Row-Crop Response to Topsoil Restored on Borrow Areas

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Borrow areas are created where soil is needed to provide fill for construction projects. The changes in row-crop productivity resulting from removal of soil for highway construction in Iowa and restoration methods, which included addition to topsoil, subsoil tillage, manure application, and 2 yr of legume growth before row cropping, were evaluated. The research was carried out from 1977 to 1981 at four locations. Corn and soybean yields from borrow areas have been below, equal to, and greater than yields from undisturbed neighboring farmland. Little or no yield increase was noted from restored topsoil at coarse-textured sites. At finer-textured sites, a marked yield increase of both crops occurred after the addition of 6 in. of topsoil but little added yield increase resulted from restoring 12 in. of topsoil. Subsoil tillage has shown little or no beneficial effect on crop yields. The manure treatment has resulted in a corn yield increase but only in the first year after application.

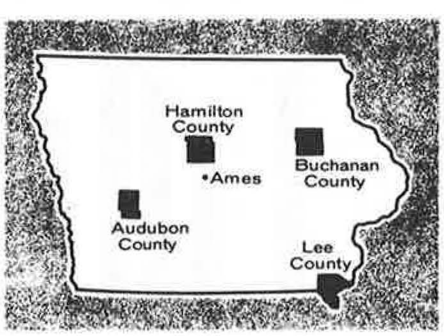
Borrow areas are created where soil is removed from one place to provide fill material needed at another place. The material removed from the borrow areas where this research was conducted was used for highway embankment construction. In all instances, the borrow needed for construction had to be obtained from beyond the right-of-way, and the land was to be returned to private ownership. All the borrow areas in this study were used for agriculture after the borrowing was completed.

When a site is selected to provide borrow material, there are generally two criteria to be determined: the suitability of the soil for construction and the proximity of the borrow to the area in which there is need for the soil.

For this research project, four borrow-area sites were selected. At each site, highway construction was under way. The sites were selected so that they represented a wide range of soil conditions that might be encountered in Iowa. The locations (Figure 1) of the sites are Audubon County, representing the deep loess soils of western Iowa; Buchanan County, representing coarse-textured or sandy soil; Lee County, where soil had developed on several feet of loess deposited over pre-Illinoian glacial till; and Hamilton County, where soil had developed on late Wisconsin glacial till.

Research was begun at the sites in Audubon and Buchanan Counties in 1978. The sites in Lee and Hamilton Counties were used for research starting in 1979. The experimental plan called for plots to receive 6 or 12 in. of salvaged topsoil, and these plots were to be compared with others that received no topsoil. In order to replace the desired depth of topsoil, trenches were cut in the subsoil to either 6 or 12 in. At the Hamilton County site, each trench was 40 ft wide and 400 ft long. After the trench was filled with topsoil, the research area was finished to a 2 percent grade to provide surface drainage. In addition to topsoil replacement, the research plan called for comparisons of manure applications versus none, subsoil tillage versus none, and corn and soybean production following 2 yr of alfalfa growth versus none. Of these additional treatments, only the response to alfalfa will be included in the results presented here.

Figure 1. Borrow-area research sites.



A row-crop rotation consisting of corn alternated with soybeans was followed at each borrow-area research site. The replications were divided so that corn and soybeans were grown each year. A similar division of plots was employed in which alfalfa was grown for 2 yr, and both corn and soybeans were allowed to appear in the same year on those plots.

Both corn and soybeans were grown by using conservation tillage practices. Fertilizer was applied according to soil test recommendations and herbicides were also applied according to label recommendations. Weeds germinated abundantly in the topsoil-treated plots and herbicides were required.

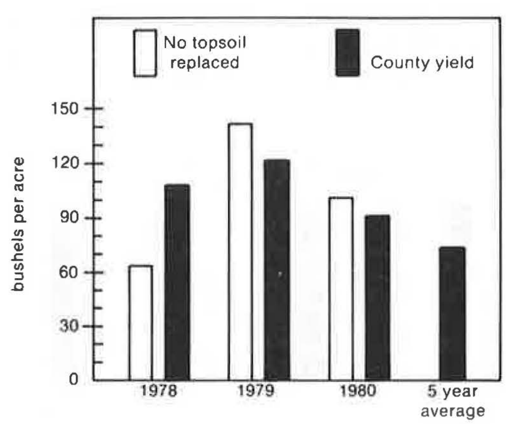
RESULTS

Research data for 3 yr have been collected at each of the four borrow sites selected to be representative of major soil materials in Iowa.

Audubon County

At the Audubon County borrow site (Figures 2 and 3), corn and soybean yields equaled or exceeded county average yields during the last 2 yr of the 3-yr study. This was done without topsoil replacement. Topsoil treatment was deleted from this site because it was too small to include such treatment. Second, topsoil was not salvaged at this site. Previous research work done by Iowa State University has shown that excellent crop yields can be achieved on loess subsoil in western Iowa if it is properly fertilized and managed. The other treatment variables were included in the research at this site, but their effects were insignificant or short-lived, as in the case of the manure application. The alfalfa treatment resulted in greatly depressed yields of row

Figure 2. Corn yield response at loess borrow area in Audubon County.



crops because it removed nearly all the plant-available water the year before row crops were planted and there was not enough precipitation to grow corn and soybeans without the subsoil moisture reserve.

Buchanan County

Corn and soybean yields exceeded county average yields [Figures 4 and 5 (0, 6, 12 refer to depth of topsoil in inches)] in only 1 of 3 yr at the Buchanan County borrow site. The first year's yields were greatly reduced as a result of the poor seedbed, which was prepared only a few days after the site was restored by heavy earth-moving machinery. All other sites used in this research were restored in the fall before the first year of crop production. In the second year of research, 1979, excellent corn and soybean yields were measured at the borrow area and they exceeded the county averages. The results of the third and final year were disappointing because heavy rains, wind, and hail damaged the corn and soybean plots so much that the yields suffered greatly. The most important result from this research site was the lack of response by corn and soybeans to topsoil replacement.

Figure 3. Soybean yield response at loess borrow area in Audubon County.

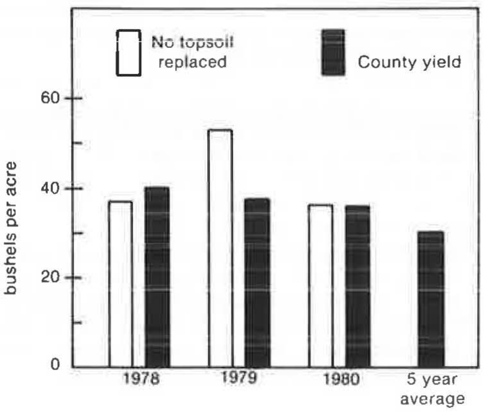


Figure 4. Corn yield response to restored topsoil at coarse-textured borrow area in Buchanan County.

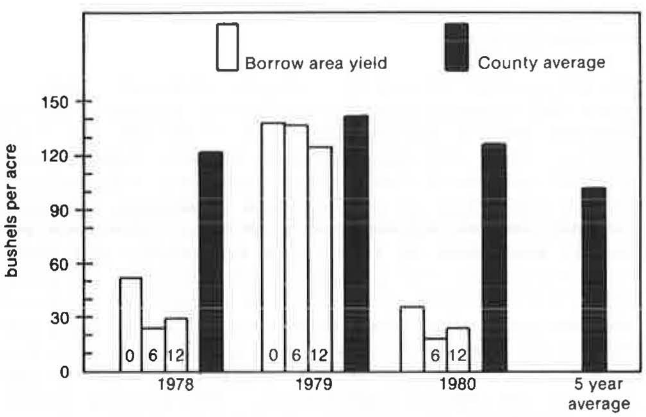
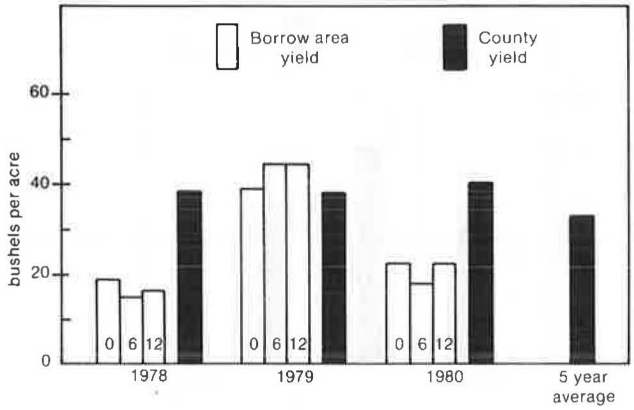


Figure 5. Soybean yield response to restored topsoil at coarse-textured borrow area in Buchanan County.



Hamilton County

Corn yields (Figure 6) have equaled county average yields at the Hamilton County borrow site in 2 out of 3 yr where topsoil was restored. Only the second year's results showed no response to topsoil, and corn yields were greatly reduced compared with the county yield. Drought severely affected all plots in 1979 and there was a differential in pollination date between plots with and without topsoil. Corn grown without topsoil pollinated 2 weeks later than corn grown on topsoil. The stress from the drought was much more severe during the earlier pollination period and a greater percentage of barren plants resulted. Alfalfa treatment tended to increase corn yields slightly, but the effect was not significant.

Soybean yield (Figure 7) at the Hamilton County site was of some interest. In the first year, yields from plots receiving topsoil were twice as great as yields from plots without topsoil. The county's average soybean yield was equaled by soybeans grown on topsoil, but there was no significant difference in yield between plots receiving 6 or 12 in. of topsoil. In the second year of the study, drought greatly reduced soybean yields at the borrow site compared with the county, but unlike corn, the yields from plots receiving topsoil were twice as great as the yields from plots receiving no topsoil. In 1981 the effect of alfalfa growth on soybean yields could be evaluated and it was significant. Soybean yields where no topsoil was restored were three times as great following 2 yr of alfalfa growth. The yield increase on plots receiving topsoil was nearly 20 bushels/acre. The explanation for the yield increase from previous alfalfa growth was a less frequent occurrence of Phytophthora root rot infection. This disease organism probably became established when the first crop of soybeans was

Figure 6. Corn yield response to restored topsoil and alfalfa treatment at late Wisconsin glacial till borrow area in Hamilton County.

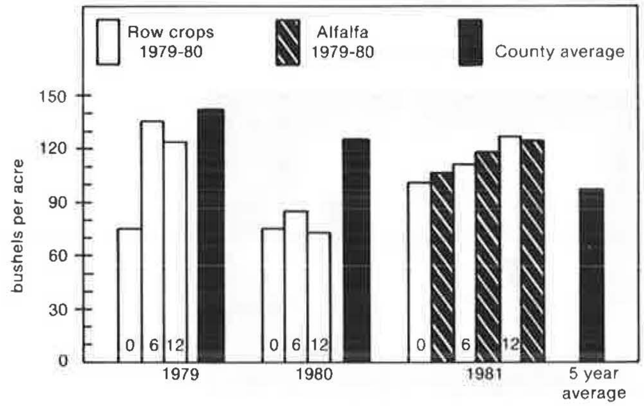


Figure 7. Soybean yield response to restored topsoil and alfalfa treatment at late Wisconsin glacial till borrow area in Hamilton County.

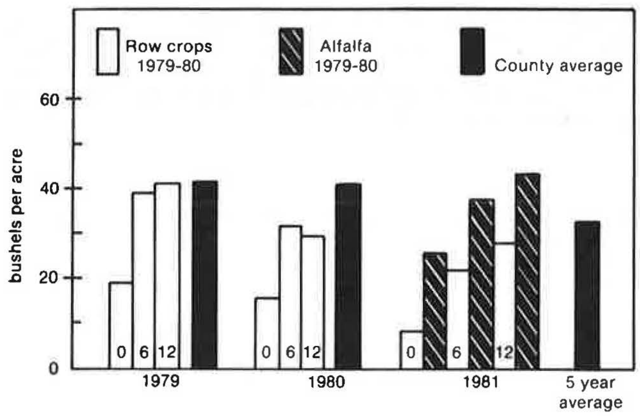
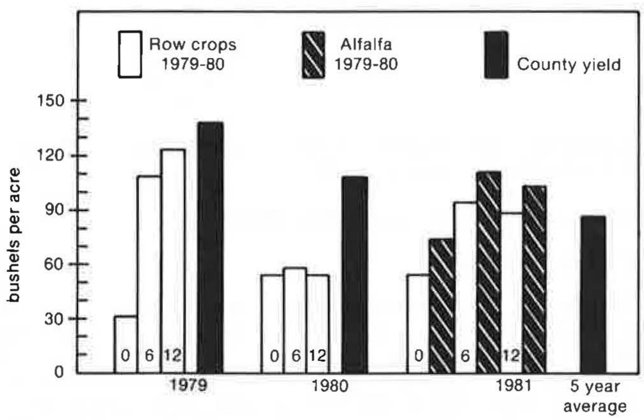


Figure 8. Corn yield response to restored topsoil and alfalfa treatment at Kansan glacial till borrow area in Lee County.



grown in 1979 and became severe in the second crop, grown in 1981. Restoration of topsoil lessened the severity of the disease somewhat but not enough to prevent a yield reduction of approximately 20 bushels/acre.

Lee County

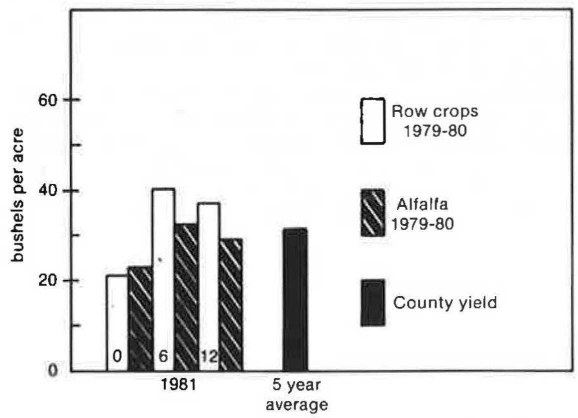
Corn yields (Figure 8) have been disappointing at the Lee County borrow site. There has been a significant response to topsoil replacement, but little difference has been found between the 6- and 12-in. depths. Corn yield appeared to increase after 2 yr of alfalfa growth, but the response was not significant.

Soybean yields (Figure 9) are reported for only the last year of the study. Topsoil replacement accounted for a large yield increase, but the difference between 6 and 12 in. of topsoil was not significant.

Two years of alfalfa growth did not improve soybean yields as it did in Hamilton County. However, there was no infection of soybeans by Phytophthora root rot at the Lee County site.

Injury of the crop or other management problems caused by weather probably accounted for much of the variability in yields at this site. In 1980 heavy rains in excess of 7 in. during 24 hr washed away plants, fertilizers, and herbicides. In 1981 the planting date was greatly delayed by wet weather and only the plots that had received topsoil were in a

Figure 9. Soybean yield response to restored topsoil and alfalfa treatment at Kansan glacial till borrow area in Lee County.



good condition when seed was planted. Consequently, plant density at harvest was greatly reduced on the subsoil plots because of poor seed germination and emergence of seedlings. Nevertheless, this did serve to point out that topsoil was a superior material when seedbeds were prepared.

CONCLUSIONS

This research showed that topsoil replacement is not always necessary at borrow areas. At coarse-textured sites that include deep loess and sandy materials, excellent yields may be obtained without topsoil replacement. Where finer-textured soil materials occur over glacial till, 1 ft of topsoil should be salvaged before borrowing and replaced when the borrow area is reclaimed. Salvaging the top foot of soil will ensure that at least 6 in. of topsoil will be restored to the borrow area because losses of up to 50 percent of the topsoil may occur through handling and shrinkage.

Alfalfa or other suitable legumes should be grown in the years immediately after a borrow area has been reclaimed. Where topsoil is not restored, this practice should be mandatory to prevent erosion. When these areas are row cropped, conservation tillage practices should be applied to continue to minimize erosion. Another benefit of conservation tillage will be a reduction in soil crusting where organic matter is low, especially when topsoil was not applied. Alfalfa treatment appears to lessen the severity of Phytophthora root rot infection in soybeans. This benefit from alfalfa is still being studied at the Hamilton County borrow site.

Subsoil tillage generally was not beneficial for row crops. The tillage equipment used for this research could not penetrate beyond 20 in. into the soil. This same zone is also greatly affected by freezing and thawing and wetting and drying. The advantage of subsoil tillage, in the first year after reclamation, is to loosen the soil when construction equipment compacts it, particularly when borrow is removed during wet conditions.

Manure application was beneficial to corn grown the first year after application. This is generally expected. However, excellent corn yields can be achieved without manure. Farmers with available manure will generally apply it to lands that they wish to improve, and borrow areas are no exception. Many of the benefits of manuring may be duplicated with good conservation tillage programs where crop residues are left at the surface. Manures can also provide a mulching effect, but other materials can serve equally well where mulch is needed.

Finally, some conclusions regarding productivity can be drawn from this research. Row-crop yields may be greatly reduced in the first year after a borrow area has been restored. Yields were greatly reduced if row-crop production was initiated immediately after reclamation without the benefit of a winter freezing and thawing. After a period of one to several years, yields from these areas can equal or exceed county average yields. Certain sites, such as those developed on glacial till, will require the replacement of at least 6 in. of salvaged topsoil and may equal countywide yield in a period of 2 yr.

ACKNOWLEDGMENT

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Establishment and Growth of Shelterbelt Species and Grass Barriers on Windswept Wyoming Rangeland

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Survival and growth of six shelterbelt species and three rangeland shrubs were evaluated for 6 yr at a single windswept site adjacent to Interstate 80 in south-central Wyoming. Placing plants behind a snow fence to reduce wind speed did not influence their establishment success or their growth rate. Rodent depredation limited establishment and growth of some species more severely than the harsh climate. After 6 yr, survival of three deciduous species planted as bare-root stock ranged from 16 to 65 percent; survival of three conifers planted as container-grown stock ranged from 73 to 91 percent. A number of years would be required for a shelterbelt to become tall enough to effectively deposit drifting snow in locations where environmental conditions are similar to those of the study site. Such plantings would require extensive land areas to retain quantities of snow similar to those retained by snow-fence systems protecting I-80. Russian olive and white rabbitbrush were about 85 cm tall after six growing seasons, and Colorado blue spruce and ponderosa pine were about 65 cm tall. The ability of a stripping treatment imposed on sagebrush rangeland to increase on-site snow storage and reduce snow relocation was also evaluated. Sagebrush was fertilized with nitrogen at rates of 0, 22.4, and 44.8 kg/ha. The stripping treatment was only effective where livestock grazing was excluded and crested wheatgrass was planted on grass strips. The grass stand caused on-site snow retention to double. Winter snow accumulation behind a snow fence decreased about 20 percent because of reduced snow relocation.

Shelterbelts have been widely planted on the Great Plains to reduce wind speed and drifting snow around farms and ranches. Technical information is available about adapted species and techniques to establish a planting (1-4). Plantings have not been made on the high plains of south-central Wyoming where Interstate 80 is located. Environmental conditions are much more severe along I-80 than on the Great Plains, and snow relocation is common in winter months. At this time, about 52 km of snow fence protect 49 km of the highway between Laramie and Walcott Junction that has the most severe winter weather. The height of approximately 70 percent of these fences is 3.8 m (5). Possibly the severity of snow relocation might be reduced by shelterbelt plantings or through management of native rangeland vegetation.

The current study was conducted in cooperation with the Wyoming State Highway Department and was designed to evaluate survival and growth characteristics of six tree and shrub shelterbelt species and three rangeland shrubs planted in a location with and without snow-fence protection. In addition, the ability of grass strips to increase on-site snow retention and reduce snow drifting on sagebrush rangeland was investigated.

STUDY SITES AND EXPERIMENTAL METHODS

Shelterbelt Study

The single shelterbelt planting site was located on the south side of I-80 about 8 km east of the town of Elk Mountain near mile 264. The site is 2300 m in elevation, and native vegetation is dominated by Wyoming big sagebrush (*Artemisia tridentata* sub. *wyomingensis*) about 10 cm tall. Soil has a sandy loam texture in the A and B horizons; the combined depth of these horizons is 30 cm. The study site was 35 by 155 m and it was enclosed by a snow fence 3.8 m tall across the downwind side and by a fence of woven wire on the remaining three sides so that livestock grazing was excluded. At study initiation, the site was plowed to kill native vegetation; 1 yr later the site was sprayed with herbicide to control weeds.

Three conifer species--Colorado blue spruce (*Picea pungens*), ponderosa pine (*Pinus ponderosa*), and white fir (*Abies concolor*)--were evaluated along with three deciduous species--Russian olive (*Elaeagnus angustifolia*), Siberian elm (*Ulmus pumila*), and Siberian peashrub (*Caragana arborescens*). Rocky mountain juniper (*Juniperus scopulorum*) is one of the most commonly planted shelterbelt species in the central Great Plains. However, at study initiation, planting stock of juniper was unavailable and this species was not evaluated.

Conifer species were grown in containers and were 10 to 15 cm tall when planted. Deciduous species were planted from bare-root stock that had been held in cold storage for about 6 weeks. Two slow-release fertilizer tablets (20 percent nitrogen, 10 percent phosphorus, 5 percent potassium) were placed in the soil adjacent to each plant as they were planted on June 27 and 28, 1975. The plants were placed in holes 61 cm in diameter in which soil was loosened to a 61-cm depth. To eliminate water stress as a survival factor, rainfall during the 1975 and 1976 growing season was supplemented by irregular waterings. Most plants that died in the first year of