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FORAGE TECHNICAL BULLETIN

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Impact of alfalfa and fertilizer on pastures:

Carbon Sequestration in Pastures

Introduction

Carbon sequestration (the storage of carbon in soils) has the potential to reduce the buildup of greenhouse gases in the atmosphere – an important environmental benefit. Agricultural production provides an excellent method for the sequestration process because during photosynthesis plants absorb CO₂ from the atmosphere and use it to produce plant material. When plants decay, the carbon within the plant is sequestered as soil organic carbon.

Perennial forage production has been proven to sequester more carbon than annual crop production. This is because annual cropping and tillage operations result in a loss of soil organic matter and carbon the soil. Therefore, converting marginal land that is being used for annual crop production to perennial crops can increase carbon sequestration. In Manitoba's Parkland region, there is Class 4 and 5 land being cropped annually even though the land contains less than 1.5% organic carbon and has low yield potential. This land has excellent potential for conversion to perennial forages.

The amount of carbon sequestered in pasture soils may vary depending on land management. The use of fertilizer or the addition of alfalfa can increase pasture productivity, and may also increase carbon storage and sequestration.

Research Study

A study was conducted at the Agriculture and Agri-Food Canada Research Centre in Brandon, MB from 1999-2007. The objective of the study was to determine the amount of carbon stored in grazed meadow bromegrass pastures that included alfalfa, fertilizer or both. It did not measure loss of carbon or nitrogen to the atmosphere.

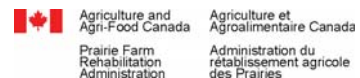
In the spring of 1994, pastures were established on a Souris fine sandy loam. The study used rotational grazing on four combinations of pasture type and fertilizer management. There were two different pasture types (100% grass or mixed alfalfa-grass) and two different fertilizer treatments (no fertilizer, or spring fertilization to full soil test recommendation levels). This resulted in a total of four treatments, shown in Table 1.

The grass-only pastures were seeded with 10 lb/acre 'Paddock' meadow bromegrass. The mixed alfalfa-grass

Table 1. Pasture Types and Fertilizer Treatments used in the Study

1) Meadow bromegrass No added fertilizer	3) Meadow bromegrass + Alfalfa No added fertilizer
2) Meadow bromegrass + Fertilizer	4) Meadow bromegrass + Alfalfa + Fertilizer

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Carbon Sequestration in Pastures

pastures were seeded with 7 lb/acre meadow bromegrass and 3 lb/acre ‘Spredor II’ alfalfa. Starting in 1995, fertilizer was surface-applied as a dry blend prior to grazing each spring. The concentration of each nutrient in the blend was based on soil samples collected the previous fall. Pastures were grazed so that approximately the same amount of plant residue remained in each pasture at the end of the grazing season. Soil samples were collected at different depths in 1999, 2002 and 2007.

Study Results

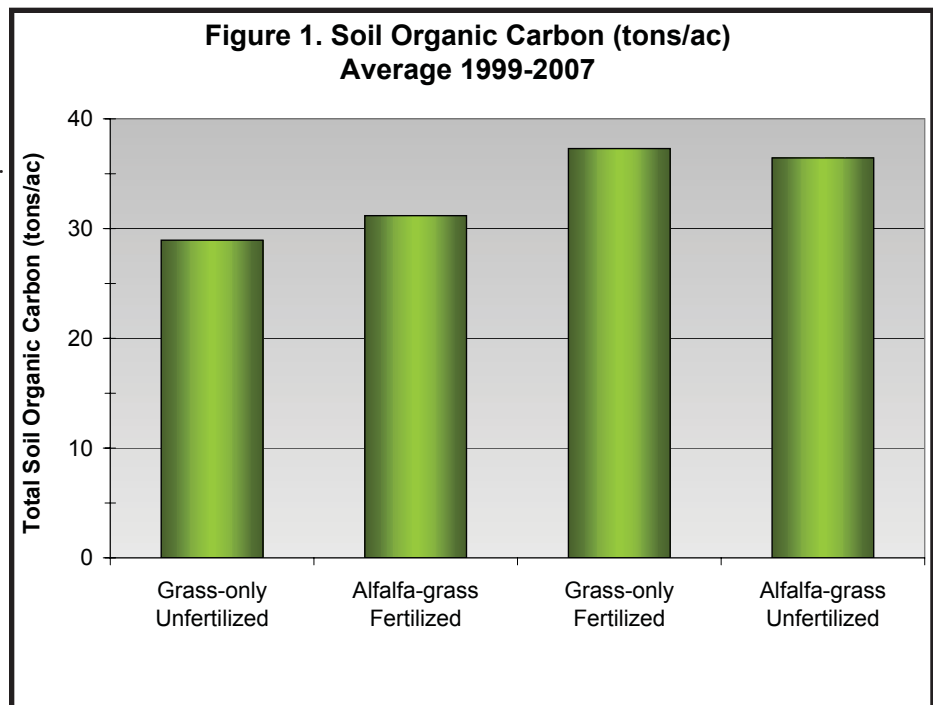
Carbon Sequestration in Pasture Soils

Figure 1 shows the average amount of carbon sequestered (in tons per acre) in the different pastures between 1999 and 2007. The highest amount of carbon sequestered was in the fertilized grass only pastures and the unfertilized alfalfa-grass pastures; between these two pastures, the amount of carbon sequestered was similar. Therefore, improving grass pastures by adding either fertilizer or alfalfa was equally effective in increasing the amount of carbon sequestered in the soil.

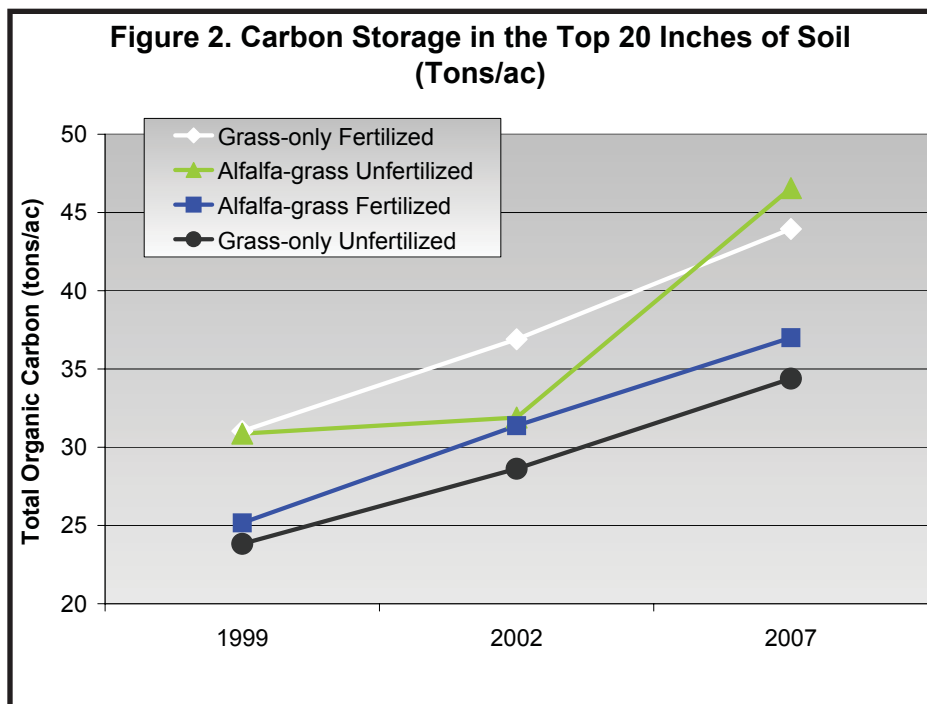
Based on these results, it would be expected that introducing both alfalfa and fertilizer to grass-based pastures would increase carbon sequestration even more than adding either one individually, but that is not what occurred in this study. Adding both fertilizer and alfalfa to grass-based pastures was not as effective in increasing carbon sequestration as adding either alfalfa or fertilizer. This is possibly due to differences in how roots develop and how carbon is stored in fertilized and unfertilized pastures. However, there was not enough data collected in this study to provide a definite answer as to why this lower-than-expected level of carbon sequestration was observed. Further research is required to explain this finding.

Fertilized pastures usually have more root development near the soil surface where the fertilizer is applied, while unfertilized pastures, especially those containing alfalfa, tend to have more root development deeper in the soil profile. Shallower root development in fertilized pastures means that the carbon in the roots is stored closer to the soil surface. The carbon stored near the surface can be more easily decomposed, which can reduce the overall amount of carbon

stored. In the grass-only pastures, the increase in forage production resulting from the added fertilizer more than offset carbon loss at the surface. However, in the fertilized alfalfa-grass pastures, carbon may have initially accumulated at shallower depths compared to the unfertilized alfalfa-grass pastures. This could have released



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the carbon more quickly, resulting in a lower amount of total carbon sequestered in this type of pasture.

Figure 2 shows that the amount of carbon stored in all of the different pastures increased over the nine years of the study. There was a slight increase in carbon storage even in the soils of unfertilized grass only pastures (shown by the blue line in Figure 2). This suggests that even without adding alfalfa or fertilizer, carbon storage tends to increase over time in grass-based pastures. This is probably because grazing animals add nitrogen to the soil through urine and manure.

Adding alfalfa to grass only pastures significantly increased the

storage of carbon in soil. By 2007, the unfertilized alfalfa-grass pasture (*the green line in Figure 2*) stored over 12 tons/acre more carbon than the unfertilized grass only pasture (*black line*).

Fertilizing grass only pastures also significantly increased soil organic carbon. By 2007, the fertilized grass only pasture (*white line in Figure 2*) stored almost 10 tons/ac more soil organic carbon than the unfertilized grass only pasture (*black line*).

As mentioned earlier, adding both alfalfa and fertilizer to grass pastures did not increase carbon sequestration compared to adding alfalfa or fertilizer alone. There was no significant difference in the amount of carbon stored between the fertilized and unfertilized mixed alfalfa-grass pastures (*green and blue lines in Figure 2*), even though forage production in the fertilized alfalfa-grass pastures was significantly higher than the unfertilized alfalfa-grass pastures (for more details, see the publication “Impact of Alfalfa and Fertilizer on Pastures: The Importance of Including and Maintaining Alfalfa”).

An important finding in this study is that even though the amount of soil carbon stored in all of the pastures increased over time, the carbon stored in the top 2.5 inches of soil was in a form that can be easily decomposed. This means that if pastures are converted back to annual cropland, the carbon stored in the top layer of soil could quickly be released back into the atmosphere.

Conclusion

Adding fertilizer or alfalfa to grass-based pastures increased the amount of carbon stored in soil. However, fertilized alfalfa-grass pastures did not sequester more carbon than unfertilized alfalfa-grass pastures. If fertilizer is added to increase carbon sequestration in pastures, it must be continued year after year to maintain higher levels of forage production. Without these continual inputs, the sequestered carbon will eventually be lost from the pasture.



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Land must also be maintained as pasture in order for long-term storage of carbon to continue. If pastureland is converted back to annual cropland, the carbon stored can easily decompose and be released back into the atmosphere.

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Sources:

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* This technical bulletin is part of a series that have been developed as a result of this collaborative study.