MATURITY STUDY OF SOME NORTHERN AND SOUTHERN VARIETIES OF BROMEGRASS

(Bromus inermis L.)

Thesis for the Degree of M. S.

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Joseph R. Dumont

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by

Joseph R. Dumont

AN ABSTRACT

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

MASTER OF SCIENCE

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Department of Farm Crops

Approved by 

ABSTRACT Joseph R. Dumont

Three southern and three northern varieties of smooth bromegrass grown alone and in mixture with alfalfa were compared for percentage of stems and dry matter in the plant on four sampling dates in June 1956. In addition, Lincoln, a southern variety, and Canadian, a northern variety, were compared for percentage of crude fiber, ether extract, and protein for the four sampling dates of June 2, 9, 20, and 30 in 1956 and 1957, and May 23 and July 10, 1957.

There were significant differences among the northern bromegrass varieties when grown alone or with alfalfa, most of the differences occurring in pure stands. Percentage of crude fiber increased with advancing maturity while percentage of protein decreased. The percentage of ether extract was quite stable. Southern varieties did not differ significantly in any of the determinations.

The Lincoln and Canadian varieties in pure stands differed significantly in dry matter, crude fiber early in one season, and protein on the latter sampling dates of 1956 and 1957.

With the exception that the Canadian variety was higher in percentage of protein in the latter stages of harvest, the Lincoln and Canadian varieties were similar in percentage of leaves, stems, dry matter, ether extract, crude fiber, and protein in the sampling period from late May to early July. The choice of which variety is to be recommended in Michigan must depend on other factors. On this basis, Lincoln, representative of the southern type, would be preferred because of its greater yield, disease resistance, and availability of seed.

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I wish to take this opportunity to express my appreciation to all those who have helped me in this work and especially Dr. M. B. Tesar, Professor in the Department of Farm Crops, Michigan State University, for his very able assistance in the planning, execution, and evaluation of this research problem.

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INTRODUCTION

Smooth bromegrass, Bromus inermis L., is used extensively in Michigan and adjoining states. Its primary use is in mixture with alfalfa for hay, silage or pasture. It is also used in conservation measures to decrease erosion from sod waterways and ditch banks or road cuts.

Bromegrass is usually grown with alfalfa because the mixture generally gives greater forage yield and protection to the soil than either the brome or the alfalfa provides if seeded alone, and the danger of bloat to grazing animals is less. The presence of a legume in the mixture also prolongs the productive life of the stand, because it increases the amount of nitrogen available in the soil and thereby keeps the grass stand from becoming sod-bound. As a grass for pasture, silage, or hay, smooth bromegrass is superior to other grasses.

In a dairy area, such as the state of Michigan, a grass should ideally be useful for pasture, hay, and silage. An ideal bromegrass variety must not mature so early that it conflicts with proper alfalfa harvest. If a grass matures too early it will be too mature at harvest and of low value as hay. The ideal bromegrass must not be too aggressive to its legume companion or too hard to control in a crop rotation. If a grass is so aggressive that it crowds out the legume, it can only be used in short rotations. This decreases its value. An ideal grass variety must be high yielding and palatable to the livestock. It must have disease resistance to several leaf diseases which often reduce yield and palatability.

Smooth bromegrass is a long-lived perennial sod grass with strong creeping rhizomes. It is adapted especially to regions of moderate rainfall and low to moderate summer temperatures.

Two types of smooth bromegrass which differ somewhat in appearance and habits of growth are recognized. They are known as northern and southern types. The southern type was introduced originally from central Europe and includes such varieties as Achenbach, Fischer, and Lincoln. They are more vigorous and form a heavier sod than the northern strains. The northern type was introduced from Siberia and is represented in this report by Canadian, Michigan, and Manchar varieties. Manchar, however, is not true to either type but more nearly resembles the northern than the southern strains.

A 1957 summary of the production of bromegrass varieties in Michigan (6) showed that five southern varieties produced 3.44 tons per acre of hay containing 12% moisture in combination with alfalfa while six northern varieties produced 3.24 tons of alfalfa-bromegrass hay per acre. The alfalfa comprised 1.75 tons (50.7%) of the hay when in association with the southern varieties but only 1.42 tons (43.6%) when in association with northern varieties. Since the northern varieties were lower yielding, less disease resistant and actually more competitive to the alfalfa, the Department of Farm Crops now recommends southern varieties of bromegrass in preference to northern varieties. One important reason why northern varieties might be preferred to southern varieties is that the southern varieties are shown by Newell and Keim (3) and Wheeler and Hill (9) to mature earlier with the result that the hay may be of poorer quality.

This study was undertaken to determine if there were any differences in maturity, crude fiber, ether extract, and protein between northern and southern varieties.

REVIEW OF LITERATURE

Newell and Keim (3) reported that the southern types of smooth bromegrass produced more vigorous seedlings under short days of fall and early spring, were more tolerant of drought and heat, possessed more vegetative vigor, and were more productive under the conditions of their tests than the strains of the northern type. They also reported that the southern strains produced a larger percentage of their total forage in early spring than did the northern strains. From their findings they suggest the designations "early" and "late" for the strains of southern and northern types, respectively. In areas of recurrent spring and summer droughts, the southern or "early" strains are preferred to take advantage of all available moisture.

Wheeler and Hill (9) in 1957 reported that the southern bromegrasses have often been shown to be superior to northern varieties in yield but have never become widely used in the northern states. They are fully winter-hardy as far north as North Dakota and are adapted to southern Minnesota. Northern growers have usually preferred the type with less vigorous root stalks because they have felt that the rapid spreading southern types grow so vigorously as to crowd out legumes and other grasses in the pasture mixtures.

Churchill (1) reported the percentage of dry matter of bromegrass when grown alone was very much the same as when grown with alfalfa. He found this percentage to vary from 31.0 to 41.6% for first cutting bromegrass grown alone over a five-year period. Churchill also reported that all strains were much higher in percentage of protein in the second

than in the first cutting. The protein content of both bromegrass and alfalfa was slightly higher when grown in mixture than when either was grown alone. In second cuttings, the percentage of protein in the bromegrass was equal to that in the alfalfa. Churchill reported the percentage of protein in the first cutting to be 8.39% when grown alone and 9.77% when grown in mixture.

Dotzenko and Ahlgren (2) and Phillips et al. (4) reported the percentage of protein to decrease steadily with advancing maturity. They also reported that the percentage of crude fiber increased steadily with advancing maturity.

Churchill (1) reported that generally the percentage of fiber was highest in the Nebraska and Kansas strains of the southern type. All strains contained a higher percentage of fiber in the first than in the second cutting. Most strains showed a higher fiber content when grown with alfalfa than when grown alone. Churchill found that the percentage of crude fiber was 34.5% when grown alone and 36.1% when grown in mixture.

Dotzenko and Ahlgren (2) reported that the percentage of protein, potassium, and phosphorus contents of bromegrass decreased with advancing maturity, whereas the percentage of fiber and calcium showed the reverse trend. They found in summarizing that the percentage of crude fiber showed highly significant effects for treatment, season, and their interaction.

Sullivan et al. (5) reported that successive cuttings of grass through the season showed fluctuations in composition, many of statistical significance, but the changes were never of great magnitude.

Phillips et al. (4) reported no significant fluctuations in the percentage of nitrogen free extract.

Wheeler and Hill (9) and the Agricultural Research Service (7) describe the varieties as follows:

"Achenbach is a typical southern regional strain developed by some selection in the late 1890's by the Achenbach brothers of Washington, Kansas. This early work produced the foundation stock of what is now the Achenbach strain. Most of the bromegrass in eastern Kansas and all of the certified bromegrass in the state traces to this source. Achenbach is similar to Fischer in adaptation to Ohio, Indiana, Illinois, and Missouri. Achenbach is equal to or superior to Lincoln in that area."

"Lincoln is a naturalized strain of bromegrass derived from Hungarian origin. It has proven particularily well adapted to the central latitudes of the United States and constitutes an excellent source of unselected material to be used in the production of selected new strains for the same region. Increased and foundation seed stocks are maintained at the Nebraska Agricultural Experiment Station, Lincoln, Nebraska. Of the southern strains, Lincoln is the leading variety in volume of certified seed production. Most of the certified seed is being certified in North Dakota, Nebraska, and Iowa."

"Lincoln was developed cooperatively at Lincoln, Nebraska, by the Agricultural Research Service of the U. S. Department of Agriculture and the Nebraska Agricultural Experiment Station. The source was old fields of bromegrass derived from an early introduction into California prior to 1898 attributed to Hungarian origin. Lincoln was certified in 1942. It is a high yielding variety that forms a good sod and is

tolerant of drought and heat. It is grown in the Dakotas and Nebraska and in states eastward to the Atlantic Ocean."

"Lancaster (Nebraska 44) is a strain which was developed over a ten-year period at the Nebraska Agricultural Experiment Station. It is a synthetic variety produced by the hybridization of several unrelated outstanding plants. Seed from the original hybridization was increased and plants were selected as outstanding among several experimental varieties in the trial plantings. The variety is superior in forage and seed yield and quality in field plot tests at the Nebraska Station. It is being certified in Nebraska and increased at the Nebraska Agricultural Experiment Station."

"Manchar is a tall, leafy, semi-bunch type of bromegrass introduced from Manchuria by the U. S. Dept. of Agriculture in 1935. Its outstanding characteristics are seedling vigor and high seed production. It is intermediate in growth habit between the southern type and the northern type. It yields well in alfalfa-bromegrass mixtures and does not become sod-bound as quickly as the common strain. This variety is increased at the Washington Agricultural Experiment Station, Pullman, Washington. Manchar recovers quickly after cutting and has some disease resistance."

MATERIALS AND METHODS

The studies were made in 1956 and 1957 on part of a uniform bromegrass nursery established in 1950 on the Farm Crops Farm, Michigan State University, East Lansing, Michigan. The purpose of the nursery was to obtain data on the yield, disease resistance, and persistence of bromegrass. The soil was a Conover silt loam tiled to secure good drainage. The plot size was 8 by 19 feet. Rates of seeding were 12 pounds bromegrass when sown alone and 3 pounds when in mixture with Ranger alfalfa broadcast at 10 pounds per acre. Each variety in this study was compared alone and in mixture with alfalfa in a split-plot design with four replications. When grown alone, bromegrass was fertilized in early April of each year with 100 pounds of nitrogen per acre applied as ammonium nitrate. Bromegrass grown with alfalfa was not fertilized with nitrogen but was fertilized each year with 300 pounds of 0-20-20 fertilizer per acre.

The studies reported here included three northern and three southern varieties. The southern varieties were Achenbach, Lincoln, and Lancaster. The northern varieties were Manchar, Michigan, and Canadian. In 1957, only Lincoln of the southern varieties and Canadian of the northern varieties were sampled as being representatives of the two different types.

Samples were taken at various dates throughout the growing season. The first plan called for samples at 7-day intervals beginning on June 2, 1956, but rain caused an extension to 10-day intervals. In 1956, complete samples were taken on June 2, 9, 20, and 30. In 1957,

sampling extended over a longer period of time with samples being taken on May 23, June 2, 9, 20, 30, and July 10.

Samples of 60 to 100 grams green weight were used during 1956. The larger sampling weights were taken toward the later sampling dates because it was determined that the 60-gram sample was too small for accurate determinations. In 1957, samples of about 300 grams were taken when enough material was available. When material was limiting, a smaller sample was taken. In several cases, there was enough material for samples from only 3 replications especially on the July 10th sampling.

Four to six samples were obtained and taken to the laboratory within 30 minutes. On the first two sampling dates in 1956, the leaves with sheaths were separated from the stems and heads immediately after the total green weight was taken. The purpose was to obtain the green weight of the leaves and sheaths alone, but this was abandoned because of high evaporation losses in the slow process of separation. From then on, the bags were stored in a refrigerator after the green weight was taken until all the samples were taken for that date, and then the leaves were separated. All samples were then placed in the air driers at about 105° F. for 5 to 7 days, removed, and weighed. The samples were then placed in storage for grinding.

All samples of Lincoln and Canadian varieties were ground to pass through a 24-mesh screen with a small hammer-mill. Most samples, especially the smaller ones, were run through twice.

In 1956, the samples were analyzed for crude fiber, ether extract, and protein by the Department of Chemistry of the Michigan Agricultural Experiment Station. In 1957, only crude fiber and protein were analyzed

because the 1956 results showed that the percentage of ether extract was quite uniform for all dates checked.

EXPERIMENTAL RESULTS

Percentage of Stems

The data for the percentage of stems and heads for all six varieties studied in 1956 and Lincoln and Canadian varieties in 1957 are presented in Table 1. The Lincoln and Canadian varieties are compared graphically for stems in alfalfa-bromegrass plots for 1956 and 1957 sampling dates in Figure 1.

There was no significant difference in percentage of stems between the Lincoln and Canadian varieties when grown alone or in mixture with alfalfa in either 1956 or 1957. Likewise, there was no significant difference in stems between averages of the northern and southern varieties.

The percentage of stems increased significantly as the season progressed from initial or later sampling dates as shown graphically in Figure 1 and Table 1. In 1956, the average per cent of stems for all varieties of bromegrass grown alone or in combination with alfalfa was 53.4% on June 2 and increased to 79.6% on June 30. In 1957, similar percentages were 47.0% on May 23 and 82.6% on June 30.

The amount of stems on the average was consistently higher in bromegrass grown with alfalfa than when grown alone in 1956. In 1957 on every sampling date, the percentage of stems of both Lincoln (southern) and Canadian (northern) varieties was higher when grown with alfalfa than when grown alone.

The Manchar variety was significantly higher than the other varieties in stems for both alfalfa-bromegrass and bromegrass alone

Table 1. Percentage of stems in bromegrass plants when grown alone or with alfalfa in 1956 and 1957.

Variety	Bromegrass Sampling Dates: May 23	June 2	June 9	June 20	June 30	July 10
			1956			
			SOUTHERN VARIETIES			
			Alfalfa-bromegrass			
Achenbach		52.2	62.0	66.4	82.1	
Lincoln		52.9	61.7	67.1	82.0	
Lancaster		55.6	59.1	71.8	81.9	
Average		53.6	60.9	68.4	82.0	
			Bromegrass alone			
Achenbach		51.6	62.0	65.8	77.7	
Lincoln		49.1	58.2	67.6	79.1	
Lancaster		49.8	60.7	66.1	75.5	
Average		50.2	60.3	66.5	77.4	
			NORTHERN VARIETIES			
			Alfalfa-bromegrass			
Manchar		59.3	70.1	74.2	83.3	
Canadian		53.2	62.5	67.0	82.9	
Michigan		54.1	65.6	71.6	82.0	
Average		55.5	66.1	70.9	82.7	
			Bromegrass alone			
Manchar		54.9	64.5	71.2	79.9	
Canadian		54.8	59.5	66.2	74.8	
Michigan		53.6	60.6	66.6	73.7	
Average		54.4	61.5	68.0	76.1	
			1957			
			Alfalfa-bromegrass			
Lincoln	49.2	63.4	69.1	80.0	84.1	89.1
Canadian	50.3	62.4	69.0	81.0	85.8	89.7
			Bromegrass alone			
Lincoln	46.1	59.3	56.4	74.6	79.4a	87.3a
Canadian	42.6	59.6	62.6	77.0	81.0	87.0a

(a) 3 replications only.

Table 1. (Cont.)

L.S.D. between:	Horizontal		Vertical	
1956	5%	1%	5%	1%
Northern & Southern var. - Alfalfa-bromegrass	N.S.	N.S.	N.S.	N.S.
Northern & Southern var. - Bromegrass alone	"	"	"	"
Southern varieties - (all cases)	"	"	"	"
Northern varieties - (all cases)	2.9	4.0	2.4	3.3
Northern varieties - Alfalfa-bromegrass	3.2	N.S.	3.7	N.S.
Northern varieties - Bromegrass alone	2.6	"	3.0	"
Lincoln & Canadian var. - Alfalfa-bromegrass	N.S.	"	N.S.	"
Lincoln & Canadian var. - Bromegrass alone	"	"	"	"
Alfalfa-bromegrass (all cases)	"	"	"	"
Bromegrass alone (all cases)	"	"	"	"
1957				
Lincoln & Canadian var. - Alfalfa-bromegrass	"	"	"	"
Lincoln & Canadian var. - Bromegrass alone	"	"	"	"
1956 & 1957				
Lincoln variety - Alfalfa-bromegrass	7.6	"	10.8	"
Canadian variety - Alfalfa-bromegrass	7.4	"	10.5	"
Canadian variety - Bromegrass alone	5.3	"	7.4	"
Lincoln variety - Bromegrass alone	N.S.	"	N.S.	"

(N.S.) Not significant.

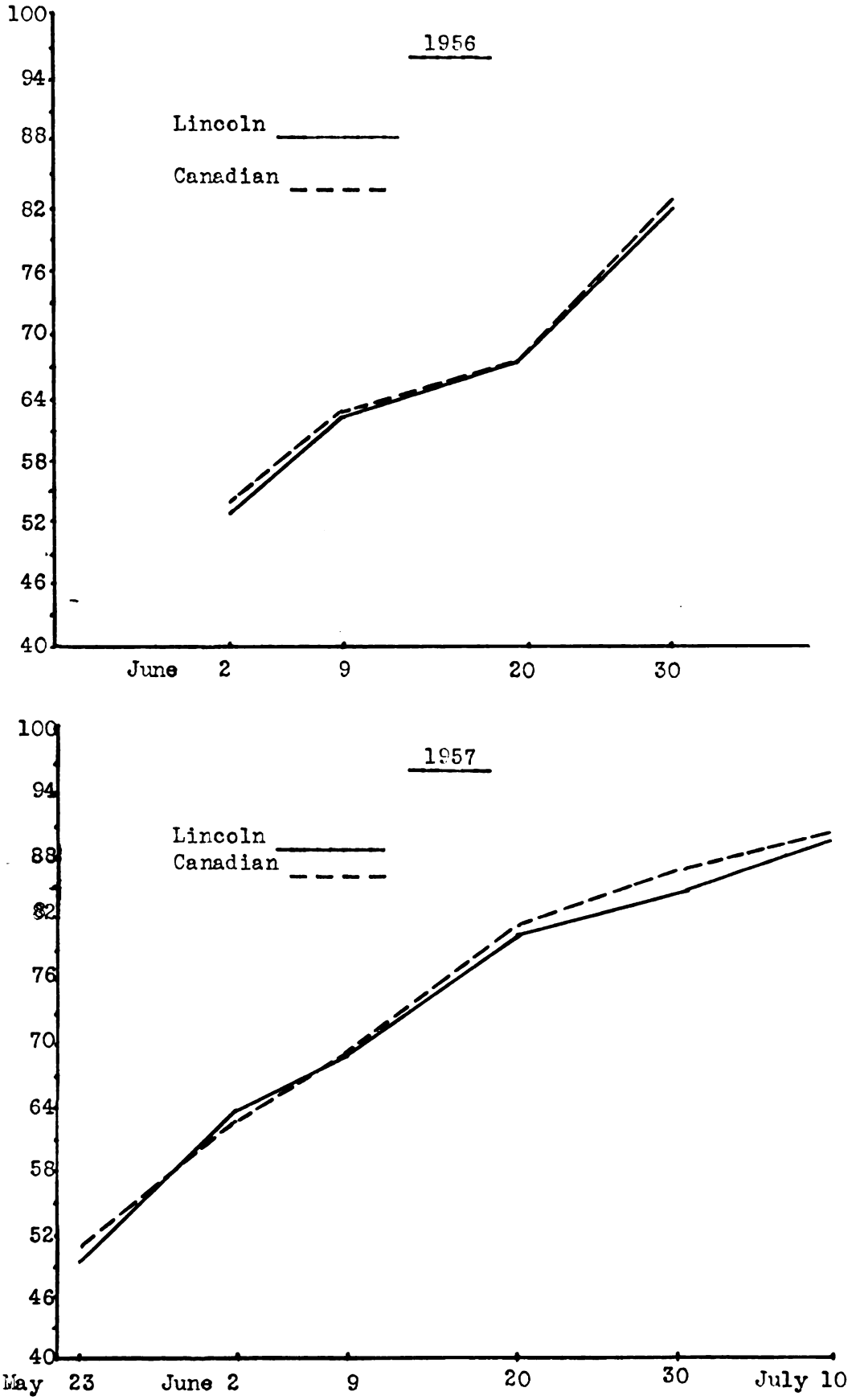

Figure 1. Percentage stems in bromegrass grown with alfalfa in 1956 and 1957.

plots in the first part of the 1956 sampling period in most instances. Manchar was 1.2 to 4.5% higher than the other five varieties during the sampling period when grown alone in 1956 and from 0.4 to 11.0% higher than the other varieties when grown with alfalfa.

The data show consistently higher percentages of stems in 1957 than in 1956, except on the June 30 sampling date. The percentage of stems in the Lincoln variety was significantly higher in 1957 than in 1956 for most dates of sampling except the one made on June 30. The percentage of stems in the Canadian variety was likewise higher in 1957 than in 1956 when the grass was grown alone or in mixture.

Percentage of Dry Matter

The data for the percentage of dry matter in the bromegrass plant for all six varieties in 1956 and also Lincoln and Canadian varieties in 1957 are presented in Table 2. The Lincoln and Canadian varieties are compared graphically for dry matter in the plant from alfalfa-bromegrass plots for 1956 and 1957 sampling dates in Figure 2.

When grown in combination with alfalfa in 1956, there was no significant difference in dry matter between the averages of northern and southern varieties. When grown alone, however, there was a trend that southern bromegrass strains as a group had more dry matter than northern strains during the last three dates of sampling (June 9, 20, and 30) but differences were not significant.

In combination with alfalfa, Lincoln and Canadian were equal in dry matter on all dates of sampling in 1956 and 1957, Figure 2. When grown alone, however, Lincoln had significantly more dry matter than Canadian during the latter part of the sampling period in both years.

Table 2. Percentage of dry matter in bromegrass grown alone or with alfalfa in 1956 and 1957.

Variety	Bromegrass Sampling Dates: May 23	June 2	June 9	June 20	June 30	July 10
			1956			
			SOUTHERN VARIETIES			
			Alfalfa-bromegrass			
Achenbach		18.1	25.4	28.2	34.5	
Lincoln		17.1	22.8	26.8	34.2*	
Lancaster		18.2	22.7	27.0	35.8	
Average		17.8	23.6	27.3	34.8	
			Bromegrass alone			
Achenbach		19.1	25.3	28.8	33.8	
Lincoln		18.1	24.0	29.4	34.7	
Lancaster		16.9	25.7	30.8	36.3	
Average		18.0	25.0	29.7	34.9	
			NORTHERN VARIETIES			
			Alfalfa-bromegrass			
Manchar		17.1	24.9	29.4	32.1	
Canadian		16.8	23.1	28.7	32.3*	
Michigan		17.9	23.9	25.6	31.9	
Average		17.3	24.0	27.9	32.1	
			Bromegrass alone			
Manchar		18.0	24.7	28.7	34.7	
Canadian		16.8	22.4	25.7	30.7	
Michigan		17.3	24.1	25.1	31.0	
Average		17.4	23.7	26.5	32.1	
			1957			
			Alfalfa-bromegrass			
Lincoln	23.6	27.9	31.7	41.7	40.4	46.5
Canadian	23.1	27.9	31.6	40.2	39.8	47.0
			Bromegrass alone			
Lincoln	22.2	27.2	31.3	41.6	42.5a	50.4
Canadian	20.4	24.7	28.3	36.7	38.0	46.0

(a) Average of three replications.
(*) Significant at the 5% level between means within the same date of sampling.

Table 2. (Cont.)

L. S. D. between:	Horizontal		Vertical	
1956	5%	1%	5%	1%
Northern & Southern var. - Alfalfa-bromegrass	N.S.	N.S.	N.S.	N.S.
Northern & Southern var. - Bromegrass alone	"	"	"	"
Southern varieties (all cases)	"	"	"	"
Northern varieties (all cases)	1.5	"	1.3	"
Northern varieties - Alfalfa-bromegrass	N.S.	"	N.S.	"
Northern varieties - Bromegrass alone	1.6	"	1.9	"
Lincoln & Canadian var. - Alfalfa-bromegrass	N.S.	"	N.S.	"
Lincoln & Canadian var. - Bromegrass alone	2.2	"	3.1	"
1957				
Lincoln & Canadian var. - Alfalfa-bromegrass	N.S.	"	N.S.	"
Lincoln & Canadian var. - Bromegrass alone	1.3	2.1	2.3	3.6
Lincoln & Canadian var. - (all cases)	1.3	1.7	1.5	2.1
1956 & 1957				
Lincoln variety - Alfalfa-bromegrass	5.8	N.S.	8.2	N.S.
Canadian variety - Alfalfa-bromegrass	3.1	5.7	4.4	8.1
Lincoln variety - Bromegrass alone	3.5	6.4	5.0	9.1
Canadian variety - Bromegrass alone	3.4	6.3	4.8	8.9

Fig

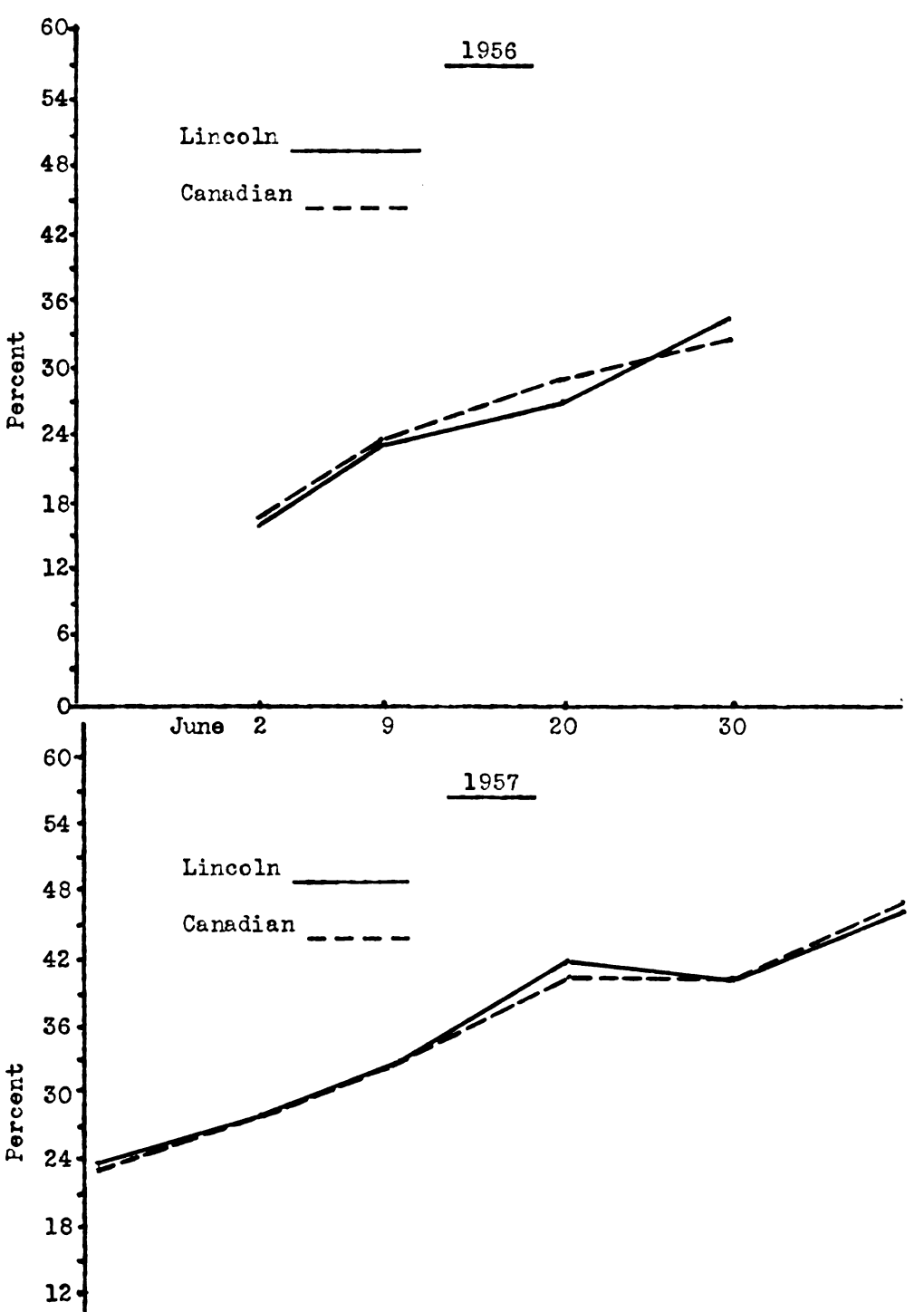

Figure 2. Percent dry matter in bromegrass grown with alfalfa in 1956 and 1957.

As the season progressed from June 2 to 30, 1956, and May 23 to July 10, 1957, the dry matter in the bromegrass varieties increased significantly with sampling dates except on the June 30 sampling in 1957.

When grown alone (but not in mixture) Manchar was significantly higher in dry matter than the other northern varieties. There were no consistent significant differences among the southern varieties, however, when grown alone or in mixture.

In almost all comparisons for similar dates of sampling, the dry matter was significantly higher in 1957 than in 1956.

Crude fiber, Ether extract & Protein

Table 3 contains data for the Lincoln and Canadian varieties on percentage of crude fiber, ether extract, and protein in leaves and stems and the whole plant for bromegrass grown alone and with alfalfa in 1956. Table 4 contains similar data for 1957 except that no ether extracts were made in 1957. Analysis of variance was calculated between Lincoln and Canadian varieties for each sampling date in 1956 and 1957 for the whole plant only.

Crude fiber was significantly higher in the plants of Lincoln bromegrass than in Canadian bromegrass in only one comparison--the earliest date of sampling on May 23, 1957, from pure stands. There was an indication in 1957 that crude fiber was higher in the Lincoln variety on June 2, 9, and 20 but the difference was not significant.

In both years, crude fiber in the leaves, stems, and total plant increased as the season progressed up to June 20. There was a slight drop, with a few exceptions, in crude fiber between the June 20 and June 30 date of sampling. No sampling was made later than June 30

Table 3. Percentages of crude fiber, ether extract, and protein in bromegrass leaves, stems, and plant from bromegrass grown alone or with alfalfa in 1956.

Variety	Constituent	Bromegrass Sampling Dates: June 2	June 9	June 20	June 30
			ALFALFA-BROMEGRASS		
			Leaves		
Lincoln	Crude fiber	26.44	28.00	33.14	31.24
	Ether extract	3.14	3.38	3.47	3.68
	Protein	17.08	15.74	15.44	12.61
Canadian	Crude fiber	26.52	28.45	32.50	31.50
	Ether extract	3.52	3.66	3.48	3.31
	Protein	16.78	15.03	14.13	12.47
			Stems		
Lincoln	Crude fiber	37.02	38.65	43.81	38.85
	Ether extract	1.38	1.55	1.36	1.24
	Protein	9.83	7.92	6.98	5.52
Canadian	Crude fiber	37.02	39.48	40.04	39.23
	Ether extract	1.09	1.01	1.61	1.05
	Protein	8.92	7.60	5.88	5.87
			Plant		
Lincoln	Crude fiber	32.87	34.58	40.32	37.48
	Ether extract	2.22	2.26	2.05	1.68
	Protein	13.20	10.92	9.78	6.79
Canadian	Crude fiber	32.16	35.37	37.45	37.90
	Ether extract	2.22	2.00	2.26	1.44
	Protein	12.55	10.36	8.71	7.02
			BROMEGRASS ALONE		
			Leaves		
Lincoln	Crude fiber	26.48	26.50	33.98	32.85
	Ether extract	3.58	3.34	3.80	3.87
	Protein	20.03	17.69	13.50	12.40
Canadian	Crude fiber	25.32	27.39	32.82	31.76
	Ether extract	4.22	4.06	4.20	3.80
	Protein	22.42	19.72	15.42	14.55
			Stems		
Lincoln	Crude fiber	37.09	39.22	41.29	39.90
	Ether extract	1.38	1.24	1.11	0.95
	Protein	10.61	8.69	6.76	5.46
Canadian	Crude fiber	37.28	40.22	41.66	38.26
	Ether extract	1.24	0.91	1.05	1.02
	Protein	12.20	9.50	7.17	6.11

(Continued)

Table 3. (Cont.)

			Plant		
Lincoln	Crude fiber	31.68	33.95	38.92	38.40
	Ether extract	2.50	2.11	1.99	1.56
	Protein	15.39	12.45	8.95*	6.92**
Canadian	Crude fiber	31.89	35.00	38.64	36.62
	Ether extract	2.59	2.19	2.11	1.72
	Protein	16.81	13.65	9.99*	8.23**

(*) Significant at the 5% level between means within same date of sampling.
(**) Significant at the 1% level.

Table 4. Percentages of crude fiber, and protein in bromegrass leaves, stems, and plant from plots of bromegrass grown alone or with alfalfa in 1957.

Variety	Constituent	Bromegrass Sampling Dates: May 23	June 2	June 9	June 20	June 30	July 10
				ALFALFA-BROMEGRASS			
				Leaves			
Lincoln	Crude fiber	28.52	28.84	29.75	30.56	31.76	31.52
	Protein	18.84	14.64	14.14	12.89	13.16	11.92
Canadian	Crude fiber	28.56	27.64	28.64	30.08	30.23	31.78
	Protein	19.44	16.03	14.91	13.92	13.51	11.55
				Stems			
Lincoln	Crude fiber	34.20	37.48	38.21	41.88	37.36	37.41
	Protein	12.70	8.25	7.22	5.94	5.84	5.85
Canadian	Crude fiber	35.14	37.40	37.72	40.65	36.87	37.18
	Protein	11.69	8.08	7.72	6.00	6.05	5.26
				Plant			
Lincoln	Crude fiber	31.38	34.32	35.61	39.61	36.47	36.76
	Protein	15.75	10.57	9.36	7.34	7.02	6.52
Canadian	Crude fiber	31.88	33.66	34.95	38.64	35.95	36.62
	Protein	15.53	11.03	9.91	7.50	7.08	5.95
				BROMEGRASS ALONE			
				Leaves			
Lincoln	Crude fiber	29.32	28.53	30.04	32.23	34.95	35.28
	Protein	19.80	17.31	14.95	12.06	10.60	9.00
Canadian	Crude fiber	26.85	27.16	27.65	30.14	32.57	32.68
	Protein	22.47	19.17	16.80	13.90	11.78	10.29
				Stems			
Lincoln	Crude fiber	35.04	39.30	40.26	41.44	37.90	37.42
	Protein	12.91	8.81	6.74	5.66	4.76	4.28
Canadian	Crude fiber	33.12	36.80	37.80	40.57	38.18	38.07
	Protein	16.41	11.11	8.27	6.86	6.25	5.66
				Plant			
Lincoln	Crude fiber	31.96**	34.90	35.81	39.12	37.06	37.09
	Protein	16.61	12.25	10.31	7.31	6.54*	5.02*
Canadian	Crude fiber	29.53**	32.93	34.02	38.19	37.10	37.44
	Protein	19.88	14.36	11.51	8.48	7.31*	6.20*

(*) Significant at the 5% level between means within same date of sampling.
(**) Significant at 1% level.

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in 1956 but in 1957 the crude fiber on July 10 was similar to that on June 30. Crude fiber was higher on any date of sampling in 1957 than in 1956.

In all cases, protein decreased and ether extract showed a gradual decrease as the bromegrass became more mature.

When grown without alfalfa, the protein was significantly higher in the Canadian than in the Lincoln variety on June 20 and 30, 1956, and June 30 and July 10, 1957, both dates being during the latter part of the sampling period when the grass was fully headed.

In the bromegrass leaves, the bromegrass stems, and the whole bromegrass plant, protein decreased steadily with advancing maturity. In 1957, for example, the protein content of Lincoln bromegrass grown with alfalfa on May 23 and July 10 was 18.84 and 11.92% in the leaves, 12.70 and 5.85% in the stems, and 15.75 and 6.52% in the entire plant. In every case, protein was higher in the leaves than in the stems when bromegrass was grown alone or in combination with alfalfa.

The percentage of protein in the whole plant and in most cases in the leaves and stems taken separately, was higher when bromegrass was grown alone than when in mixture with alfalfa during the first part of the growing period. As the season progressed, however, the difference became smaller but the higher percentage of protein was still evident when the grass was grown alone. It should be noted that the bromegrass when grown alone was fertilized with 100 pounds of nitrogen in the spring.

In the Lincoln and Canadian varieties from alfalfa mixtures during 1956, the ether extract varied from 3.14 to 3.87% in the leaves, from 1.01 to 1.55% in the stems, and from 1.44 to 2.26% in the total plant. In pure stands, the ether extract varied from 3.34 to 4.22% in

the leaves, 0.91 to 1.38% in the stems, and 1.56 to 2.59% in the whole plant.

Weather Data

A study of weather data in Tables 5 and 6 reveals that temperatures were more variable in 1956 than in 1957. The mean temperature in June 1956 varied from 45 to 80 degrees with a low of 38 and a high of 92 degrees. The mean temperature in June 1957 varied from 52 to 82 degrees with a low of 41 and a high of 93 degrees. The mean temperature varied only 1 degree for the months of May and June 1956 and 1957.

Rainfall distribution for May and June varied somewhat for 1956 and 1957. Precipitation in May 1956 totalled 6.26 inches as compared to 6.12 inches in May 1957. Precipitation in June 1956 was 2.80 inches as compared to 2.42 inches in June 1957. There was a period of about three weeks of no rain in late May and early June 1956 followed by 1.36 inches of precipitation in 4 days ending on June 18. Distribution in 1957 shows a dry period of about 10 days in early June followed by 0.76 inches of precipitation over a 7-day period ending on June 19.

Figure 5. United States Weather Bureau data for May and June 1956 from the East Lansing Experiment Farm Station.

Day	Month							
	May				June			
	Rainfall inches	Temperature High	Low	Mean	Rainfall inches	Temperature High	Low	Mean
1	----	57	34	46	----	51	39	45
2	.09	60	41	50	----	56	38	47
3	.09	57	38	48	.06	58	40	49
4	.57	54	36	45	----	65	50	58
5	.13	54	38	46	----	71	48	60
6	.80	51.	36	44	----	78	48	63
7	----	52	32	42	----	81	54	68
8	----	55	30	42	.03	80	63	72
9	1.86	64	37	50	----	82	54	68
10	.22	64	48	56	----	86	60	73
11	.05	75	49	62	----	90	60	75
12	1.24	82	60	71	----	92	68	80
13	.12	82	65	74	----	91	68	80
14	----	--	51	(65)	----	89	69	79
15	.43	60	40	50	.09	86	67	76
16	.03	47	32	40	.77	82	68	75
17	.18	51	40	46	.38	81	68	74
18	.02	63	38	50	.12	75	60	68
19	----	59	42	50	----	78	50	64
20	----	57	34	46	----	86	62	74
21	.01	80	47	64	----	86	68	77
22	.30	82	60	71	.15	82	64	73
23	----	60	37	48	----	86	70	78
24	----	54	31	42	.81	84	62	73
25	----	62	39	50	----	72	55	64
26	.10	71	46	58	.39	82	54	68
27	----	72	52	62	----	74	60	67
28	----	70	48	59	----	69	52	60
29	.02	82	52	67	----	76	49	62
30	----	81	65	73	----	84	57	70
31	----	74	46	60				
	6.26	64.4	43.4	53.9	2.80	78.4	57.5	68.0

(65) East Lansing Station mean.

Table 6. United States Weather Bureau data for May, June, and July 1957 from the East Lansing Experimental Farm Station.

Day	May				June				July			
	Rainfall	Temperature			Rainfall	Temperature			Rainfall	Temperature		
	inches	High	Low	Mean	inches	High	Low	Mean	inches	High	Low	Mean
1	----	79	46	62	.46	70	50	60	----	75	52	64
2	----	53	33	43	----	62	41	52	----	83	54	68
3	----	45	30	38	----	72	49	60	----	84	69	76
4	----	54	36	45	----	80	50	65	1.34	81	65	73
5	----	59	33	46	----	76	52	64	----	73	60	66
6	----	70	36	53	----	78	52	65	.02	81	57	69
7	----	74	50	62	.01	62	48	55	----	84	58	71
8	----	77	56	66	----	68	43	56	1.30	78	66	72
9	.19	60	43	52	----	70	44	57	T	76	58	67
10	1.29	56	48	52	----	83	55	69	----	75	50	62
11	.69	62	52	57	.18	76	68	72				
12	.13	67	56	62	----	75	60	68				
13	----	74	59	66	.28	78	62	70				
14	.11	64	37	50	.07	82	63	72				
15	.94	53	33	43	.04	82	67	74				
16	T	48	38	43	----	89	72	80				
17	----	48	42	45	----	91	72	82				
18	.60	45	42	44	.19	93	70	82				
19	1.80	52	44	48	T	84	57	70				
20	T	60	45	52	----	74	52	63				
21	----	79	60	70	----	80	62	71				
22	----	69	46	58	.51	89	68	78				
23	.17	67	47	57	----	81	58	70				
24	----	66	46	56	T	67	52	60				
25	.20	73	55	64	T	69	59	64				
26	----	55	44	50	----	71	60	66				
27	T	68	39	54	.09	76	64	70				
28	----	73	48	60	.59	68	58	63				
29	----	79	53	66	----	74	59	66				
30	----	78	56	67	----	76	59	68				
31	----	--	--	(71)								
	6.12	64.0	45.5	54.8	2.42	76.5	57.5	67.0				

(71) East Lansing Station mean.
(T) Trace of precipitation.

DISCUSSION

Very few significant differences were detected between northern and southern types of smooth bromegrass and then only in pure stands. There was a significant difference between the Lincoln and Canadian varieties in dry matter in the total plant from pure stands in 1956 and 1957. There were significant differences between Lincoln and Canadian in per cent protein in the total plant on June 20 and 30, 1956, and June 30 and July 10, 1957. There was also a significant difference in crude fiber in the total plant from pure stands on May 23, 1957. The differences in protein were detected only at the end of the sampling period and growing season. The difference in crude fiber was detected only on the earliest sampling date.

Weather data for the sampling periods of 1956 and 1957 offered comparisons as to what effect rainfall and temperature may have on smooth bromegrass. In late May and early June 1956, there was a 3-week drought followed by 1.36 inches of precipitation over a 4-day period ending about June 18. Data on percentage stems and dry matter in the total plant appear to reflect the drought and precipitation as a slow rate of increase before the June 20 sampling and a rapid rate of increase following the precipitation. Bromegrass was less mature on any date in 1956 than in 1957 presumably because of the May and June drought but differences in maturity were small on the June 30 date.

The variation in maturity on the June 20 sampling appeared to be the result of the severity of the droughts and the following rate and total amount of precipitation. In 1956, limited moisture resulted

in reduced plant growth until the rains came. In 1957, moisture was not limiting but the higher temperatures caused the plants to mature more rapidly which probably resulted in an increase in the percentage stems and dry matter as compared to the decrease in rate of 1956. The variation about the June 20 sampling appeared in the percentage of crude fiber and to a lesser degree, in the protein in some cases.

The small samples of 1956 may have added error to the data from those sampling dates, but the trends noted in the 1956 data were confirmed by the earlier and later samplings of 1957. The Manchar and Lancaster varieties were most variable from the trends and this may have been due to faulty sampling or too small samples.

The data indicate that the bromegrass may have been as much as three weeks more mature on June 2, 1957, than on June 2, 1956. However, this difference was cut to a week or less by the June 30 sampling date due to a faster rate of maturation during June 1956. This was indicated in the percentage of crude fiber, dry matter, stems and protein. This is further evidence of the marked difference in the two growing seasons in 1956 and 1957.

The percentage of crude fiber increased steadily with advancing maturity up to June 20 after which date it remained constant or decreased slightly. Dotzenko and Ahlgren (2) and Phillips et al. (4) reported data that were confirmed by this finding. Part of this leveling was probably due to head maturation or flowering. In some cases the data showed a decrease in percentage of dry matter in the leaves at that stage but the major change was in the percentage of dry matter in the stem and head.

The percentage of protein decreased steadily with advancing maturity as reported by Churchill (1), Dotzenko and Ahlgren (2) and Phillips et al. (4). These data are not in agreement, however, with data of Churchill (1) in Michigan who reported that percentage of protein was slightly higher in mixtures of alfalfa-bromegrass than in pure stands. The higher percentage of protein in bromegrass when grown alone than when grown with alfalfa was probably due to the fact that 100 pounds of nitrogen per acre was added to the grass in this study. Churchill did not report fertilizing bromegrass with nitrogen in his study.

The percentage of ether extract was quite stable for all sampling dates in 1956 so no ether extracts were made in 1957. Phillips et al. (4) reported no significant differences in the percentage of nitrogen free extract. A slight downward trend was noted with advancing maturity.

The Manchar variety, which is an intermediate variety between the southern and northern strains, was highest of all varieties in percentage of stems and dry matter in the stems in both pure and mixed stands. This appears to indicate that Manchar has fewer leaves than the other varieties tested or is earlier maturing.

The northern varieties were generally more competitive with the alfalfa in the mixtures than were the southern varieties. The Lancaster variety was observed to be easily the least competitive with alfalfa of all the varieties tested.

The southern varieties possibly possessed more vegetative vigor as reported by Newell and Keim (3) and Wheeler and Hill (9). This

difference was more noticeable when bromegrass was grown alone than when grown with alfalfa.

Since smooth bromegrass will generally be grown in mixture with alfalfa in this area, it would appear that the minor differences in maturity evidenced by percentage of crude fiber, dry matter, and stems should not be a reason for favoring either type. This is especially true for the Lincoln and Canadian varieties which are representatives of the southern and northern types, respectively.

Even though the southern type as a group headed about 7 to 10 days earlier than the northern type, the percentage of stems and crude fiber was fairly constant between types, probably because the southern type was more leafy with the result that the percentage of stems, dry matter, and crude fiber were similar for both types when grown with alfalfa. Because of similarities in the above factors, it is likely that the digestibility of the two types of bromegrass would be fairly similar at any stage when grown with alfalfa. When grown alone, digestibility of the northern type would be expected to be slightly higher than that of the southern type.

SUMMARY AND CONCLUSIONS

Three southern and three northern type smooth bromegrass varieties were compared alone and in alfalfa-bromegrass mixtures for percentage stems and dry matter on four sampling dates in June 1956. These same determinations were made in 1957 on the Lincoln and Canadian varieties which were also compared for percentage crude fiber, ether extract, and protein for the four June 1956 sampling dates and six sampling dates in May, June, and July 1957.

1. When grown with alfalfa, northern and southern varieties (Canadian and Lincoln varieties even more specifically) did not vary significantly in percentage of stems, dry matter, protein or crude fiber during any sampling period in either year with the exception of dry matter on June 30, 1956, when Lincoln had 1.9% more dry matter than Canadian.

2. When grown alone, Lincoln was significantly higher than Canadian in (a) percentage of dry matter and (b) crude fiber early in one season. Lincoln was significantly lower than Canadian in crude protein during the latter sampling dates of 1956 and 1957.

3. Southern varieties did not differ significantly among themselves in any of the determinations. Northern varieties differed significantly within the group in percentage of stems and dry matter in pure stands and in percentage of stems only from mixed stands. The differences were due primarily to the Manchar variety which was significantly higher in stems than the other varieties when grown alone or with alfalfa.

4. Crude fiber increased with advancing maturity while the protein decreased. Ether extract was quite stable.

5. Little difference would be expected in digestibility between the southern and northern (or Lincoln and Canadian) types at any stage of growth when grown with alfalfa since there were no significant differences in crude fiber or protein. When grown alone, digestibility of the northern would be expected to be somewhat higher than that of the southern type, because the Canadian variety was significantly lower in dry matter and higher in protein at the end of the growing season than the Lincoln variety.

6. If a choice is to be made between the Lincoln and Canadian varieties grown with alfalfa in Michigan, it must be made for reasons other than any differences in percentages of stems or leaves, dry matter, crude fiber, or ether extract. With the exception that the Canadian variety was higher in percentage of protein in the later stages of harvest, the data from this experiment show these two varieties of different types to be similar in the factors studied when grown with alfalfa.

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