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thesis entitled

A Comparison of Seeding Rates of Four Cool Season Grasses with Alfalfa in Binary Mixtures

presented by

Michael L. Metzger

has been accepted towards fulfillment
of the requirements for

Masters degree in Crop and Soil Sciences

Major professor

Date 8-1-95

A COMPARISON OF SEEDING RATES OF FOUR COOL SEASON GRASSES WITH ALFALFA IN BINARY MIXTURES

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Crop and Soil Sciences

1995

ABSTRACT

A COMPARISON OF SEEDING RATES OF FOUR COOL SEASON GRASSES WITH ALFALFA IN BINARY MIXTURES

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Traditionally, forages have been grown in monocultures for maximum yield and quality. With the renewed interest in grass-legume mixtures for sustainable forage production in Michigan concerns have been expressed for the impact of grass seeding rate and the relationship on forage biomass. Thus, a randomized complete block experiment was designed to evaluate the effect of varying the grass seeding rate when the alfalfa seeding rate was constant on grass dry matter yield, alfalfa dry matter yield, total dry matter yield, and forage quality at three cutting dates for four harvests. In most cases the binary mixtures produced a higher yield of total dry matter than the alfalfa seeded alone. In many cases seeding grasses with legumes reduced the weed component only during the first harvest of following seeding and not in subsequent harvests.

ACKNOWLEDGMENTS

I would like to thank the many people who helped with my research along the way. Many thanks go to Dr. Moline for his patience and understanding. I would also like to thank my parents for the support. They seemed to know when to push and when to stand back and watch. I would like to thank Rusty Plummer, who was the technician who helped me get the research established. I would also like to thank Dana Barclay and John Gingras who helped with the final presentation of the data. There were also several undergraduates and others who helped along the way. A thank you to you all.

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INTRODUCTION

Forage legumes are an important part of feeding ruminant livestock, because animals can efficiently convert these fibrous feeds into meat, milk, and fiber. In the United States there has been a traditional emphasis placed upon high legume yields. Alfalfa (*Medicago sativa* L.) is one of the primary forage legumes used for animal feeds in the north, central, and western regions of the USA. It has the highest feeding value of all commonly grown hay crops (Marten, et al. 1988)

Grass-legume forage mixtures are an important part of animal agriculture in the temperate United States and Canada (Casler 1988). In recent years there has been a renewed emphasis on putting animals on pastures (Michigan Ag. Statistics). Alfalfa alone when grazed has a high potential to cause bloat in ruminant animals. On the other hand when grass is growing in combination with alfalfa, the bloat hazard is much less (Casler and Carlson 1995). Other advantages of using mixtures over pure stands of either grass or alfalfa include erosion and weed control and prolonged stand longevity (Drolsom and Smith, 1976). Potential disadvantages are differences in growth habit, regrowth potential and physiological growth requirements, which often prohibit effective use of management techniques to maintain the components of the mixture (Casler, 1988). In 1986, Smith et al. determined that even if both parts of the binary mixture could be maintained that it was

even more difficult to maintain them at a specified level. This becomes very difficult to achieve when trying to manage the mixture based on the needs of only one component of the mixture (Smith, 1968).

Several temperate grasses are commonly grown with alfalfa for pasture, hay, or silage in the temperate zone of the United States and Canada. Management of the binary mixtures is usually based on traditional monoculture alfalfa management criteria (Smith et al, 1986). Bromegrass (*Bromus inermis* L.), orchardgrass (*Dactylis glomerata* L.), and timothy (*Phleum pratense* L.) are all commonly grown with alfalfa throughout the northern United States (Casler and Carlson 1995, Christie and McElroy 1995, McElroy and Kunelius 1995). Ryegrass (*Lolium perenne* L.) tends not to be as persistent as other perennial temperate grasses and is grown where the winters tend to be less harsh (Balasko, Evers, and Duell 1995). Performance of grass-legume mixtures is possibly not being optimized (Rogers, 1966), because the best cultivars for pure stands are not necessarily the best for mixtures with alfalfa (Casler and Drolsom, 1984; Weiss and Mukerji, 1950; Wilsie, 1949). Also, it is possible that some cultivars producing large amounts of seeds could be dominating the markets regardless of forage production (Casler, 1988). High productivity in pure stands is often associated with poor competitive ability in mixed stands (van den Bergh, 1968 and Rhodes, 1969). In 1949 Wilsie concluded that yield testing of binary mixtures cannot be replaced by pure stand yield trials. A major limitation for some of the grasses, including timothy and smooth bromegrass, has been their persistence under three cut systems that are harvested for hay or silage (Smith, 1968).

Establishment seeding rates for binary mixtures of grass and alfalfa were originally set up on a seeds per square foot basis (Ahlgren 1956). Wheeler in 1950 recommends 10 pounds of alfalfa and 6 to 8 pounds of bromegrass when grown for hay. He also recommends that 5 to 8 pounds of orchardgrass be used in grass-alfalfa mixtures. Wheeler also recommends that timothy be sown at 3 to 5 pounds per acre and that the alfalfa should be at 4 to 6 pounds per acre and that ryegrass should be planted at 4 to 6 pounds per acre when used in a mixture for hay or pasture. With increasing costs of production and questions relating to maintainability, we thought it necessary to determine how much grass to seed along with alfalfa.

Materials and Methods

This study was conducted in 1991 at three locations in Michigan: the Michigan State University Campus Teaching and Research Farm in East Lansing, the Southwest Research and Extension Center in Benton Harbor, and the Lake City Experiment Station in Lake City. Soils were tested at all locations, and based upon Michigan State University soil test lab recommendations no fertilizer was applied at establishment.

The plots at all three locations were established by drilling the alfalfa conventionally at 13.4kg/ha, and then broadcasting on the grass seed by hand on to each plot. The plots at the Southwest location were established on June 7, 1990. This location was summer seeded, because irrigation was available for establishment if needed, but there was enough rainfall that no irrigation was applied. These plots were harvested once during the establishment year on August 7, 1990 but no data were taken. The Lake City location was planted on August 3, 1990 and the East Lansing location was planted on August 27, 1990 each in the same manner. Soil types varied by location. The soil type at the CTRC is a Capac loam(Fine-loamy, mixed, mesic Areic Ochraqualfs). The soil type at the LCES is a Nester sandy loam(Fine, mixed Typic Eutroboralfs), and the soil type at the SWMREC is a Selfridge loamy sand(Loamy, mixed, mesic Aquic Arenic Hapludalfs).

Seeding rates were selected based upon the recommended rates. These rates were originally setup based on a seeds per square foot basis. The medium rate (which was the currently recommended rate) was based on 28 seeds per square foot. Timothy was seeded at .45, .89, and 1.78 kg/ha for the low, medium, and high seeding rates respectfully. In the 10 foot by 20 foot plots this corresponded to 1.045g for the low seeding rate plot, 2.091g for the medium seeding rate plot and 4.181g for the high seeding rate plots. Orchardgrass was planted at .89, 1.78, and 3.56 kg/ha for the three seeding rates or 2.091g of seed for the low seeding rate plots, 4.181g of seed for the medium seeding rate, and 8.363g for the high seeding rate plots. Bromegrass at 8.363g for the low seeding rate, 16.726g for the high seeding rate, and 33.451g for the high seeding rate was used in the plots to correspond to 3.56, 7.12, and 14.24 kg/ha for bromegrass. Ryegrass was seeded at 2.2, 4.5, and 8.9 kg/ha. The low seeding rate plots were seeded with 5.267g of seed, the medium seeding rate with 10.453g of seed, and the high seeding rate with 20.097g of ryegrass seed. Alfalfa was seeded at 13.4 kg/ha, or 76 seeds per square foot in all plots.

The plots were scheduled for harvest based on the alfalfa being at one-tenth bloom. Three harvests were taken from each plot during 1991. The weather in Michigan for the 1991 growing season was extremely hot and dry. Yields for the cool season grasses need to take this consideration into account. Samples for dry matter yield were taken randomly from each plot using a quarter meter quadrat. The plant material was cut using hand grass shears. After all plots had been sampled, the entire area was cut using a flail chopper and the plant material hauled away.

Samples were taken to the lab for hand separation of alfalfa, desired grass, and other. These samples were then placed in drying ovens to determine dry matter yield.

Analysis of variance calculations(ANOVA) for DM yields were then performed. Means for DM were separated by Fischer's Protected Least Significance Difference (LSD) test at the 5% level of significance.

Results and Discussion

Campus Teaching and Research Center

First Harvest

Dry matter production in the first harvest of 1991 (Table I), had significant differences due to both grass mixture and seeding rate. The ryegrass mixture produced significantly more dry matter than the orchardgrass or timothy mixtures. There was no statistical differences in yields between ryegrass and bromegrass. Timothy produced significantly more than orchardgrass. There was no significant difference in dry matter yield in orchardgrass due to seeding rate. The high seeding rate of bromegrass produced significantly more dry matter than alfalfa alone during first harvest. Both high and medium ryegrass seeding rate mixtures produced significantly more than both the alfalfa alone or low ryegrass seeding rates during first harvest. The high ryegrass seeding rate produced significantly more than the medium ryegrass mixture. There were no significant differences in forage production between low ryegrass seeding rates and the alfalfa seeded alone. Both the high and the medium seeding rate of timothy yields were significantly more than the low timothy or the alfalfa seeded alone. The were no significant differences in production between the high and the medium timothy or the low timothy and the alfalfa alone.

Based on grass seeding rates, there were significant differences in legume dry matter yield for the first harvest of the 1991 growing season. Orchardgrass, bromegrass,

Table I. First harvest forage yields(DM in kg/ha) for grass-legume seeding rate studies at the CTRC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	2576	0	660	3236
Alfalfa plus Orchardgrass	**High**	1372	1728	860	3960
	Medium	1116	820	636	2572
	Low	1476	596	884	2952
Alfalfa plus Bromegrass	**High**	1836	2352	380	4572
	Medium	1360	1992	716	4068
	Low	1552	1428	912	3892
Alfalfa plus Ryegrass	**High**	1148	5724	252	7124
	Medium	1028	5324	228	5776
	Low	620	3160	204	3980
Alfalfa plus Timothy	**High**	644	4384	324	5352
	Medium	832	3924	660	5412
	Low	980	856	784	2620
LSD.05		**540**	**928**	**416**	**1044**

ryegrass, and timothy produced similar results when legume production was compared with alfalfa seeded alone. Alfalfa alone produced significantly more legume forage than all of the grasses in co-culture with the alfalfa. Also there were no significant differences

in legume dry matter production between high, medium, or low within any of the grass mixtures during first harvest.

The 1991 first harvest had significant differences in grass dry matter production when comparing seeding rate and grass specie mixture. Ryegrass yields were significantly higher in grass dry matter yields than orchardgrass, bromegrass, or timothy. Timothy produced significantly more than orchardgrass or bromegrass. There was no significant difference in grass dry matter production between orchardgrass and bromegrass. The high seeding rate of orchardgrass yields were significantly more in grass composition than the low seeding rate of orchardgrass.. There were no significant differences in grass production between the low and the medium orchardgrass seeding rates or between the high and the medium seeding rates. Bromegrass had no significant differences in grass yields between any of the seeding rates. The high ryegrass seeding rate produced significantly more grass dry matter than the medium seeding rate. The medium ryegrass seeding rate, in turn, produced significantly more grass then the low seeding rate of ryegrass. There was no significant difference in grass dry matter production between the high and the medium timothy seeding rates. Both the high and the medium timothy seeding rates produced significantly more grass than the low timothy seeding rate. There were no significant differences in weed dry matter in any of the treatments during the first harvest of the 1991 growing season. Weed production was negatively correlated ($r=.76$ $P \geq .01$) with grass production($y=5514-4.6957x$) during first harvest following seeding.

Second Harvest

In the second harvest of 1991 (Table II) there were significant differences in total production based only on grass mixture. Bromegrass produced significantly more dry matter than ryegrass or timothy reflecting season of growth. Orchardgrass yields were significantly higher than timothy in the second harvest. There were no significant differences between orchardgrass and bromegrass or between ryegrass and timothy.

Table II. Second harvest forage yields(DM in kg/ha) for grass-legume seeding rate studies at the CTRC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	2852	0	100	2952
Alfalfa plus Orchardgrass	**High**	1364	1548	84	2996
	Medium	1932	1072	12	3016
	Low	1892	476	292	2656
Alfalfa plus Bromegrass	**High**	2204	784	76	3064
	Medium	2456	800	60	3316
	Low	2144	632	24	2800
Alfalfa plus Ryegrass	**High**	1500	908	12	2420
	Medium	2024	424	0	2448
	Low	1400	1096	236	2732
Alfalfa plus Timothy	**High**	1272	724	40	2040
	Medium	1784	404	176	2368
	Low	1448	416	140	2004
LSD.05		**488**	**276**	**104**	**428**

Legume dry matter yields differ

ed significantly based upon grass seeding rates. Alfalfa alone produced significantly more forage than all of the treatments mixed with orchardgrass. The high seeding rate of orchardgrass produced significantly less legume forage than the medium and the low rates of orchardgrass. There was no significant difference in legume dry matter yield between the medium and the low orchardgrass treatments. The high and the low seeding rates of bromegrass produced significantly less legume dry matter than alfalfa seeded alone. There were no significant differences between yields of alfalfa and those of the medium treatment of bromegrass. Bromegrass in co-culture with alfalfa produced no significant differences in legume dry matter production. All of the mixtures that had ryegrass in co-culture with alfalfa produced significantly less than the alfalfa seeded alone. The medium ryegrass seeding rate produced significantly more legume than either the high or the low ryegrass seeding rates. There was no significant difference in legume dry matter production between the high and the low ryegrass treatments. Alfalfa alone produced significantly more legume dry matter than any of the timothy treatments. The medium rate of timothy produced significantly more legume than the high timothy seeding rate during second harvest. There were no significant differences between the medium and the low timothy treatments or between the high and the low timothy treatments.

The second harvest of the 1991 growing season had significant differences in grass dry matter production based on seeding rate only. The high orchardgrass treatment produced significantly more grass than the medium seeding rate. The medium seeding rate yielded significantly more grass than the low orchardgrass treatment. There were no significant differences between bromegrass seeding rates. The medium treatment of

ryegrass produced significantly less grass dry matter than either the and the low ryegrass treatments. There was a significant difference in grass production between the high and the low ryegrass treatments. The high timothy seeding rate yielded significantly more grass than the medium and low rates of timothy. There was no significant difference in grass production between the medium and the low timothy treatments. There were no significant differences among all treatments in the amount of weed dry matter produced in the second harvest of the 1991 growing season.

Third Harvest

The third harvest of forage in 1991 produced many significant differences based only upon grass seeding rates (Table III). Alfalfa seeded alone produced significantly less total dry matter than any of the treatments containing alfalfa orchardgrass in co-culture. The medium seeding rate of orchardgrass produced significantly more total dry matter than the high or the low seeding rates. There were no significant differences in production between the high and the low orchardgrass treatments. The high and the medium seeding rate treatments of bromegrass produced significantly more total dry matter than the alfalfa seeded alone. There were no significant differences between alfalfa alone and the low seeding rate of bromegrass or between the high and the medium seeding rates of bromegrass. Alfalfa seeded alone produced significantly less total dry matter than the

medium and the low seeding rate mixtures of ryegrass. There were no significant

Table III. Third harvest forage yields(DM in kg/ha) for grass-legume seeding rate studies at the Main Campus Experiment Station. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	1348	0	324	1672
Alfalfa plus Orchardgrass	**High**	952	792	176	1924
	Medium	1876	472	304	2652
	Low	1128	480	532	2140
Alfalfa plus Bromegrass	**High**	1664	328	316	2308
	Medium	1464	348	320	2132
	Low	1200	580	128	1908
Alfalfa plus Ryegrass	**High**	1648	176	60	1884
	Medium	1736	128	96	1960
	Low	1796	192	196	2184
Alfalfa plus Timothy	**High**	1556	144	176	1880
	Medium	1888	200	68	2156
	Low	1572	176	324	2072
LSD.05		**240**	**72**	**76**	**252**

differences in yield between alfalfa seeded alone and the high ryegrass seeding rate or between the medium and the low ryegrass seeding rate treatments. The medium and the low timothy seeding rates produced significantly more total dry matter than the alfalfa seeded alone in the third harvest. There were no significant differences between the alfalfa

seeded alone and the high timothy seeding rates. The high, medium, and low timothy seeding rates had no significant differences in production of total yield.

In third harvest 1991, significant differences in legume dry matter yield were based on both grass mixture and seeding rates. There were no significant difference in legume production between the orchardgrass and bromegrass treatments. The orchardgrass treatment produced significantly less legume than either the ryegrass or timothy treatments. The bromegrass mixtures produced significantly less legume than the ryegrass mixtures. The were no significant differences in the amount of legume produced between the bromegrass and timothy mixtures. The medium orchardgrass treatment produced significantly more legume dry matter than the alfalfa seeded alone treatment, the high, and the low orchardgrass treatments. Alfalfa alone produced significantly more legume than the low seeding rate of orchardgrass. There were no significant differences in alfalfa grown alone and the high orchardgrass seeding rate or between the high and the low orchardgrass seeding rates. The high bromegrass seeding rates produced significantly more legume dry matter than alfalfa alone. Both the high and the medium seeding rates of bromegrass produced significantly more legume than the low bromegrass treatment. There were no significant differences between alfalfa alone and the medium or low bromegrass seeding rates. The high and medium bromegrass had no significant difference in legume production. All ryegrass treatments produced significantly less legume dry matter than alfalfa alone. There was no significant difference in legume yield between any of the ryegrass treatments. The medium timothy treatment produced more legume dry matter than alfalfa alone. There were no significant differences in legume yield between

alfalfa alone and the high timothy seeding rate or between alfalfa alone and the low timothy rate.

Grass dry matter yields were significantly different based on grass mixture, seeding rate, and an interaction between the two. The orchardgrass mixture produced significantly more grass dry matter than the bromegrass, ryegrass, or timothy mixtures. The bromegrass mixture produced significantly more grass than the ryegrass or timothy. The were no significant differences in grass yield between the ryegrass and timothy mixtures.

Total Seasonal Yield

Total 1991 seasonal forage yields at the Crops Teaching and Research Center (CTRC) site averaged 8796.5 kg/ha for the growing season (Table IV). Keeping in mind the hot and dry conditions that were experienced during

Table IV. Seasonal averages of DM yield in kg/ha at the CTRC for 1991.

	Legume	Grass	Weeds	Total
Alf/Orchardgrass	4970	1994	1216	8179
Alf/Bromegrass	5664	2311	1003	8978
Alf/Ryegrass	4917	4081	591	9590
Alf/Timothy	4688	2807	944	8439

the growing season these were very good yields. There were significant differences among grass seeding rates for total 1991 yields(Table V). The orchardgrass treatments were not significantly different in total forage production for the growing season. The high and the medium seeding rates of bromegrass produced significantly more than the alfalfa seeded alone. The high seeding rate of bromegrass had a significantly higher yield than the low seeding rate of bromegrass. There were no significant differences in total

Table V. Total forage yields(DM in kg/ha) for grass-legume seeding rate studies at the CTRC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	None	6776	0	1080	7856
Alfalfa plus Orchardgrass	High	3689	4066	1122	8877
	Medium	4920	2364	951	8235
	Low	4494	1546	1709	7749
Alfalfa plus Bromegrass	High	5708	3465	772	9944
	Medium	5282	3140	1094	9516
	Low	4892	2639	1064	8596
Alfalfa plus Ryegrass	High	4293	6807	326	11426
	Medium	4786	5071	324	10181
	Low	3815	4448	635	8897
Alfalfa plus Timothy	High	3473	5256	542	9271
	Medium	4501	4526	905	9932
	Low	4001	1447	1249	6697
LSD.05		988	992	488	1152

yield between the high and the medium bromegrass or between the medium and the low bromegrass treatments. The high and the medium seeding rates of ryegrass produced significantly more total biomass for the growing season than either the low ryegrass treatment or the alfalfa alone. There were no significant differences in production between the high and the medium ryegrass seeding rates or between the low seeding rate and alfalfa alone. The medium seeding rate of timothy produced significantly more total forage than the low timothy seeding rate and alfalfa alone. There were no significant differences between alfalfa alone and the low timothy seeding rate or between the high and the medium timothy seeding rates. There was no significant difference between the high, medium, or low bromegrass seeding rate.

The legume portion of the total seasonal yield for the 1991 growing season had significant differences in production based only on seeding rates at this location Table V). There was significantly more legume produced in the alfalfa seeded alone plots than in any of the alfalfa orchardgrass co-culture treatments. The medium seeding rate of orchardgrass produced significantly more legume dry matter than the high seeding rate of orchardgrass. There were no significant differences in legume production between the high and the low orchardgrass seeding rates or between the medium and the low orchardgrass seeding rates. The alfalfa alone treatment also produced significantly more legume than either the medium or the low bromegrass seeding rates. There were no significant differences in legume production between alfalfa alone and the high seeding rate of bromegrass or between the medium and the low seeding rates of bromegrass. The ryegrass treatments all produced significantly less legume dry matter than the alfalfa seeded alone treatment.

There were no significant differences between the high, medium, or low ryegrass seeding rates. Alfalfa alone produced significantly more legume dry matter than any of the timothy alfalfa treatments. The medium seeding rate of timothy produced significantly more legume than the high seeding rate of timothy. There were no significant differences between the medium and the low timothy seeding rates or between the high and the low timothy seeding rates.

There were significant differences in total grass production based on both grass used in the mixture as well as grass seeding rate. The ryegrass mixtures produced significantly more grass than either the orchardgrass, bromegrass, or timothy. There were no significant differences between orchardgrass, bromegrass or timothy. The high seeding rate of orchardgrass produced more grass than the medium or the low orchardgrass seeding rate treatments. There was not a significant differences between the medium and the low seeding rate of orchardgrass for grass production. There were no significant differences in grass production among bromegrass seeding rates. The high seeding rate of ryegrass produced significantly more grass dry matter than the medium and the low ryegrass seeding rates. There was no significant difference in grass production between the medium and the low ryegrass treatments. Both the high and the medium seeding rates of timothy produced more grass than the low timothy seeding rate. There was no significant difference in grass yield between the high and the medium timothy seeding rate. There were no significant differences in weed production among all treatments for the total 1991 growing season.

In summary, forage yield analysis at the CTRC demonstrated the complexity of analysis for management purposes. These yields were also affected by the hot dry weather during the growing season. From component analysis, 1) weeds were 42% in all mixtures and negatively correlated ($r=-.86$ $P \geq .01$) to total grass yields ($y=1693-.21507x$). 2) more forage was produced with grass-legume co-culture than with alfalfa seeded alone. 3) while ryegrass + alfalfa gave the highest total yield for the season it had the lowest alfalfa and weed component.

Lake City Experiment Station

First Harvest

Given the hot and dry growing conditions for the 1991 season at the LCES, forage yields were very good. The total forage yield for the first harvest at the LCES of the 1991 growing season had no significant differences for either grass mixture or seeding rate. There were significant differences in legume yield based on mixture only (Table VI). The orchardgrass mixture produced significantly more legume dry matter than the bromegrass, ryegrass, or timothy. There were no significant differences in legume yield between bromegrass, ryegrass, or timothy.

Grass yields for the first harvest had significant differences based on both grass mixture and seeding rate. The orchardgrass mixture produced significantly less grass dry matter than the bromegrass, ryegrass, and timothy. The ryegrass mixture produced significantly more grass dry matter than the bromegrass. There was no significant yield

Table VI. First harvest forage yields(DM in kg/ha) for grass-legume seeding rate studies at the LCES. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	None	2240	0	936	3172
Alfalfa plus Orchardgrass	High	3016	260	772	4044
	Medium	2924	340	500	3764
	Low	3348	152	632	4128
Alfalfa plus Bromegrass	High	688	2112	740	3540
	Medium	2016	1508	708	4228
	Low	1544	828	556	2928
Alfalfa plus Ryegrass	High	1256	2460	740	4456
	Medium	1124	2240	556	3924
	Low	1972	2804	1228	6008
Alfalfa plus Timothy	High	1484	2792	312	4592
	Medium	2044	1644	480	4172
	Low	2232	1436	180	3844
LSD.05		656	588	300	740

difference between bromegrass and timothy or between ryegrass or timothy. The orchardgrass treatments had no significant differences between seeding rates. The high seeding rate of bromegrass produced significantly more grass dry matter than the medium or the low bromegrass treatments. The medium seeding rate had significantly more grass dry matter than the low bromegrass seeding rate. The low ryegrass treatment produced significantly more grass than the medium ryegrass treatment. There were no significant

differences in yield between the high ryegrass treatment and the medium ryegrass treatment or between the high and the low ryegrass treatments. There were no significant differences in weed dry matter during the first harvest of the 1991 growing season at the LCES.

Second Harvest

The total dry matter yield for the second harvest of the 1991 growing season had significant differences based on grass mixtures and seeding rate (Table VII). The orchardgrass, bromegrass, and timothy mixtures produced significantly more forage than the ryegrass mixture. Alfalfa alone produced significantly less total dry matter than the high, medium or low orchardgrass seeding rates. The medium orchardgrass produced significantly less than the low orchardgrass treatment. The was no significant differences in total yield for second harvest between the high and the low orchardgrass seeding rates. The high, medium, and low seeding rates of bromegrass produced significantly more total yield than alfalfa alone. There were no significant differences in second harvest total yield between the high and the medium bromegrass treatments or between the medium and the low bromegrass treatments. The low seeding rate of ryegrass produced significantly more total yield than the high seeding rate of ryegrass. There were no significant differences in total yield production between the clear seeded alfalfa, the medium, or the low ryegrass

Table VII. Second harvest forage yields(DM in kg/ha) for grass-legume seeding rate studies at the LCES. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	1940	0	52	1992
Alfalfa plus Orchardgrass	**High**	1251	1328	60	2642
	Medium	1810	516	24	2352
	Low	1858	698	108	2667
Alfalfa plus Bromegrass	**High**	1553	748	24	2304
	Medium	1364	1002	40	2405
	Low	1373	1181	92	2657
Alfalfa plus Ryegrass	**High**	1119	757	40	1916
	Medium	1113	883	40	2041
	Low	1282	904	32	2221
Alfalfa plus Timothy	**High**	2184	480	16	2680
	Medium	1947	726	88	2767
	Low	2200	446	12	2660
LSD.05		**244**	**160**	**20**	**280**

seeding rates. All timothy co-culture treatments produced significantly more total yield for the second harvest than the alfalfa alone treatment. There was no significant differences between the high, medium, or low timothy seeding rate.

The legume yield for the second harvest of the 1991 season at Lake City had significant differences based on both grass mixture and seeding rate. The timothy mixture produced significantly more legume dry matter than orchardgrass, bromegrass, or ryegrass

mixtures. The legume yield in the ryegrass mixture was significantly less than the orchardgrass mixture for the second harvest. There were no significant differences in yield between orchardgrass and bromegrass or between bromegrass and ryegrass for the second harvest. The alfalfa alone treatment had significantly more legume yield than the high seeding rate of orchardgrass for this harvest period. However, there was significantly less legume dry matter in the high orchardgrass seeding rate than in the medium and the low seeding rates of orchardgrass. There were no significant differences in legume yield between the medium and the low orchardgrass seeding rate. The alfalfa alone treatment produced significantly more legume dry matter than any of the bromegrass co-culture seeding rates. There were no significant differences in legume yield between the high, medium, or low bromegrass seeding rates. Alfalfa alone produced significantly more legume dry matter in the second harvest than any of the ryegrass co-culture treatments. there was no significant difference in legume yield between the high, medium, or low ryegrass seeding rates. The low seeding rate of timothy produced significantly more legume dry matter than the clear seeded alfalfa or the medium seeding rate of timothy. The high seeding rate of timothy also produced significantly more legume than the clear seeded alfalfa. There were no significant differences in legume production between the alfalfa seeded alone and the medium seeding rate of timothy, between the low and the high seeding rates of timothy, or between the high and the medium seeding rates of timothy.

Grass yield also had significant differences in yield due to grass mixture, seeding rate, and an interaction between the two during the second harvest at the LCES. The timothy mixture produced significantly less grass than the orchardgrass, bromegrass, or

ryegrass. There were no significant differences in yields between orchardgrass, bromegrass, or ryegrass. The high seeding rate of orchardgrass produced significantly more grass than the low or the medium seeding rate of orchardgrass. The grass yield for the low seeding rate was significantly higher than the medium seeding rate. The high bromegrass treatment produced significantly less grass than the medium and the low seeding rates. The low bromegrass seeding rate had significantly higher grass yields than the medium seeding rate of bromegrass. There were no significant differences in grass yield between any of the ryegrass treatments. The grass yield for the medium timothy seeding rate was significantly higher than either the high or the low timothy treatments. The was no significant difference in grass yield between the high and the low timothy seeding rates for the second harvest. There were no significant differences in weed dry matter production for the second harvest in 1991 at the LCES.

Third Harvest

There were no significant differences in total forage production for the third harvest at the LCES. Legume production had significant differences based on grass mixtures and seeding rates during the third harvest (Table VIII). The timothy mixture produced significantly more legume dry matter than the orchardgrass, bromegrass, or ryegrass mixtures. There was significantly more legume dry matter in the alfalfa alone treatment than in any of the orchardgrass co-culture treatments. The medium and the low orchardgrass seeding rates produced significantly more legume than the high seeding rate

Table VIII. Third harvest forage yields(DM in kg/ha) for grass-legume seeding rate studies at the LCES. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	1320	0	200	1519
Alfalfa plus Orchardgrass	**High**	658	1177	256	2091
	Medium	1038	737	243	2017
	Low	913	637	204	1755
Alfalfa plus Bromegrass	**High**	771	434	335	1540
	Medium	961	392	223	1576
	Low	904	255	261	1420
Alfalfa plus Ryegrass	**High**	623	1041	244	1907
	Medium	960	564	148	1673
	Low	702	845	221	1768
Alfalfa plus Timothy	**High**	1323	302	252	1877
	Medium	1207	352	200	1760
	Low	1111	325	148	1585
LSD.05		**160**	**100**	**44**	**216**

of orchardgrass. There was no significant difference in legume dry matter yield between the medium and the low seeding rates of orchardgrass during the third harvest. Alfalfa alone produced significantly more legume dry matter than any of the bromegrass co-culture treatments. The medium rate of bromegrass produced significantly more legume dry matter than the high bromegrass seeding rate. There were no significant differences in legume production between the medium and the low bromegrass seeding rates or between

the high and the low bromegrass seeding rates. Legume yield for the alfalfa alone treatment was significantly higher than all of the ryegrass co-culture seeding rates. The medium seeding rate of ryegrass produced significantly more legume than either the high or the low seeding rate of ryegrass during the third harvest. There was no significant difference in legume production between the high and the low ryegrass treatments. The high seeding rate of timothy and alfalfa alone produced more legume dry matter than the low seeding rate of timothy. There were no significant differences in legume production between the medium and the low timothy seeding rates or between the alfalfa, timothy high, and timothy medium treatments.

Grass dry matter yields for the third harvest at the LCES had significant differences based on grass mixtures, seeding rate, and an interaction between the two. The orchardgrass and ryegrass mixtures both produced more grass dry matter than either the bromegrass or timothy. The were no significant differences between orchardgrass and ryegrass or between bromegrass and timothy. The high seeding rate of orchardgrass produced significantly more grass than either the medium or the low orchardgrass seeding rates. There was a significantly higher grass yield in the medium orchardgrass treatment than in the low orchardgrass seeding rate. The high and the medium seeding rates of bromegrass produced significantly more grass than the low bromegrass seeding rate. There were no significant differences between the high and the medium bromegrass treatments. The grass yields for the high ryegrass seeding rates were significantly higher than the medium and the low ryegrass seeding rates. The low ryegrass treatment produced significantly more grass dry matter than the medium ryegrass treatment for the third

harvest. There were no significant differences in grass dry matter production between the timothy seeding rates. There were no significant differences in weed production during the third harvest of 1991 at the LCES.

Total Seasonal Yield

There were significant differences in total forage yield due to seeding rates only (Tables IX, X). All treatments with orchardgrass in co-culture with alfalfa produced

Table IX. Seasonal average of DM yield in kg/ha for the LCES in 1991.

	Legume	Grass	Weeds	Total
Alfalfa/Orchardgrass	5575	1461	998	8034
Alfalfa/Bromegrass	4163	2115	1043	7321
Alfalfa/Ryegrass	3914	3125	1110	8150
Alfalfa/Timothy	5308	2126	721	8155

significantly more forage than alfalfa alone. There were no significant differences between orchardgrass seeding rates. Clear seeded alfalfa and the low seeding rate of bromegrass produced significantly less total forage than the medium bromegrass seeding rate. There were no significant differences between alfalfa alone and the low seeding rate or between the high and the medium seeding rate. The ryegrass co-culture treatments produced significantly more total forage than clear seeded alfalfa. The low seeding rate of ryegrass produced significantly more dry matter than either the high or the medium ryegrass

seeding rate. There was no significant difference in yield between the medium and the high ryegrass seeding rates. The was significantly less total forage production in clear

Table X. Total seasonal forage yields(DM in kg/ha) for grass-legume seeding rate studies at the LCES. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	5499	0	1185	6684
Alfalfa plus Orchardgrass	**High**	4926	2764	1089	8779
	Medium	5757	1594	773	8124
	Low	6117	1486	946	8549
Alfalfa plus Bromegrass	**High**	2995	3296	1094	7385
	Medium	4340	2901	970	8211
	Low	3818	2264	921	7003
Alfalfa plus Ryegrass	**High**	3002	4259	1020	8281
	Medium	3202	3687	750	7639
	Low	3955	4554	1486	9995
Alfalfa plus Timothy	**High**	4992	3575	581	9148
	Medium	5200	2722	775	8697
	Low	5542	2205	372	8089
$LSD_{.05}$		**792**	**592**	**340**	**944**

seeded alfalfa than in the timothy alfalfa co-culture treatments. The high seeding rate of timothy produced significantly more than the low seeding rate of timothy. There was no

significant difference between the high and the medium seeding rates of timothy or between the medium and the low timothy seeding rate.

There was a significant difference in legume yield for the 1991 growing season based on grass mixture and seeding rate. The timothy and orchardgrass mixtures produced significantly more legume than the bromegrass or ryegrass mixture for the total growing season. There was no significant difference in legume yield between timothy and orchardgrass or between bromegrass or ryegrass. The medium and the low seeding rate of orchardgrass produced significantly more legume than the high seeding rate of orchardgrass. There were no significant differences between the medium seeding rate of orchardgrass, the low seeding rate of orchardgrass, or alfalfa alone or between the high seeding rate of orchardgrass and alfalfa alone. Alfalfa alone produced significantly more legume during the 1991 growing season then any of the bromegrass/alfalfa co-culture seeding rates. There was significantly less legume produced in the high bromegrass seeding rate treatment than in either the medium or low seeding rate treatments. There were no significant differences in legume yield between the medium and the low seeding rate of bromegrass. Clear seeded alfalfa produced significantly more legume than any of the ryegrass/alfalfa co-culture treatments. The high seeding rate of ryegrass produced significantly legume than the low seeding rate of ryegrass. There were no significant differences between the high and medium seeding rates of ryegrass or between the medium and the low seeding rates of ryegrass. There were no significant differences between clear seeded alfalfa and any of the timothy/alfalfa seeding rates.

Grass yields for the 1991 growing season were significantly different based on both seeding rate and grass mixtures. There was significantly more ryegrass production than orchardgrass, bromegrass, or timothy. The orchardgrass treatment yields for grass were significantly less than bromegrass and timothy. There was no significant difference in grass yield between bromegrass and timothy. The high seeding rate of orchardgrass produced significantly more grass than the medium and the low seeding rates. There was no significant difference between the medium and the low treatments. The bromegrass high and medium treatments produced significantly more grass dry matter than the low treatment. There was no significant difference in total seasonal grass yield between the high and the medium seeding rates. The grass yields the low ryegrass treatment were significantly more than the medium ryegrass treatment. There were no significant differences between the high and the medium treatments or between the high and the low treatments of ryegrass. The high seeding rate of timothy produced significantly more grass dry matter than the medium and the low seeding rates. There was no significant difference in grass yield between the medium and the low seeding rate. There was no significant difference in weed production for the 1991 growing season and no significant correlation to grass:weed yields.

In summary, forage yield analysis at the LCES also demonstrated the complexity of analysis for management purposes. Taking into consideration the hot and dry growing season in 1991, the following conclusions can be drawn from the LCES: 1) Weeds were (36% of DM) present in all mixtures, and 2) There was more (18%) total forage production in mixtures that in pure seeded alfalfa.

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First Harvest

The conditions at the SWMREC were also very hot and dry during the 1991 growing season. The first harvest during the 1991 growing season had significant

Table XI. First harvest yields(DM in kg/ha) for grass-legume seeding rate studies at the SWMREC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	None	2084	0	368	2452
Alfalfa plus Orchardgrass	High	1876	356	356	2588
	Medium	1596	400	188	2184
	Low	1572	308	452	2332
Alfalfa plus Bromegrass	High	1660	860	304	2820
	Medium	2020	448	220	2688
	Low	2288	724	360	3372
Alfalfa plus Ryegrass	High	1356	688	348	2392
	Medium	1328	456	340	2004
	Low	544	532	304	1380
Alfalfa plus Timothy	High	2276	480	392	3148
	Medium	2384	288	156	2800
	Low	2064	520	560	3144
LSD.05		324	176	208	380

differences in yield due to mixtures. The average production of all of the seeding rates of bromegrass and timothy was significantly higher than alfalfa alone (Table XI). Orchardgrass was not significantly different in forage production than alfalfa seeded alone. However ryegrass mixtures had significantly lower yields than alfalfa alone. The low seeding rate of ryegrass produced significantly less than either the ryegrass medium or high seeding rate during first harvest 1991. The bromegrass seeded at the high and medium seeding rates produced significantly less total forage during first harvest than bromegrass at the low seeding rate.

The alfalfa portion of the sward produced significant differences in yield based on mixtures during the first harvest. The alfalfa alone plots produced more legume than did the average of the orchardgrass and ryegrass plots. There were no statistical differences in the legume production of the alfalfa alone plot and the average of the bromegrass and timothy plots. Timothy and orchardgrass had no statistical difference in yield based on the different seeding rates. The low seeding rate of ryegrass produced less legume than either of the high or the medium seeding rate which were not significantly difference. Bromegrass medium and low seeding rates had a statistically higher legume yield than did the bromegrass high seeding rate. There were no significant differences in legume production between the medium and low bromegrass rates.

The grass portions of the sward varied statistically based on the seeding rates. The medium seeding rate of timothy yielded significantly less than either the high or the low timothy seeding rates. There was statistically no difference in grass production between the high and low timothy seeding rates. The high seeding rate of ryegrass produced

significantly more grass than the medium and the low rates. Bromegrass showed the same trend as timothy with the medium rate producing less grass than both the high and the low rate. Orchard grass showed no significant difference in grass yield due to seeding rate.

Second Harvest

The total forage production for the second harvest of the 1991 (Table XII) growing season had statistical differences due to mixtures. The average production for the ryegrass plots was significantly less then all of the other averages including alfalfa alone. There were no significant differences in total forage production due to grass seeding rates during this harvest.

The legume part of the sward showed significant differences due to seeding mixtures. The average of the legume portion of the alfalfa-orchardgrass and alfalfa-ryegrass seedings at all rates were significantly less than alfalfa alone. The ryegrass mixture produced less alfalfa than all of the other grass legume mixtures. There were no significant differences in alfalfa production due to grass seeding rates.

Grass production differed significantly due to both mixtures and seeding rates. The average grass production in the timothy plots was significantly less than the grass produced in all of the other mixtures. The other three grasses had no statistical difference in yield for the second harvest. The timothy plots showed no statistical difference in grass yield based on seeding rate. The low seeding rate ryegrass plot yielded significantly less grass than the high and medium seeding rate. There were no differences in grass yield between

Table XII. Second harvest yields(DM in kg/ha) for grass-legume seeding rate studies at the SWMREC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	**None**	2800	0	204	3004
Alfalfa plus Orchardgrass	**High**	2324	152	420	2896
	Medium	2352	40	476	2868
	Low	2600	172	368	3140
Alfalfa plus Bromegrass	**High**	3112	264	116	3492
	Medium	2788	140	528	3456
	Low	2912	36	180	3124
Alfalfa plus Ryegrass	**High**	1900	160	72	2136
	Medium	2196	164	248	2612
	Low	1716	60	44	1820
Alfalfa plus Timothy	**High**	2696	40	92	2824
	Medium	2784	44	156	2984
	Low	2860	28	144	3032
LSD.05		**360**	**48**	**76**	**416**

these two seeding rates. The bromegrass seeding rates showed statistical differences among all three seeding rates. Grass yield for bromegrass seeded at the low rate was less than the grass yield at the medium rate which was less than the grass yield at the high seeding rate. The orchardgrass medium seeding rate produced significantly less grass than either the orchardgrass high or orchardgrass low seeding rates.

Third Harvest

The third and final harvest of the 1991 season exhibited no significant differences in total yield due to either mixtures or seeding rate (Table XIII). The amount of legume

Table XIII. Third harvest yields(DM in kg/ha) for grass-legume seeding rate studies at the SWMREC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	None	2096	0	472	2568
Alfalfa plus Orchardgrass	High	1712	1112	208	3036
	Medium	1800	628	552	2980
	Low	2528	1016	484	2952
Alfalfa plus Bromegrass	High	1852	124	592	2572
	Medium	1756	140	16	1912
	Low	1716	320	1008	3044
Alfalfa plus Ryegrass	High	988	848	308	2144
	Medium	1472	64	952	2488
	Low	884	524	680	2088
Alfalfa plus Timothy	High	1776	72	368	2216
	Medium	2252	224	228	2708
	Low	1904	128	548	2580
LSD.05		364	180	160	496

produced for this harvest varied significantly due to both mixture and seeding rate. The ryegrass mixture produced significantly less legume than all of the other mixtures. The medium seeding rate for timothy produced significantly more legume than the high or the low timothy seeding rates. Alfalfa alone did not yield more than the timothy medium rate mixture, but alfalfa alone produced yields with significantly more total legume than the timothy high and low seeding rate mixtures. All of the ryegrass seeding rates produced significantly less alfalfa than the alfalfa alone plots. The ryegrass medium seeding rate produced significantly more legume than either the low or the high seeding rate. The bromegrass plots had no significant difference in legume production than alfalfa alone due to seeding rate. The orchardgrass high and low seeding rates both produced significantly less legume than the alfalfa alone plots for the third harvest. The medium orchardgrass seeding rate produced more legume than did the low orchardgrass seeding rate.

The grass yields for the third harvest also varied significantly for both mixtures and seeding rates. The orchardgrass plots produced more grass than the ryegrass plots which in turn were more than the grass yields of the bromegrass and timothy plots which were not significantly different. The medium timothy seeding rate produced significantly more grass than the timothy high seeding rate. The low seeding rate was not different for either the high or the low seeding rate. The high seeding rate ryegrass plots produced significantly more grass for the third harvest than the low ryegrass seeding rate which in turn produced more grass than the medium ryegrass rate. The low seeding rate of bromegrass produced significantly more grass than both the high and the medium rate. There were no significant differences in grass yield between the high bromegrass seeding

rates and the medium bromegrass seeding rates. Both of the low and the high orchardgrass seeding rates produced significantly more grass than the medium seeding rate of orchardgrass.

This was the only harvest at this location in which weed yields varied significantly, due to both mixtures and seeding rates. The ryegrass mixture produced significantly more weeds than the other mixtures. The orchardgrass high seeding rate produced significantly less weeds than the two lesser seeding rates which were not significantly different. The weeds in the bromegrass medium seeding rate was less than the bromegrass high seeding rate which was significantly less than the low bromegrass seeding rate. The ryegrass high seeding rate produced significantly less weeds than the low ryegrass seeding rate which contained less weeds than the ryegrass medium seeding rate. The low timothy seeding rate produced a greater volume of weeds than either the high or the medium timothy seeding rates.

Total Seasonal Yield

There were significant differences in total seasonal yield based only on grass mixtures (Table XIV). There was more total forage produced in the orchardgrass, bromegrass, and timothy mixtures than in the ryegrass mixture.

The legume portion of the total seasonal yield had significant differences based on grass mixture, seeding rate, and an interaction (Table XV). Ochardgrass, bromegrass, and timothy mixtures all produced significantly more legume for the total season than the

ryegrass mixture. The bromegrass and timothy mixtures were also higher yielding than

Table XIV. Seasonal averages of DM yield in kg/ha at the SWMREC for 1991.

	Legume	Grass	Weeds	Total
Alfalfa/Orchardgrass	5761	1395	1169	8325
Alfalfa/Bromegrass	6698	1018	1108	8824
Alfalfa/Ryegrass	4130	1167	1058	6355
Alfalfa/Timothy	6991	605	882	8478

the orchardgrass mixture. There were no significant differences in total legume production between the bromegrass and the timothy mixtures. Alfalfa seeded alone produced significantly more legume than any of the alfalfa orchardgrass mixes. There were no significant differences in legume production between the high, medium, or low orchardgrass seeding rates. There were no significant differences in total legume production between alfalfa seeded alone and any of the bromegrass seeding rates. Alfalfa seeded alone had significantly higher yields than all three of the ryegrass seeding rates. The medium seeding rate of ryegrass produced significantly more legume than either the high or the low seeding rates of ryegrass. The high seeding rate of ryegrass produced more legume dry matter than the low seeding rate of ryegrass. There was more alfalfa dry matter produced in the medium seeding rate of timothy than in the high seeding rate of timothy. There were no significant differences in total seasonal legume production between alfalfa seeded alone, the medium or the low timothy seeding rates.

The grass segment of the total seasonal yield had significant differences based on both grass mixture and seeding rate. The orchardgrass mixture produced significantly

Table XV. Total Forage Yields(DM in kg/ha) for grass-legume seeding rate studies at the SWMREC. 1991.

Seeding Mixtures	Grass Seeding Rate	COMPONENTS OF YIELD			
		Legume	Grass	Weeds	Total
Alfalfa	None	6981	0	1042	8023
Alfalfa plus Orchardgrass	High	5913	1620	986	8519
	Medium	5746	1070	1215	8031
	Low	5624	1495	1305	8424
Alfalfa plus Bromegrass	High	6621	1250	1012	8883
	Medium	6562	726	764	8052
	Low	6911	1077	1548	9536
Alfalfa plus Ryegrass	High	4245	1698	730	6673
	Medium	4996	684	1422	7102
	Low	3148	1117	1024	5289
Alfalfa plus Timothy	High	6746	589	851	8186
	Medium	7398	554	539	8490
	Low	6829	674	1255	8758
LSD.05		628	288	312	784

more total grass than the timothy, bromegrass, or ryegrass. Bromegrass and ryegrass produced significantly more grass than the timothy mixture. There were no significant

differences between the bromegrass and ryegrass mixture or between the orchardgrass and ryegrass mixtures. The high and the low seeding rate of orchardgrass produced significantly more grass than the medium seeding rate of orchardgrass. There were no significant differences between the high and the low seeding rates of orchardgrass. The medium seeding rate of bromegrass had significantly higher yields than the high and the low seeding rates of bromegrass. There were no significant differences between the high and the low seeding rates of bromegrass. The high seeding rate of ryegrass produced significantly more grass for the total season than the medium or the low ryegrass treatments. The low ryegrass seeding rate had a significantly higher grass yield than the medium ryegrass seeding rate. There were no significant differences between the timothy seeding rate treatments. There were also no significant differences in weed yields for the total 1991 growing season.

In summary while the individual dynamics within a harvest were different in legume, grass, and weed component, each produced less total forage for the season than alfalfa seeded alone. Orchardgrass, bromegrass, and timothy were less aggressive than the extremes of ryegrass at the SWMREC. Ryegrass seeded at 3 rates (14, 28, and 56 seeds/s ft.) changed the dynamics of the binary forage crop indicating that in the SWMREC environments, which included a hot and dry growing season in 1991, mixtures of alfalfa plus bromegrass, orchardgrass, or timothy have a wide range of acceptable seeding rates.

CONCLUSIONS

The data from this research shows that seeding rate recommendations vary with climate and soil type. The same mixtures were planted a three different locations in Michigan with three different climates. Each location had different results. At some locations alfalfa seeded alone produced more total dry matter than the co-culture mixtures. At other sites the mixtures produced more total dry matter than the alfalfa seeded alone.

A correlation was run between seeding rates and the amount of weeds in the study. At one site weeds were found to be negatively correlated to seeding rate.

Further research that could be done would include looking at the results and temperatures and rainfall. Also, plots like these could be grazed to see what differences would occur with grazing as opposed to harvesting for hay.

These data were taken during the 1991 growing season. This season was extremely hot and dry at all three locations. More data would need to be taken over several years to see which seeding rates would be best in varying temperatures and rainfall amounts as well as to see which would be most productive and persistent.

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