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NOT FOR PUBLICATION

PROGRESS REPORT

FORAGE CROP INVESTIGATIONS 1960

FORAGE MANAGEMENT

Field Husbandry Department
Ontario Agricultural College
Guelph

FORAGE PROGRESS REPORT 1960

This report contains data on O.A.C. trials. It is not complete in that only the data summarized by May 1, 1961, are included. However, it does contain most of the data. The report is prepared for use of the members of the Field Husbandry Department and for those associated with the forage program.

A federal-provincial program is in operation in variety and mixture testing and in orchardgrass breeding. This report does not cover the data collected by other stations in this co-ordinated program. The complete set of data from all stations is available.

CONTENTS

(Year refers to year trial was seeded, and number in brackets is experiment number)

1960 GROWING SEASON WEATHER RECORDS

Temperature		April	May	June	July	August	September
Harrow	Max.	56.1	63.0	74.9	78.9	79.5	75.7
	Min.	39.3	49.1	56.6	59.1	61.8	56.8
Ridgetown	Max.	56.6	64.3	75.1	78.9	78.9	74.2
	Min.	38.6	47.4	54.9	58.3	60.3	56.2
Guelph	Max.	53.3	61.8	72.3	76.3	76.6	72.4
	Min.	35.2	47.1	52.4	55.5	55.7	51.8
Kemptville	Max.	52.3	71.0	75.3	79.7	80.9	70.1
	Min.	34.3	49.5	52.6	54.7	53.2	48.7
Ottawa	Max.	49.3	70.5	74.1	77.9	79.4	69.0
	Min.	33.7	50.2	54.2	55.9	54.7	50.9
New Liskeard	Max.	44.7	65.8	71.3	74.0	75.6	63.4
	Min.	24.5	42.7	48.5	50.9	51.1	44.0
Kapuskasing	Max.	41.3	61.1	70.8	71.7	73.8	60.7
	Min.	23.0	39.2	46.1	49.4	51.8	41.7
Gore Bay	Max.	47.2	63.1	68.9	73.2	76.0	65.9
	Min.	29.7	43.1	47.1	52.4	52.0	48.6
Fort Francis	Max.	47.4	64.2	70.3	78.1	77.1	65.3
	Min.	28.4	40.5	48.4	51.3	56.4	44.0

Rainfall	April	May	June	July	August	September
Harrow	1.8	3.0	5.2	2.1	1.7	0.8
Ridgetown	3.2	2.4	4.2	1.7	1.9	1.8
Guelph	2.5	5.1	3.2	3.9	1.4	0.4
Kemptville	3.4	3.7	2.3	1.4	1.2	1.9
Ottawa	2.7	4.2	2.3	2.0	1.5	1.9
New Liskeard	---	---	---	3.6	3.3	4.2
Kapuskasing	3.2	1.9	2.0	2.4	4.2	2.2
Gore Bay	4.9	4.3	4.9	2.9	2.1	2.8
Fort Francis	2.1	2.4	3.3	3.8	3.7	1.9

DEPARTURES OF 1960 GROWING SEASON WEATHER RECORDS FROM NORMAL

Temperature		April	May	June	July	August	September
Harrow	Max.	0.0	-5.4	-4.0	-4.9	-2.4	1.0
	Min.	3.1	2.3	-1.1	-3.1	1.8	2.4
Ridgetown	Max.	3.9	-0.5	-1.6	-3.0	-1.2	2.1
	Min.	3.1	1.6	-1.4	-2.8	0.6	2.3
Guelph	Max.	2.6	-1.8	-1.8	-.26	-0.7	2.5
	Min.	2.8	4.2	-0.2	-1.4	0.1	2.8
Kemptville	Max.	0.8	4.5	-1.2	-1.7	2.1	0.0
	Min.	3.5	5.4	-1.1	-3.3	-2.4	0.6
Ottawa	Max.	-0.5	5.2	-1.1	-1.9	1.6	0.2
	Min.	2.5	7.0	1.2	-1.6	-0.3	3.0
New Liskeard	Max.	-1.2	3.6	-1.1	-2.8	0.8	-1.5
	Min.	0.2	6.3	1.0	-2.2	0.4	0.9
Kapuskasing	Max.	-0.9	3.5	1.4	-2.8	2.5	-0.5
	Min.	3.6	5.3	1.0	-1.8	2.2	0.1
Gore Bay	Max.	-0.6	3.8	-2.4	-4.5	0.6	1.6
	Min.	2.4	4.6	-1.3	-2.3	-1.6	1.2
Fort Francis	Max.	-0.6	1.9	-1.2	0.5	2.8	1.3
	Min.	0.0	-0.7	-2.7	-4.3	2.3	-1.3

Rainfall	April	May	June	July	August	September
Harrow	-0.7	0.6	2.2	-0.2	-0.5	-1.7
Ridgetown	0.2	-0.7	1.3	-1.2	-0.5	-1.1
Guelph	-0.2	2.0	0.1	0.4	-1.5	-2.6
Kemptville	0.8	0.4	-0.3	-2.1	-1.4	-1.3
Ottawa	0.1	1.4	-1.1	-1.5	-1.5	-1.2
New Liskeard	---	---	---	0.0	0.4	-0.9
Kapuskasing	1.5	-0.4	-0.8	-0.9	1.0	-1.0
Gore Bay	2.6	2.0	2.4	0.9	0.0	-0.3
Fort Francis	0.0	-0.2	-0.6	0.2	-0.2	-1.4

NORMAL GROWING SEASON WEATHER RECORDS FOR CERTAIN ONTARIO STATIONS

Temperature		April	May	June	July	August	September	October
Harrow	Max.	56.1	68.4	78.9	83.8	81.9	74.7	62.5
	Min.	36.2	46.8	57.7	62.2	60.0	54.4	43.5
Ridgetown	Max.	52.7	64.8	76.7	81.9	80.1	72.1	60.2
	Min.	35.5	45.8	56.3	61.1	59.7	53.9	43.6
Guelph	Max.	50.7	63.6	74.1	78.9	77.3	69.9	57.3
	Min.	32.4	42.9	52.6	56.9	55.6	49.0	38.7
Kemptville	Max.	51.5	66.5	76.5	81.4	78.8	70.1	57.1
	Min.	31.8	44.1	53.7	58.0	55.6	48.1	36.8
Ottawa	Max.	49.8	65.3	75.2	79.8	77.8	68.8	55.4
	Min.	31.2	43.2	53.0	57.5	55.0	47.9	36.8
New Liskeard	Max.	45.9	62.2	72.4	76.8	74.8	64.9	52.5
	Min.	24.3	36.4	47.5	53.1	50.7	43.1	33.8
Kapuskasing	Max.	42.2	57.6	69.4	74.5	71.3	61.2	47.9
	Min.	19.4	33.9	45.1	51.2	49.6	41.6	31.9
Gore Bay	Max.	47.8	59.3	71.3	77.7	75.4	64.3	54.7
	Min.	27.3	38.5	48.4	54.7	53.6	47.4	37.3
Fort Francis	Max.	48.0	62.3	71.5	77.6	74.3	64.0	52.1
	Min.	28.4	41.2	51.1	55.6	54.1	45.3	35.0

Rainfall	April	May	June	July	August	September	October
Harrow	2.5	2.4	3.0	2.3	2.2	2.5	1.8
Ridgetown	3.0	3.1	2.9	2.9	2.4	2.9	2.6
Guelph	2.7	3.1	3.1	3.5	2.9	3.0	2.4
Kemptville	2.6	3.3	2.6	3.5	2.6	3.2	2.8
Ottawa	2.6	2.8	3.4	3.5	3.0	3.1	2.7
New Liskeard	1.7	2.2	3.3	3.6	2.9	3.3	2.3
Kapuskasing	1.7	2.3	2.8	3.3	3.2	3.2	2.1
Gore Bay	2.3	2.3	2.5	2.0	2.1	3.1	2.8
Fort Francis	2.1	2.6	3.9	3.6	3.9	3.3	2.1

CO-ORDINATOR'S REPORT

on

PROVINCIAL MIXTURE TRIALS

February 1961

I. Hay-Pasture Mixture Trials.

In the 1956 planning conference hay-pasture mixture trials were planned for areas of well and fair drained soil conditions. These two groups of mixtures were designated as Series A. Additional trials from which data have been obtained and used by this committee have been designated as Series B. The summarized data of these trials have been presented at the November meeting of this committee.

1. Tests for well drained sites.

i. Series A.

At the 1956 planning conference it was decided that this series would be terminated when three years of satisfactory data had been obtained. Ten tests will have reached this stage by the end of 1961. The data from these tests have led to the consolidation of mixture recommendations and have indicated the value of simple mixtures.

At the present time no further testing of mixtures for well drained conditions is suggested in this phase of the mixture evaluation.

At the conclusion of all of these tests it is proposed that these data be published in the form of a technical bulletin.

ii. Series B.

This series of mixtures was seeded at New Liskeard in 1959. It contains 11 mixtures (for details see page 29 of report to the Forage Crop Sub-Committee in 1960). This series was desired due to the failure of the Series A trials. It was designed especially to assess mixtures for conditions of that soil and climate. This test is in excellent condition and yielding valuable data on the use of DuPuits, Vernal and Rhizoma alfalfa, ladino clover and birdsfoot trefoil in mixtures. This test will be continued until three years of data have been collected.

2. Tests for imperfectly drained sites.

i. Series A.

This series was seeded in 1956 and 1957. At the 1960 planning conference it was decided that these trials should remain for a period of five years. In this way the value of birdsfoot trefoil could be more fairly assessed. Six trials are in the process of completion. Complete data should be available by the end of 1963.

It is suggested that a new fertilizer practice be adopted and used on the mixtures of this trial that contain below fifty percent legume. In most trials the alfalfa, red clover and/or ladino will have died leaving only grass. Trefoil plots, however, should still contain a high proportion of legume.

Legumes - 50% or above	0-20-20	200# each fall
Legumes - 30-50%	5-20-20	200# each fall
Legumes - below 30%	0-20-20	200# each fall, 200# of aeroprills.

ii. Series B.

At the last annual meeting a group of mixtures was compiled for testing under (1) flooded, and (2) poor and fair internal soil drainage conditions. To more correctly assess the effect of the flooding on the various mixtures two locations were described which would influence the length of time that surface water remained on the tests. (1) heavy soil that flooded and remained for a considerable period of time in the spring, and (2) a medium soil that flooded but did not remain long during the spring. The effect of internal drainage was to be assessed on soils that were classified as having poor and imperfect internal drainage according to the classification in Publication 296. These latter two conditions were to be surface drained so as to remove any surface water.

Careful selection of the sites for these trials is essential. It is suggested that the intended sites for these trials be chosen during the late winter or early spring when such conditions as area flooding can be observed and staked for spring planting.

It is necessary to obtain sufficient replication of this trial under each of these specific conditions to be meaningful in a statistical analysis.

STATUS OF TESTS CONDUCTED BY MEMBERS OF THE FORAGE CROP SUB-COMMITTEE

(The detailed results are on file under Crop Recommendations Committee reports)

Zone	Testing Station	Number and status of test				
		Hay-Pasture Good Drainage		Hay-Pasture Fair Drainage		Pasture
		Series A	Series B	Series A	Series B	Series A
1	Ridgetown	1957*(fair)[2]		1958(fair)		
		1958(good)				
4	Guelph	1957(good)[1]		1957(good)	1960+(good)	
	Mindemoya	1958(fair)				
	Foxboro	1958(good)				
5	Ottawa	1957(good)				
	Kemptville	1957(good)				1959(good)
6	Arthur			1958(fair)		
7	Eau Claire			1957(good)		
	Noelville			1957(fair)		
	Fort William	1957(good)				
		1958(good)				
	New Liskeard		1959(good)			
8	Kapuskasing	1957(good)		1957(fair)		

1 plowed fall of 1960

2 plowed fall of 1959

* year of seeding

\+ established 1960 in 2 locations

PROVINCIAL HAY-PASTURE MIXTURES FOR AREAS OF GOOD DRAINAGE

Series A

COMPOSITION OF MIXTURES

Mixture No.	Component and seeding rate
1	Vernal 8 + Lasalle 2 + Climax 4 + Lincoln 6
2	Vernal 8 + Lasalle 2 + Climax 4 + Orchard 3
3	Vernal 8 + Lasalle 2 + Climax 4
4	Vernal 10 + Lincoln 10
5	Vernal 6 + Lasalle 3 + Ladino 1 + Climax 5 + Lincoln 6
6	Vernal 5 + Lasalle 3 + Alsike 1 + Ladino 1 + Climax 3 + Lincoln 5 + Orchard 2
7	Vernal 8 + DuPuits 2 + Climax 6
8	Vernal 5 + DuPuits 5 + Climax 4 + Lincoln 6
9	Vernal 10 + Climax 6
10	Vernal 6 + Lasalle 4 + Climax 2 + Lincoln 5 + Orchard 4
11	Rhizoma 5 + Lasalle 2 + Altaswede 2 + Alsike 1 + Climax 4 + Lincoln 4 + Meadow fescue 3
12	Rhizoma 5 + Altaswede 4 + Alsike 1 + Climax 8
13	Rhizoma 8 + Lasalle 2 + Climax 4 + Lincoln 6

PROVINCIAL HAY-PASTURE MIXTURES FOR AREAS OF GOOD DRAINAGE

Series B

Location: New Liskeard   Year seeded: 1959   Harvest year: 1960

Dry matter in lbs.* per acre

Mixture No.	Components	Hay	Aftermath	Total Hay + Aftermath
3	DuPuits 10 + Lincoln 10	1826	1318	3144
4	Vernal 8 + Lasalle 2 + Climax 6	1940	1263	3203
1	Vernal 8 + Lasalle 2 + Climax 4 + Lincoln 6	2335	1304	3639
2	Vernal 10 + Lincoln 10	1994	986	2980
11	Vernal 10 + Climax 6	1802	1190	2992
8	Lasalle 6 + Ladino 2 + Climax 6	1578	784	2362
7	Rhizoma 7 + Lasalle 2 + Ladino 1 + Climax 4 + Lincoln 6	2204	1156	3360
9	Rhizoma 5 + Lasalle 2 + Mammoth 2 + Alsike 1 + Climax 4 + Lincoln 4 + M.fescue 3	2137	784	2921
10	Rhizoma 5 + Mammoth 4 + Alsike 1 + Climax 8	1676	1172	2848
5	Empire 7 + Climax 5	954	354	1308
6	Viking 7 + Climax 5	1533	1015	2548

* Yields of dry matter to nearest pound per acre

PROVINCIAL HAY-PASTURE MIXTURES FOR AREAS OF IMPERFECT DRAINAGE

Series A

COMPOSITION OF MIXTURES

Mixture No.	Components and seeding rates
1	Vernal 6 + Lasalle 3 + Ladino 1 + Climax 5 + Lincoln 6
2	Vernal 2 + Lasalle 5 + Alsike 2 + Climax 6
3	Vernal 3 + Lasalle 5 + Alsike 2 + Climax 4 + Orchard 2 + Meadow fescue 3
4	Vernal 3 + Lasalle 5 + Ladino 1 + Alsike 1 + Climax 3 + Orchard 2 + Lincoln 5
5	Vernal 4 + Viking 3 + Climax 6
6	Viking 5 + Lincoln 8
7	Viking 5 + Lincoln 5 + Climax 2
8	Viking 5 + Climax 5
9	Lasalle 6 + Alsike 2 + Climax 6
10	Empire 5 + Climax 5
11	Empire 5 + Alsike 1 + Climax 5
12	Viking 5 + Reed canary 6
13	Viking 5
14	Empire 5
15	Viking 5 + Alsike 1 + Climax 5

HAY CONDITIONING AND RAKING TIME

Location: Brampton | Test 150 | Cut June 27, 1960

	Leaf Loss pounds per acre			Percent Leaf in Bales	% D.M. when Baled	Curing hours			Total hours		
	Raking Loss	Windrow Loss	Total*			Cut to Rake	Rake to Bale	Total	Cut to Rake	Rake to Bale	Total
Conditioned											
Wilted on top	181	334	1057	35.0	81.8	5	28	33	5	70	75
Dry on top	131	474	1146	32.9	82.5	10	23	33	24	51	75
Swath cured	205	403	1134	33.1	81.3	28	5	33	70	5	75
Average	172	404	1112	33.7	81.9						
Unconditioned											
Wilted on top	20	355	915	36.6	65.7	6	27	33	6	69	75
Dry on top	30	451	1028	34.4	77.3	24	14	38	52	42	94
Swath cured	165	445	1152	33.0	78.0	31	7	38	73	21	94
Average	72	417	1031	34.7	73.7						

* includes leaves lost before cutting (average 542 pounds per acre)

Vernal alfalfa - yield 4800 pounds per acre. 21.3% dry matter when cut.

Rainfall - .24 inches night of June 27-28 followed by 2 days dull weather. Windrows turned once by hand.

MIXTURES SEEDED ON COLLEGE FARMS, 1960

1. Fl (10 acres) Poultry Pasture

   Ladino 4 + Brome 10

2. S2 (5 acres) Sheep Pasture

   Viking 8
   Climax 4

3. Victoria Road (20 acres)

   Vernal 10
   Lincoln 10

4. Auld Farm (20 acres) 10A

   DuPuits 10
   Lincoln 10

5. Kay Farm (20 acres) Field A. Hay 1 year, then pasture.

   Vernal 8
   Ladino 2
   Brome 10

6. Kay Farm (25 acres) Field L. Hay-Pasture.

   Vernal 10
   Ladino 1
   Brome 10

HAY GROWTH CURVES, 1960

Two growth types of 4 species were seeded to be harvested at weekly intervals from May 1 through July 17 in the first crop year. The purpose is to determine curve of dry matter and digestible nutrient build-up through the first growth period.

The varieties are: DuPuits, Vernal alfalfa; Saratoga, Canadian brome; Climax, Essex timothy; and Frode and Ottawa 200 orchard.

Vernal and Saratoga were seeded at Ridgetown to allow comparison of growth curves at different locations.

Field seedings were made at Brampton of Vernal, Climax, Saratoga and Frode to provide material for determination of % D.D.M. in sheep feeding trials. The forage will be cut at 3-4 harvest dates. Small plot trials will be harvested at Brampton from these blocks to relate the sheep trial data to the small plot data at Guelph.

Forage was cut at 3 dates from Empire and Viking trefoil for a sheep digestion trial.

MIXTURE DIVERSITY TRIAL, 1960 (310)

This trial included:

Associations	Cutting Regimes
DuPuits + Lincoln	
+ Climax	Early Hay
+ Frode	
Vernal + Lincoln	Medium Hay
+ Climax	
+ Frode	Late Hay

No companion crop was used and growth was vigorous so the series was cut twice to study yield and competition in the seedling year. The data are in the "Breeding and Strain Testing" report, page 54. Timothy and brome stands were so severely reduced by the alfalfa competition that the trial will not be used further.

EMPIRE-BROMEGRASS MIXTURES FOR PASTURE, 1957

Total Pounds of Dry Matter per Acre

		1960			Total			
Empire 5 +		May 26	July 5	Aug.25	1960	1958	1959	3-year Average
Can.brome	6	1782	2780	2762	7324	6598	6634	6852
	9	1681	2791	2698	7170	6181	6679	6677
	12	1760	2695	2800	7255	5924	6635	6605
	15	1736	2830	2823	7389	5918	6556	6621
	18	1575	2656	2792	7022	5463	6855	6447
	Ave.	1707	2750	2775	7232	6017	6672	6640
Lincoln	6	2223	2471	2873	7387	6510	6854	6917
	9	2183	2439	2826	7535	6690	7148	7124
	12	2139	2450	2771	7298	6203	6831	6777
	15	2130	2510	3014	7597	6295	7146	7013
	18	2135	2436	2849	7344	6305	6812	6820
	Ave.	2162	2461	2067	7432	6400	6958	6930
Saratoga	6	2011	2504	2927	7621	6787	6975	7128
	9	2091	2618	2888	7509	6782	7298	7196
	12	2076	2451	2785	7374	6565	6791	6910
	15	2022	2561	3019	7659	6361	6981	7000
	18	2086	2408	2902	7473	6657	6486	6872
	Ave.	2057	2508	2904	7527	6630	6906	7021

EMPIRE-BROMEGRASS MIXTURES FOR PASTURE, 1957

Pounds of Trefoil per Acre

Empire 5 +		1960 May 26	1960 July 5	1960 Aug.25	Total 1960	Total 1958	Total 1959	3-year Average
Can.brome	6	756	1760	2204	4720	3892	3109	3907
	9	847	1901	2167	4918	3767	3653	4113
	12	859	1919	2225	5003	3570	3609	4061
	15	891	1940	2238	5069	3366	3886	4107
	18	778	1911	2222	4911	3371	4049	4110
	Ave.	826	1886	2190	4924	3593	3661	4060
Lincoln	6	685	1822	2176	4683	3846	3321	3950
	9	739	1839	2334	4912	3546	3431	3963
	12	746	1853	2258	4857	3524	3481	3954
	15	756	1968	2303	5027	3178	3762	3989
	18	601	1885	2177	4663	3430	3704	3932
	Ave.	706	1873	2492	4848	3505	3540	3957
Saratoga	6	590	1792	2512	4894	3589	3101	3861
	9	710	1926	2535	5171	3431	3371	3991
	12	761	1864	2328	4953	3278	3158	3796
	18	684	1302	2508	4493	3390	2945	3609
	Ave.	691	1736	2249	4919	3349	3135	3801

EMPIRE-BROMEGRASS MIXTURES FOR PASTURE, 1957

Pounds of Brome per Acre

		1960			Total			
Empire 5 +		May 26	July 5	Aug.25	1960	1958	1959	3-year Average
Can.brome	6	983	991	501	2475	2706	3283	2821
	9	774	828	479	2081	2416	2095	2464
	12	826	690	486	2002	2354	2816	2391
	15	731	850	563	2144	2552	2535	2410
	18	720	717	499	1936	2092	2606	2211
	Ave.	807	815	505	2128	2424	2827	2460
Lincoln	6	1417	580	276	2273	2664	3311	2749
	9	1366	521	221	2108	3144	3542	2931
	12	1253	598	291	2142	2679	3225	2682
	15	1279	471	169	1919	3126	3209	2751
	18	1460	504	306	2270	2875	2957	3400
	Ave.	1355	535	253	2142	2898	3249	2763
Saratoga	6	1331	667	548	2546	3198	36819	3142
	9	1350	680	335	2365	3351	3715	3144
	12	1278	508	455	2241	3287	3516	3015
	15	1228	762	561	2551	3303	3720	3191
	18	1377	1050	571	3998	3367	3412	3592
	Ave.	1313	733	494	2740	3301	3609	3217

VIKING-BROMEGRASS MIXTURES FOR PASTURE, 1957

Total Pounds of Dry Matter per Acre

		1960				Total			
Viking 5 +		May 26	July 5	Aug. 5	Oct.11	1960	1958	1959	3-year Average
Can.brome	6	2044	3127	1517	937	7634	6358	9958	7983
	9	1992	3085	1465	1046	7587	6672	9296	7852
	12	2078	2936	1504	1010	7528	6272	8403	7401
	15	2073	3086	1416	863	7438	5749	9206	7464
	18	1916	3017	1423	1009	7364	6020	9163	7516
	Ave.	2020	3050	1467	973	7510	6215	9205	7643
Lincoln	6	2099	2985	1491	961	7535	7651	9481	8222
	9	2335	2878	1468	1008	7689	7670	9190	8183
	12	2279	2931	1514	1029	7752	7249	9034	8012
	15	2119	2935	1568	1118	7740	7178	9494	8137
	18	2176	3069	1536	1242	8023	7507	9087	8206
	Ave.	2202	2960	1515	1071	7748	7451	9257	8152
Saratoga	6	2249	2994	1573	1073	7889	7496	9369	8251
	9	2206	2915	1505	1018	7644	6857	9262	7921
	12	2192	2998	1490	1103	7783	7035	9467	8095
	15	2200	2947	1492	996	7634	6917	9465	8005
	18	2143	2832	1515	920	7410	6581	9245	7745
	Ave.	2198	2937	1515	1022	7672	6977	9362	8004

VIKING-BROMEGRASS MIXTURES FOR PASTURE, 1957

Pounds of Trefoil per Acre

Viking 5 +		1960 May 26	1960 July 5	1960 Aug. 5	1960 Oct.11	Total 1960	Total 1958	Total 1959	3-year Average
Can.brome	6	1308	2638	1363	849	6158	3749	6514	5474
	9	1275	2426	1369	895	5965	4023	5892	5293
	12	1401	2326	1357	906	5990	3825	5237	5017
	15	1391	2474	1301	736	5902	3090	6400	5131
	18	1313	2290	1279	912	5794	3499	6468	5254
	Ave.	1338	2431	1334	860	5962	3637	6102	5234
Lincoln	6	1142	2496	1420	888	5946	5705	5975	5875
	9	1227	2371	1413	929	5940	4309	5871	5373
	12	1172	2464	1446	961	6043	3893	5523	5153
	15	1160	2562	1497	1056	6275	3475	5961	5237
	18	1156	2264	1464	1141	6025	4009	5731	5255
	Ave.	1171	2431	1448	995	6046	4078	5812	5312
Saratoga	6	1371	2537	1517	988	6413	3833	5843	5363
	9	1251	2677	1414	936	6278	3594	6120	5331
	12	1242	2523	1420	995	6180	3637	5865	5227
	15	1135	2506	1447	845	5933	3156	5903	4997
	18	1250	2826	1416	841	6333	2852	5871	5019
	Ave.	1250	2614	1443	921	6227	3414	5920	5187

VIKING-BROMEGRASS MIXTURES FOR PASTURE, 1957

Pounds of Brome per Acre

		1960				Total			
Viking 5 +		May 26	July 5	Aug. 5	Oct.11	1960	1958	1959	3-year Average
Can.brome	6	675	473	148	71	1367	2609	3228	2401
	9	654	659	88	130	1531	2649	2988	2389
	12	609	610	126	88	1433	2451	2949	2278
	15	615	612	108	108	1443	2659	2576	2226
	18	556	667	127	91	1441	2481	2558	2160
	Ave.	622	604	119	97	1443	2570	2860	2291
Lincoln	6	878	426	44	35	1383	2946	3148	2492
	9	1033	159	29	40	1261	3361	3074	2565
	12	1005	379	34	34	1452	3336	3193	2660
	15	897	353	48	45	1343	3703	3309	2785
	18	936	204	49	56	1245	3498	2866	2536
	Ave.	950	304	41	42	1337	3368	3118	2608
Saratoga	6	789	399	48	49	1285	3663	3296	2748
	9	890	515	66	55	1526	3263	2963	2584
	12	871	496	48	82	1497	3398	3379	2758
	15	992	369	38	130	1529	3761	3343	2877
	18	830	515	72	62	1479	3729	3141	2783
	Ave.	874	459	54	76	1463	3563	3224	2750

ALFALFA-EMPIRE MIXTURES FOR PASTURE - 1958

Pounds of dry matter per acre

		Narragensett				Vernal				Grimm			
Alfalfa	Empire	1958+	1959	1960	Ave.	1958	1959	1960	Ave.	1958	1959	1960	Ave.
3	3	1502	7229	5689	6459	1619	6447	5586	6017	1513	6250	5613	5932
	6	1523	7291	6035	6665	1672	6739	5910	6325	1605	6490	5536	6013
	9	1488	7404	5735	6570	1582	6680	5931	6306	1610	6328	5590	5959
	Ave.	1504	7308	5820	6565	1624	6622	5809	6216	1576	6356	5580	5968
6	3	1503	6998	5330	6164	1749	7188	5183	6186	1357	6731	5203	5967
	6	1577	7534	5285	6410	1670	7586	5496	6541	1505	7018	5067	6043
	9	1492	7148	5246	6197	1796	7425	5997	6711	1484	7379	5316	6348
	Ave.	1524	7227	5287	6257	1738	7400	5559	6479	1449	7043	5195	6119
9	3	1511	8104	5693	6899	1649	7222	5073	6148	1498	7328	4506	5917
	6	1397	7577	5550	6564	1687	7531	5197	6364	1557	7443	4659	6051
	9	1472	7963	5590	6777	1767	7503	5472	6488	1568	7021	4968	5995
	Ave.	1460	7881	5611	6746	1701	7418	5247	6333	1541	7264	4711	5988

\+ fall cut only in seeding year

EFFECT OF DALAPON AND CULTIVATION ON THE STAND AND VIGOR OF EMPIRE TREFOIL
HADATI FARM, 1960

Rate of application lbs.	No. of discings+	Trefoil plants per sq. ft.* No.	Weight of trefoil Tops gms.	Roots gms.	Weeds %
0	0	0.3	0.20	0.20	Trace
5	0	46.6	2.93	2.28	Trace
5	2	43.1	3.61	3.12	15.0

+ Dalapon applied May 3, 1960, discing May 27, 1960
* counts made November 14, 1960

EFFECT OF FEEDING TREFOIL SEED TO ANIMALS ON GERMINATION - GUELPH, 1960

State of seed	Fecal Seed Soft	Hard*	Laboratory seed
Soft	1.2%	8.3%	67.0%
Dead	98.8	3.3	2.5
Hard	0.0	88.4	29.3
Total live seed	1.2	96.7	96.3

* germination percentage after scarification

FEEDING TREFOIL SEED TO ANIMALS - GUELPH, 1960

State of seed	No. of seeds per 0.5 oz. of manure 0-24 hrs.*	24-48 hrs.	48-72 hrs.	72-96 hrs.
Soft	55.3	53.3	20.5	10.0
Hard	6.1	18.4	23.5	11.0
Total live seed	61.4	71.7	43.0	21.0
Lbs. manure collected	33	30	28	28

* collection period

RESIDUAL ACTION OF HERBICIDES ON EMERGENCE OF TREFOIL IN FLATS IN THE GREENHOUSE - GUELPH, 1960

Days after spraying when seeded	Dalapon (5#/acre)			Brushkill (20 oz./acre)			Amino triazole (2 lbs./acre)		
	Test 1	Test 2	Ave.	Test 1	Test 2	Ave.	Test 1	Test 2	Ave.
0	70.4*	120.1	95.2	39.3	8.1	23.7	3.7	1.6	2.6
7	46.9	48.1	47.5	50.6	16.0	33.3	7.5	12.3	9.9
14	46.0	55.3	50.6	53.9	25.7	39.8	3.4	122.2	62.3
21	144.8	125.5	135.1	62.1	102.8	82.5	33.3	132.0	82.6

* percent germination of check

RATE OF DALAPON ON GERMINATION OF TREFOIL IN PETRI DISHES, 1960

Rate of dalapon lbs./acre	Days after seeding				
	7	10	14		
	Live seed	Live seed	Live seed	Dead	Hard
0	60.5	60.5	61.5	2.5	36.0
5	57.0	62.5	62.5	6.5	31.0
10	67.5	68.5	69.0	3.5	27.5

GRANULAR vs. LIQUID DALAPON ON GERMINATION OF TREFOIL IN PETRI DISHES - 1960

Rate of Dalapon	Granular			Liquid		
	dead	live seed	Weight of 100 seedlings+	dead	live seed	Weight of 100 seedlings+
0	2.0%	98.0%	0.061 gms.	3.0%	97.0%	0.52 gms.
5	6.0	94.0	0.076	1.5	98.5	0.59
10	4.5	95.5	0.084	2.5	97.5	0.69
15	6.5	93.5	0.088	3.5	96.5	0.65

\+ weight in grams of 100 seedlings

RATES OF DALAPON ON THE GERMINATION PERCENTAGE OF TIMOTHY IN PETRI DISHES - 1960

Rate of Dalapon	7 days		12 days		Weight of 100 seedlings+
	dead	live seed	dead	live seed	
0 lbs.	2.5%	97.5%	4.5%	95.5%	.021 gms.
5	2.0	98.0	11.0	89.0	.022
10	1.0	99.0	7.0	93.0	.022
15	2.5	97.5	8.0	92.0	.026

\+ weight in grams of 100 seedlings

DATE OF SEEDING AND HARVESTING RAPE AND KALE

Height in Inches

Location: C-5

Test 146

Date Measured		May 26	June 7	June 20	July 4	July 15	July 28	Aug. 8
		Date of Seeding						
July 5	Rape	8	5	3				
	Kale	5	4	2				
July 12	Rape	10	9	7				
	Kale	9	5	4				
July 29	Rape	25	23	20	3	1		
	Kale	24	16	13	2	1		
August 8	Rape	29	27	26	9	3	1	
	Kale	28	23	23	5	2	1	
August 18	Rape	33	31	30	11	10	2	1
	Kale	33	28	28	8	6	1	1
August 24	Rape	35	32	32	14	11	4	3
	Kale	35	30	31	9	7	3	2
September 1	Rape	36	35	34	18	15	9	5
	Kale	38	34	35	15	10	6	4
September 20	Rape	35	35	33	22	18	15	12
	Kale	40	35	35	21	18	11	9
October 3	Rape	33	34	30	24	22	19	16
	Kale	41	37	37	26	23	16	14
October 14	Rape	31	34	30	25	24	20	18
	Kale	40	37	38	28	26	20	18
October 28	Rape	26	26	29	25	23	20	19
	Kale	40	36	37	28	26	22	19

Varieties used:

Rape: Garton's Early Giant
Kale: Dunn's Marrowstem

Location: C-5

DATE OF SEEDING AND HARVESTING RAPE AND KALE

Test 146

Percent Dry Matter

Date Harvested		Date Seeded						
		May 26	June 7	June 20	July 4	July 15	July 28	Aug. 8
August 24	Rape	10.5	10.9	10.8	9.9	9.8	----	----
	Kale	10.6	10.3	9.9	11.0	11.2	----	----
September 1	Rape	11.9	12.2	12.9	9.1	10.3	9.2	8.9
	Kale	10.9	10.6	11.0	9.0	10.2	9.9	9.6
September 14	Rape	14.1	14.0	14.8	10.9	11.1	10.3	10.4
	Kale	12.5	12.7	11.9	10.9	10.7	11.1	11.6
September 30	Rape	13.9	15.3	16.2	10.8	11.2	10.6	11.0
	Kale	13.1	13.4	13.0	10.1	9.1	10.1	10.0
October 14	Rape	16.4	16.2	16.2	11.5	12.9	12.3	12.2
	Kale	13.5	14.6	14.8	11.2	10.9	11.5	11.9
October 28	Rape	18.7	19.9	18.2	14.1	14.2	13.8	13.9
	Kale	15.6	17.1	16.0	13.5	13.0	13.4	13.0
November 11	Rape	17.6	17.6	17.7	12.8	13.1	13.3	12.2
	Kale	14.4	15.6	15.1	12.8	11.6	11.7	12.0

Varieties used:

Rape: Garton's Early Giant
Kale: Dunn's Marrowstem

DATE OF SEEDING AND HARVESTING RAPE AND KALE

Green Weight in Tons

Location: C-5 Test 146

Varieties: Rape - Garton's Early Giant; Kale - Dunn's Marrowstem

Date Harvested		Date Seeded						
		May 26	June 7	June 20	July 4	July 15	July 28	Aug. 8
August 24	Rape	29.0	23.7	21.0	8.3	3.2	---	---
	Kale	26.1	18.3	19.3	2.0	0.9	---	---
September 1	Rape	26.8	24.1	21.4	9.4	6.3	1.3	0.4
	Kale	30.4	25.2	23.6	5.0	1.9	0.6	0.2
September 14	Rape	26.6	26.0	22.9	17.6	10.9	6.7	3.8
	Kale	30.9	28.8	28.5	12.8	7.5	4.1	1.7
September 30	Rape	22.9	20.5	20.5	20.7	15.4	10.8	7.3
	Kale	39.0	28.7	28.4	19.6	16.3	6.9	5.8
October 14	Rape	22.3	21.8	22.2	21.7	16.9	12.8	10.1
	Kale	37.5	32.9	31.9	27.4	20.2	9.2	7.7
October 28	Rape	18.4	17.4	17.5	20.2	21.2	14.8	11.4
	Kale	33.3	29.3	30.2	21.9	21.4	11.6	10.1
November 11	Rape	13.9	15.9	14.4	19.3	15.4	13.6	11.5
	Kale	30.4	27.6	28.2	22.8	19.9	12.2	11.2

Dry matter in tons

August 24	Rape	3.01	2.55	2.25	0.80	0.31	----	----
	Kale	2.77	1.89	1.89	0.21	0.09	----	----
September 1	Rape	3.17	2.92	2.72	0.85	0.64	0.11	.006
	Kale	3.30	2.64	2.55	0.45	0.19	0.06	.001
September 14	Rape	3.75	3.64	3.38	1.90	1.20	0.68	0.38
	Kale	3.84	3.64	3.37	1.37	0.80	0.33	0.18
September 30	Rape	3.20	3.16	3.26	2.22	1.68	1.14	0.77
	Kale	4.97	3.82	3.60	1.99	1.48	0.68	0.57
October 14	Rape	3.61	3.50	3.52	2.48	2.17	1.56	1.22
	Kale	5.05	4.93	4.67	3.05	2.21	1.04	0.90
October 28	Rape	3.83	3.32	3.14	2.83	3.01	2.04	1.57
	Kale	5.18	5.05	4.87	2.90	2.77	1.53	1.30
November 11	Rape	2.43	2.78	2.54	2.46	2.02	1.79	1.37
	Kale	4.35	4.70	4.24	3.23	2.28	1.41	1.36

ROW WIDTH AND RATE OF SEEDING KALE

Location: E — Test 148 — Seeded: June 6, 1960

Row Width and Rate of Seeding		Percent Dry Matter	Yield Green Tons/acre	Yield Dry matter Tons/acre	Height cms.	Stem Diameter cms.	Dry weight in grams 25 plants	Percent leaf
		August 22 Harvest*						
27 Inch Rows								
Dunns Marrowstem	1	11.6	15.9	1.85	58	1.3	346	56.5
	2	11.6	14.9	1.71	67	1.7	530	56.2
	3	11.3	16.3	1.84	60	1.3	329	57.5
	4	12.6	15.4	1.91	56	1.2	291	54.1
	5	12.1	14.9	1.77	54	1.0	201	54.1
	Average	11.8	15.5	1.82	59	1.3	339	55.7
Sharpes 1000 Headed	1	11.9	13.4	1.57	68	1.5	793	58.6
	2	12.5	12.6	1.55	60	1.1	412	56.2
	3	13.0	13.7	1.75	57	1.0	402	61.4
	4	13.2	12.4	1.61	53	0.9	277	55.3
	5	12.6	13.2	1.64	55	0.9	268	59.9
	Average	12.6	13.1	1.62	59	1.1	430	58.3
Broadcast								
Dunns Marrowstem	2	11.1	16.6	1.84	47	1.4	259	58.8
	4	11.6	15.1	1.74	40	1.0	173	60.5
	6	12.4	17.4	2.13	39	1.0	133	58.9
	8	14.0	15.8	2.18	35	0.8	95	63.5
	Average	12.3	16.2	1.97	40	1.1	165	60.4
Sharpes 1000 Headed	2	11.6	13.7	1.56	49	0.9	257	66.7
	4	12.6	14.1	1.72	43	0.7	158	64.9
	6	12.8	15.9	2.04	42	0.7	133	61.5
	8	13.3	15.9	2.03	40	0.6	116	58.2
	Average	12.6	14.9	1.84	44	0.7	166	62.8

* no fall harvest due to drought

OAT VARIETIES ON FORAGE ESTABLISHMENT

Location: Guelph - B | Test 145 | Seeded: May 5, 1960

Oat Variety	Oat Seeding Rate (bu./ac.)	Oat Yield (lb/ac.)	Height (ins.)	Main Culms (ft.of row)	Fertile Culms (ft.of row)	Stooling Index	Late Green Stools (ft.of row)	Establishment June 7 plants/sq.ft. Alfalfa	Establishment June 7 plants/sq.ft. Trefoil	Establishment October 4 plants/sq.ft. Alfalfa	Establishment October 4 plants/sq.ft. Trefoil	Trefoil* Vigor Oct.4
Branch	1	3089	51.3	11.7	17.2	1.47	0.5	32.0	24.8	25.8	17.3	2.8
	2½	3449	48.2	22.0	22.9	1.04	1.5	29.2	22.3	23.6	15.6	3.4
	Ave.	3269	49.7	16.8	20.0	1.25	1.0	30.6	23.5	24.7	16.4	3.1
Rodney	1	3300	48.0	11.4	21.5	1.88	1.0	33.4	24.2	25.9	16.1	2.0
	2½	2375	45.1	22.2	22.9	1.03	1.7	31.0	24.7	25.4	16.2	3.2
	Ave.	2837	46.5	16.8	22.2	1.45	1.3	32.2	24.4	25.6	16.1	2.6
Clintland	1	3044	42.5	11.5	18.7	1.62	3.5	32.2	19.8	25.3	19.8	1.6
	2½	3208	41.8	22.1	22.8	1.03	5.2	32.8	25.4	27.4	18.9	1.6
	Ave.	3126	42.1	16.8	20.7	1.32	4.3	32.4	22.6	26.3	19.3	1.6
Shield	1	2637	43.3	10.7	24.6	2.29	6.4	32.4	22.5	22.7	17.0	2.0
	2½	2511	41.1	21.6	28.1	1.30	10.7	30.6	24.1	24.5	17.0	2.0
	Ave.	2574	42.2	16.1	26.3	1.79	8.5	31.5	23.3	23.6	17.0	2.0

* vigor rating - 1 high vigor; 4 low vigor

COMPANION CROP MANAGEMENT

Location: Guelph - D14 | Test 130 | Seeded: May 1959

Management	Hay Yields - tons per acre				
	First Crop		Second Crop		
	Yield	Legume content	Yield	Legume Content	Total Yield
Oats cut 10" left	2.27	1.35	1.79	1.29	4.06
Oats cut 24" left	2.43	1.48	1.91	1.36	4.34
Oats cut 24" removed	2.24	1.36	1.81	1.26	4.05
Oats for hay	2.27	1.45	1.77	1.24	4.04
Oats - 14" grain	2.26	1.34	1.68	1.21	3.94
Oats - 7" grain	2.19	1.32	1.75	1.19	3.94
Barley - grain	2.18	1.50	1.85	1.45	4.03
Mixed grain	2.27	1.59	1.80	1.40	4.07
No companion	2.58	0.94	1.78	1.05	4.36

COMPANION CROP MANAGEMENT

Location: Guelph — Tons of Hay - Yield Summary* — Seeded May - '56, '57, '58, '59

Management	4-Year Average - First Crop			**3-Year Average - Second Crop			4-Year Average
	Yield	Legume Content	% Legume	Yield	Legume Content+	% Legume+	Total Yield
Oats cut 10" left	2.35	0.94	40.6	1.56	1.18	68.0	3.53
Oats cut 24" left	2.47	1.02	42.5	1.59	1.26	72.7	3.66
Oats cut 24" removed	2.31	0.99	44.2	1.59	1.25	72.7	3.51
Oats for hay	2.38	1.18	52.0	1.57	1.29	75.7	3.55
Oats - 14" grain	2.39	1.18	50.8	1.55	1.25	76.5	3.55
Oats - 7" grain	2.31	1.26	54.1	1.63	1.25	72.8	3.54
Barley - grain	2.26	1.44	65.1	1.68	1.43	81.5	3.49
Mixed grain	2.19	1.51	69.6	1.68	1.35	80.4	3.31
No companion	2.53	0.98	39.7	1.56	1.27	71.0	3.71

* summary of plant stands and companion crop yields in 1959 report

** no second crop in 1958 due to drought

\+ two year average

METHODS OF SEEDING WITH A GRAIN DRILL

F.H. 33-8

Location: Brampton | Hay Yields in Tons | Outline - 1956 Report

Seeding Method	1959 Seeding - 1960 Hay: First Crop Yield	1959 Seeding - 1960 Hay: First crop Legume Component	1959 Seeding - 1960 Hay: Second Crop Yield	1959 Seeding - 1960 Hay: Total Yield	Three Year Average: First Crop Yield	Three Year Average: First crop Legume Component	Three Year Average: First crop Percent Legume	Three Year Average: Second Crop Yield	Three Year Average: Total Yield
Before hoe, shallow	2.07	0.70	1.32	3.39	1.77	1.02	61.1	0.94	2.71
After hoe, shallow	1.91	1.12	1.16	3.07	1.72	1.15	66.7	0.84	2.56
After hoe, shallow, pack	2.00	1.11	1.29	3.29	1.78	1.15	65.3	0.91	2.69
After hoe, shallow, harrow	2.02	1.18	1.31	3.33	1.84	1.28	70.5	0.93	2.77
After hoe, regular	1.83	1.05	1.27	3.10	1.61	1.06	66.0	0.82	2.43
With oats, shallow	2.04	1.14	1.42	3.46	1.81	1.23	69.2	0.94	2.75
With oats, regular*	1.95	0.97	1.28	3.23	1.72	1.12	68.6	0.88	2.61
With oats, regular, harrow	1.81	0.90	1.23	3.04	1.74	1.16	67.8	0.90	2.63
Band, shallow	2.22	1.26	1.33	3.55	1.82	1.20	66.7	0.89	2.71
After hoe, broadcast, harrow*	1.83	1.17	1.25	3.08	1.65	1.20	70.9	0.85	2.50

* two years' data in average

BAND SEEDING

F.H. 33-13

Location: Brampton

Hay Yields - Tons

Outline - 1956 Report

Treatment	1959 Seeding - 1960 Hay				Hay Summary - 3-Year Average				
	First Crop Yield	First crop Legume Component	Second Crop Yield	Total Yield	First Crop Yield	First crop Legume Component	First crop Percent Legume	Second Crop Yield	Total Yield
Band	1.58	0.88	1.25	2.83	1.61	1.05	64.4	0.82	2.45
Band harrow	1.66	1.17	1.25	2.91	1.82	1.24	69.4	0.85	2.67
Band pack	1.81	1.22	1.36	3.17	1.78	1.23	70.2	0.87	2.65
Band 16" drills	2.03	0.76	1.32	3.35	1.77	0.94	55.7	0.85	2.62
Band no oats	2.08	0.87	1.42	3.50	1.97	1.04	54.5	0.88	2.84
Broadcast pack	1.91	1.26	1.31	3.22	1.71	1.28	65.6	0.89	2.75
Broadcast harrow	1.86	0.95	1.31	3.17	1.84	1.18	65.7	0.89	2.74

SEEDBED FIRMING AND COVERAGE

F.H. 33-15

Location: Brampton | Hay Yields - Tons | Outline - 1956 Report

Treatment	1959 Seeding - 1960 Hay: First Crop Yield	First crop Legume Component	Second Crop Yield	Total Yield	Hay Summary - 3-Year Average: First Crop Yield	First crop Legume Component	First crop Percent Legume	Second Crop Yield	Total Yield
Pack before	1.84	0.80	1.28	3.12	1.85	1.18	63.3	0.95	2.79
Pack after	1.84	0.74	1.29	3.13	1.98	1.28	64.2	0.97	2.97
Pack before and after	2.01	1.11	1.32	3.33	2.05	1.42	69.3	0.98	3.03
Pack before, harrow after	1.67	0.90	1.17	2.84	1.91	1.23	67.3	0.93	2.85
Harrow	1.70	0.83	1.13	2.83	1.92	1.23	62.0	0.89	2.81
Band	1.80	0.88	1.36	3.16	1.88	1.26	66.0	0.98	2.86
Chains	1.71	0.85	1.35	3.06	1.86	1.22	62.6	0.98	2.85
Check	1.92	0.73	1.32	3.24	1.76	1.18	58.7	0.95	2.91

MANAGEMENT PRACTICES ON NEW SEEDINGS

F.H. 33-11

Location: Brampton | Hay Yields - Tons | Outline - 1956 Report

	1959 Seeding - 1960 Hay				Hay Summary - 3-Year Average				
	First Crop Yield	First crop Legume Component	Second Crop Yield	Total Yield	First Crop Yield	First crop Legume Component	First crop* Percent Legume	Second* Crop Yield	Total Yield
Clip early, left	1.74	0.58	1.20	2.94	1.62	0.82	35.9	0.88	2.02
Clip early, remove	1.50	0.65	1.17	2.67	1.49	0.83	46.3	0.90	1.88
Clip early, remove, fertilize	1.83	0.63	1.12	2.95	1.77	0.82	40.8	0.88	2.14
Clip late, left	1.59	0.57	1.15	2.74	1.55	0.75	37.7	0.86	1.70
Clip late, remove	1.59	0.69	1.07	2.66	1.55	0.83	41.5	0.87	1.54
Unclipped	1.86	0.66	1.16	3.02	1.76	0.88	37.5	0.86	2.15

* two year average

VIKING SEEDING RATE x TIMOTHY SEEDING RATE, 1958 (443)

Total Yield in Pounds per Acre

Viking seeding rate	Timothy 0 1959	Timothy 0 1960	Timothy 2 1959	Timothy 2 1960	Timothy 6 1959	Timothy 6 1960	Timothy 12 1959	Timothy 12 1960	Average 1959	Average 1960	Average Ave.
2	3057	3863	4829	4917	4590	4740	3612	3507	4022	4257	4140
6	5079	4958	6162	4859	5210	5373	4009	4821	5115	5003	5059
12	6769	5883	7186	5456	5497	6155	5399	5457	6213	5738	5976
Ave.	4966	4901	6059	5077	5090	5423	4340	4595			
	4434		5568		5257		4468				

Pounds per Acre of Trefoil (443)

Viking seeding rate	Timothy 0 1959	Timothy 0 1960	Timothy 2 1959	Timothy 2 1960	Timothy 6 1959	Timothy 6 1960	Timothy 12 1959	Timothy 12 1960	Average 1959	Average 1960	Average Ave.
2	1019	2680	1830	2956	722	2948	286	1598	964	2546	1705
6	2584	3079	2343	3274	1895	3610	678	3445	1575	3365	2620
12	2924	3210	3014	3320	1425	4342	1377	3459	2185	3583	2884
Ave.	2175	2990	2395	3184	1327	3633	780	2834			
	2582		2790		2485		1807				

Pounds per Acre of Timothy (443)

Viking seeding rate	Timothy 0 1959	Timothy 0 1960	Timothy 2 1959	Timothy 2 1960	Timothy 6 1959	Timothy 6 1960	Timothy 12 1959	Timothy 12 1960	Average 1959	Average 1960	Average Ave.
2	----	----	2225	1586	2247	1437	2390	1257	2287	1760	2024
6	----	----	2729	1899	2363	1580	1814	1243	2302	1574	1938
12	----	----	3581	1943	2571	1529	2493	1577	2865	1683	2274
Ave.	----	----	2845	1810	2394	1549	2233	1359			
	----		2328		1972		1796				

Pounds per Acre of Weeds (443)

Viking seeding rate	Timothy 0 1959	Timothy 0 1960	Timothy 2 1959	Timothy 2 1960	Timothy 6 1959	Timothy 6 1960	Timothy 12 1959	Timothy 12 1960	Average 1959	Average 1960	Average Ave.
2	2037	1183	776	424	1620	357	936	606	1342	645	994
6	2493	1930	1090	176	952	326	1517	435	1513	717	1115
12	3845	2673	591	194	1501	219	1529	398	1866	871	1369
Ave.	2791	1929	819	265	1357	468	1327	447			
	2360		542		913		887				

VIKING SEEDING RATE x CANADIAN BROMEGRASS SEEDING RATE, 1958 (439)

Total Yield in Pounds per Acre (439)

Viking seeding rate	Canadian bromegrass seeding rate								Average		
	0		2		6		12				
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	1884	4210	2591	4690	1926	4385	2438	5559	2209	4711	3460
6	4295	4860	3504	5021	3060	5463	3093	5291	3488	5159	4324
12	4198	5425	4042	5690	3193	5206	2971	4940	3601	5305	4427
Ave.	3459	4832	3379	5467	2726	5015	2834	5264	3099	5058	
	4146		4423		3866		4049				

Pounds of Trefoil per Acre (439)

Viking seeding rate	Canadian bromegrass seeding rate								Average		
	0		2		6		12				
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	533	1683	1565	2889	691	2475	1350	3006	1034	2518	
6	3274	3018	2406	3121	1923	3554	1943	2820	2386	3136	
12	2962	2879	2209	3545	2049	2838	1581	2610	2222	2968	
Ave.	2256	2527	2090	3185	1554	2953	1624	2812	1880	2871	
	2392		2638		2254		2218				

Pounds of Bromegrass per acre (439)

Viking seeding rate	Canadian bromegrass seeding rate								Average		
	0		2		6		12				
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2			422	1151	534	1114	604	962	520	1076	
6			529	1335	613	1736	681	1297	607	1456	
12			637	1641	523	1325	670	1416	610	1462	
Ave.			529	1376	556	1392	651	1228	578	1332	
			952		974		940				

Pounds of Weeds per Acre (439)

Viking seeding rate	Canadian bromegrass seeding rate								Average		
	0		2		6		12				
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	1351	2527	603	651	701	797	483	592	784	1142	963
6	1021	1843	569	567	536	872	469	1175	648	1112	880
12	1236	2516	1106	510	621	1045	720	1122	920	1299	1110
Ave.	1202	2295	759	576	619	905	557	963	784	1184	
	1749		668		762		760				

VIKING SEEDING RATE x LINCOLN SEEDING RATE, 1958 (440)

Total Yield in Pounds per Acre (440)

Viking seeding rate	Lincoln seeding rate 0		2		6		12		Average		
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	2046	4612	1450	5534	1301	4711	1536	4306	1583	4791	3187
6	2089	5555	2290	5484	1523	5388	1166	5034	1767	5365	3566
12	2646	5289	3163	5218	1906	5454	2723	4744	2609	5176	3892
Ave.	2253	5152	2301	5401	1576	5184	1808	4695			
	3702		3851		3380		3251				

Pounds of Trefoil per Acre (440)

Viking seeding rate	Lincoln seeding rate 0		2		6		12		Average		
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	1024	2209	672	2610	258	2257	147	1552	525	2157	1341
6	1403	4029	2031	3084	735	2748	426	2083	1149	2986	2068
12	1398	3091	1893	3216	1197	3555	1595	1992	152	2964	2243
Ave.	1245	3110	2348	2970	730	2847	689	1876			
	2178		2659		1789		1283				

Pounds of Brome per Acre (440)

Viking seeding rate	Lincoln seeding rate 0		2		6		12		Average		
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	----	----	344	1101	532	1342	935	1737	604	1393	999
6	----	----	427	1850	472	1623	470	1424	456	1632	1044
12	----	----	554	1633	503	1693	785	2034	614	1340	977
Ave.			441	1528	503	1553	730	1732			
			985		1028		1232				

Pounds of Weeds per Acre (440)

Viking seeding rate	Lincoln seeding rate 0		2		6		12		Average		
	1959	1960	1959	1960	1959	1960	1959	1960	1959	1960	Ave.
2	1076	2403	434	664	511	1064	454	1055	619	1297	958
6	280	1526	432	555	315	1017	270	1534	324	1158	741
12	1410	2201	716	315	206	205	348	770	670	873	771
Ave.	922	2043	527	511	344	762	324	1120			
	1488		519		553		722				

EFFECT OF WEEDING AND DRILL WIDTHS

1. Pounds of dry matter from first harvest, 1960.

	Trefoil + weeds			Trefoil			Weeds			Trefoil plants/sq.ft.		
	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	O.A.C.
Weeded												
0 companion crop	2461	3021	2741	2461	2792	2626	0	229	115	12.3	16.2	9.4
7" drills	2413	3039	2726	2378	2813	2596	35	226	130	14.3	14.1	10.4
14" drills	2439	2893	2666	2290	2636	2463	149	257	203	14.0	15.2	10.2
Ave.			2711			2562			149	13.6	15.2	12.7
Not weeded												
0 companion crop	1961	3275	2618	1642	2449	2045	319	827	573	11.3	15.1	8.9
7" drills	1832	2981	2406	1559	2403	2185	273	578	425	11.8	16.1	8.1
14" drills	1945	3356	2651	1485	2811	1944	460	545	519	10.8	15.1	9.5
Ave.			2558			2032			506	11.3	15.4	8.8

2. Pounds of dry matter for season, 1960.

	Trefoil + weeds			Trefoil			Weeds		
	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.
Weeded									
0 companion crop	6503	5946	6225	6205	5504	5854	298	442	370
7" drills	6446	5928	6187	6023	5427	5725	423	501	462
14" drills	6286	5690	5988	5771	5223	5497	515	467	491
Ave.			6133			5692			441
Not weeded									
0 companion crop	5334	6267	5801	4591	5057	4824	743	1210	977
7" drills	5511	5854	5682	4770	4774	4772	741	1080	910
14" drills	5423	6321	5872	4509	5449	4979	914	872	893
Ave.			5785			4858			927

EFFECT OF HERBICIDE x ROW WIDTH x MANAGEMENT

1. Pounds of dry matter from first harvest, 1960.

	Trefoil + weeds			Trefoil			Weeds			Trefoil plants/sq.ft.		
										May		Sept.
	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	O.A.C.
Chemical												
0 oats	2429	2520	2475	2295	2125	2210	135	396	265	10.1	16.0	9.7
7" pasture	2021	2688	2354	1908	2219	2064	113	469	290	8.0	16.1	8.8
silage	2091	2409	2250	2032	1991	2013	59	418	239	6.8	18.5	8.6
grain	1964	2453	2209	1847	2122	1985	117	331	224	8.8	18.0	8.5
Ave.			2271			2021			251	7.9	17.5	8.6
14" pasture	2194	2673	2434	2094	2259	2175	100	414	257	8.7	17.5	9.5
silage	2213	2581	2397	2134	2093	2114	79	488	284	8.0	15.7	9.6
grain	2235	2561	2400	2083	2195	2139	152	371	267	9.3	15.2	9.6
Ave.			2411			2143			268	6.7	16.1	9.6
No Chemical												
0 oats	2363	3052	2708	1962	2564	2264	401	488	444	10.6	19.4	10.3
7" pasture	2135	3178	2657	1750	2661	2206	385	517	451	10.3	19.5	11.8
silage	2099	2920	2510	1765	2525	2145	334	395	365	10.5	18.8	12.1
grain	2289	3083	2686	1905	2731	2318	384	352	368	10.3	20.2	10.9
Ave.			2617			2223			394	10.4	19.5	11.6
14" pasture	1949	2680	2314	1644	2339	1992	305	341	322	10.3	10.1	10.1
silage	1974	2543	2259	1659	2189	1924	315	354	335	11.3	11.5	11.5
grain	1982	2732	2357	1616	2326	1971	366	406	386	10.0	10.1	10.1
Ave.			2310			1962			348	10.6	10.6	10.6

2. Pounds per acre for season, 1960.

		Trefoil + weeds			Trefoil			Weeds		
		O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.	O.A.C.	Kaine	Ave.
Chemical										
0 oats		6162	5056	5608	5718	4324	5016	444	751	593
7" drills	pasture	5816	5380	5598	5466	4553	5010	350	827	588
	silage	5817	5098	5458	5478	4274	4876	339	824	581
	grain	5794	5038	5416	5403	4448	4926	391	590	490
	Ave.			5491			4937			554
14" drills	pasture	6020	5398	5709	5592	4586	5089	428	812	620
	silage	6157	5254	5706	5813	4499	5156	344	755	550
	grain	5959	5213	5586	5492	4533	5013	467	680	573
	Ave.			5667			5086			581
No Chemical										
0 oats		5773	5836	5804	4877	5001	4939	896	834	865
7" drills	pasture	5635	6008	5821	4705	5112	4908	930	896	913
	silage	5774	5557	5665	4949	4931	4940	825	626	725
	grain	5895	5905	5900	5077	5315	5196	818	590	704
	Ave.			5795			5015			780
14" drills	pasture	5361	5273	5317	4567	4692	4629	794	581	688
	silage	5695	5172	5433	9840	4577	4708	855	595	725
	grain	5543	5435	5489	4656	4754	4705	887	681	784
	Ave.			5413			4681			732

THE EFFECT OF ROW WIDTH AND HERBICIDES ON THE YIELD OF OATS

1. Silage - Pounds per acre of dry matter

	Oats + weeds + trefoil				Oat component			
Treatment	O.A.C.	Kaine	O.A.C.	Ave.	O.A.C.	Kaine	O.A.C.	Ave.
Chemical								
7"	5280	2966	4258	4168	5228	2303	4236	3923
14"	5830	3481	5073	4794	5802	2701	4859	4461
O Chemical								
7"	6233	3959	4424	4872	5008	2016	4256	3760
14"	6920	3477	4769	5055	5641	1344	4530	3838

2. Pasture - Pounds per acre of dry matter

	Oats + weeds + trefoil				Oat component			
Treatment	O.A.C.	Kaine	O.A.C.	Ave.	O.A.C.	Kaine	O.A.C.	Ave.
Chemical								
7"	3890	1801	2252	2648	3141	1597	1677	2138
14"	4493	2388	2914	3265	3499	2008	2664	2723
O Chemical								
7"	4854	2414	2021	3096	3104	1233	1964	3150
14"	4265	2690	2594	3183	2459	1207	2309	1991

.3. Grain - Pounds per acre.

Treatment	Pounds of grain per acre					Pounds of straw per acre				
	O.A.C.	Kaine	Hespeler	O.A.C.	Ave.	O.A.C.	Kaine	Hespeler	O.A.C.	Ave.
Chemical										
7" drills	2518	1852	1314	2850	2133	3512	1442	1175	3637	2442
14" drills	2519	1977	1653	3030	2295	3006	1162	1316	4087	2395
Ave.	2518	1915	1484	2940	2214	3259	1302	1246	3862	2419
No Chemical										
7" drills	2721	1368	1470	3219	2194	2045	1101	1339	4390	2469
14" drills	2301	886	1215	2690	1773	2359	596	860	2868	1671
Ave.	2511	1127	1343	2955	1984	2702	848	1100	3639	2070

4. Characteristics of Viking trefoil plants during seedling year.

Management	Top weight[1] (gms.)			Stem diameter (mms.)			Axillary branches (No.)			Crown branches (No.)			Stem length (cms.)		
	June	July	Sept.	June	July	Sept.	June	July	Sept.	June	July	Sept.	June	July	Sept.
Chemical															
0 oats	3.96*	6.04	6.38	1.17	1.41	1.48	1.86	6.40	4.65	1.22	2.64	3.89	12.68	18.77	25.00
7" drills	1.03	1.52	7.52	0.81	0.87	1.30	0.23	2.38	3.21	0.25	1.16	6.01	11.28	14.89	22.98
14" drills	1.26	1.88	7.55	0.89	0.95	1.34	0.42	2.59	3.38	0.32	1.33	5.14	12.03	15.16	22.68
Ave.	2.08	3.15	7.15	0.96	1.08	1.37	0.84	3.79	3.75	0.60	1.71	5.01	11.99	16.27	23.55
No Chemical															
0 oats	4.18	3.24	4.80	1.12	1.16	1.18	2.19	4.46	2.60	1.47	3.68	5.44	16.34	18.69	21.42
7" drills	1.20	1.47	4.42	0.83	0.81	1.02	0.27	2.40	1.75	0.13	2.33	5.50	16.02	15.42	19.52
14" drills	1.61	1.84	3.90	0.93	0.90	1.06	0.61	2.72	1.87	0.32	2.49	5.49	15.64	16.49	19.06
Ave.	2.33	2.18	4.37	0.96	0.96	1.09	1.02	3.19	2.07	0.64	2.83	5.48	16.00	16.87	20.00

[1] weight of 10 plants

* data average of three tests

GRASS VARIETIES FOR SEED PRODUCTION

Guelph - D18 | Test 129 | Seeded May 1958

Variety	Yield - Pounds per acre 1959	1960
Orchardgrass		
Hercules	243	90
Frode	278	112
S-37	213	48
Oron	227	87
Danish	247	98
Bromegrass		
Lincoln	429	---
Lyon	443	---
Saratoga	352	---
Canadian brome	551	---
Timothy		
S-48	---	24
Climax	---	177
Common	---	154

HARVESTING TIMOTHY FOR SEED

Location: Brampton — Seeded August 1958

Percent hulled	Yield seed lbs./acre	100 seed weight in mgs.	Percent hulled
Swath	552	3.51	15.9
Direct combine	404	3.43	20.6

CYLINDER SPEED - DIRECT COMBINE TIMOTHY

Location: Brampton — Seeded August 1958

Cylinder speed	100 seed weight in mgs.	Percent hulled
1100	3.40	6.0
1300	3.57	19.2
1450	3.66	33.2
1675	3.56	37.7

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Confidential - not for publication
COPY NUMBER

TWELFTH ANNUAL REPORT

OF THE

Legume Research Committee in Ontario

MARCH 1960

ONTARIO AGRICULTURAL COLLEGE, GUELPH, CANADA

TWELFTH ANNUAL REPORT

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LEGUME RESEARCH COMMITTEE

in

ONTARIO

Ontario Agricultural College
Guelph, Ontario
March, 1960

CONTENTS

THE EFFECT OF CALCIUM AND MAGNESIUM SUPPLY ON NECTAR PRODUCTION IN RED CLOVER AND SNAPDRAGON

R.W. Shuel - Department of Apiculture

ABSTRACT

The effect of factorial combinations of 3 levels each of calcium and magnesium, encompassing an approximately 9-fold variation in concentration, was investigated in 3 experiments, one with red clover and two with snapdragon. Plants were grown in pure sand and the essential elements supplied in solution by daily sub-irrigation. The pH of the culture solution was kept uniform within each experiment. Although calcium and magnesium supply affected nectar yield in all experiments, the variation in magnitude and pattern of the effects preclude any generalizations as to the most favourable conditions of calcium and magnesium nutrition for nectar production. Secretion in red clover was comparatively sensitive to the availability of the two elements, the best factorial combination (intermediate calcium plus high magnesium) producing more than twice as much nectar per inflorescence as the poorest. Nectar production did not appear to be correlated with vegetative growth. Inter-treatment variation in nectar yield was less marked in snapdragon. In the winter crop the combination of high calcium with high magnesium, which was also the best for growth and flower production, surpassed the poorest by about 50 per cent. In the spring crop the low calcium treatments, suboptimal for growth, produced the most nectar, though nectar secretion was rather poor in all treatments. The observed effects of nutrition on secretion were not related to the influence of pH on ion uptake, as pH was constant. Neither did they appear to be related to nitrogen, phosphorus, or potassium concentration in the plant.

Good nectar flows have been reported for plants growing on calcareous soils. To what extent good nectar yields in these areas may be due to the amount of calcium (and/or magnesium) available to the plant, to effects on the uptake of other elements via the regulation of soil pH, or to a mere coincidence of good nectar species with calcareous habitats, has not been shown.

The purpose of the present study was to test the effect of nectar production of various factorial combinations of calcium and magnesium and if possible to correlate variation in nectar yield with growth and mineral composition of the plants. In order to rule out pH effects on ion uptake, pH was maintained as uniform as possible for all treatments.

Three experiments were carried out. Results of the first (red clover), reported in preliminary form at the 1959 annual meeting of this Committee, are now discussed in greater detail. Snapdragon was used in the other experiments. The first crop was harvested in December, 1958. As the weather at this time was cloudy and hence probably limited nectar secretion, another crop was grown in the spring in the hope that more favourable weather might be encountered during the secretory period. In the event, the weather was even less favourable at this time (May, 1959).

METHODS

Genetic variability was minimized by using a clonal population of red clover and the F_1 hybrid generation of snapdragon. Plants were grown in sand in glazed 2-gallon crocks, sub-irrigated daily with solutions containing all essential mineral elements. Each crock accommodated 1 red clover or 2 snapdragon plants. Distilled water was used in all solutions and pH's were maintained at 6.0 to 6.2 for red clover, and 6.4 to 6.6 for snapdragon. Variation in osmotic pressure was kept within 12 or 13 per cent. Solutions were changed weekly.

Red Clover

A factorial arrangement including all combinations of each of the following concentrations of calcium and magnesium, expressed as parts per million in the culture solution, was used:

Ca_1	- 40	Mg_1	18.3
Ca_2	- 120	Mg_2	55
Ca_3	- 360	Mg_3	165

Four plants were used in each treatment.

Snapdragon

A similar arrangement was employed with the following concentrations (ppm in culture solution):

Winter, 1958				Spring, 1959			
Ca_1	- 40	Mg_1	- 18.3	Ca_1	- 30	Mg_1	- 15
Ca_2	- 120	Mg_2	- 55	Ca_2	- 90	Mg_2	- 45
Ca_3	- 300	Mg_3	- 140	Ca_3	- 270	Mg_3	- 135

Each treatment comprised 8 snapdragon plants.

Concentrations of nitrogen, phosphorus, potassium, iron and the trace elements were the same for all treatments within an experiment. Some variability in sodium, chloride, and sulphate was unavoidable because of the wide range of variation in calcium and magnesium; previous data had indicated the influence of this source of variation on nectar secretion to be relatively unimportant.

Reporting of Nectar Data

Red Clover

Volumes of nectar and weights of nectar sugar have been reported on the basis of an inflorescence, adjusted by co-variance to an average inflorescence weight (Table 2). As inflorescence weight is correlated with number of florets, the adjusted values provide a fairly good index of nectar per floret. Potential plant yields were estimated as the products of numbers of inflorescences and average nectar sugar per inflorescence (unadjusted). Nectar sugar concentrations are also recorded in Table 2.

Snapdragon

As nutritional effects on volume and concentration of nectar were masked by post-secretion evaporation, only sugar yields have been recorded (Tables 3,4).

Other Data

Growth (as shoot and root weights) and flower production have also been included in the tables. Standard A.O.A.C. analyses of calcium and magnesium, and nitrogen, phosphorus, and potassium were made. The last three were determined because they are known to influence nectar secretion. The results have not been included in Table 1. Variation in phosphorus and potassium was minor. Variation in nitrogen, while considerable, bore no systematic relationship to nectar yields or plant size.

RESULTS

Uptake of Calcium and Magnesium

According to the data in Table 1, the content of both calcium and magnesium in the plant tissues increased with their respective concentrations in the culture solutions. The Ca_3 level of calcium suppressed magnesium uptake to some extent. The order of variation in tissue concentration of calcium and magnesium was much less than the variation in nitrogen, phosphorus and potassium supplied at similar concentrations in earlier studies.

Nectar Production

Red Clover - (Table 2) The quantity of nectar per inflorescence adjusted to an average weight varied with both calcium and magnesium supply. At the Ca_2 and Ca_3 levels, nectar yield increased with increasing magnesium. At the Ca_1 level, Mg_2 was best. At the lowest level of supply of magnesium, nectar yield increased as the supply of calcium was increased. At the intermediate and high levels of magnesium, Ca_2 was best.

The most favourable combination, Ca_2 Mg_3, produced more than twice as much nectar as either of the two poorest, Ca_1 Mg_1 and Ca_1 Mg_3. The estimated production of nectar per plant paralleled the average production per inflorescence, as intertreatment differences were not significant.

Apparently the effects of calcium and magnesium nutrition on nectar secretion were not closely related to either vegetative or reproductive growth, although the 3 treatments producing the highest nectar yields per inflorescence adjusted to an average weight, also had the largest inflorescences. Sunny weather during the sampling period was favourable to nectar production.

Snapdragon

Winter Crop - (Table 3) Once again the quantity of nectar secreted was a function of both calcium and magnesium supply. At every level of calcium the intermediate level of magnesium gave the lowest nectar yield. At the low and high levels of magnesium, the intermediate level of calcium supported the poorest nectar yield. At the intermediate level of magnesium, the intermediate and high levels of calcium were inferior to the low level. Nectar yield was about 50 per cent higher in the best factorial combination, Ca_3 Mg_3, than in the poorest, Ca_3 Mg_2. The former also produced the largest plants and the most flowers.

Spring Crop - (Table 4) Here the interaction of the two elements were relatively unimportant. The lowest level of calcium, which was suboptimal for vegetative growth, supported the highest nectar production. The order of inter-treatment variation in nectar secretion was comparatively low, due probably to the unfavourable weather conditions.

SUMMARY

1. Although calcium and magnesium supply influenced nectar production, the degree and pattern of the effect were different in the three experiments.

2. Secretion in red clover was comparatively sensitive to the availability of the two elements. Sunny weather during the sampling period favoured high nectar yields. The high or intermediate level of calcium combined with the high level of magnesium supported the best nectar yields. No significant correlation was observed between nectar yields and vegetative or reproductive growth; however, the plants in treatments supporting the 3 highest nectar yields also had the largest flower heads.

3. Inter-treatment differences in nectar yield were less extreme in snapdragon. Solar irradiation was probably a limiting factor. In the winter crop the best nectar yields came from plants receiving a combination of high calcium and high magnesium. The same combination promoted the best vegetative growth and flower production. In the spring crop the most nectar was obtained from the low calcium treatments, the least from the high calcium treatments. The former were suboptimal for growth, the latter optimal.

4. Because of the variation in response to calcium and magnesium in the 3 experiments, no generalizations can be made with respect to the most favourable conditions of calcium and magnesium nutrition for nectar production. It may be stated that the observed effects on secretion were not related to the influence of pH on ionic uptake. Furthermore, comparison of the results of analyses of nitrogen, phosphorus and potassium concentrations in shoot tissue with nectar data revealed no systematic relationship.

TABLE 1

PERCENTAGE OF CALCIUM AND MAGNESIUM IN SHOOTS OF
RED CLOVER AND SNAPDRAGON AT THREE LEVELS EACH OF CALCIUM AND MAGNESIUM

% oven-dry weight

TREATMENT	RED CLOVER		SNAPDRAGON (December 1958)		SNAPDRAGON (May 1959)	
	Ca	Mg	Ca	Mg	Ca	Mg
Ca_1 Mg_1	1.11	0.44	0.90	0.63	1.09	0.51
Ca_1 Mg_2	1.03	0.47	0.81	0.68	1.05	0.58
Ca_1 Mg_3	1.13	0.75	0.88	0.72	0.90	0.62
Ca_2 Mg_1	1.29	0.39	0.98	0.53	1.39	0.51
Ca_2 Mg_2	1.29	0.47	0.91	0.64	1.30	0.53
Ca_2 Mg_3	1.28	0.65	0.83	0.76	1.18	0.60
Ca_3 Mg_1	1.74	0.40	1.26	0.51	1.35	0.41
Ca_3 Mg_2	1.54	0.39	1.18	0.61	1.30	0.45
Ca_3 Mg_3	1.42	0.49	0.99	0.59	1.30	0.52
Variation between duplicate analyses						0.01
Standard error of a mean	±0.033	±0.015	±0.034	±0.026		

TABLE 2

PLANT GROWTH AND NECTAR PRODUCTION IN RED CLOVER AT THREE LEVELS EACH OF CALCIUM AND MAGNESIUM - JULY 1958

TREATMENT	Mean Wt. of Shoots (Fresh)	Mean Wt. of Roots (Air-dry)	Mean No. of Inflorescences per Plant	Mean Wt. of Inflorescence	Mean Sugar Conc. of Nectar	Adjusted Mean Volume of Nectar per Inflorescence	Unadjusted Mean Wt. of Nectar Sugar per Inflorescence	Adjusted Mean Wt. of Nectar Sugar per Inflorescence	Estimated Mean Wt. of Nectar Sugar per Plant
	g.	g.		mg.	%	(µl)	(mg.)	(mg.)	(mg.)
Ca_1 Mg_1	366	80.0	44.0	1342	59.8	27.5	20.1	21.1	885
Ca_1 Mg_2	378	83.8	41.2	1363	57.6	40.8	28.2	28.8	1160
Ca_1 Mg_3	318	55.8	36.2	1283	55.6	31.0	19.7	21.8	711
Ca_2 Mg_1	329	69.8	50.2	1406	56.3	31.3	22.6	22.6	1135
Ca_2 Mg_2	312	78.0	56.5	1528	58.7	44.0	36.7	34.2	2080
Ca_2 Mg_3	341	79.0	55.2	1589	60.8	56.3	48.5	44.9	2680
Ca_3 Mg_1	280	56.3	42.0	1343	59.6	36.2	26.7	27.7	1122
Ca_3 Mg_2	274	65.0	41.2	1266	57.4	43.1	29.2	31.6	1206
Ca_3 Mg_3	298	89.0	54.2	1444	59.4	49.2	38.6	37.7	2090
Statistical Significance									
F	4.84 (Ca_3 vs Ca_1, Ca_2,)	3.19	0.85	5.73	6.78	18.56	21.17	15.52	----
P	<0.05	<0.05	>0.5	<0.001	<0.001	<0.001	<0.001	<0.001	----

TABLE 3

PLANT GROWTH AND NECTAR PRODUCTION IN SNAPDRAGON AT THREE LEVELS EACH OF CALCIUM AND MAGNESIUM - DECEMBER 1958

TREATMENT	Mean Wt. of Shoots (Fresh)	Mean Wt. of Roots (Air-dry)	Mean No. of Flowers per plant	Mean Wt. of Nectar Sugar per Flower	Estimated Mean Wt. of Nectar Sugar per Plant
	g.	g.		mg.	mg.
Ca_1 Mg_1	48.0	0.91	36.1	3.06	1085
Ca_1 Mg_2	47.8	0.78	35.0	2.67	945
Ca_1 Mg_3	46.8	0.83	33.3	2.89	960
Ca_2 Mg_1	47.9	0.65	31.6	2.68	847
Ca_2 Mg_2	47.4	0.72	34.2	2.41	823
Ca_2 Mg_3	48.2	0.72	34.7	2.66	921
Ca_3 Mg_1	45.7	1.15	34.2	3.42	1170
Ca_3 Mg_2	51.3	0.85	36.6	2.33	851
Ca_3 Mg_3	55.7	0.75	41.0	3.74	1535
Statistical Significance					
F	2.65	5.28	4.84	5.93	
P	<0.05	<0.001	<0.001	<0.001	

TABLE 4

PLANT GROWTH AND NECTAR PRODUCTION IN SNAPDRAGON AT THREE LEVELS EACH OF CALCIUM AND MAGNESIUM - MAY 1959

TREATMENT	Mean Wt. of Shoots (Fresh)	Mean Wt. of Roots (Air-dry)	Mean No. of Flowers per Plant	Mean Wt. of Nectar Sugar per Flower	Estimated Mean Wt. of Nectar Sugar per Plant
	g.	g.		mg.	mg.
Ca_1 Mg_1	33.2	0.92	35.3	2.69	948
Ca_1 Mg_2	36.4	0.92	34.2	2.71	925
Ca_1 Mg_3	33.6	0.87	32.8	2.69	881
Ca_2 Mg_1	37.2	0.80	34.4	2.61	898
Ca_2 Mg_2	34.0	0.81	32.2	2.30	740
Ca_2 Mg_3	34.5	0.97	34.8	2.65	921
Ca_3 Mg_1	38.3	1.00	34.8	2.52	875
Ca_3 Mg_2	42.1	0.84	38.6	2.14	826
Ca_3 Mg_3	40.9	0.97	35.0	2.43	848
Statistical Significance					
F	2.40	2.90	0.78	3.88	
P	<0.05	<0.05	>0.05	<0.005	

Nyctinastic Movements and Endogenous Rhythms in Red Clover[1]

by

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ABSTRACT

The opening and closing of leaves of red clover (Trifolium pratense L.) were studied with respect to the pattern of movements under different photoperiods, the adjustment of movements when plants were changed from one photoperiod to another, the relative effects of light and darkness on leaf movement, and preliminary investigations of the physiological nature of nyctinastic responses. Three different forces are considered as contributing to leaf movement patterns (1) a direct response to light or darkness (2) the effect of previous light/dark experiences (3) the basic endogenous rhythm of the plant.

Variations in the opening and closing of clover leaves were noted during experiments involving the growing of red clover at different photoperiods. Thus when a group of plants had their daylength lengthened from 12 to 18 hours they continued their former leaf-closure pattern for several days. Plants growing under 18 hours invariably had shown considerable leaf closure movement prior to the lights out. It was evident that the leaf closure pattern was not just a simple response to darkness, but was, to a certain extent at least, a response to an endogenous, or internal rhythm within the plant.

This leaf movement, then, represents the response of a delicate turgor-sensitive tissue to some rhythmic, physiological process within the plant. Since this rhythm is different for different photoperiods, and since it is an inherent process in

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[1]Contribution to the 12th Annual Meeting of the Legume Research Committee in Ontario, March 1960. The work is part of a thesis study by the senior author and is part of a project on the physiology of legumes sponsored by the Committee.

the leaf, the question arises as to whether it is an outward manifestation of some physiological process associated with the rhythm that changes a vegetative plant to a reproductive one. In other words, is the biological clock timing leaf movement the same as the one that is responsible for the photoperiodic controlled vegetative-reproductive switch. If it is, then leaf movement could serve as a highly sensitive biological thermometer in the study of this more important phenomenon.

What is now called the nyctinastic movement of leaves was first recorded in the writings of Pliny (about 23-79 A.D.) and Albertus Magnus (1193-1280). Linnaeus drew attention to sleep movements of leaves and petals of certain plants and Darwin dealt extensively with the subject in his book Power of Movement in Plants (1). Studies were also made by Sachs, Pfeffer, Jost, and other plant physiologists.

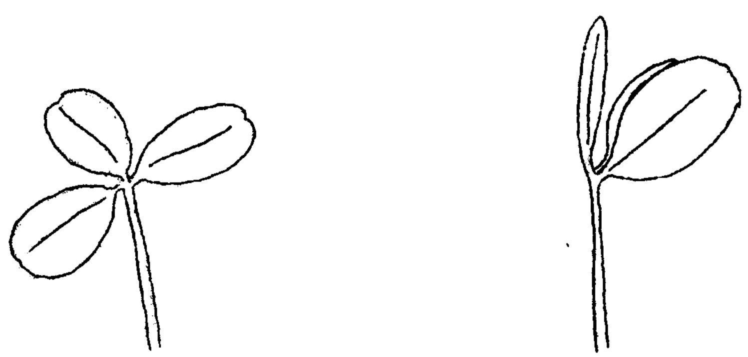
Recently there has been renewed interest in this field, largely because of the work of Bunning, of Germany. Last summer, at the IX International Botanical Congress he chaired a very popular symposium on this subject followed by an informal discussion group. Our work at Guelph was very timely in relation to these sessions.

The emphasis on the work in this study so far has been to establish the normal opening and closing pattern of leaves of red clover under different photoperiods, to observe the change in pattern as clovers were switched from one photoperiod to another, and to try to establish the relative importance of the light and the dark period to subsequent leaf movement. Only very preliminary attempts have been made to study the physiology of this movement.

METHODS

The experimental work was carried out in the mercury-arc light panels of the Botany Department. Plants of the L7 clone of Leon red clover were used. This clone is strongly vegetative at 14 hours or less daylength and reproductive at 16 hours or more. Procedures with respect to plant propagation, maintenance and growth are essentially the same as described in previous years to this group.

The unit for observation is the leaf with the angle between the two lateral leaflets the criterion for measurement. All three leaflets move on closing. The two laterals when open



Leaflets Open   Leaflets Closed

are nearly flat, or at an angle of 180 degrees. They fold in together when closing so that when fully closed they would have to be pried apart to insert a piece of paper between them. The terminal leaflet bends forward until its movement is stopped by the folded leaflets. Opening is the reverse procedure.

All clover plants are not equally responsive, and the leaves on a particular plant vary widely. This caused much trouble in the earlier work. Recently fully expanded leaves of vigorously growing plants were found to be most consistently responsive, and a strict routine of watering and other care was necessary if reproducible results were to be obtained.

Most of the data reported are the means of from 10-20 plants per treatment.

EXPERIMENTAL

Our first experiments were designed to establish the true pattern of opening and closing of clover leaves growing under different photoperiods. Angles of closing for one experiment are shown in Figure 1. Closing movement at all photoperiods commenced several hours before darkness. With the onset of dark the 16 and 18 hour plants were about completely closed.

Figure 2 presents a similar set of curves with respect to opening. Only 12 hour plants showed opening movement before the lights came on. All plants moved rapidly with the onset of light. However, after from 1 to 1½ hours of light, opening ceased and there was a closing of about 10 degrees. Then the leaves continued opening at a reduced pace. This "opening pause", as we call it, will be seen in other figures.

When a clover plant is changed to a longer photoperiod by extending the length of day we find it tending to follow its old closure rhythm for a day or two and then gradually adjusting over a period of about a week to its new circumstance. Such a transition is illustrated in Figure 3. The adjustment from long day to short is much faster, being complete in about 2-3 cycles (Figure 4).

When the daylength is increased by advancing the onset of light we get a very interesting pattern the first day from the 18 hour plants (Figure 5). All plants opened rapidly with the onset of light, the 18 hour plants, however, only half-opened and remained in this position during the remainder of the observation period. During the second cycle it opened fully and by the third appeared to be normal for the photoperiod.

When the daylength was shortened, by extending the dark period beyond the normal onset of light, leaves under all photoperiods commenced opening in the dark during their first cycle (Figure 6). The lag from the previous pattern of 2½ hours for the 18 hour plants, as compared with 1 hour for 16 hours, none for 14 hours and -1 hours for 12 hours is of interest, particularly when it makes the duration of time from beginning of closure (during the previous light) to commencement of leaf opening, 11½, 11, 10½, and 11½ hours for the 4 daylengths respectively. The curves for the former 18 and 16 hour plants were similar and both hit a lag in opening when about half open. Had the lights not come on, these plants probably would have remained in this position and followed the pattern of the 12 and 14 hour plants that were in continued darkness. Within 3 cycles the former 18 hour plants had adjusted to a normal 12 hour opening pattern.

Figures 1 - 6

Figure 1. The closure movement of clover leaves of plants maintained under photoperiods of 12, 14, 16, 18 hours for 18 days, on a basis of common light initiation.

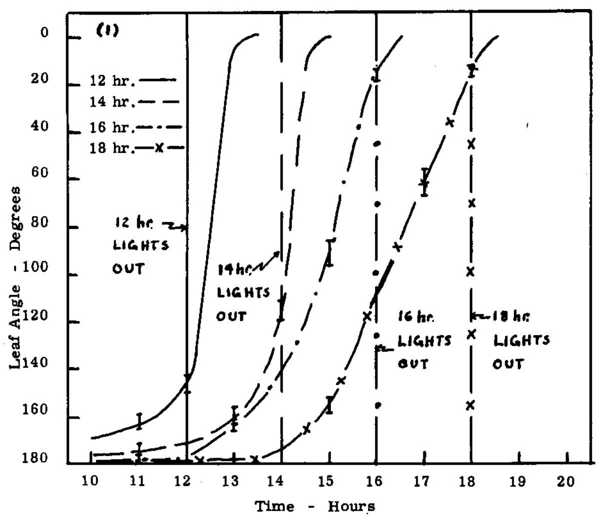
Figure 2. The opening movement of clover leaves of plants maintained under photoperiods of 12, 14, 16, 18 hours for 18 days, on a basis of common light initiation.

Figure 3. The adjustment pattern in closure movements of clover leaves of plants transferred from a 12 hour to an 18 hour daylength.

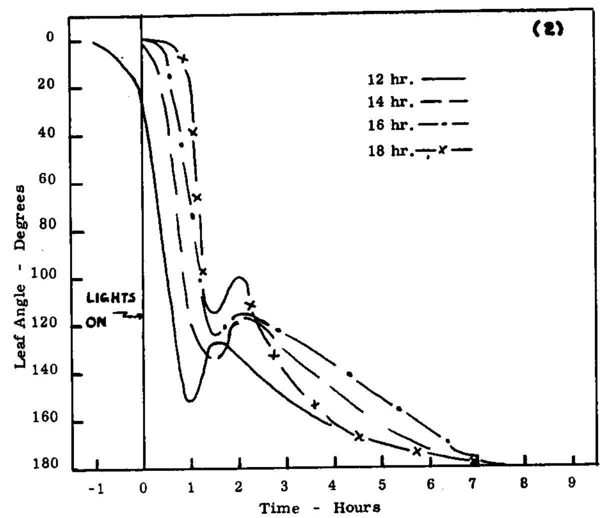
Figure 4. The closure movement of clover leaves of plants when the light period was shortened from a 14, 16, 18 to a 12 hour daylength. First cycle.

Figure 5. The opening movement of clover leaves of plants when the dark period was shortened from 12 to 10, 8, 6 hours (12, 14, 16, 18 hour daylength). First cycle.

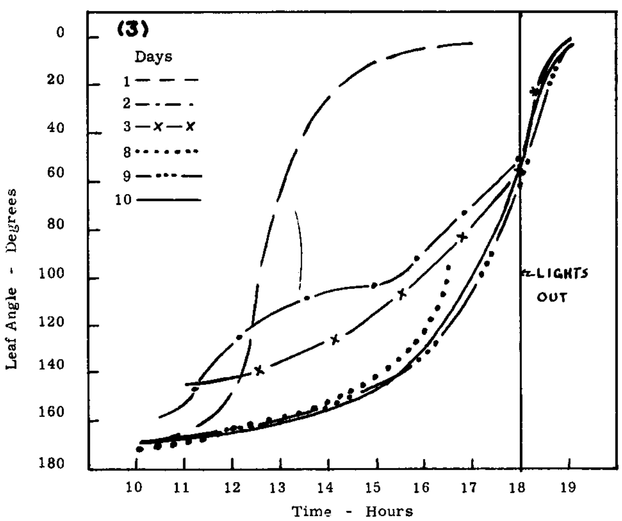
Figure 6. The opening movement of clover leaves of plants when the dark period was extended from 10, 8, 6 to 12 hours. First cycle.



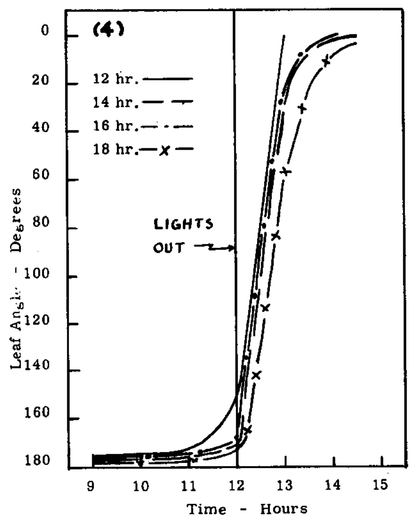
(1)
12 hr.
14 hr.
16 hr.
18 hr.
12 hr. LIGHTS OUT
14 hr. LIGHTS OUT
16 hr. LIGHTS OUT
18 hr. LIGHTS OUT
Leaf Angle - Degrees
Time - Hours



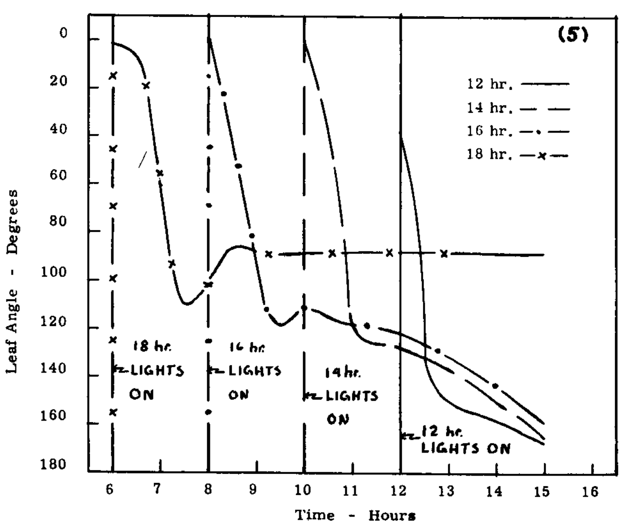
(2)
12 hr.
14 hr.
16 hr.
18 hr.
LIGHTS ON
Leaf Angle - Degrees
Time - Hours



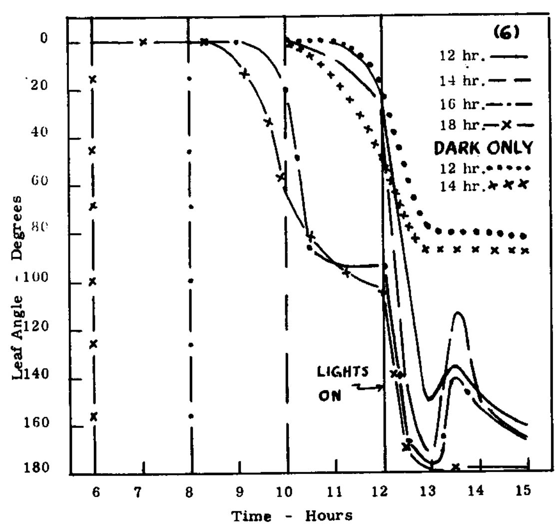
(3)
Days
1
2
3
8
9
10
LIGHTS OUT
Leaf Angle - Degrees
Time - Hours



(4)
12 hr.
14 hr.
16 hr.
18 hr.
LIGHTS OUT
Leaf Angle - Degrees
Time - Hours



(5)
12 hr.
14 hr.
16 hr.
18 hr.
18 hr. LIGHTS ON
16 hr. LIGHTS ON
14 hr. LIGHTS ON
12 hr. LIGHTS ON
Leaf Angle - Degrees
Time - Hours



(6)
12 hr.
14 hr.
16 hr.
18 hr.
DARK ONLY
12 hr.
14 hr.
LIGHTS ON
Leaf Angle - Degrees
Time - Hours

The relative effects of light and darkness on the closure pattern were examined in experiments where major adjustments were made in these photoperiodic components.

In studying the effects of darkness a group of 10 plants was placed in continuing darkness at the completion of a normal 12 hour light period. For the complete picture of the response, presented in Figure 7, data from other experiments and from two separate series of observations in this phase of the work have been combined.

During the first 12 hours of darkness the leaves closed, following the normal pattern. At what was formerly the dark to light switch they opened, but with only half the normal response. At the former light to dark switch they closed, reaching full closure about midway in the former dark period. Again they opened but this time to a full 180 degrees at about midway of the second former light period. This was followed by complete closure during the former third dark period. By this time plants were becoming somewhat disorganized and observations were ended. We have, then, a rhythm in leaf movement that takes place in complete darkness, a rhythm that is roughly following the pattern of former light/dark experience and therefore may be attributed to an endogenous physiological rhythm established within the plant by that light/dark experience.

The effect of the dark period on subsequent leaf movement was further studied in experiments where minimal dark periods followed the normal 12 hour daylength. Data are shown in Figure 8. With no darkness the leaves closed completely in light following a pattern somewhat slower than that of normal dark closure. In light after ½ hour of darkness the leaves continued their closure movement for about half an hour, opened about 20 degrees during the next hour, resumed closing, opened again about 20 degrees, and finally closed. In light after 1 hour of darkness the leaves opened to about 90 degrees in an hour, and then completely closed. This pattern for 1 hour was consistent in all tests up to $4\frac{1}{2}$ hours of darkness, the limit for observations in this experiment. It will be recalled from Figure 5, however, that leaves in light following a 6 hour dark period, opened about halfway and maintained this position during the remainder of the observation period (at least 6 hours).

Figures 7 - 12

Figure 7. The movement of clover leaves during 48 hours of continued darkness following a normal 12:12 light/dark photoperiod.

Figure 8. The effect of minimal dark periods following a normal 12:12 hour dark/light photoperiod on the movement of clover leaves.

Figure 9. The movement of clover leaves during 48 hours of continued light following a normal 12:12 hour dark/light photoperiod.

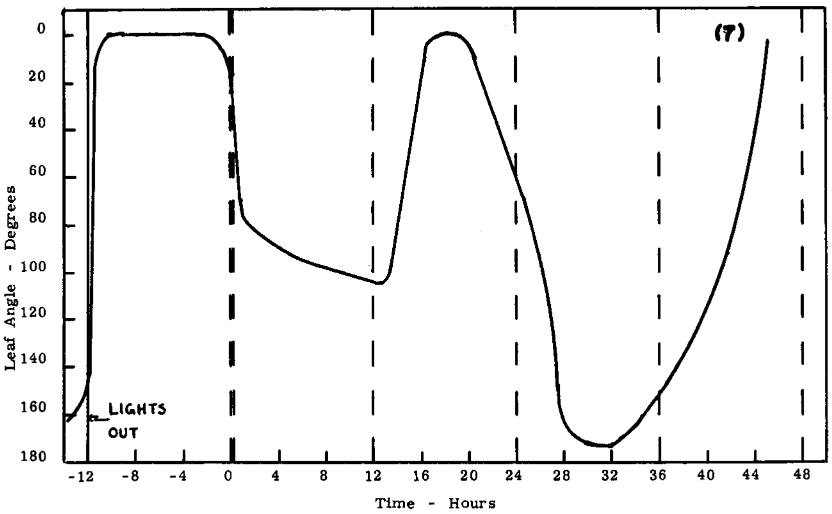
Figure 10. The effect of minimal light periods following a normal 12:12 hour light/dark photoperiod on the movement of clover leaves.

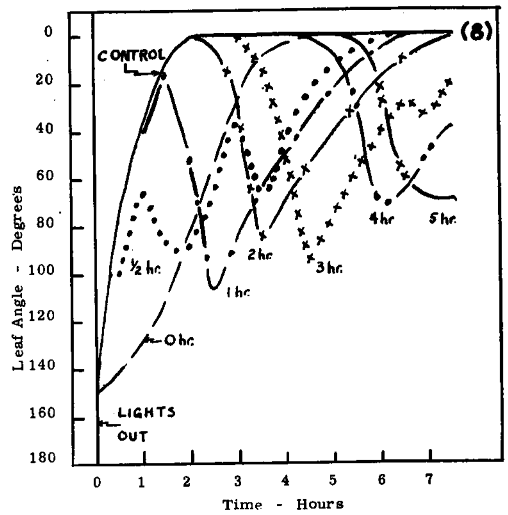
Figure 11. A comparison of the closure movements of attached leaves, detached leaves, and detached leaves with vacuum.

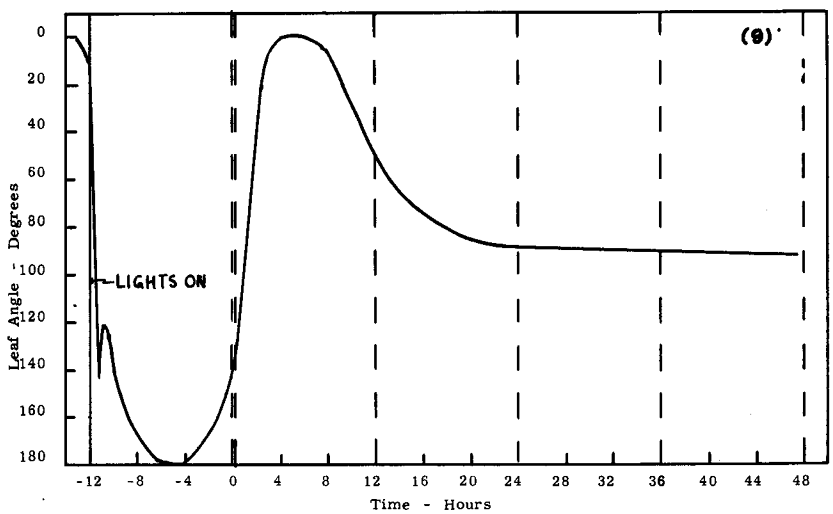
Figure 12. The effect of various concentrations of IAA on the closure movement of clover leaves.

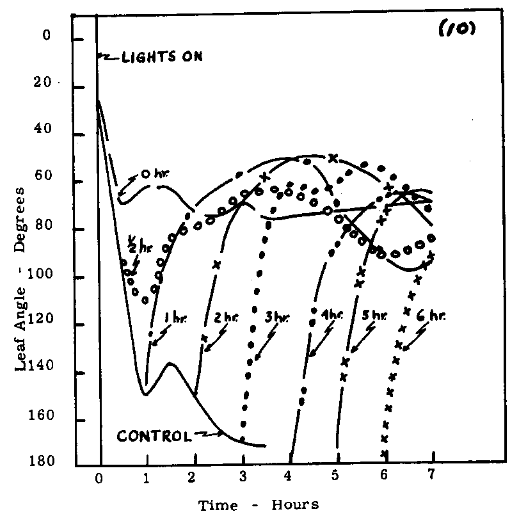
A similar series of experiments were designed to study the effect of light. Leaf movement curves from plants where the light period at the end of the 12 hours normal light was extended indefinitely are shown in Figure 9.

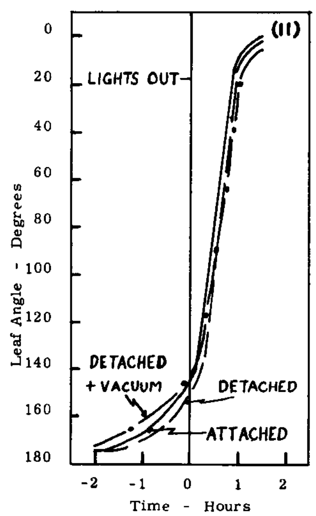
During what was formerly the dark period the leaflets closed completely. After about 4 hours they commenced to open and reached about a half open condition at what would have been

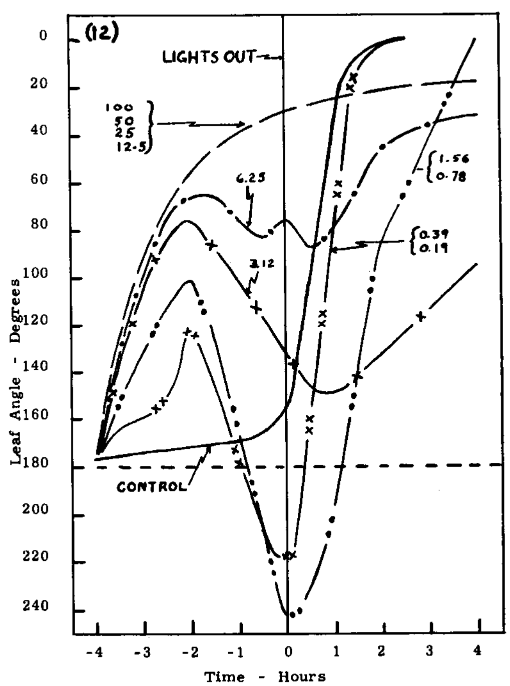

(7)
Leaf Angle - Degrees
LIGHTS OUT
Time - Hours


(8)
CONTROL
½ hr
1 hr
2 hr
3 hr
4 hr
5 hr
0 hr
LIGHTS OUT
Leaf Angle - Degrees
Time - Hours


(9)
LIGHTS ON
Leaf Angle - Degrees
Time - Hours


(10)
LIGHTS ON
0 hr
½ hr
1 hr
2 hr
3 hr
4 hr
5 hr
6 hr
CONTROL
Leaf Angle - Degrees
Time - Hours


(11)
LIGHTS OUT
DETACHED + VACUUM
DETACHED
ATTACHED
Leaf Angle - Degrees
Time - Hours


(12)
LIGHTS OUT
100
50
25
12.5
6.25
3.12
1.56
0.78
0.39
0.19
CONTROL
Leaf Angle - Degrees
Time - Hours

the start of the second dark period. They remained in this condition for at least the next 30 hours.

Short periods of light, followed by darkness gave leaf movement patterns shown in Figure 10. With no light at the end of the normal dark period the leaves opened about one half and remained in that position. With $\frac{1}{2}$ hour of light and then darkness, the leaf at first continued tis opening movement and then closed to about 90 degrees.

With darkness after 1 hour of light the leaves closed rapidly to about 60 degrees and then opened about 30 degrees and remained in a half open condition. A similar response was observed from all light periods from 1 to $5\frac{1}{2}$ hours, except that from $3\frac{1}{2}$ hours and over the leaves closed directly to the 90 degree position.

Only a preliminary start was made in an attempt to study the physiology of this leaf movement mechanism. Experiments have shown the same opening and closing response from leaves detached from the plant with petioles in water solution as from those that were attached. A comparison of leaf closure movements is presented in Figure 11. The leaf, then, is an active unit for at least part of the movement picture.

This <u>in vitro</u> use of detached leaves, of course, presents a technique that will be useful in further physiological studies, in that it permits the feeding of experimental solutions. A few experiments of this nature have been carried out. Figure 12 illustrates the effect of various concentrations of indole - 3 - acetic acid on leaf closure movements.

With this auxin we were able to stimulate closure movements under conditions where the leaves should have remained open.

The reflexing of the leaflets at very low dosages is also of interest. Perhaps Cumming's idea of an endogenous rhythm in the IAA level of clover plants is part of this picture (2). If it is, then we may perhaps have a gauge to measure the internal levels of this growth regulator.

DISCUSSION

We have presented briefly a picture of the movement of the leaves of red clover. Under a 12 hour day leaves commence to close shortly before dark, and to open shortly before the onset of light. As we increase the length of day, more of the closing process takes place in the light and under favourable conditions leaves of 16 and 18 hour daylengths are completely closed before dark. While leaves under a 12 hour day (12 hour night) commenced opening about an hour before the onset of light, the 14, 16, and 18 (10, 8, 6 hour dark) only opened after the lights went on. The "opening pause" in this movement appears to be typical, although not recorded in all experiments.

While the plant took several days to adjust its closing pattern when daylength was lengthened by extension of the light period, it quickly adjusted to a shortened daylength. Opening quickly adjusted to a new onset of light. Apparently a certain minimum of dark or light is needed for maximum expression in the ensueing light or dark period.

After 24 hours in continuous darkness the plant had developed a full rhythm movement with peaks and troughs 12 hours apart, falling in the middle of the previous dark or light periods. Under continuous light the leaves finally assumed a half open position.

The results indicate the possibility that three different forces were behind the leaf responses of clovers, namely, a direct response to light or darkness; a movement rhythm associated with recent light/dark experience; and a basic endogenous rhythm.

The rapid opening movements of leaves with the onset of light; even though only temporary, would appear to be a direct response to the illumination. The speed-up of closing of a partially closed leaf with the onset of dark would also appear to be in this category.

The response of leaves in light following brief dark periods, or in the dark following brief light periods would indicate a relationship between the movement and the previous photo-experience. The opening patterns of the 18, 16, 14, and 12 hour plants when their dark periods were extended would also support this view.

A basic endogenous rhythm only became apparent when the plants had longer than 24 hours in continual darkness. This rhythm would appear to masked much of the time by the more active responses to direct forces, or to those from recent experiences.

References.

1. Darwin, C. Power of Movement in Plants. D. Appleton and Company, New York. 1895.

2. Cumming, B. The control of growth and development in red clover (Trifolium pratense L.) III Endogenous diffusable auxin. Can. Jour. Bot. 37: 1049-1062. 1959.

Evidence supporting the presence of a photoperiodic and gibberellin sensitive "initial" phase in the flowering process of red clover

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Abstract

The use of vegetative, intermediate, and reproductive photoperiods and applications of gibberellin permitted the isolation of an "initial" phase in the reproductive process of red clover. This initial phase can be triggered by a reproductive photoperiod (18 hours), low temperature experience or gibberellin and lasted 1-2 weeks following a vegetative-reproductive shift in photoperiod. This phase is apparently different from the low temperature requiring thermophase of a biennial, or the internode elongation phase of a reproductive plant. Physiologically the action of the reproductive photoperiod in activating this phase is probably quite different from its induction of flower primordia. The initial phase, however, must be activated before a reproductive photoperiod may induce flower primordia.

Evidence supports the thesis that stem elongation of a reproductive plant is largely a response from endogenous gibberellin rather than auxin.

Over the past several years data regarding the responses of red clover to photoperiod and to gibberellin have been presented to this group. While the individual experiments were probably of interest, it was difficult to see where they fit into the flowering picture as a whole. During the past summer, in a paper before the IX International Botanical Congress, certain of these results were presented as evidence of the presence of a photoperiodic and gibberellin sensitive initial phase in the flowering process. This paper follows the discussion as presented at Montreal. The data are from experiments reported to this group in previous years.

Contribution to the Annual Meeting of the Legume Research Committee of Ontario, March 1960. This work is part of a study on the physiology of legumes sponsored by the Committee.

An understanding of the nature of the vegetative shoot is necessary at this point. An unextended shoot, whether it be a rosette in the first year of a biennial or an unextended clover shoot is not a dormant shoot. It is producing new nodes and new leaves. The only difference between this shoot and one that is elongating is that the internodes are extending in the latter. Under a vegetative photoperiod, then, internode elongation of red clover is either not stimulated or may be suppressed.

Experiments with the application of gibberellin to red clover growing under a strongly vegetative photoperiod (13 hours) have shown that:

1. Elongation of internodes occurred and continued until about 2 weeks after the last treatment.
2. The amount of elongation was quantitative, either in respect to dosage or number of treatments.
3. After a period of growth, the plant resumed its former short internode type of development and produced a secondary crown.
4. Internode elongation could again be stimulated by resuming the gibberellin treatments or by a reproductive photoperiod.
5. Elongation of the clover internodes under the strongly vegetative photoperiod was continued for over 6 months by weekly treatments of gibberellin (16 stems studied averaged 26 internodes and 44 inches in height). This elongation took place with no evidence of determinate flower bud formation.
6. Gibberellin induced growth was only from elongation of the younger internodes.

Under a 15 hour photoperiod check plants were strictly vegetative. Two or three treatments with gibberellin initiated stem elongation and the plant continued growth through to flowering. Three weeks pre-treatment under 18 hours, without gibberellin, or two weeks low temperatures also resulted in similar growth and flowering.

It would appear that at this "critical" photoperiod if the initial phase of flowering is "triggered" the 15 hour photoperiod is long enough to support subsequent internode elongation and flowering. At this photoperiod, then, we can separate a "triggering" process that is non-responsive from an "elongation" process that is responsive to a 15 hour photoperiod.

Under a 18 hour photoperiod treated plants responded with growth about one week ahead of the untreated. Other than this one weeks advantage, which the plants maintained throughout their growth, the growth rate, heights at different growth phases, and time intervals between those phases were not affected.

Examination of internode lengths shows that only the lower internodes (nodes which were youngest at the time of treatment) were affected by the treatment. It would appear, then, that as in the 13 hour plants the treatments with gibberellin were only effective for a limited period.

Strangely enough the increment of growth from the gibberellin under 18 hours approximated the gibberellin supported growth under 13 hours. This suggests, then, that at 18 hours the gibberellin supported shoot extension was complimentary to that supported by the photoperiod.

Examination of response of clover to a vegetative to reproductive photoperiodic switch in which treatments with gibberellin were started at 0, 1, 2, and 3 weeks after the switch showed little or no effect from the treatment during the first week. This suggests a parallel reaction of the gibberellin and the photoperiod during this first week, a reaction which became complimentary during the second.

There is, then, marked differences in development up to the 3 inch stage from the different applications of gibberellin. After this stage there was no effect of the chemical on subsequent development.

From the point of view of this study, four stages of reproductive development may be recognized, namely:

1. Initial
2. Internode elongation
3. Induction of flower primordia
4. Expression of flowering

A summary of factors influencing these phasic responses is presented in Table 1.

Table 1. A summary of the phasic responses of the clover material to photoperiod, gibberellin and low temperatures.

	Photoperiod		
	13 hrs.	15 hrs.	18 hrs.
Phasic Response	Responses initiated by		
Growth Initiation	G. or L.T.?	G. or L.T.	G. or P. L.T.?
Internode Elongation	G. only	G. or P.	G. or P.
Flower Induction	None	P.	P.
Flower Expression	None	P. (Weak)	P.

G. = gibberellin; P. = photoperiod; L.T. = Low Temperature

Under the vegetative photoperiod (13 hours) the daylength is unable to support either the initial or internode elongation phases. Gibberellin, and possibly low temperature, support the initial phase while gibberellin alone supports internode elongation. There is no floral expression.

At the "critical" 15 hour photoperiod the daylength is unable to support the initial phase, but once this is "triggered" can support internode elongation and subsequent phases. Gibberellin and low temperature affect the initial phase while gibberellin supports photoperiod with stem elongation. Photoperiod alone handles the subsequent phases.

At 18 hours reproductive photoperiod, daylength, gibberellin and possibly low temperature support the initial phase; photoperiod and gibberellin both effect internode elongation; while the photoperiod alone controls later development.

Quantitatively the effect of the gibberellin on the elongation phase was similar under both vegetative (13 hours) and reproductive (18 hour) photoperiods. This would support Lockhart's[1] proposals that stem elongation is more a response to endogenous gibberellins than to auxins.

There was no evidence that the early treatments with gibberellin directly influenced flower induction or expression, a finding not in agreement with a number of other workers.

The studies indicate an initial phase of the flowering process in red clover, that may be promoted by a reproductive photoperiod or by gibberellin. While low temperature will also promote this phase, it is different from the low temperature

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[1]Lockhart, J.A. Plant Phys. 32: 204-206, 1957.

requiring thermophase of a biennial, since it is activated by the reproductive photoperiod and the thermophase is not.

Under a reproductive photoperiod it would appear that the initial phase was from one to two weeks duration. The action of the long day during this period is probably related to that of gibberellin, and conceivably is entirely different from the action of the reproductive photoperiod in the induction of flower primordia. The stem must go through the initial phase before photoperiodic induction can take place.

LEGUME RESEARCH COMMITTEE REPORT

Tests of Commercial Legume Inoculants

D.C. Jordan, Dept. of Microbiology

Abstract

Tests were conducted on 104 powder-type legume inoculants submitted for analysis by the Field Crops Branch, Toronto.

11.5% of the inoculants were found to be unsatisfactory on the basis of low counts of viable root nodule bacteria per gram of powder. 22% of the alfalfa-clover group were unsatisfactory, and of this group, 42.1% of those produced under the trade name "Legume-Aid" were classified as unsatisfactory. Contamination in the cultures varied from 8% to 84%, and consisted mainly of Actinomycetes.

For the third consecutive summer, commercial legume inoculants obtained by the Field Crops Branch, Toronto, have been tested to determine the number of viable root nodule bacteria, efficiency of nodulation and extent of contamination.

Tests were conducted on 104 inoculants produced by three U.S.A. companies under the following trade names:

(1) Nodogen, Nitronox, Co-op. A. Dickenson Co. 2750 West 35th St. Chicago, U.S.A.

(2) Legume-Aid. Agricultural Laboratories, Columbus, Ohio.

(3) Nitragen. Nitragen Co. Inc. Milwaukee 9, Wisconsin.

The inoculants consisted of 50 clover-alfalfa, 16 soybean, 26 trefoil and 12 ladino cultures, all of which were well within their expiry time.

With the exception of the bean group, all cultures were tested by the plate count method and the most probable number method. The latter is recommended by the University-Department of Agriculture Laboratory Service, Australia. This method is based on the ability of serial dilutions of the inoculant to produce nodules on the proper host plant. It is carried out in duplicate, and the number of rhizobia per gram of dry inoculant is found by reference to Fisher and Yates statistical tables.

Because of the great difficulty in visually separating Rhizobium colonies from those of certain contaminants, the plate count method was deemed unsatisfactory for evaluating powdered legume inoculants. Consequently, with the exception of the bean group, the cultures were graded by the most probable numbers method. The host plants were grown in sterile special medium and the numbers, size, and color of the nodules were noted.

Results of M.P.N. Method and Plate Counts on Legume Inoculants

As the minimum requirement for successful nodulation is 1×10^6 viable rhizobia per gram of dry weight inoculant, the following cultures were classified as unsatisfactory: CA15, CA17, CA18, CA29, CA32, CA34, CA39, CA41, CA42, CA48, CA50, T21.

All the cultures were contaminated, largely by actinomycetes. Contamination varied from 8 to 84% of the total numbers of colonies present.

No correlation was found between the numbers of rhizobia as determined by the plate count method and the numbers of rhizobia as determined by the nodulation method. Also no correlation was found between unsatisfactory inoculants and moisture content, per cent contamination, expiry date or distribution.

11.5% of the total number examined proved to be unsatisfactory; 22% of the alfalfa-clover inoculants were unsatisfactory. In this group 42.1% of those produced under the trade name of "Legume-Aid" proved to be unsatisfactory. Contamination of cultures varied from 8% to 84%

LOT NO.	COMPANY	NO. RHIZOBIA (DILUTION METHOD) PER GM. DRY WT.	NO. RHIZOBIA (PLATE METHOD) PER GM. DRY WT.	PER CENT CONTAMINATION
CA 1	Co-op	84×10^{6}	490×10^{7}	11%
CA 2	Nodogen	37×10^{7}	720×10^{7}	21%
CA 3	Nitronox	87×10^{5}	350×10^{7}	21%
CA 4	Nodogen	90×10^{5}	600×10^{7}	15%
CA 5	Nodogen	82×10^{6}	400×10^{7}	15%
CA 6	Co-op	35×10^{7}	660×10^{7}	16%
CA 7	Co-op	34×10^{7}	450×10^{7}	19%
CA 8	Nodogen	34×10^{7}	950×10^{7}	20%
CA 9	Legume-Aid	32×10^{7}	1200×10^{7}	10%
CA 10	Legume-Aid	31×10^{7}	1340×10^{7}	9%
CA 11	Legume-Aid	32×10^{7}	1260×10^{7}	8%
CA 12	Legume-Aid	33×10^{7}	1200×10^{7}	8%
CA 13	Nitronox	92×10^{5}	430×10^{7}	30%
CA 14	Co-op	28×10^{6}	790×10^{7}	22%
CA 15*	Legume-Aid	84×10^{4}	1050×10^{7}	22%
CA 16	Legume-Aid	27×10^{6}	1390×10^{7}	26%
CA 17*	Legume-Aid	24×10^{4}	1300×10^{7}	20%
CA 18*	Legume-Aid	26×10^{4}	740×10^{7}	18%
CA 19	Nodogen	28×10^{6}	550×10^{7}	53%
CA 20	Co-op	28×10^{5}	270×10^{7}	21%
CA 21	Co-op	92×10^{6}	770×10^{7}	31%
CA 22	Legume-Aid	94×10^{5}	1030×10^{7}	19%
CA 23	Co-op	88×10^{6}	1120×10^{7}	23%
CA 24	Nodogen	88×10^{6}	990×10^{7}	23%
CA 25	Nodogen	28×10^{5}	540×10^{7}	13%
CA 26	Nitronox	84×10^{6}	820×10^{7}	22%

CA = clover-alfalfa
B = soybean
T = birdsfoot trefoil
L = ladino
* = unsatisfactory

LOT NO.	COMPANY	NO. RHIZOBIA (DILUTION METHOD) PER GM. DRY WT.	NO. RHIZOBIA (PLATE METHOD) PER GM. DRY WT.	PER CENT CONTAMINATION
CA 27	Co-op	28×10^{6}	1100×10^{7}	26%
CA 28	Nitronox	94×10^{5}	640×10^{7}	14%
CA 29*	Legume-Aid	83×10^{4}	630×10^{7}	12%
CA 30	Co-op	25×10^{5}	900×10^{7}	21%
CA 31	Co-op	27×10^{5}	590×10^{7}	36%
CA 32*	Nodogen	91×10^{4}	530×10^{7}	35%
CA 33	Legume-Aid	24×10^{5}	1000×10^{7}	26%
CA 34*	Co-op	88×10^{4}	160×10^{7}	34%
CA 35	Co-op	27×10^{5}	980×10^{7}	32%
CA 36	Co-op	27×10^{5}	400×10^{7}	42%
CA 37	Co-op	27×10^{5}	350×10^{7}	40%
CA 38	Nitronox	92×10^{5}	460×10^{7}	43%
CA 39*	Nitronox	92×10^{4}	270×10^{7}	29%
CA 40	Co-op	26×10^{5}	520×10^{7}	24%
CA 41*	Legume-Aid	88×10^{4}	630×10^{7}	25%
CA 42*	Legume-Aid	82×10^{4}	530×10^{7}	27%
CA 43	Legume-Aid	84×10^{6}	450×10^{7}	27%
CA 44	Nodogen	28×10^{5}	410×10^{7}	41%
CA 45	Co-op	28×10^{5}	290×10^{7}	19%
CA 46	Legume-Aid	88×10^{5}	800×10^{7}	33%
CA 47	Legume-Aid	25×10^{6}	640×10^{7}	18%
CA 48*	Legume-Aid	25×10^{4}	890×10^{7}	20%
CA 49	Legume Aid	80×10^{6}	580×10^{7}	15%
CA 50*	Legume-Aid	26×10^{4}	690×10^{7}	24%
B 1	Nodogen		730×10^{7}	20%
B 2	Nodogen		360×10^{7}	26%
B 3	Nodogen		500×10^{7}	27%
B 4	Legume-Aid		1050×10^{7}	12%
B 5	Nodogen		550×10^{7}	26%
B 6	Nodogen		50×10^{7}	84%
B 7	Legume-Aid		320×10^{7}	19%
B 10	Legume-Aid		160×10^{7}	33%
B 11	Legume-Aid		580×10^{7}	35%
B 12	Nodogen		170×10^{7}	31%
B 13	Nodogen		520×10^{7}	19%
B 14	Nodogen		640×10^{7}	27%
B 15	Nodogen		790×10^{7}	56%
B 16	Nodogen		750×10^{7}	23%
B 17	Nodogen		870×10^{7}	32%
B 18	Legume-Aid		980×10^{7}	11%
T 2	Co-op	85×10^{5}	220×10^{7}	44%
L 1	Legume-Aid	25×10^{6}	230×10^{7}	41%
L 2	Co-op	79×10^{5}	270×10^{7}	48%
L 3	Nodogen	76×10^{5}	92×10^{7}	41%
L 4	Co-op	28×10^{6}	160×10^{7}	41%
L 5	Co-op	27×10^{5}	270×10^{7}	42%

LOT NO.	COMPANY	NO. RHIZOBIA (DILUTION METHOD) PER GM. DRY WT.	NO. RHIZOBIA (PLATE METHOD) PER GM. DRY WT.	PER CENT CONTAMINATION
L 6	Legume-Aid	25×10^{6}	180×10^{7}	26%
L 7	Co-op	28×10^{6}	240×10^{7}	24%
L 8	Co-op	29×10^{6}	120×10^{7}	39%
L 9	Legume-Aid	82×10^{5}	140×10^{7}	46%
L 10	Co-op	29×10^{6}	170×10^{7}	39%
L 11	Legume-Aid	27×10^{5}	410×10^{7}	48%
T 1	Nodogen	30×10^{7}	120×10^{7}	64%
T 3	Nodogen	30×10^{6}	240×10^{7}	58%
T 4	Nodogen	89×10^{6}	320×10^{7}	45%
T 5	Nodogen	38×10^{7}	260×10^{7}	36%
T 6	Co-op	36×10^{7}	290×10^{7}	39%
T 7	Legume-Aid	22×10^{5}	18×10^{7}	58%
T 8	Nodogen	69×10^{5}	15×10^{7}	66%
T 9	Co-op	27×10^{7}	68×10^{7}	62%
T 10	Nodogen	84×10^{6}	290×10^{7}	54%
T 11	Legume-Aid	34×10^{7}	500×10^{7}	43%
T 12	Nodogen	86×10^{6}	260×10^{7}	65%
T 13	Co-op	29×10^{6}	140×10^{7}	47%
T 14	Legume-Aid	80×10^{6}	190×10^{7}	44%
T 15	Co-op	35×10^{7}	210×10^{7}	45%
T 16	Nodogen	30×10^{6}	110×10^{7}	51%
T 17	Nodogen	74×10^{5}	64×10^{7}	52%
T 18	Nodogen	30×10^{6}	140×10^{7}	45%
T 19	Legume-Aid	25×10^{5}	240×10^{7}	32%
T 20	Legume-Aid	88×10^{5}	310×10^{7}	40%
T 21*	Legume-Aid	24×10^{4}	500×10^{7}	25%
T 22	Legume-Aid	78×10^{6}	200×10^{7}	23%
T 23	Nitragin	82×10^{5}	110×10^{7}	51%
T 24	Nodogen	88×10^{6}	230×10^{7}	45%
T 25	Legume-Aid	25×10^{6}	220×10^{7}	37%
T 26	Legume-Aid	33×10^{7}	310×10^{7}	49%
T 27	Nodogen	38×10^{7}	80×10^{7}	56%

REPORT OF DEPARTMENT OF SOILS FOR LEGUME RESEARCH COMMITTEE IN ONTARIO - MARCH 1960

The Department of Soils has conducted work on the placement of fertilizer for the establishment and growth of alfalfa and alfalfa-brome seeded with oat companion crop.

In 1958, alfalfa at 15 pounds per acre was seeded with oats drilled at 8 pecks on 14" spacing. The alfalfa drills were either placed with the oat drills, or between the oat drills, and fertilizer was drilled either with the oats or in the drill between the oat drills. A single and a double rate of phosphorus was used with one level of nitrogen, and was equivalent to 300 pounds of 10-5-0, and 10-10-10 per acre. The potassium requirement was added separately.

The yield and uptake of fertilizer phosphorus was measured for oats and alfalfa at oat harvest time. The yield of alfalfa was measured again in 1959. The results are given in the following tables.

Yield Alfalfa - gm. per 40' Row

Placement of Fertilizer	30-15-0	30-30-0
Fertilizer and alfalfa with oats	44	39
Fertilizer between oat drills - alfalfa with oats	41	31
Fertilizer with oats alfalfa between oat drills	116	157
Fertilizer and alfalfa between oat drills	111	185
Mean	78	103

Establishment as reflected in yield of alfalfa at oat harvest was increased by placing alfalfa between oat drills and further increased by placing 30-30-0 pounds of fertilizer in a band below it rather than in the oat drills. There was no change in alfalfa yield due to the placement of 30-15-0 pounds of fertilizer. Increasing the fertilizer application increases the yield of alfalfa planted between the oat drills.

Fertilizer Phosphorus Uptake - Mgm. P per 40' row

Fertilizer and alfalfa with oats	27.4
Fertilizer between oat drills, alfalfa with oats	3.6
Fertilizer with oats, alfalfa between oat drills	15.8
Fertilizer and alfalfa between oat drills	87.2
30-15-0 lb. fertilizer application	28.7
30-30-0 lb. fertilizer application	38.3

Fertilizer phosphorus uptake was lowest when alfalfa was placed in drill with oats and fertilizer between oat drills, and highest when alfalfa and fertilizer were placed together between the oat drills. Placing fertilizer and alfalfa with oats resulted in greater uptake than placing alfalfa between oat drills and fertilizer in the oat drill. Increasing fertilizer rate increased fertilizer phosphorus uptake.

The yield of oats was not influenced by fertilizer rate, but was highest where fertilizer and alfalfa were placed in the drill and lowest where fertilizer only was placed in the oat drill, and alfalfa was placed between the oat drills.

With the 300 pound application of 10-5-0 drilled with oats, the seeding of alfalfa with the oats resulted in greater fertilizer phosphorus uptake by the oats than occurred where alfalfa was seeded between the oat drills. This effect was not significant at the higher phosphorus rate.

The mean percentage of the total plant phosphorus derived from fertilizer was 25.1 for alfalfa as compared to 23.0 for oats.

The mean percentage recovery of fertilizer phosphorus was 0.65 for alfalfa as compared to 14.1 for oats.

The yield of alfalfa in the succeeding year was not significantly influenced by the placement of the alfalfa or the fertilizer in the year of establishment.

It is concluded that while differences in growth and nutrient uptake can be demonstrated for the year of seeding there are no benefits in the succeeding hay year.

New seedings of alfalfa brome in 1959 again suggested that good seedlings growth was obtained when seeded between oat drills and that further increases could be obtained through seeding half the seed with oats and half between the oat drills. Placing fertilizer close to the alfalfa brome seed also increased growth.

Varying the placement of the fertilizer applied with oats influenced its uptake by alfalfa brome seeded in the drill with the oats. This did not significantly influence the total uptake of phosphorus, however. The values given in the following table show that placement with seed resulted in the highest uptake and broadcast application the lowest uptake. While individual yield values were not significantly different, the mean for the "with seed" and "2 below" placements was better than the mean for the other two placements.

	Fertilizer Phosphorus Uptake by Alfalfa-Brome mgm. per 20' plot		Yield of Alfalfa Brome gm. per 20' plot	
Fertilizer at 200 lb. 5-20-20				
placed - with seed	2.29		4.59	
- 2" below seed	3.58		4.56	
- 1" to side seed	1.67		3.22	
- broadcast	0.41		3.63	
Mean		1.99		4.00
Fertilizer at 600 lb. 5-20-20				
placed - with seed	7.67		5.75	
- 2" below seed	2.28		5.44	
- 1" to side seed	2.98		4.00	
- broadcast	.61		4.93	
Mean		3.38		5.03
L.S.D. (.05)	2.86		2.63	

Again, seeding alfalfa in the oat drills increased the uptake of fertilizer phosphorus by the oat crop.

The mean percentage of the total plant phosphorus derived from fertilizer was 22.0 for the alfalfa brome as compared to 17.7 for the oats.

The mean percentage of fertilizer phosphorus application recovered by alfalfa-brome was 0.2 for the 200 lb. application and 0.1 for the 600 lb. application, as compared to 10 and 5.6 respectively for oats.

It is concluded at present from this work that while alfalfa and alfalfa-brome mixtures appear to benefit in terms of growth and phosphorus fertilizer uptake from minimum competition and close placement of fertilizer, the result in ultimate yield may be small and insignificant.

The suggested effect of the alfalfa in increasing phosphorus fertilizer uptake by the companion crop warrants further study. Likewise the extremely low efficiency of fertilizer use by alfalfa and alfalfa-brome mixture detracts from the practice of fertilizing for the benefit of these seedlings and means to increase this efficiency should be sought.