Short duration grazing on alfalfa
by Rodolfo Abel Agustinho

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agronomy
Montana State University

Abstract:
Livestock grazing alfalfa (Medicago sativa L.) usually have higher average daily gains and higher total gains per hectare than livestock grazing pure grass pastures. Problems of stand maintenance and weed encroachment occur if grazing management is not adequate. A grazing method that maintains alfalfa stands and prevents weed encroachment is needed.

This study was conducted to determine the effect of ten Short Duration Grazing (SDG) treatments by comparison of these treatments with traditional grazing and haying treatments. Field studies were conducted at two locations, and greenhouse studies were performed with two alfalfa cultivars in 1987. Information on forage production, plant morphology and accumulation of root reserves was obtained. The best forage production was obtained under hay and traditional grazing treatments. Forage production decreased with increased clipping stress. Leaf area decreased in all the SDG treatments with successive harvests. Leaf area variability increased with high clipping stressed. The ratio of axial bud:crown bud did not produce a defined response. Root reserve accumulation was similar at greenhouse and field studies. Total nonstructural carbohydrates were lower with the high stress treatments and higher with the traditional grazing and hay treatments. Forage quality increased with clipping stress but was high under all treatments.

Forage quality and distribution throughout the season were also considered in the evaluation of the grazing systems.

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APPROVAL

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Rodolfo Abel Augustinho

This thesis has been read by each member of the author's graduate committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

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CHAPTER 1

INTRODUCTION

Alfalfa (Medicago sativa L.) is the most important forage crop in the world. It is very high yielding, has excellent nutritional quality and is very widely adapted.

Most research has been conducted on how to improve alfalfa's hay production, and only limited research has been conducted on how to best manage alfalfa as a pasture crop. Grazing decreases alfalfa stand life and allows for rapid weed encroachment. A better grazing management system for alfalfa is needed.

Short Duration Grazing (SDG) has been used effectively on other forage species but has not been evaluated for use on alfalfa. The objective of this study was to evaluate the effect of various SDG treatments on alfalfa's yield, morphological characteristics, root reserves, and nutritional value.

CHAPTER 2

LITERATURE REVIEW

History

Alfalfa is the most important forage crop in the world and is grown on more than 33 million hectares (ha) worldwide (5). Alfalfa has a long history as a forage crop. Ancient civilizations (Persians, Medes, Romans) utilized alfalfa to feed domestic animals. Alfalfa was used in Turkey more than 3000 years ago. This geographic area appears to be the main distribution point of alfalfa during its early dissemination (5).

Alfalfa was introduced to the new world by Spanish conquerors shortly after the discovery of America. Initial use was only in South America (81).

In 1851 seed from Chile was planted in California. From this time, an impressive invasion occurred in two periods. For the first 50 years, alfalfa spread primarily throughout the western States. Since the turn of the century, expansion has been primarily in the central and the eastern United States (31). Currently, more than 50% of the alfalfa hectareage is in the midwestern and eastern United States (36,44).

Severe droughts occurred between 1934 and 1936, and alfalfa during this time yielded much better than the common forage crops

(Timothy--Phleum pratense L. and clovers--Trifolium spp.). This greatly improved alfalfa's popularity and resulted in an explosive expansion of the crop in the eastern States (82).

Other factors important to this expansion include: genetic improvement (decreased winter kill and improved pest resistance); adjusting the soil environment (liming and fertilization); improved seed bed preparation and seeding techniques; discovering the physiological principles for crop management (hay and pasture); improved nitrogen fixation (better rhizobia); and new knowledge about pesticides (19).

Cutting Frequency

Many agronomic studies have been conducted on alfalfa. They can generally be divided into hay production and grazing utilization.

Most research has been done on hay production and has generally concentrated on maximizing yield and stand life (especially as affected by winterkill). Research conducted early in this century is considered to include some classic studies.

In 1916, McKee (52) stated that very little work had been done to determine the effect of clipping on subsequent yields of alfalfa. Some state Agricultural Experiment Stations were advising against clipping, while others claimed better weed control, invigorated growth, and greater root development from clipping.

In 1924, Graber (29) stated that alfalfa's response to various cutting treatments was pronounced. Forage yield, stand longevity, plant vigor, and winter hardiness were greatly affected by cutting frequency at various growth periods. Plants were cut three, four, five, and six times per year. He concluded that

> ...the lessened vigor, diminution of stands, and consequent lower yields from early and frequent cutting of alfalfa was in part due to: 1) lack of sufficient root reserves for normal growth or an exhaustion of the reserves sufficient to cause actual death; 2) lessened absorptive capacity of plant roots for nutrients; 3) competition from encroaching weeds and grass due to less vigorous plants and thinning stands; and 4) greater susceptibility to winter-killing of plants with low food storage.[1]

Graber (29) stated

> A better understanding of the chemical and biological nature of root reserves, their utilization and disposition may well prove significant in the improvement of some of our field practices, such as the proper maintenance of our hay crops, pastures and lawns, the eradication of certain weeds, and the solution of many of our winter-killing difficulties.[2]

This basic knowledge persisted for several years and was used as a basis for many studies by other researchers (1,30,32,39,56,90,95) who generally confirmed his findings about alfalfa growth behavior.

In 1930, Willard (95) found that extensive reductions of alfalfa root reserves, as measured by total root weight per hectare, consistently resulted in reduced yield and vigor. He did not mention the kind of root reserves.

Cooper and Watson (16) reported on the Total Available Carbohydrates (TAC) in roots of sainfoin (Onobrychis viciifolia

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[1]Graber, L. F. 1924. Hay crops: the growth of alfalfa with various cutting treatments. J. Am. Soc. Agron. 16. Page 172.
[2]Ibid.

Scop.) and alfalfa under several management regimes. They concluded that cutting treatments had little effect on the final TAC level in roots of either species at the end of the growing season.

Reynolds (65) compared nonstructural carbohydrates trends in alfalfa roots with six harvest frequencies (eight, six, five, four, three, and two cuts per year). He obtained the lowest forage yield and the lowest carbohydrate levels with the eight-cut treatment. Many other researchers (4,21,22,23,25,27,55,62,66,72) obtained similar results.

Fall Management

In 1937, Silkett, Megee and Rather (73) analyzed the effect of late summer and early fall cutting on alfalfa winter hardiness in Michigan. They found that total season hay yield from alfalfa cut on critical September dates was significantly less than that of plants which were not cut on these dates. Alfalfa plants cut in September were more susceptible to winter injury.

Rather and Dorrance (64) used sheep to graze the plots during the fall and arrived at similar results. Many researchers (22,33,39,45,51,71,75) have corroborated their findings.

A recent study by Tesar and Yager in 1985 (89) contradicts previous ideas concerning fall management. They state that the third cutting may be made in September or early October in southern Michigan without decreasing subsequent yield or stand persistence. Perhaps the cultivars they were testing had better winterhardiness than cultivars previously studied. Their findings are not in agreement with a recent Montana study (Welty and Ditterline, unpublished data) who found that cutting alfalfa 15-30 days prior to a killing frost severely reduced stand life and yield.

Many researchers attempted to obtain higher production through an increased number of cuttings per year (1,9,20,21,39,41,42,43,46, 47,54,58,59,65,77,78,85,86,88,92,96,97). All studies analyzed alfalfa production under hay management and found decreased yield with increased cutting frequency.

Grazing Alfalfa

There are a limited number of studies related to alfalfa under grazing, and most studies were conducted with alfalfa in mixtures with grasses (1,7,11,12,13,15,23,24,82,85,92,94,97).

In 1924, Cox (19) stated that the alfalfa's value as a pasture crop was becoming better understood but that little research has been done to compare alfalfa with other legumes and with pasture grasses.

Some of the research that followed was done under range conditions (7,11,12,15), and most studies were conducted using simulated grazing. Simulated grazing studies have received criticism, and there is still no agreement on the reliability of these studies (2,7,13,18,49,50,63,91). The main objection is that different results in forage production are obtained under simulated grazing than with grazing animals.

In 1984, Counce, Bouton, and Brown (17) studied alfalfa persistence under mowing and continuous grazing. They reported that the prospects for selecting alfalfa for persistence under grazing was promising, but that such selection could lead to less productive alfalfa cultivars unless care is taken to insure productivity as well as persistence.

In 1939, Hildebrand and Harrison (39) analyzed alfalfa production under a wide combination of frequencies and clipping intensities. They cut alfalfa every 7, 14, and 30 days to heights of 2.5, 7.5, 15, 22.5, and 30 cm. They concluded that: 1) cutting alfalfa frequently and close to the crown resulted in depleted food reserves in the roots and markedly decreased hay yield and plant vigor; 2) alfalfa cut frequently at 30 cm resulted in decreased yield due to leaf loss from mature stems and a lack of vegetative growth; 3) alfalfa remained vigorous when cut back to a 15 cm height either biweekly or monthly. One-week intervals between cuttings failed to allow sufficient stored food to maintain the plant under unfavorable periods of growth; 4) cutting back to the 22.5 cm level resulted in good yields of top growth and roots when cut at weekly or biweekly intervals, whereas the monthly interval of cutting allowed the plants to mature and retarded vegetative growth; and 5) although cutting at 30 cm resulted in an abundance of food storage, the top growth yield above the cutting level was relatively low due to the maturing of the tops below the cutting level.

In 1958, Gross et al. (34) conducted a simulated grazing experiment. They harvested several alfalfa cultivars whenever plant height reached 20 cm. They obtained five and six harvests per year, but dry matter production was lower compared with traditional hay management. They concluded that frequent cutting depressed the yields of all cultivars.

Dennis et al. (21) conducted a three-year study with different clipping frequencies. They began harvesting each season when the alfalfa was 20 cm tall and harvested every one, two, three, four, and six weeks. Alfalfa yield was associated with cutting interval. The more often alfalfa was cut, the less productive it became. Weed invasion increased, and root production and winter survival of alfalfa decreased in all plots cut frequently. Regrowth was stimulated by frequent cutting for a short period, after which new growth was curtailed.

Most recently, Veronesi et al. (93) conducted a study looking for tolerance to frequent cutting regimes. They performed two cycles of phenotypic recurrent selection on alfalfa for its ability to withstand frequent harvesting and evaluated the selected material by harvesting when the plants' height reached 0.30 m, 0.45 m, and 1/10 bloom. The selected alfalfa yielded more than the control for all treatments. The highest yield was obtained with the 0.30 m cutting level. They concluded that the selected alfalfa had increased persistence, dry matter, and crude protein yield within each harvest treatment, but the selection did not eliminate the differences among harvest treatments. They felt the common farming technique of cutting alfalfa at 1/10 bloom was best for exploiting alfalfa's potential, even with materials selected for tolerance to frequent cutting regimes.

A relatively new grazing system called Short Duration Grazing (SDG) has been successfully used on range and pasturelands (grasses) in southern Africa and the United States (28,38,40,61,87). This system involves subdividing existing range or pasture units into several paddocks (37,67) and grazing each paddock at a high stocking densities for a short time period so that all plants are uniformly grazed (69). All SDG studies have been conducted in areas with different climatic conditions than Montana's and with different types of vegetation (mainly grasses).

In 1980, Savory and Parson (68) described some of the main points of the grazing system. They state that it is not possible to work under rigid preconceptions. The stock (cattle, sheep or goats) are concentrated into substantial herds wherever possible for the desired herd effect of trampling, dunging, and urinating as they move around the paddock. The concentrated stock are held in each paddock for a very short time through the vegetation's growing months. These short periods are ideally anything from one day to about five days. The short grazing periods are interspersed with short rest periods ranging from 30 to 60 days. On planted pastures and with rhizomatous grasses, these rests are further reduced but not, as a general rule, on native range. Stocking rates are generally increased as soon as it is considered safe. The method is generally, but not always, applied through the use of a grazing cell layout of fencing. These areas, or cells, are developed with very simple, inexpensive fencing from a central point called a cell center. The cell center generally contains water and whatever handling facilities are desired. There are several variations of this theme depending upon topography, herd structures, and fixed features of the ranch.

Alfalfa has not been evaluated using this grazing management system.

CHAPTER 3

MATERIALS AND METHODS

Yield studies were established in the spring of 1986 at the Arthur H. Post Field Research Laboratory near Bozeman, Montana, and at the Northwestern Agricultural Research Center near Kalispell, Montana, to evaluate the effect of different harvest regimes on alfalfa. Two cultivars (Spredor II and Maxim) were seeded in a randomized complete block design with 13 harvest treatments per cultivar, and four replications (Tables 1, 2, and 3). Treatments one to nine were a 3 x 3 factorial of cutting frequency and cutting intensity. Cutting frequencies were 8, 16 and 32 days and cutting intensities were 67, 50 and 33 percent topgrowth removal (Table 1). Treatment 10 was a graduated Short Duration Grazing (SDG) treatment with variable harvesting frequencies and intensities. Plots were cut frequently, but at low intensities early in the grazing season and were cut less frequently but with greater intensity later in the season (Table 2). Treatments 11-13 were controls in which the alfalfa was harvested using traditional grazing and hay (Table 3).

Table 1. Factorial arrangement of clipping frequencies and intensities used to evaluate alfalfa's response to simulated Short Duration Grazing at Bozeman and Kalispell, MT, 1987.

TREATMENT IDENTIFICATION (#)	(ident.)	DAYS BETWEEN HARVEST (days)	TOPGROWTH REMOVED (%)	TOTAL HARVESTS PER TREATMENT (#)
I	8/67	8	67	14
II	8/50	8	50	14
III	8/33	8	33	14
IV	16/67	16	67	7
V	16/50	16	50	7
VI	16/33	16	33	7
VII	32/67	32	67	4
VIII	32/50	32	50	4
IX	32/33	32	33	4

Table 2. Clipping frequencies and intensities of Graduated Short Duration Grazing (SDG) (Treatment 10) applied on alfalfa at Bozeman and Kalispell, MT, and in the greenhouse, 1987.

HARVEST (#)	TOPGROWTH REMOVED (%)	HARVEST FREQUENCY (days)
1	33	8
2	33	8
3	33	16
4	50	16
5	50	32
6	67	Fall Management

Table 3. Traditional grazing and hay treatments (controls) applied on alfalfa at Bozeman and Kalispell, MT, and the greenhouse, 1987.

TREATMENT (#)	IDENTIFICATION (ident.)	TREATMENT DESCRIPTION
11	Prebud	After initial harvest (same date as the other treatments), it was cut at prebud stage to a height of 10 cm until August 14 (three cuts), then deferred until October 16 (Fall Management harvest)
12	Prebloom	Same as prebud, except at prebloom stage (two seasonal and fall harvest)
13	Hay	Harvested twice at ten percent bloom to a height of 10 cm and Fall Management harvest

Bozeman

1986

The experiment was seeded on May 16, 1986, in a Bozeman silt loam (Argic, Udic, Cryoboroll) soil that had previously been fertilized with 100 Kg/Ha of phosphorus. The fertilizer was incorporated and the seed bed firmly packed. Seeding rate was 11.2 Kg/Ha pure live seed (PLS) and the inoculated seed was planted approximately one cm deep. Plots were 1.5 m wide (five rows 30 cm apart) and 6 m long. A single row of orchardgrass (Dactylis glomerata L.) was established between each plot. The experiment was irrigated as needed to avoid moisture stress.

Management treatments were not imposed the establishment year. Only two hay harvests were made (August 4 and November 21). The plants were cut to a 10 cm height at each harvest. Total Dry Matter production was 3,704 and 3,396 Kg/Ha dry forage at each harvest, respectively.

Weeds were controlled by hand weeding in the establishment and 1.12 Kg/Ha AI Metribuzin [4-amino-6-(1,1-dimethoethil)-3-(methylthio)-1,2,4-triazin-5(4H)-one][3] was applied in November 1986.

1987

Replication one was severely infested with Canada thistle (*Cirsium arvense* (L.) Scop.) and was eliminated from the study. The other three replications were relatively weed free.

All plots (except the traditional hay treatment) were harvested to the appropriate height when the alfalfa was 40 cm tall (May 23), and the harvest management treatments (Tables 1, 2, and 3) were then imposed (Table 4). Only one cultivar (Maxim) was used because weather precluded starting the management treatments on Spredor II at the correct time. The first harvest on the graduated short duration grazing treatment (SDG) was harvested one week earlier (May 15) than the other treatments because it rained immediately after these plots were harvested (Appendix A).

[3]Mention of a trademark, proprietary, product, or vendor is included for the benefit of the reader and does not imply endorsement by Montana State University to the exclusion of other suitable products.

Table 4. Harvest dates at Bozeman and Kalispell, MT, and the greenhouse in 1987.

HARVEST (#)	BOZEMAN (date)	KALISPELL (date)	GREENHOUSE (date)
1	15/15	5/4	4/27
2	5/23	5/12	5/5-7
3	5/31	5/20	5/13
4	6/8	5/29	5/21
5	6/16	6/5	5/29
6	6/24	6/12	6/6-10
7	7/5	6/22	6/14
8	7/13-14	6/29	6/22
9	7/21	7/7	6/30
10	7/29	7/15	7/8-11
11	8/6	7/23	7/16-19
12	8/14	7/31	7/24
13	10/16 (a)	8/7	8/1
14	--	8/14-18	8/9
15	--	9/25 (a)	8/17
16	--	--	8/25 (b)

(a) Fall Management Harvest
(b) Harvest at ground level

Immediately before harvest, plant height (cm) was determined (average of five measurements per plot) in order to calculate the appropriate cutting height for each treatment.

The plots were trimmed to a length of approximately five meters before each harvest. Forage yield was determined by cutting the center two rows of each plot to the appropriate height with a flail