mulch and protect the soil surface. The effect of mulch on reducing runoff and erosion is well known. The advantage of greater intake of water in the grooves is at least partially nullified by the heavy growth of weeds that covered these channels in practically every year of the experiment.

The crop that followed vertical mulching was corn and in the latter part of this work continuous corn was used. It is problematic whether a meadow crop may have gained more from vertical mulching.

The lack of effect on corn yields may be explained by the combination of three factors that are favorable for water supply to the corn roots in the area used for this experiment: a generally ample rainfall in the summer months; a fairly large water holding capacity of the soils; and the rather favorable drainage and aeration conditions that allow the roots to penetrate deeply with the result that large volumes of soil water is at their disposal. In California, vertical mulching used with irrigation on tight soils has given increased yields of alfalfa and orchard crops.

The over-all conclusion is that the possible benefits of vertical mulching of corn land in Indiana are outweighed by the cost, the time and the concomitant disadvantages of this technique.

Nevertheless, it must not be overlooked that it is possible that a modification of vertical mulching, using the proper implements, may well show it to be a very profitable operation.

Any research that is based on field observations and is dependent on the vagaries of the weather is slow in giving clear-cut results. This is especially true where the technique to be tested is not clearly defined from the beginning. Nevertheless it seems to be safe to state that vertical mulching of corn fields on soils with fair infiltration and percolation capacities is of little value. This refers to the vertical mulch systems used in this experiment. If vertical mulching would be used under other conditions its value may be considerable. Such changes of conditions refer to the nature of the soil, the steepness of the slope, the intensity of rainfall, the need for irrigation, the type of crop, and the depth and spacing of the channels.

In view of the great amount of erosion that continues to threaten our fields it seems highly advisable to proceed with research on vertical mulching. Depth, width and spacing of the channels should be modified and soils should be chosen that have an infiltration problem.

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