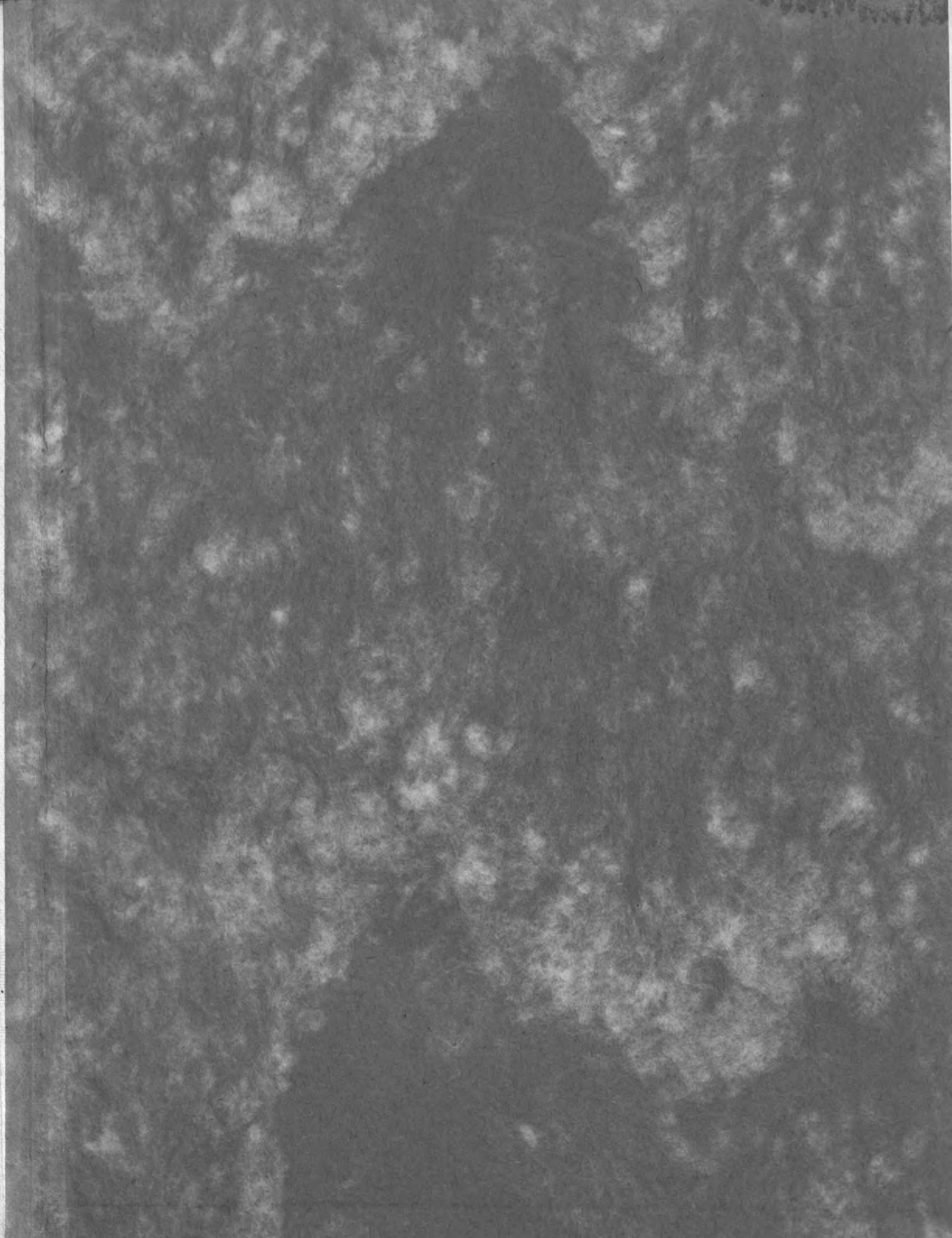
GROWTH STUDIES IN ALFALFA

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE
Carlton S. Garrison

1938

THESIS



GROWTH STUDIES IN ALFALFA

A THESIS

Submitted to the Faculty of Michigan State College
of Agriculture and Applied Science in partial
fulfillment of the requirements for the
Degree of Master of Science

Carlton S. Garrison

December, 1938

THESIS

ACKNOWLEDGMENT

The writer is very grateful to Mr. E. E. Down for invaluable advice and assistance in the pursuit of this work.

To Mr. H. M. Brown whose interest and cooperation made this work possible, the writer wishes to express his sincere appreciation.

CONTENTS

GROWTH STUDIES IN ALFALFA

INTRODUCTION

It had been observed in the alfalfa breeding nursery that there were certain noticeable differences existing between the individual plants within a strain in the amount of growth made early in the spring, in the time of appearance of the secondary shoot growth and in yielding ability. The purposes of the investigation here reported were: (1) to study (a) the amount of growth made by the individual plants by May 1, (b) the number of days from May 1 to the date when the secondary shoot growth was observed to be one to two inches high, (c) the yielding ability, in green weight, of the plant at time of observance of secondary shoots, and (d) the relationships between these characters; and (2) to determine whether the several strains differed from each other in regard to these characters.

REVIEW OF LITERATURE

Among all of the published material relating to growth studies in alfalfa no literature was found pertaining to this particular problem.

MATERIAL AND METHODS

The data for this study were secured from the alfalfa breeding nursery which was set out in July, 1934, one plant in a place with the plants spaced 33 inches in the row and the rows 36 inches apart. The nursery was planted in four series of 101 rows each; each row of the north three series, A, B, and C, was 27

plants long while the fourth series, D, was 29 plants long, Figure 1. Series B and D were the replications of Series A and C, respectively. The entire nursery consisted of 150 different strains plus the check. A check (designated by x in tables) was planted in the east row and every four th row thereafter. The other 75 rows of a series were each the progeny of a high yielding plant of the previous nursery. The systematic replications were such that a strain appeared in two adjacent series, that is plots 0-100 were in series A and B, and plots 100½ - 200 in series C and D. Around the entire nursery was a row of plants used as a border.

It was decided that this exploratory study should be made on only a portion of the nursery rather than the whole nursery. The areas selected for this study consisted of the first 26 plots in series A and C and their replicates. All of the data presented was secured on the first cutting in 1936.

Each plant in the alfalfa breeding nursery was given a rating according to the amount of growth made by May 1, 1936. Four ratings, based entirely on plant height, were used. Rating "1" included all plants which had made a growth of only a trace to two inches high. Rating "2" included those plants which had made a growth of two to four inches. Rating "3" included those plants which had made a growth of 4 to 6 inches. Rating "4" included all plants having made a growth greater than six inches.

At various times during the last half of May, the nursery

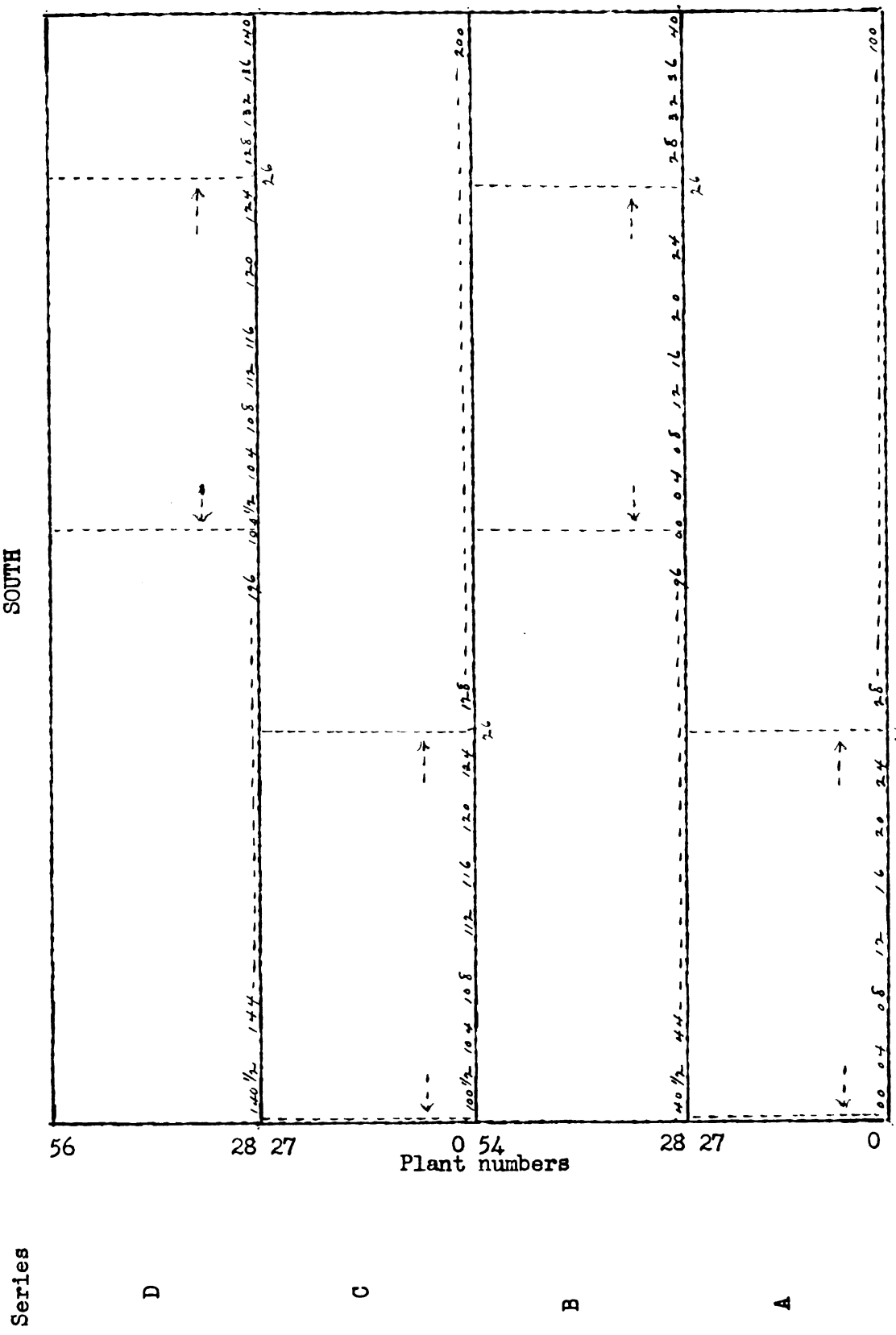


Fig. 1. Diagram of the alfalfa breeding nursery.

was examined to determine whether secondary shoots had begun to appear. During the last few days of May and the first days of June some plants were observed to have their secondary shoots. On June 4 all plants so observed were recorded, cut and weighed. On June 12 and 19 similar notes and cuttings were made. The plants remaining uncut on June 19 were so slow in showing secondary shoots that two weeks were allowed to elapse before the plants were again cut on July 2. On the final date of cutting, July 16, all remaining plants, whether they had yet formed secondary shoots or not, were cut. This was done to allow ample time for the second crop to develop seed.

The number of days to observance of secondary growth (hereafter, more briefly called date of cutting) was determined from May 1, the day the May ratings were taken.

Green weights were taken immediately after cutting and were recorded in grams.

The more detailed data are presented in two parts, by series A and B and by series C and D, as that formed a convenient method of dividing the otherwise long tables. However, in the statistical analysis for significance of differences between strain means the entire area was treated as a whole and plots $100\frac{1}{2}$ to 125 were considered to be a continuation of plots 0 to 25. In the analysis of variance there were assigned, therefore, 103 degrees of freedom to total, 1 to replication, 51 to strains, and 51 to error.

RESULTS AND DISCUSSIONS

May Rating

The May rating values were taken by two persons, one taking those on plots 0 to 16 of series A, the other taking all of the other ratings.

Table 1, which is arranged according to plot number, shows the frequencies of the individual May ratings, the number of plants in each plot, the plot means, the strain means (average of series A and B), and the number and per cent of plants in each May rating group for plots 0 to 25. The strains varied in May rating from 2.20 to 3.11, giving a range of .91. The average for all strains was 2.57. The average May rating for series A was 2.26 and series B 2.89. The large difference of .63 between the two series averages may be partially explained by the fact that two persons took the May ratings for series A as mentioned above.

The average for the two replications gave a more even distribution between ratings 1 and 4, and 2 and 3 than was the case in the individual series. The average shows 7.3% and 10.4% in ratings 1 and 4, and 38.7% and 43.6% in ratings 2 and 3, respectively.

Table 1

Number of plants per plot classified according to May rating, total number (N) of plants per plot, plot mean rating and strain mean rating. Order that of plot numbers in series A and B.

Plot No.	Series A.						Series B.						Strain mean
	May rating				N	Mean	May rating				N	Mean	
	1	2	3	4			1	2	3	4			
00x	4	20	2		26	1.92	1	7	17		25	2.64	2.27x
01	6	15	1		22	1.77		3	9	4	16	3.06	2.32
02	4	14	6		24	2.08	1	1	18	6	26	3.12	2.62
03	2	12	10		24	2.33		1	12	11	24	3.42	2.88
04x	6	15	4		25	1.92		6	12	3	21	2.86	2.35x
05	4	12	9		25	2.20		9	15	3	27	2.78	2.50
06	6	12	5		23	1.96	1	10	12	3	26	2.65	2.33
07	1	18	6		25	2.20		1	11	13	25	3.48	2.84
08x	3	20	2		25	1.96		8	15	1	24	2.71	2.33x
09	5	14	3	1	23	2.00	1	4	11	3	19	2.84	2.38
10	1	16	8		25	2.28		1	17	8	26	3.27	2.78
11	2	15	10		27	2.30	2	4	16	3	25	2.80	2.54
12x	2	19	4		25	2.08		6	16	2	24	2.83	2.45x
13	4	17	4		25	2.00		2	15	4	21	3.10	2.50
14	5	17	4		26	1.96	3	3	13	4	23	2.78	2.35
15	4	16	3		23	1.96	2	6	9	1	18	2.50	2.20
16x	5	20			25	1.80	1	9	14	2	26	2.65	2.24x
17		9	13	4	26	2.81		5	18	1	24	2.83	2.82
18		3	18	4	25	3.04		4	14	7	25	3.12	3.08
19	1	10	11	2	24	2.58		3	19	1	23	2.91	2.74
20x	1	14	11		26	2.38		9	13	3	25	2.76	2.57x
21	1	8	12	4	25	2.76		6	9	4	19	2.89	2.82
22	1	7	12	5	25	2.84	2	1	14	3	20	2.90	2.87
23	1	4	13	6	24	3.00		2	14	7	23	3.22	3.11
24x	4	11	9	2	26	2.35		7	13	2	22	2.77	2.54x
25	1	15	9	1	26	2.38	3	10	7	2	22	2.36	2.38
Total No.	74	353	189	29	645		17	128	353	101	599		
%	11.5	54.7	29.3	4.5			2.8	21.4	58.9	16.9			
Av.						2.26						2.89	2.57
Total, both series							91	481	542	130	1244		
%	"		"				7.3	38.7	43.6	10.4			

In this and all other tables the checks are marked with an x.

In Table 2 are given the data on May ratings for series C and D similar to those in Table 1 for series A and B. The strains varied in May rating from 1.98 to 3.02, a range of 1.04. The average for all strains was 2.42. The average May rating for series C was 2.30 and for series D was 2.53.

The average of series C and D shows 12.2%, 43.1%, 35.7% and 9.0% for ratings 1, 2, 3, and 4, respectively. As in series A and B, the greater numbers of plants were found in ratings 2 and 3 with a total of 78.8%.

The totals for all four series are the following:

Rating	1	2	3	4	Total
No. of plants	251	1043	1008	248	2550
%	9.8	40.9	39.5	9.7	100

In Table 3 is given the average May rating of each strain with the check average inserted in its proper place. It is seen that there are many significant (5% point) differences and some highly significant (1% point) differences between strains.

Table 2

Number of plants per plot classified according to May rating, total number (N) of plants per plot, plot mean rating and strain mean rating. Order that of plot numbers in series C and D.

Plot No.	Series C						Series D						Strain mean
	May rating						May rating						
	1	2	3	4	N	Mean	1	2	3	4	N	Mean	
100½x	9	12	5	1	27	1.93	4	15	8	1	28	2.21	2.07x
101	5	10	8	1	24	2.21	1	16	9	2	28	2.43	2.33
102	4	11	3	2	20	2.15	1	9	6	2	18	2.50	2.32
103	3	8	11	1	23	2.43	1	11	9	3	24	2.58	2.51
104x	9	14	3	1	27	1.85		16	10	2	28	2.50	2.18x
105		14	7	3	24	2.54	3	9	10	4	26	2.58	2.56
106		10	9	6	25	2.84	1	7	12	6	26	2.88	2.86
107	2	9	8	7	26	2.77	3	7	12	5	27	2.70	2.74
108x	10	11	4	1	26	1.85	4	11	13		28	2.32	2.09x
109	1	10	8	2	21	2.52		7	18	3	28	2.86	2.71
110	2	7	9	4	22	2.68	1	2	14	5	22	3.05	2.86
111	7	8	8	1	24	2.13	4	8	10	6	28	2.64	2.40
112x	5	11	6	3	25	2.28	5	15	7	1	28	2.14	2.21x
113		7	13	5	25	2.92	2	1	16	8	27	3.11	3.02
114	2	11	7	3	23	2.48		10	10	2	22	2.64	2.56
115		11	9	1	21	2.52		7	17	4	28	2.89	2.73
116x	7	13	7		27	2.00	2	17	9		28	2.25	2.13x
117	2	15	6		23	2.17	4	9	12	2	27	2.44	2.32
118		7	18	1	26	2.77	4	6	10	7	27	2.74	2.75
119	4	13	5	2	24	2.21	2	9	10	2	23	2.52	2.36
120x	1	18	6		25	2.20	3	14	11		28	2.29	2.25x
121	6	10	9		25	2.12	2	15	6		23	2.17	2.15
122	6	13	5		24	1.96	7	9	7		23	2.00	1.98
123	4	12	7	2	25	2.28	3	10	12	3	28	2.54	2.42
124x	4	16	6		26	2.08		15	10		25	2.40	2.24x
125	6	16	3	1	26	1.96	3	11	8	2	24	2.38	2.16
Total No.	99	297	190	48	634		60	266	276	70	672		
%	15.6	46.8	30.0	7.6			8.9	39.6	41.1	10.4			
Av.						2.30						2.53	2.42
Total, both series							159	563	466	118	1306		
% " "							12.2	43.1	35.7	9.0			

Table 3

May ratings in ascending order of strain averages.

Strain	Rating	Dif.	Strain	Rating	Dif.
122	1.98		103	2.51	
		.17			.05
121	2.15		105	2.56	
		.01			.02
125	2.16		11	2.58	
		.04			.13
15	2.20		109	2.71	
		.04			.01
1	2.24		18	2.72	
		.04			.01
Ck.	2.28		115	2.73	
		.04			.01
102	2.32		19	2.74	
		.00			.00
117	2.32		107	2.74	
		.01			.01
6	2.33		118	2.75	
		.00			.03
101	2.33		10	2.78	
		.02			.04
14	2.35		17	2.82	
		.01			.00
119	2.36		21	2.82	
		.02			.01
2	2.38		23	2.83	
		.00			.01
9	2.38		7	2.84	
		.00			.02
25	2.38		106	2.86	
		.01			.00
13	2.39		110	2.86	
		.01			.01
111	2.40		23	2.87	
		.02			.01
123	2.42		3	2.88	
		.08			.14
5	2.50		113	3.02	
		.00			
114	2.50				
		.01			

Difference between two strain means must be at least .66 to be significant (5% point) or .88 to be highly significant (1% point).

Number of Days to Observance of Secondary Shoots

Table 4 shows the plots arranged according to plot number for series A and B and gives the distribution of plants within a strain cut on the various dates when notes were taken on presence of secondary shoots. Also included in the table are the number of plants in each plot, the plot means, the strain means (average of series A and B), and the number and per cent of plants cut on each date within each series for plots 0 - 25.

The strains varied in the average number of days to date of cutting from 37.2 to 45.1, a range of 7.9 days. The average for the 26 strains means was 39.7 days. The average number of days to the date of cutting for series A was 39.3 days, and for series B it was 39.9 days.

Series B was very similar to A in the per cent of plants cut at the various cutting dates. The percentages for both series together were 62.8%, 26.4%, 7.1%, 5.3% and 0.2% for the five cutting dates of 35, 43, 50, 63 and 77 days, respectively, from May 1.

Table 5 gives the data on the number of days to date of cutting for series C and D similar to that in Table 4 on series A and B.

The strains varied in the average number of days to the date of cutting from 37.6 to 47.0 days, a range of 10.6 days. The average number of days to the date of cutting for the 26

Table 4
Average number of days from May 1 to the date of cutting, arranged according to plot numbers.

Plot No.	Series A							Series B							Strain Mean
	35	43	50	63	77	No. of plants	Mean	35	43	50	63	77	No. of plants	Mean	
	6/4	6/12	6/19	7/2	7/16			6/4	6/12	6/19	7/2	7/16			
00x	19	6	1			26	37.4	20	4	1			25	36.9	37.2x
01	14	6	1	1		22	39.1	11	4		1		16	38.8	39.0
02	16	6	2			24	38.3	17	4	4	1		26	39.6	39.0
03	11	10	3			24	40.2	12	7	4	1		24	41.0	40.6
04x	21	4				25	36.3	18	2		1		21	37.1	36.7x
05	16	8		1		25	38.7	14	9	1	3		27	41.3	40.1
06	19	1	3			23	37.3	10	10	4	2		26	42.5	40.1
07	18	5	2			25	37.8	21	3	1			25	36.6	37.2
08x	20	4	1			25	36.9	18	5	1			24	37.3	37.1x
09	12	6	1	3	1	23	43.2	10	7	1	1		19	40.2	41.8
10	16	6	2	1		25	39.2	13	8	4	1		26	40.8	40.0
11	23	3	1			27	36.4	17	6		2		25	39.2	37.7
12x	18	7				25	37.2	17	6		1		24	38.2	37.7x
13	7	8	5	4	1	25	46.7	9	5	5	2		21	43.1	45.1
14	13	7	4	2		26	41.6	12	5	3	3		23	42.3	41.9
15	14	7		2		23	39.9	15		1	2		18	38.9	39.5
16x	18	7				25	37.2	21	5				26	36.5	36.8x
17	14	8	3	1		26	40.3	8	7	5	4		24	45.1	42.6
18	18	7				25	37.2	18	2	4	1		25	39.2	38.2
19	10	13	1			24	40.0	16	5	2			23	38.0	39.0
20x	14	11		1		26	39.5	20	3		2		25	38.2	38.9x
21	13	9		3		25	41.2	8	6	3	2		19	42.8	41.9
22	16	5	3	1		25	39.5	11	4	2	2	1	20	43.0	41.1
23	14	8		2		24	40.0	11	6	4	2		23	42.1	41.0
24x	18	6	2			26	38.0	18	3		1		22	37.4	37.7x
25	13	6	1	6		26	43.9	11	6	2	3		22	42.4	43.2
Total	405	174	36	38	2	645		376	142	52	38	1	599		
%	62.8	27.0	5.6	4.3	0.3			62.8	22.0	8.7	6.3	0.2			
Av.							39.3							39.9	39.7
Total, both series								781	306	88	66	3	1244		
% " "								62.8	24.6	7.1	5.3	.2			

Table 5

Average number of days from May 1 to the date of cutting arranged according to plot numbers

Plot No.	Series C							Series D							Strain Mean
	35	43	50	63	77	No. of plants	Mean	35	43	50	63	77	No. of plants	Mean	
	6/4	6/12	6/19	7/2	7/16			6/4	6/12	6/19	7/2	7/16			
100½x	21	5	1			27	37.0	21	6		1		28	37.7	37.4x
101	15	7	2			24	38.6	10	11	5	2		28	42.8	40.9
102	7	7	3	3		20	44.3	3	5	4	6		18	49.9	47.0
103	16	6	1			23	37.7	17	5		2		24	39.0	38.4
104x	20	4	3			27	37.9	25	1	2			28	36.4	37.1x
105	14	5	4	1		24	40.3	16	2	4	4		26	42.2	41.3
106	17	6	1		1	25	39.2	20	3	1	2		26	38.7	38.9
107	20	4	1	1		26	37.9	16	7	2	2		27	40.3	39.1
108x	18	6	1	1		26	38.5	24	4				28	36.1	37.3x
109	14	6	1			21	38.0	19	4		5		28	41.1	39.8
110	15	5	1	1		22	38.8	15	3	2	2		22	40.0	39.4
111	12	5	4	3		24	42.7	17	5	3	3		28	41.0	41.8
112x	18	5	1	1		25	38.3	20	3	3	2		28	39.5	38.9x
113	17	7	1			25	37.8	19	5	2	1		27	38.6	38.2
114	19	3	1			23	36.7	14	6	2			22	38.5	37.6
115	13	4	3	1		21	40.0	15	6	2	5		28	42.8	41.6
116x	16	10		1		27	39.0	19	6	3			28	38.3	38.6x
117	14	6	2	1		23	39.6	15	7		5		27	42.3	41.1
118	15	8	3			26	39.2	13	7	1	6		27	43.9	41.6
119	10	7	2	5		24	44.4	13	4	4	2		23	41.4	42.9
120x	21	3	1			25	36.6	19	9				28	37.6	37.1x
121	14	3	4	4		25	42.8	12	10		1		23	39.7	41.3
122	8	10	4	2		24	43.2	3	6	9	5		23	49.0	46.0
123	12	7	2	3	1	25	43.5	14	8	6			28	40.5	41.9
124x	23	3				26	35.9	17	7	1			25	37.8	36.8x
125	12	10	4			26	40.4	13	7	1	3		24	41.5	40.9
Total	401	152	51	28	2	634		409	147	57	59	0	672		
%	63.3	24.0	8.0	4.4	0.3			60.9	21.9	8.5	8.8	0			
Av.							39.6							40.6	40.1
Total, both series								810	299	108	87	2	1306		
% " "								62.0	22.9	8.3	6.7	.1			

strain means was 40.1. The average number of days to the date of cutting for series C was 39.4 days and for series D it was 40.6 days.

The results in series D were very similar to those of series C. The percentages for both series together were 62.0%, 22.9%, 6.7% and .1% for the five successive cutting dates respectively.

Considering all four series together, the number of plants cut on each date and the percentage that number was of the total are as follows:

Date Cut	June 4	June 12	June 19	July 2	July 16	Total
Number of days after May 1	35	43	50	63	77	
Number of plants	1591	605	196	153	5	2550
% of total	62.4	23.7	7.7	6.0	.2	100

In Table 6 are given the strain averages of the number of days to the cutting date. It is seen that there are some significant (5% point) and a few highly significant (1% point) differences between strains in number of days after May 1 until secondary shoots emerge.

Table 6

Number of days from May 1 to the date secondary shoots were observed (date of cutting) arranged in ascending order of strain averages.

Strain	Days	Dif.	Strain	Days	Dif.
7	37.2		23	41.0	
		.2			.0
Ck.	37.4		117	41.0	
		.2			.1
114	37.6		19	41.1	
		.2			.2
11	37.8		103	41.3	
		.4			.0
18	38.2		121	41.3	
		.1			.3
113	38.3		115	41.6	
		.1			.0
103	38.4		118	41.6	
		.5			.2
106	38.9		111	41.8	
		.1			.1
1	39.0		9	41.9	
		.1			.0
107	39.1		21	41.9	
		.3			.1
110	39.4		14	42.0	
		.4			.6
109	39.8		17	42.6	
		.1			.4
15	39.9		119	43.0	
		.0			.3
5	40.1		22	43.3	
		.0			1.8
6	40.1		13	45.1	
		.0			.2
10	40.1		25	45.3	
		.1			.7
2	40.2		122	46.0	
		.3			.9
123	40.5		102	46.9	
		.1			
3	40.6				
		.3			
101	40.9				
		.0			
125	40.9				
		.1			

Difference between two strains must be at least 3.3 days to be significant (5% point) or 4.4 days to be highly significant (1% point).

Yield

In Table 7 are given the plot and the strain means for the yield (green weight in grams) per plant of series A and B, and of series C and D, arranged according to plot number.

The strain means for series A and B varied from 467 to 840 grams per plot, a range of 373 grams. The average of the 26 strain means was 673 grams. The average yield per plot for series A was 646 grams and for series B it was 671 grams.

The strain means for series C and D varied in yield from 520 to 907 grams per plot, a range of 387 grams. The average of the 26 strains means was 756 grams. The average yield per plot for series C was 743 grams, and for series D it was 769 grams.

In Table 8 is given the average plant yield of hay per strain. It can be seen that there are some significant (5% point) and several highly significant (1% point) differences between strains.

Table 7

Mean yield of hay per plant arranged according to plot number.

Plot No.	Series A	Series B	Strain mean	Plot No.	Series C	Series D	Strain mean
00x	702	772	737x	100½x	800	775	787x
01	533	526	530	101	745	795	775
02	693	722	780	102	831	805	819
03	765	817	791	103	773	909	842
04x	612	759	679x	104x	707	953	832x
05	637	640	639	105	875	937	907
06	600	520	558	106	861	928	895
07	687	796	742	107	822	827	825
08x	598	760	677x	108x	735	890	815x
09	463	546	501	109	831	831	831
10	851	689	768	110	836	847	842
11	687	590	640	111	659	704	683
12x	660	621	641x	112x	648	674	662x
13	688	839	757	113	750	767	759
14	590	667	626	114	770	697	734
15	460	477	467	115	892	911	903
16x	620	671	646x	116x	747	660	703x
17	877	800	840	117	674	647	659
18	758	806	782	118	947	785	864
19	766	712	740	119	498	676	585
20x	575	683	628x	120x	702	633	666x
21	646	616	633	121	626	532	581
22	647	667	671	122	578	654	615
23	584	601	592	123	818	850	835
24x	541	693	611x	124x	676	772	723x
25	527	512	520	125	519	522	520
Av.	646	671	673		743	769	756

Table 8

Green weight per plant arranged in ascending order of strain averages.

Strain	Grams	Dif.	Strain	Grams	Dif.
15	467		19	740	
		34			2
9	501		7	742	
		19			15
25	520		13	757	
		0			2
125	520		113	759	
		10			9
1	530		10	768	
		28			7
6	558		101	775	
		23			7
121	581		18	782	
		4			9
119	585		3	791	
		8			13
23	593		103	804	
		23			14
122	616		102	818	
		10			7
14	626		107	825	
		7			6
21	633		109	831	
		5			4
5	638		123	835	
		3			5
11	641		17	840	
		19			1
117	660		110	841	
		11			23
22	671		118	864	
		12			30
111	683		106	894	
		18			9
Ck.	701		115	903	
		3			4
2	704		105	907	
		30			
114	734				
		6			

Differences between two strains must be at least 123 grams to be significant (5% point) or 164 grams to be highly significant (1% point).

Relationship Between May Rating and Number of Days to Observance of Secondary Shoots

Not all the plants in any one of the May rating groups were observed to have their secondary shoots by the same date of cutting, Table 9, although rating groups (3 and 4) showed more than 90% of their plants with secondary shoots at the first two dates of cutting.

Table 9

The number and per cent of plants of each May rating group harvested on the various cutting dates.

May Rating	Number and per cent of plants harvested										Total	
	June 4		June 12		June 19		July 2		July 16			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	77	30.7	74	29.5	32	12.7	66	26.3	2	.7	251	100
2	586	56.2	296	28.4	99	9.5	60	5.8	2	.2	1043	100
3	705	68.9	212	21.0	64	6.3	26	2.6	1	.1	1008	100
4	223	89.9	23	9.3	1	.4	1	.4	0	0	248	100
Total	1591	62.4	605	23.7	196	7.7	153	6.0	5	.2	2550	100

The coefficient of correlation, -.326, between May rating and date of cutting on an individual plant basis, is highly significant statistically though not very great biologically - the squared variability in May rating accounting for only 10.6 per cent of the squared variability in date of cutting. The coefficient indicates

that there is a tendency for the more vigorous plants on May 1 to produce their secondary shoots early.

When the plot averages were compared and the covariance due to series and strains eliminated, the correlation coefficient was found to be -.154, a non-significant value. Even though the coefficient is not significant it may be noted that it has the same sign as does the coefficient obtained from the individual plants.

Relationship Between May Rating and Yield

The plants which received a rating of 3 or 4 on May 1 gave higher yields than did the plants which received ratings of 1 and 2, Table 10. Ratings 3 and 4 gave an average yield of 849 grams and 1005 grams, respectively, while ratings 1 and 2 gave average yields of 328 grams and 599 grams respectively.

Table 10

The average yield of plants when grouped according to their May ratings.

May rating	Number of plants	Per cent of plants in each group	Per cent of total yield in each group	Average yield
1	251	9.8%	4.5%	328
2	1043	40.9%	34.5%	599
3	1008	39.5%	47.2%	849
4	248	9.7%	13.8%	1005
Total	2550	General Average		711

While the plants were grouped by ratings quite symmetrically, the average yield tended to vary in the direction of the plants receiving the higher ratings. Rating 1 with 9.8% of the total number of plants included only 4.5% of the total yield; rating 2 with 40.9% of the plants included only 34.5% of the total yield; rating 3 with 39.5% of the plants included 47.2% of the total yield, while rating 4 with only 9.7% of the plants included 13.8% of the total yield.

After the covariance due to series and strains was eliminated, the coefficient of correlation was .209, a non-significant value, indicating that though within a strain there was little relationship between plot average May rating and green weight of plant, yet the relationship was in the positive direction.

Relationship Between the Number of Days To Observance of Secondary Shoots and Yield

The results given in Table 11 show that as the number of days to the observance of secondary shoots (date of cutting) increased the average yield per plant decreased. The increase in the average yield of the July 16 cutting over that of July 2 can be explained as due to the small number of plants, five, which were cut on the later date.

The per cent of plants cut on the various cutting dates corresponds very closely to the per cent of the total yield in each of the groups, indicating a fairly close relationship between earliness of secondary shoot observance and yield.

Table 11

Average yield per plant on the various cutting dates.

Cutting Date	No. of days to cutting date	Per cent of plants cut	Per cent of total yield	Average Yield (Grams)
June 4	35	62.4	65.8	750
June 12	43	23.7	23.2	696
June 19	50	7.7	7.2	667
July 2	63	6.0	3.6	421
July 16	77	.2	.2	664

This relationship is further substantiated by the coefficient of correlation between plot averages. After the covariance due to series and strains had been eliminated, the coefficient of correlation was -.569, which is highly significant.

Relationship Between May Rating, Number of Days to the Date of Cutting, and Yield

Within each May rating, as the number of days to cutting increased there was no definite relationship with yield but within the date of cutting as the May rating increased the average yield per plant increased. This is brought out by Table 12 in which are given the number of plants and the average yield for each date of cutting within each May rating group. In only May rating "1" was there a continuous decrease in average yield per plant as the length of the growing period increased from June 4 up to July 2.

Table 12

The number of plants and the average yield in grams for each of the dates of cutting within each May rating.

Cutting date	No. of days to date of cutting	May rating								Total No.of plants	Average Yield
		1		2		3		4			
		No.of plants	Yield	No.of plants	Yield	No.of plants	Yield	No.of plants	Yield		
June 4	35	77	400	586	595	705	836	223	1003	1591	750
" 12	43	74	379	296	613	212	889	23	1009	605	696
" 19	50	32	324	99	630	64	887	1	1220	196	667
July 2	63	66	178	60	509	26	802	1	1320	153	421
" 16	77	2	645	2	855	1	320	0	0	5	664
Total plants		251		1043		1008		248		2550	
Average yield			328		599		849		1005		711

Table 13 allows a comparison between the strain averages for May rating, number of days to date of observance of secondary shoots (date of cutting) and yield. An examination of this table substantiates further the point made earlier that there is little relationship between May rating and either number of days to secondary shoot emergence or yield. A similar conclusion might be made between the date of cutting and yield.

Table 13

Strain averages arranged in order of May rating. Within a rating the order is that of number of days to cutting. Yield is in grams.

Strain	Rating	Days	Grams	Strain	Rating	Days	Grams
122	1.98	46.0	616	114	2.50	37.6	734
				5	2.50	40.1	630
121	2.15	41.3	581	103	2.51	38.4	804
125	2.16	40.9	520	105	2.56	41.3	907
				11	2.58	37.8	641
15	2.20	39.5	767				
1	2.24	39.0	530	109	2.71	39.8	831
Ck.	2.28	37.4	701	18	2.72	38.2	782
				115	2.73	41.6	903
117	2.32	41.0	660	107	2.74	39.1	825
102	2.32	46.9	818	19	2.74	41.1	740
6	2.33	40.1	558	118	2.75	41.6	864
101	2.33	40.9	775	10	2.78	40.1	768
14	2.35	42.0	626				
119	2.36	43.0	585	21	2.82	41.9	633
2	2.38	40.2	708	17	2.82	42.6	840
9	2.38	41.9	501	23	2.83	41.0	593
25	2.38	45.3	520	7	2.84	37.2	742
13	2.39	45.1	757	106	2.86	38.9	894
				110	2.86	39.9	841
111	2.40	41.8	683	23	2.87	43.3	671
123	2.42	40.5	835	3	2.88	40.6	791
				113	3.02	38.3	759

Since yield in hay is the last, in point of life cycle, of the three variables studied and since high yields of hay are desired, yield was considered the dependent variable with May rating and number of days to secondary shoot observance as independent variables. The coefficient of multiple correlation (R) obtained by covariance after eliminating the effect of series and strain, was found to be .582, which is highly significant statistically though not large enough to aid materially in selecting for high yield of hay when May rating and number of days to observance of secondary shoots are known.

CONCLUSIONS

This investigation was made on a part of the regular alfalfa breeding nursery with a view to determining whether the differences which had been observed between various plants were characteristic of the strains. The three types of differences studied were: May rating, number of days from May 1 to the observance of secondary shoots (date of cutting) and yield of hay.

Significant differences were found between the strain averages in each of the three types of differences studied. This indicates that some of the factors which govern May rating, number of days to observance of secondary shoots and yield of hay are inherited and characteristic of the several strains. The stability of these characteristics could not be studied as

only one year's results were available.

There was found a slight tendency for the more vigorous plants on May 1 to produce their secondary shoots earlier than the less vigorous plants. (On a single plant basis, r was -.326, and on a plot basis, -.154.)

The more vigorous plants on May 1 tended to produce the higher yields of hay. (r was .209.)

The earlier the plants produced their secondary shoots the greater the yield of hay. (r was -.569.)

From a strain standpoint, whatever the factors were which tended for vigorous growth in the spring (May rating) and for early production of secondary shoots (number of days to observance of secondary shoots) also tended for high yield of hay.

($R_{Y.MD}$ was .582.)

ROOM USE ONLY

ROOM USE ONLY