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FORAGE TECHNICAL BULLETIN

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Impact of alfalfa and fertilizer on pastures: Pasture Carrying Capacity

Introduction

The carrying capacity of a pasture is the maximum number of animals that can graze a pasture throughout the grazing season without harming it. The carrying capacity ensures adequate forage for grazing animals and leaves enough residual forage for regrowth the following year. Residual forage protects soil from erosion and increases the forage yield the following year by improving stand vigour, soil moisture and nutrient cycling. Improving the productivity of a pasture can increase its carrying capacity.

Research Study

A ten-year grazing study was conducted at the Agriculture and Agri-Food Canada Brandon Research Centre from 1994 to 2004 to determine how the carrying capacity of grass-based pastures can be improved by adding alfalfa and/or fertilizer. 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.

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

The grass only pastures were seeded with 10 lb/acre 'Paddock' meadow bromegrass. The mixed alfalfa-grass pastures were seeded with 7 lb/acre 'Paddock' 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 fertilizer blend was based on soil samples collected the previous fall.

Each pasture was 9.1 acres in size and was divided into five paddocks for rotational grazing. Four tester animals were assigned to each pasture and these animals remained in their designated pasture for the entire grazing season. The gains of these tester animals were used to determine individual animal performance on the different pastures. Additional animals were used to adjust stocking rates twice-weekly so that the amount of forage remaining after the grazing period was equal in each pasture. The presence and gains of these additional animals were used to determine the carrying capacities of the different pastures. All the animals in all the treatments were rotated at the same time.

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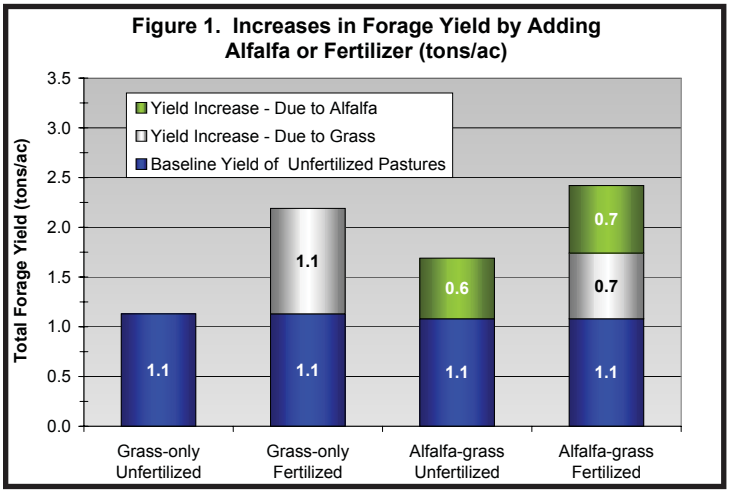
Information was collected on forage production, animal performance, and maximum stocking potential. For each paddock, forage production was calculated by measuring the forage dry matter yield when the animals entered it, minus the residual forage dry matter present at the end of the previous grazing period. For each grazing season, total forage production was measured by totalling the forage production for all rotations in each paddock, then averaging across all five paddocks.

Study Results

Effect of Alfalfa or Fertilization on Forage Yield

Figure 1 shows the improvement in forage yield achieved by adding alfalfa, fertilizer, or both to grass only pastures over the ten years of the study. The blue bars *(dark grey if printed in black and white)* show the average yield of the unfertilized grass only pasture. The green bars *(light grey if printed in black and white)* show the increase in forage yield resulting from alfalfa in the mixed alfalfa-grass pastures. The white bars show the additional grass yield resulting from adding alfalfa and/or fertilizer.



Fertilizing the grass only pasture to full soil test recommendation improved season-long forage yield by 1.1 tons/acre, doubling forage productivity compared to unfertilized pure grass pasture.

The unfertilized alfalfa-grass pasture had an average alfalfa content of 36% over the ten years of the study. This resulted in a yield increase of 0.6 tons/ac each year, which was achieved without any additional input costs.

Fertilizing the alfalfa-grass pasture to full soil test recommendations improved forage yield by 1.4 tons/ac each year, resulting in a total yield that was double that of the grass only pastures. Half of this yield increase was due to an increase in alfalfa yield, and half was due to an increase in grass yield. The yield increase in the fertilized alfalfa-grass pasture was achieved with less than half the fertilizer cost required for the grass only pasture.

Effect of Adding Alfalfa or Fertilizer on Carrying Capacity

Carrying capacity can be measured in Animal Unit Days (AUDs). An AUD is the daily forage requirement for one animal unit. One animal unit is a 1000 pound cow (with or without a calf up to 300 lbs); however, grazing animals of different weights and classes have different forage requirements. Table 2 shows the Animal Unit Equivalent conversions used to adjust for different classes of livestock. For example, a 1500 pound cow will consume 1.5

Table 2. Animal Unit Equivalent Conversions

Class of Animal	Animal Unit Equivalents
Cow, 1000 lb, with or without a calf	1
Cow, 1500 lb, with or without a calf	1.5
Bulls, 2 years and over	1.5
Yearling heifers and steers	0.7
Weaned calves	0.5
Horse, 2 year old	1
5 Ewes or does with or without lambs or kids	1
Bison cow	1.5

times as much forage as a 1000 pound cow, giving an animal unit equivalent of 1.5.

For each type of pasture, predicted carrying capacities were calculated as follows: first, the percentage yield increase resulting from adding alfalfa and/or fertilizer to unfertilized grass pasture was determined (as seen in Figure 1). The same percentage was then used to calculate the increase in predicted carrying capacity. However, Figure 2 shows differences between the predicted carrying capacity and the actual measured carrying capacity in each pasture. Actual carrying capacity was calculated using average animal live weights and stocking rate increases.

The actual carrying capacities in pastures with added alfalfa and/or fertilizer were higher than for the unfertilized grass only pasture; however, they were not as high as predicted. The difference between the predicted and actual carrying capacities is likely due to a faster rate of passage of higher quality, higher moisture content forages through the rumen. In pastures with added fertilizer and/or alfalfa, there is usually an increase in the amount of lush leaf material, leading to forage with a higher moisture content. The faster rate of passage through the rumen could lead to much higher forage consumption per animal, and therefore a lower carrying capacity. This is supported by the higher daily forage consumption per animal unit on pastures with added alfalfa and/or fertilizer (shown in Figure 3).

Effect of Precipitation on Carrying Capacity

Figure 4 shows a strong relationship between animal unit days (blue) and precipitation during the growing season (green). The soils in this study (Souris fine sandy loam) have a very low water holding capacity and regular rainfall is required to maintain productivity in these forage systems. During periods of moisture stress, plant growth, forage quality, stocking rate, individual gain, and total gain per acre are all severely reduced. Moisture stress occurred frequently throughout the ten

Figure 2. Predicted versus Actual Carrying Capacity (Animal Unit Days) 10-Year Average

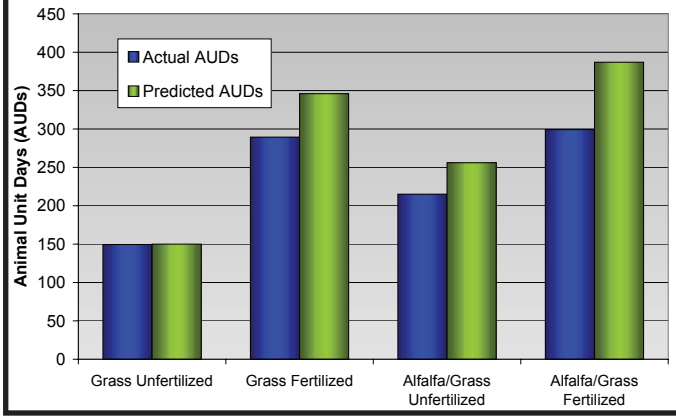


Figure 3. Estimated Forage Consumption 10 year Average (Lbs per Animal Unit per Day)

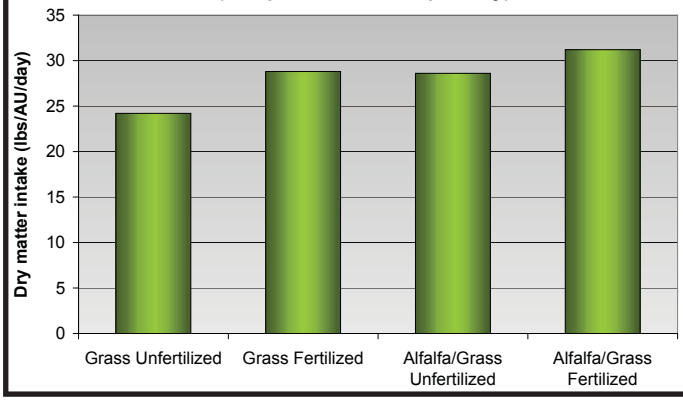
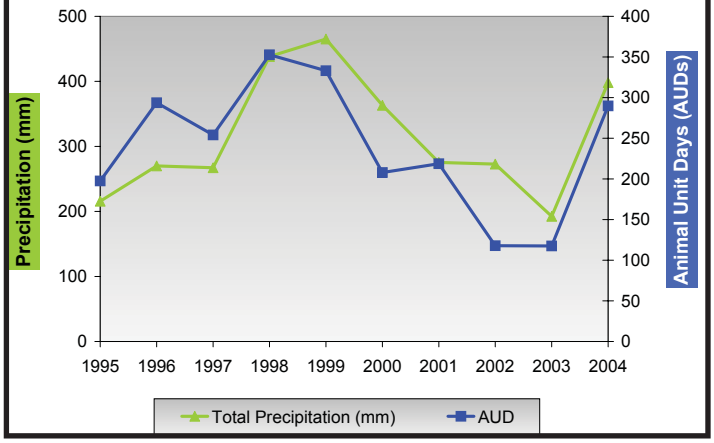
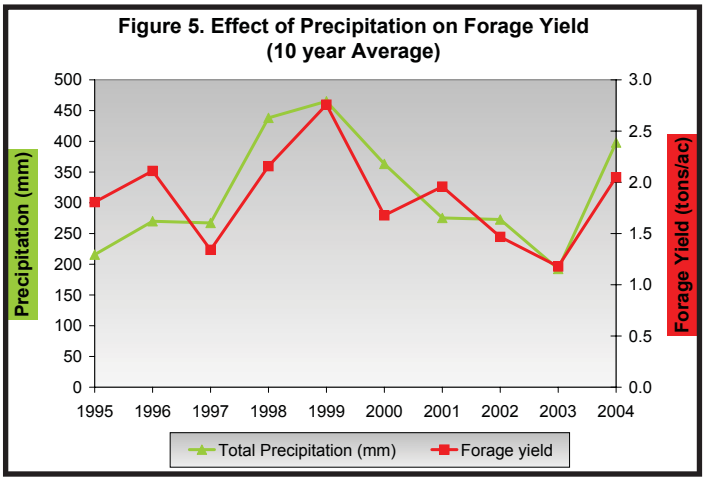


Figure 4. Effect of Precipitation on Carrying Capacity



growing seasons of this study, reducing the effectiveness of added fertilizer.

The same trend is seen in Figure 5, which shows the relationship between precipitation during the growing season (green) and forage yield (red) for the ten years of the study.



Conclusion & Recommendations

Adding alfalfa to grass-based pastures at the time of seeding is one of the most cost-effective methods of increasing forage production, stocking rate, and total gain per acre. Table 3 shows that applying fertilizer to either grass-only or alfalfa-grass pastures increased carrying capacity by more than 90% compared to unfertilized grass only-pastures. However, the fertilizer cost for alfalfa-grass pastures was less than half of that for grass-only pastures. More importantly, unfertilized alfalfa-grass pastures increased carrying capacity by more than 40% with no fertilizer cost.

Table 3. Carrying Capacity and Fertilizer Cost for Different Pasture Management Strategies

Management strategy	Increase in carrying capacity compared to unfertilized grass only pastures	Fertilizer cost per acre (2007 cost)
Alfalfa-grass unfertilized	43%	$0
Alfalfa-grass fertilized	99%	$31
Grass only fertilized	93%	$65

Adding fertilizer also increased the productivity of grass-based pastures. However, maximum target forage yields were often not achieved even though fertilizer was applied to full soil test recommendations. Because of moisture limitations on the sandy loam soil used in this study, adding commercial fertilizer to full soil test recommendations is not economically justifiable in most years. This is especially true as fertilizer costs rise. However, improved productivity could be achieved with much lower rates of fertilizer. Further studies are needed to establish these economic and productive thresholds.

Even though pasture improvements like adding alfalfa and/or fertilizer can increase forage yield, this extra productivity does not necessarily translate into the same increase in stocking rate and carrying capacity. The higher quality forage did increase individual animal gain, but it also increased forage consumption per animal. The result was lower-than-predicted carrying capacities and total gain per acre on pastures with added fertilizer and/or alfalfa.

Despite lower-than-predicted carrying capacities, adding alfalfa to grass-based pastures without applying

fertilizer was the most profitable of the four pasture management strategies. However, it is important to realize that alfalfa content in pastures tends to decline consistently over time. Good grazing management practises like shorter grazing periods and longer rest periods, especially as plants are entering into fall dormancy, can reduce or limit the rate of decline of alfalfa plants in the stand. Good grazing management will allow the benefit of including alfalfa to be optimized.

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