

Ecofallow – A Reduced Tillage System – and Plant Diseases

How will crop residues associated with reduced tillage affect the onset and development of plant diseases? This important factor should be taken into account if one is considering adoption of a reduced tillage cropping system. Some plant pathogenic fungi and bacteria overwinter in and on residue from diseased plants of the previous year, and the residue can serve as the primary source of large amounts of inoculum for disease development early in the growing season (1,2,3). Obviously, reduced tillage is not the only factor involved in these plant disease consequences (1). One major reason for the recent upsurge in some crop diseases, however, has been the tremendous increase in acreage of crops grown under reduced tillage systems that leave large quantities of plant residue relatively undisturbed in the field until shortly before planting the same field back to the same crop. A unique 3-yr reduced tillage rotation system known as ecofallow has reduced the incidence and severity of many of the disease problems often associated with other reduced tillage systems.

What Is Ecofallow?

Ecofallow is a system of controlling weeds and conserving soil moisture in a crop rotation with minimum disturbance of crop residue and soil (6). The system evolved out of a study initiated by Wicks and Smika (5,6) to determine the feasibility of reduced tillage in a winter wheat-grain sorghum-fallow rotation for the semiarid Central Great Plains of the United States. The study was initiated in 1962 at the University of Nebraska North Platte Station, and although the detailed aspects of the ecofallow concept have changed and evolved to a workable system, the original reduced or conventionally tilled plots have been maintained as such up to this time. The experimental design was a complete randomized block with five replications. Three complete blocks of treatments were set up to provide one block for each phase of the rota-

tion each year, allowing data to be taken each year on all phases of the rotation (4). To date, 16 yr of data have been accumulated on each phase of the winter wheat-grain sorghum-fallow rotation, and, in

addition, 9 yr of data have been obtained on the feasibility of replacing grain sorghum with corn in the rotation. The 3-yr ecofallow cropping system with planting and harvesting dates is shown in Table 1,



Fig. 1. Ecofallow grain sorghum. The grain sorghum is planted directly into wheat residue without any seedbed preparation. Note the heavy amount of wheat residue between the rows of grain sorghum. Many of the benefits of ecofallow are associated with this residue.

and the conventional and ecofallow treatments are described in Table 2.

Yield and Conservation Benefits

Most of the benefits gained under the ecofallow system are associated with the fallow period between wheat harvest and grain sorghum (or corn) planting. These benefits are primarily related to the heavy amount of wheat residue that has been maintained weed-free by herbicides and left undisturbed on the soil surface (Fig. 1). Wheat yield increases of 8–10% and grain sorghum yield increases of 40–50% have commonly been obtained with the ecofallow system over the conventional system (Table 2). Similar yield increases have been obtained with corn.

The conservation benefits of ecofallow relate primarily to the management of the wheat residue from wheat harvest to grain sorghum planting. The wheat residue increases water infiltration and reduces soil temperature and evaporation, wind and water erosion, and runoff and water sedimentation. In addition, the standing stubble traps snow and reduces wind velocities at the soil surface; this alone can add 1–3 in. of soil moisture. The net gain in terms of soil moisture storage efficiency (5) has averaged 2 in. (Table 3). This may not seem much of an increase in soil water storage, but it has been estimated that it takes 9 in. of soil water to produce the first bushel of grain sorghum and that each additional inch of water adds 10 bushels per acre. The 2 in. of additional soil water stored under ecofallow thus adds, on the average, about 20 bushels of grain sorghum.

Disease Consequences

Because plant diseases have often increased in other reduced tillage systems (1,3), the long-term effect of ecofallow on the plant diseases is important. During the first 9 yr of developing the ecofallow concept, Wicks and Smika made two observations regarding diseases (*personal communications*): 1) They never observed any foliar disease problems on either grain sorghum or wheat, and 2) they consistently observed more grain sorghum plants lodged in the conventionally tilled plots than in the ecofallow plots at harvest time. To substantiate their observations, we initiated a study in 1972 to determine the long-term effect of ecofallow on plant diseases. We have now collected 7 yr of data; during this time, foliar diseases were never observed to be a problem on grain sorghum or wheat, whether grown under ecofallow or conventional tillage. On the other hand, the incidence of stalk rot of grain sorghum, a stress disease caused by *Fusarium moniliforme*, was dramatically reduced under ecofallow compared with that under conventional tillage. The 3-yr averages of stalk rot incidence and grain sorghum yield are shown in Table 3. Incidence was reduced from 39 to 11%, and yield was

increased from 43 to 61 bushels per acre. Although the feasibility of corn replacing grain sorghum in the rotation system has not been studied for nearly as long,

similar disease consequences have been found.

Because stalk rot diseases of row crops are considered to be stress diseases, the

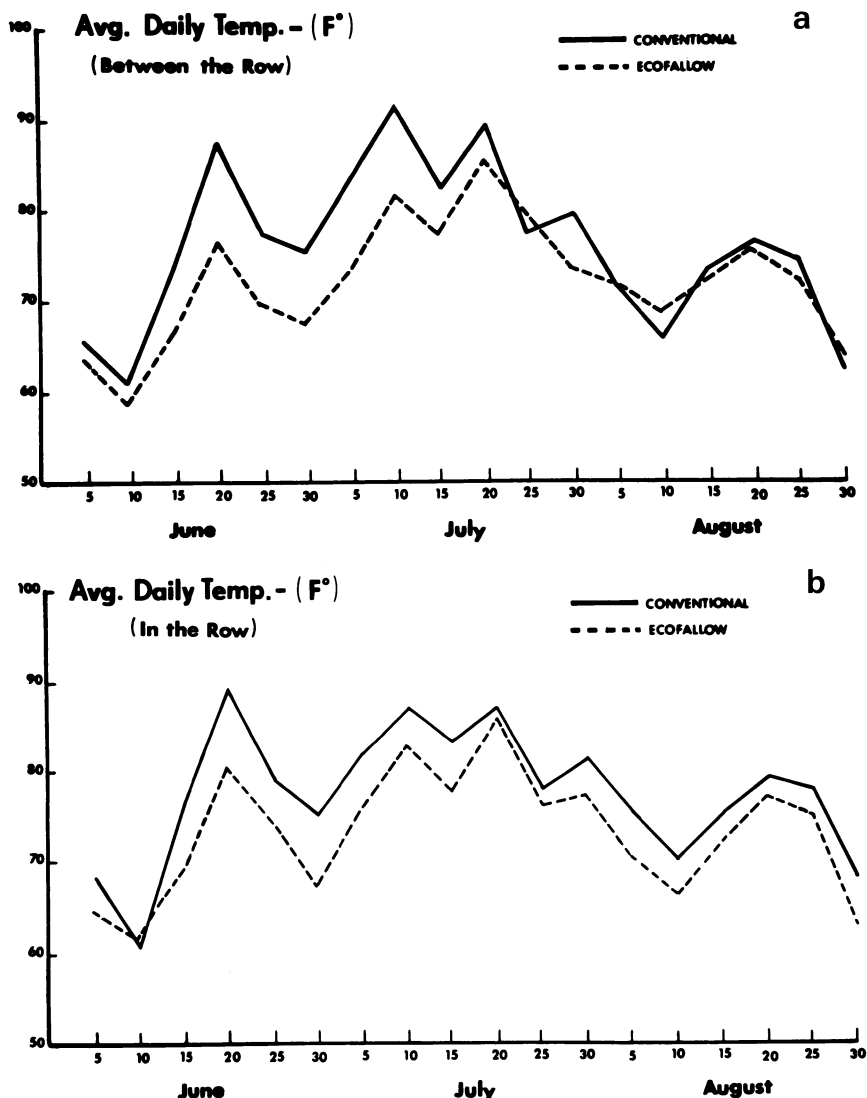


Fig. 2. Effect of conventionally tilled and ecofallowed grain sorghum on the average daily soil temperatures at the 1–2 in. depth (A) between the rows and (B) in the row.

Table 1. The ecofallow cropping system is a reduced tillage system involving a winter wheat-grain sorghum or corn-fallow rotation scheme developed for the low rainfall areas of western Nebraska and Kansas and eastern Colorado

First year

Plant winter wheat in weed-free grain sorghum or corn stubble in September.

Third year

Plant grain sorghum or corn in weed-free wheat stubble in May and harvest in September or October. Apply herbicides as needed to control weeds during this fallow period.*

Second year

Harvest wheat in July. Apply herbicides to control weeds during this fallow period.*

Fourth year

Rotation cycle starts over again when wheat is planted in weed-free grain sorghum or corn stubble in September.

*There are two fallow periods in this 3-yr rotation system. One occurs between wheat harvest and grain sorghum or corn planting time (a time span of about 10 mo) and requires maintenance of weed-free wheat stubble. The other occurs between grain sorghum or corn harvest and wheat planting time (a time span of about 12 mo) and requires maintenance of weed-free grain sorghum or corn stubble.

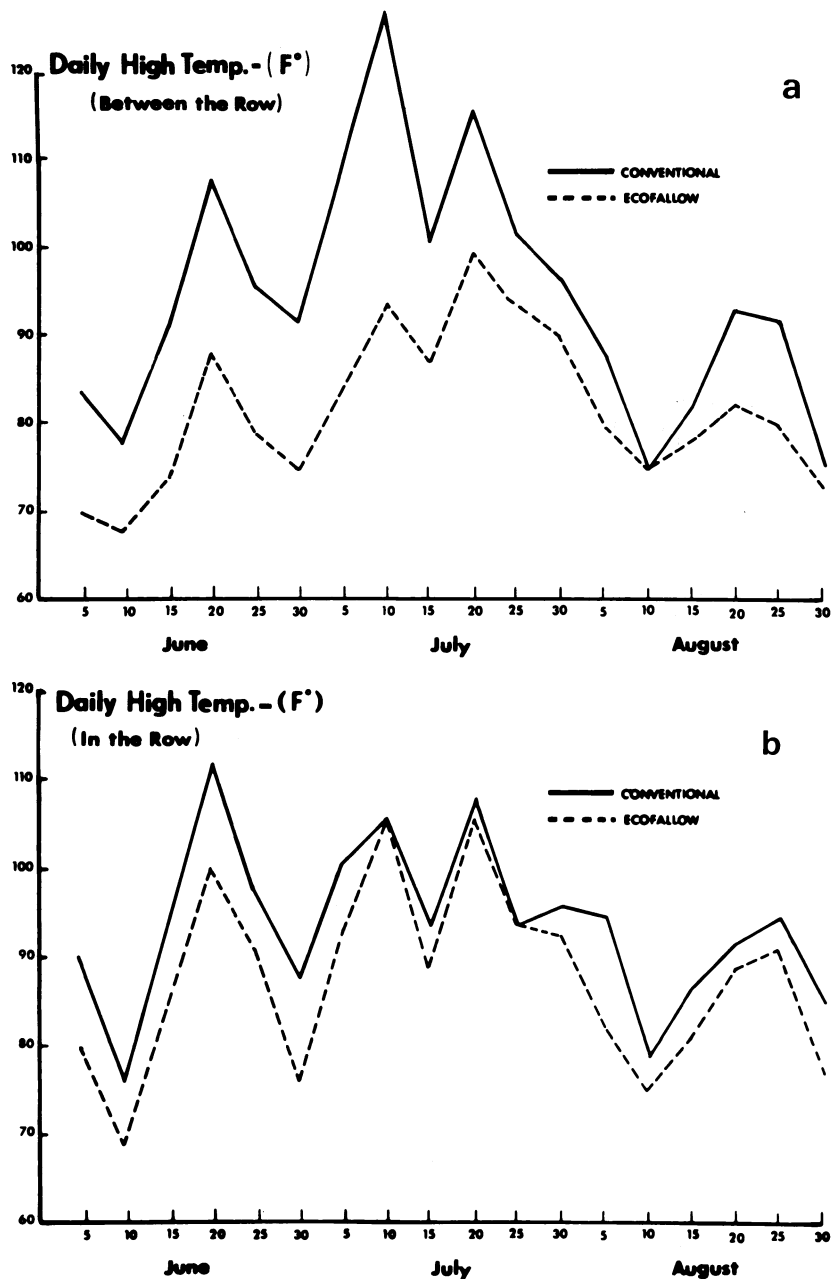


Fig. 3. Effect of conventionally tilled and ecofallowed grain sorghum on the daily high soil temperatures at the 1-2 in. depth (A) between the rows and (B) in the row.

Table 2. Conventional and ecofallow winter wheat-grain sorghum-fallow rotation treatments^a

Conventional

Use sweep tillage operations as needed to control weeds throughout the rotation period and conventional tillage to prepare seedbed. Sorghum is cultivated as needed and sprayed with 2,4-D ester. The 10-yr average yields are 49 bu/acre of grain sorghum and 39 bu/acre of wheat.

Ecofallow^b

Use paraquat herbicide after wheat harvest and atrazine in the fall. No seedbed preparation is done before planting grain sorghum in the spring; preemergence application of atrazine and propachlor is done. Use contact herbicide and/or sweep tillage to control weeds as needed during fallow period following grain sorghum crop. The 10-yr average yields are 72 bu/acre of grain sorghum and 43 bu/acre of wheat.

^aCorn can replace grain sorghum in the rotation, and similar yield increases have been obtained under ecofallow. Herbicide recommendations for the ecofallow treatments are continually being evaluated and revised. Current recommendations can be found in *A 1979 Guide for Herbicide Use in Nebraska; University of Nebraska Institute of Agriculture and Natural Resources, Cooperative Extension Service—E. C. 79-130.*

^bThe most important fallow period associated with ecofallow is the one between wheat harvest and grain sorghum planting.

increased soil moisture storage efficiency with ecofallow is undoubtedly an important factor in the lower incidence of stalk rot. The effect of the wheat residue on the soil temperature, however, may be just as important a factor in reducing both stress on the plants and the subsequent incidence of stalk rot. To investigate the effect of the wheat residue on soil temperatures, dual-recording thermographs were set to monitor the soil temperatures throughout the grain sorghum growing season. The planter and planting procedure used in the ecofallow sorghum plots explains some of the differences found in temperatures in the row and between the rows within the ecofallow treatments. A flexible Buffalo-Till planter equipped with 8-in. sweeps set so the wheat residue was removed from over the top of the row was operated at a ground speed that resulted in very little residue being covered with soil between the rows. The probes, which were buried at a depth of 1 to 2 in., were thus placed both in and between the rows.

The average soil temperatures under ecofallow were several degrees lower between the rows up until the time the plant canopy was fully developed in mid-July; thereafter, the differences were much less (Fig. 2A). The average temperatures in the row, however, were slightly lower under ecofallow throughout the growing season (Fig. 2B). The daily high soil temperatures were much lower between the rows under ecofallow throughout the growing season, especially up until the time the canopy developed (Fig. 3A). The daily high temperatures in the row were also lower throughout the growing season under ecofallow (Fig. 3B); the differences, however, were not nearly as great as between the rows. The daily temperature fluctuations (determined by subtracting the lows from the highs) between the rows were dramatically lower under ecofallow throughout the growing season (Fig. 4A), whereas the fluctuations in the row were similar under ecofallow and conventional tillage (Fig. 4B).

The increased soil moisture storage and the lower, more constant soil temperatures associated with ecofallow are undoubtedly two major factors accounting for the lower incidence of stalk rot. Under these more favorable growing conditions, the plants are less vulnerable to the fungi that cause stalk rot.

The ecofallow system differs from most reduced tillage practices in that one crop is planted directly into the residue of a different crop rather than into the residue of the same crop. Growing two different crops may, then, be a useful mechanism to avoid the disease pitfalls encountered when monoculturing is practiced under reduced tillage. Monoculturing with reduced tillage has allowed certain diseases to increase due to host susceptibility and pathogen specificity. The use of two dif-

Table 3. The effect of ecofallow on stalk rot and yield of grain sorghum grown in a winter wheat-grain sorghum-fallow rotation and soil water storage efficiency from wheat harvest to grain sorghum planting time^w

Treatment	Stalk rot ^x (%)	Yield ^x (bu/acre)	Soil water storage efficiency ^y (%)
Conventional	39 a ^z	43 a	35 a
Ecofallow	11 b	61 b	60 b

^w 3-yr averages.

^x Mean of five replications. For the stalk rot data, 100 stalks were examined in each plot. For the yield data, three 40-ft rows were combine-harvested in the middle of each plot and adjusted to 14% moisture.

^y Efficiency % = $\frac{\text{storage total}}{\text{precipitation total}} \times 100$.

On the average, an additional 2 in. of water are conserved under ecofallow during this period.

^z Values not followed by the same letters are significantly different. $P = 0.01$, according to Duncan's multiple range test.

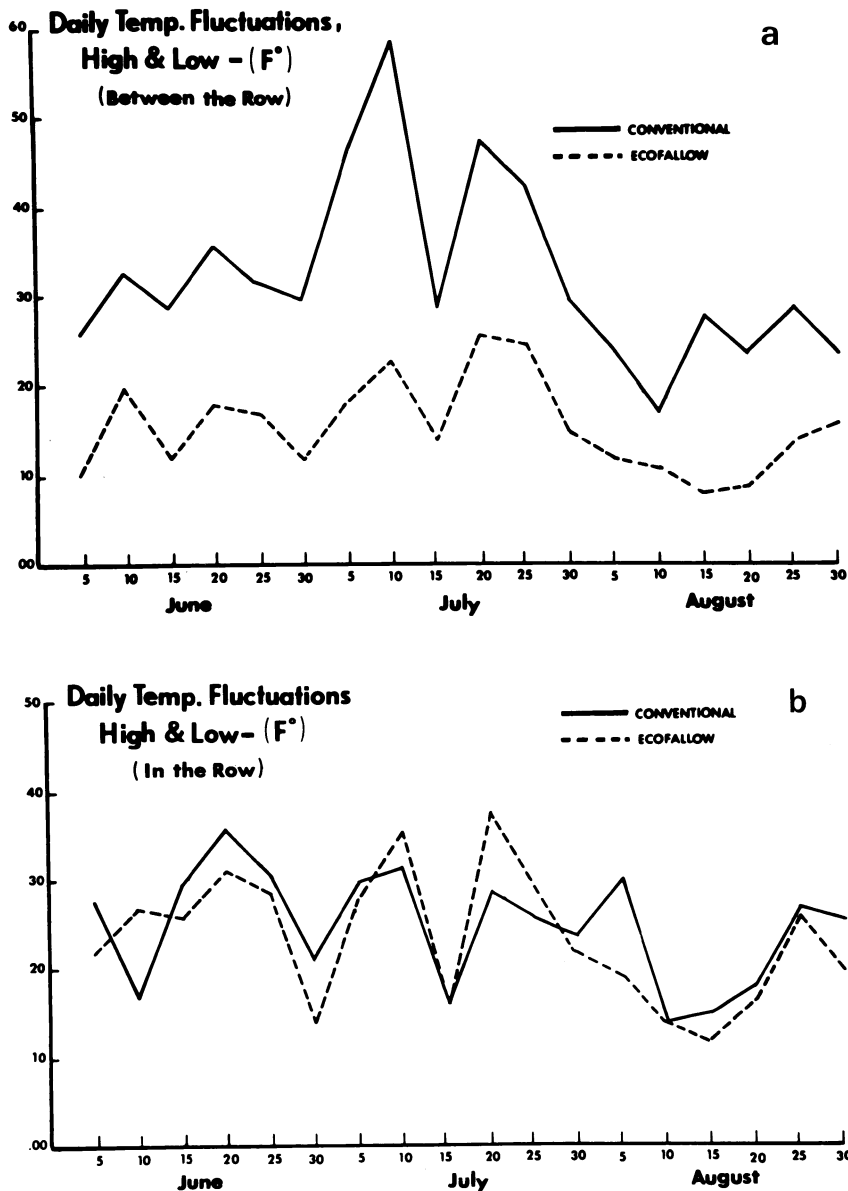


Fig. 4. Effect of conventionally tilled and ecofallowed grain sorghum on the daily soil temperature fluctuations (high temperature minus low) at the 1-2 in. depth (A) between the rows and (B) in the row.

ferent crops appears to us to be an important factor in breaking this link in the buildup of diseases.

Recent observations on the long-term disease consequences of a 2-yr wheat ecofallow rotation system in western Nebraska add support to the importance of using two different crops in the rotation. In this system, wheat is planted in September and harvested the next July. The wheat stubble is then maintained weed-free throughout the following 15-mo fallow period through the use of herbicides and sweep tillage, if necessary. In September of the second year, wheat is planted directly into the wheat residue of the previous crop.

This cropping system has been used extensively in western Nebraska and Kansas and eastern Colorado and Wyoming, and acreage is increasing each year. No particular disease problems appear to be associated with this cropping system; during the past 2 yr, however, tan spot caused by *Pyrenophora trichostoma* and leaf blotch caused by *Septoria tritici* have increased to the point of concern. Both these foliar diseases are capable of being destructive under favorable disease development conditions, since none of the current wheat cultivars have useful resistance. This increase in foliar diseases in the wheat ecofallow monoculturing system suggests the importance of using two different crops, as in the wheat-grain sorghum ecofallow system, to help prevent disease buildup.

Farmer Acceptance and Geographical Adaptation

The acceptance of ecofallow as a viable cropping practice by farmers in Nebraska is quite evident by the increase in acreage using this reduced tillage system (Table 4). Acreage has grown from 200 acres in 1973 to 100,000 acres in 1978, and an estimated 200,000 acres will be under ecofallow in 1979. Undoubtedly, the drought problems experienced during the past 3 yr in southwest and southcentral Nebraska have given impetus to this acreage increase.

There do not appear to be any major stumbling blocks to prevent the use of this 3-yr rotation system in other semiarid regions of the world where wheat and grain sorghum or corn can be grown. In addition, the current energy conservation and ecology-conscious attitude throughout the world makes ecofallow an appealing cropping practice alternative that also shows promise of providing more dependable nonirrigated crop production.

Summary

The 3-yr ecofallow rotation system and the experimental site involved in this study have provided a unique opportunity to evaluate the long-term effects of reduced tillage on plant diseases. In addition, the large acreage under this crop-

Table 4. Farmer acceptance of ecofallow as a cropping practice is evident by the substantial increase in wheat stubble acreage that has been chemically treated and planted to grain sorghum or corn in Nebraska

Year	Ecofallow acreage planted to corn or sorghum (acres)
1973	200
1974	5,000
1975	12,000
1976	18,000
1977	60,000
1978	100,000
1979	200,000*

*Estimated acreage.

ping practice has allowed the disease consequences of ecofallow to be evaluated on a wide geographical area basis. Our findings show that plant diseases have not increased under this reduced tillage system; in fact, the incidence of stalk rot of grain sorghum and corn has decreased. We feel the use of two different crops in this system is an important factor in preventing the buildup of plant diseases that has commonly occurred with monoculturing under reduced tillage.

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