SIMULATED SOIL EROSION AND CROP PRODUCTIVITY

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ABSTRACT

Several different soil types were employed to study the effects of simulated soil erosion on wheat and canola productivity. Varying amounts of topsoil were scraped from the surface of experimental fields and crops were grown using three levels of fertilizer applications. Topsoil removal treatments included 0 cm removed, (a basis for comparison), 5, 10, and 20 cm of topsoil removed. Fertilizer application treatments consisted of no fertilizer applied, recommended rate of fertilizer applied and approximately double the recommended rate. Crops utilized for this study were Columbus wheat and Westar canola. It was found that yields generally decreased as the amount of topsoil removed increased. Data indicated yields to be severely depressed on all topsoil removal treatments where no fertilizer was applied. Soil texture played a role in determining the outcome of yields in that on the coarse textured soils, even twice the recommended rate of fertilizer was not able to bring the yields back to that of the control. The recommended rate of fertilizer application was able, on the other hand, to mitigate topsoil losses on the fine textured soils and in some cases yields exceeded the control at twice the recommended rate of fertilizer.

Introduction

Soil erosion is a natural ongoing process that, with the influence of man, is accelerating to heights that can threaten our potential productivity. It has been well documented that crops grown on eroded soils will yield lower than crops grown on uneroded soils. This loss in productivity is due to a loss in fertility and because of the other changes that occur due to soil erosion. To elaborate, soil erosion is responsible for losses of vital soil nutrients, losses of soil organic matter, a decrease in the water holding capacity, changes in the soil structure and soil texture, a root zone depletion and exposure of the subsoil, all generally adverse changes in the soil indicative by the loss in productivity.

Much research has been done to determine productivity losses due to erosion. Langdale et al. (1979) found that a loss of 15 cm of topsoil from a Southern Piedmont soil resulted in a 42% reduction in corn yields. Battiston et al. (1987), studying yields on eroded and uneroded sites, found the eroded sites yielded on average only 59% of that on noneroded areas. A study using simulated soil erosion was conducted by Tanaka and Aase (1989). They found that removal of 0.06, 0.12 and 0.18 m of topsoil reduced spring wheat yields an average of 9, 28 and 45% compared to the 0.00 m soil removal treatment. Such results make clear the need to look seriously at the control of soil erosion.

To date the best way to study the effect soil erosion has on crop productivity is by simulating soil erosion. The objective of this study was to examine the losses in productivity due to erosion by scalping the soil surface to different depths as a means of simulating erosion.

Materials and Methods

Six field sites were developed in Manitoba. Soil texture varied and included a Pembina clay loam, a Ryerson fine sandy loam, a Reinland loamy very fine sand, a Newdale clay loam, a Willowcrest fine sand and a Waskada very fine sandy clay loam.

Two sites were 0.33 ha in total area and four sites were 0.71 ha. The sites were set up in a completely randomized split plot design with pathways both within and among treatment plots. Four topsoil removal treatments, 0, 5, 10, and 20 cm and three fertilizer regimes 0, recommended rate based on fall soil tests, and approximately double the recommended rate constituted the main plot and the subplot treatments respectively. Each topsoil removal treatment was replicated four times resulting in 48 observations from each site.

Seed bed preparation was done according to conventional farming methods. Nitrogen, sulfur and potassium fertilizers were hand broadcast to appropriate subplots and disced down for good incorporation before seeding. The recommended rate of phosphorus was added with the seed and for double the recommended rate treatments, half was seed placed and the other half was drilled in below the seed. Seeding of Columbus wheat in year one, two and five and Westar canola in years three, four and six and appropriate field maintenance including necessary weed control was accomplished by conventional methods.

Crop emergence was tabulated to assess potential differences due to treatment differences. The general conditions of plants was constantly monitored to correlate specific plant conditions with respect to treatments. Rainfall was recorded with recording rain gauges and volumetric rain gauges and where incomplete due to equipment malfunction, information was obtained from Atmospheric Enviroment stations located closest to the research plots.

Soil Analyses

Physical soil analyses of the experimental soils included bulk density, field capacity, permanent wilting point, available moisture and particle size analysis. Chemical analyses of the soils consisted of pH and conductivity determinations, nitrate-nitrogen determinations, available phosphorus determinations, exchangeable potassium, sulfate-sulfur, organic matter content and sulfur concentrations.

Plant Analyses

Midseason tissue analyses for nitrogen, phosphorus, potassium and sulfur were conducted on the ground tissue of ten randomly selected plants from each subplot. From the final yield samples, tissue analyses on the straw was conducted to determine nitrogen, phosphorus, potassium and sulfur content. In the case of canola, oil and protein content of the seed was determined and for wheat, the nutrient content of the seed was examined.

Yields

Yields were determined by sampling one random representative square meter from within each subplot for the first four years. In the last two years, to decrease the level of error, two randomly chosen square meters from each subplot were selected. Yields were determined and an average for each subplot was calculated.

Results and Discussions

Crop Emergence

Crop emergence was monitored because it has been documented (Hirch 1984) that crust strengths of eroded soils increased as the level of topsoil removal increased. In this case of simulated erosion, removing topsoil unselectively, no differences in emergence of the subplots were observed. Topsoil removal did not significantly impede the emergence of wheat or canola seedlings.

Crop Conditions

Soon after emergence, it was evident that distinctly different growth stages were present among the treatments. Where no fertilizer was added, growth of the plants was slower, development was retarded, stems were thinner and plants were a pale green color. The condition worsened as the amount of topsoil removed increased. Where plots had been fertilized, the plants were developing more rapidly, grew thicker stems and donned a darker more healthy looking green color. As a rule, plants grown with the recommended rate of fertilizer and those grown with double the recommended rate, rarely showed any significant visual differences.

Midseason Plant Analysis

Ten random plants were selected from each subplot and nutrient analyses was conducted on the dry, ground samples. Where no fertilizer was added, nutrient content was a bit lower than where fertilizer was added however, there were no statistically significant differences among treatments.

Straw Productions

It was found that adding fertilizer to the various topsoil removal treatments increased the amount of straw produced. This is of great significance because an increase in straw returned to the soil, increases the nutrients added to the soil and also increases the soil surface cover. This in turn reduces the amount of erosion that can occur.

Final Harvest

It was found that yields were reduced as the level of topsoil removed increased. With fertilizer additions yields were increased with fine textured soils responding best. In some cases, the recommended rate of fertilizer was able to bring the yields above the control of no topsoil removed and no fertilizer added. In fine textured soils the additions of fertilizer were better able to overcome the loss of topsoil. The recommended rate of fertilizer was able to bring yields back to that of the control. Twice the recommended rate did not significantly increase yields further (Figure 1).

In coarse textured soils, the mitigating effects of fertilizer were not as great. Yields were raised to the level of the control but not until double the recommended rate of fertilizer had been added (Figure 2). This indicated that nutrient deficiencies could be overcome, although production costs will be considerably increased. In the Willowcrest, the coarsest soil, the results showed that fertilizer was even less effective in restoring yields. Even at twice the recommended rate of fertilizer, yields were severely depressed as topsoil removal increased (Figure 3). The loss of topsoil results in the loss of yields which fertilizer additions can not restore. Massee and Waggoner (1985) also found that reductions in yields due to the removal of 15 cm of topsoil could not be restored by additions of fertilizer. Where yields were not increased despite the large fertilizer applications, it is assumed that some factor other than fertility is reducing productivity.

In summary, it was found that simulated erosion resulted in productivity losses. Fine textured soils responded better to fertilizer applications than coarse textured soils. In some cases, even double the recommended rate of fertilizer was not able to overcome the losses of topsoil, clearly indicating that factors other than nutrient losses are responsible for productivity losses due to erosion. Further study of the actual changes to the soil that occur due to soil erosion may elucidate the cause of the loss in productivity observed in this experiment.

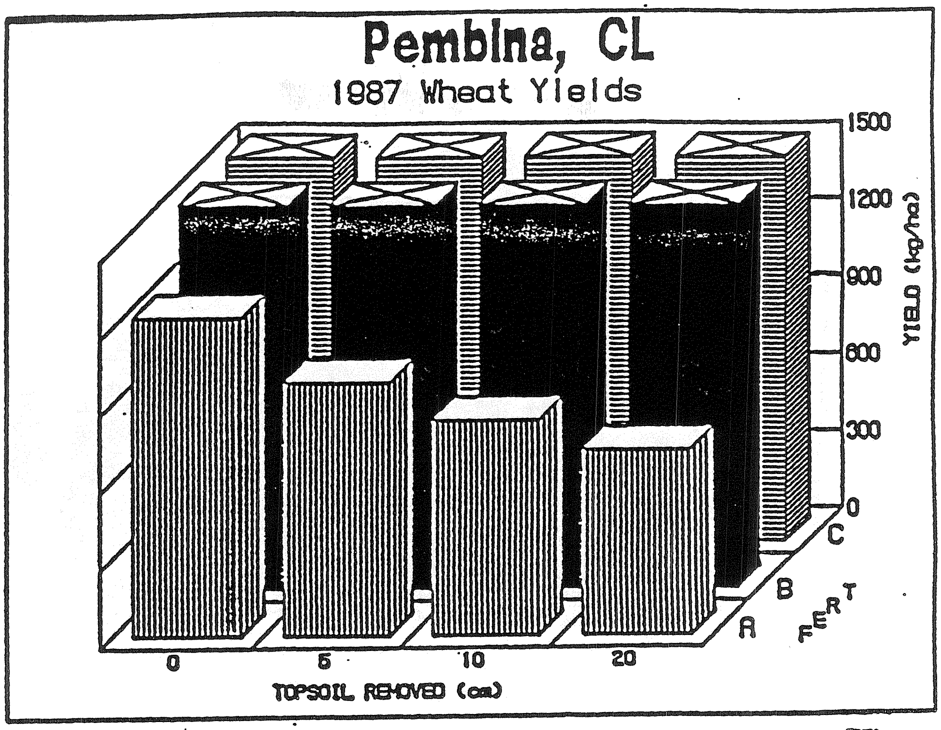

Figure 1. Effect of topsoil removal and fertilizer applications on wheat yields grown on a Pembina clay loam.

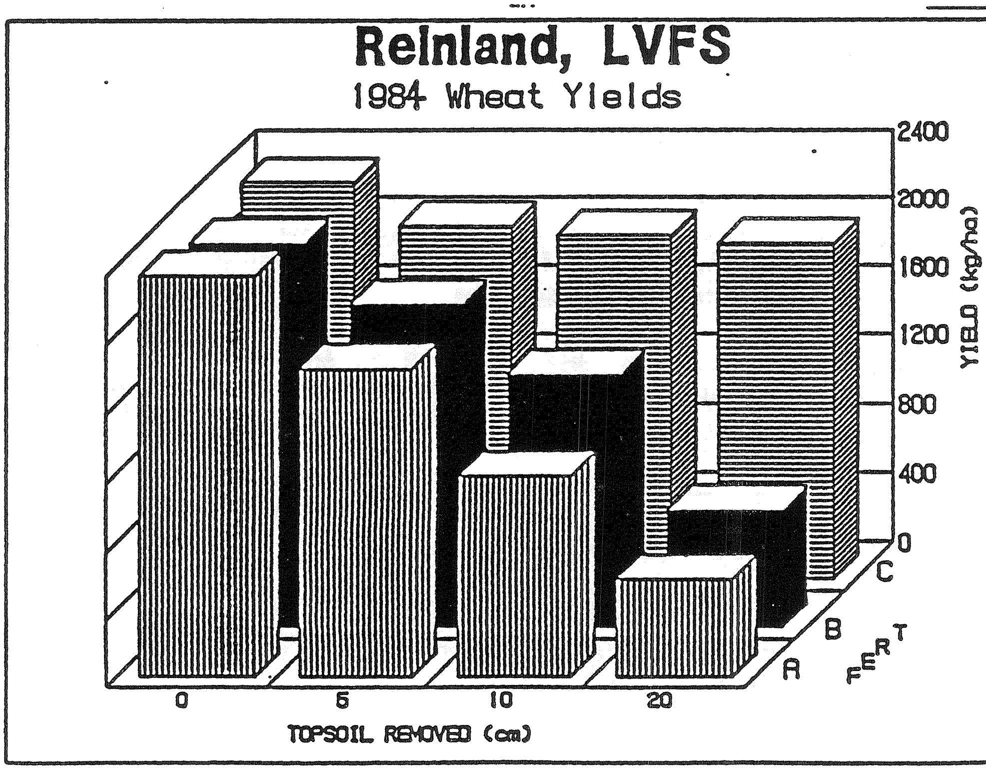

Figure 2. Effect of topsoil removal and fertilizer applications on wheat yields grown on a Reinland loamy very fine sand.

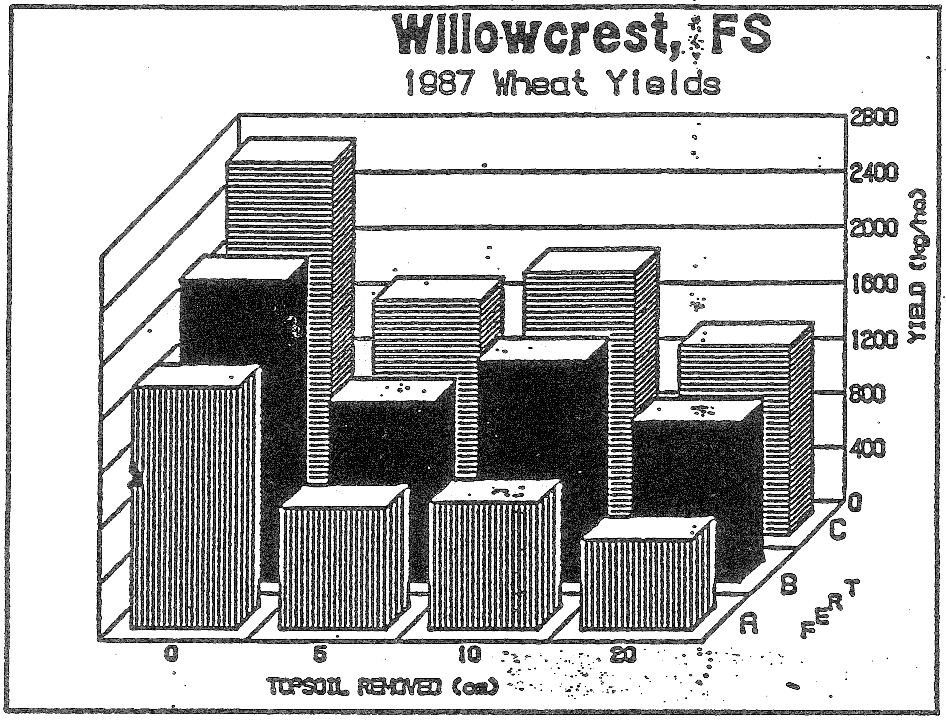

Figure 3. Effect of topsoil removal and fertilizer applications on wheat yields grown on a Willowcrest fine sand.

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