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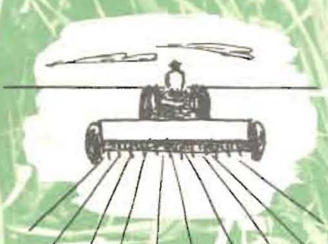
PROGRESS REPORT

HAY INVESTIGATIONS 1953



Ontario Agricultural College, Guelph, Canada.

CONTENTS

Report of the Executive Committee

Organization and Responsibilities

Hay is the most important field crop grown on the livestock farms of Ontario. Of the 8.3 million acres in cropland approximately 3.7 are devoted to hay production. Hay forms the basis of the ration for most classes of livestock and plays a major role in the economics of meat and milk production and in the health of the animals. Further, it is a valuable crop for soil building.

The production of a high volume of good quality hay involves a number of complex problems which demand an intensive research programme. Many such problems require investigational work by several departments working together if more effective progress is to be made. Hence, in January, 1953, the Hay Research Committee was appointed to co-ordinate hay research at the O. A. C. The responsibility of the Committee is to assist in the integration of the hay research being carried out by the different departments to assure a balanced hay research programme. No research projects are planned and directed by the Committee. Each project is directed by the project leader.

The Executive or Policy Committee consists of:

Dr. J.D. MacLachlan - President, O. A. C.
G. N. Rhunke - Director of Research
W.E. Tossell - Committee Chairman
M.A. MacGregor - Secretary
D. R. Campbell - Agricultural Economics Department
C. G. E. Downing - Agricultural Engineering Department
H. D. Branion - Nutrition Department
R. G. Knox - Animal Husbandry Department
N. R. Richards - Soils Department

Hay research was broken down into four major sections. A sub-committee or working committee was formed in each of the 4 sections. The sub-committee chairmen, members of the Executive Committee, are responsible for co-ordinating the work in each section and for bringing to the attention of the Executive Committee any problems in which the Committee might provide assistance.

Members of the sub-committees include: (1) Permanent members - a representative from each Department primarily concerned with the particular section (2) other research workers connected with active projects. The sub-committees are as follows:

1. <u>Production:</u> Production includes seeds and seeding, tillage practices, soil management, crops, management of the growing crop,

time to cut and the economics of hay production. Permanent members of the Production Sub-Committee are:

W.E. Tossell - Field Husbandry (Chairman)
G.L. Byers - Agricultural Engineering
M.A. MacGregor - Agricultural Economics
I. Motzok - Nutrition
J.W. Ketcheson - Soils

(2) Preservation: This includes machines and methods for cutting, curing, and storing, structures for storing, and the economics involved. Permanent members of the Preservation Sub-Committee are:

C.G.E. Downing - Agricultural Engineering (Chairman)
D.R. Campbell - Agricultural Economics
E.V. Evans - Nutrition
W.O. Kennedy - Animal Husbandry

(3) Utilization: Utilization includes the use of the stored hay in the production of livestock and livestock products. Permanent members of the Utilization Sub-Committee are:

R.G. Knox - Animal Husbandry (Chairman)
H.D. Branion - Nutrition
M.A. MacGregor - Agricultural Economics

(4) Quality Assessment: Quality assessment, as considered in this section includes the correlation of visual physical characters of hay with analytical data and with feeding value.

H.D. Branion - Nutrition (Chairman)

Activities:

As an aid to assessing the amount of hay research at the O.A.C. a summary was prepared of all projects completed or current at the time of the formation of the Committee. This summary revealed a total of 40 projects of which 15 were completed and 25 were current. The summary was distributed to all members of sub-committees. Following this, attention was given to evaluating and co-ordinating the current projects before the 1953 growing season commenced.

As an aid in planning a balanced long-term research programme, reviews of literature on several phases were prepared. These reviews were presented and discussed along with current research at meetings of the sub-committees. From the reviews and discussion, lists were prepared of the major problems requiring research.

1. The Effect of the Operation of Tillage Machinery on Soil and Crop Yields

Downing, C. G. E., Byers, G. L., and Webber, L. R. (Ag. Eng. & Soils)

R. P. O. Ag. Eng. 5
Objectives: 1. To compare the effect on soil structure of various tillage implements.
2. To compare crop yields when these primary tillage implements are used.
3. To study the efficiency of operation and economics of using these machines either singly or in combination.
Location: Brecken Farm, Bronte, and College Farm, Arkell.
Procedure: Both soil building and soil depleting rotations were laid out on a loam soil and on a clay soil. In the longer rotations, treatments were replicated three times, twice in the short rotations. All tillage treatments were completed in the fall. Spring operations were the same for all treatments.
Results: For brevity (as two locations and several rotations are involved) location, treatment, and results are shown in the following tables.

	Arkell - Hay Tons/acre	
	4 yr. rotation (poor)	4 yr. rotation (good)
Rotary Tillage	2.34	1.26
Moldboard Plow	1.99	1.22
One-way Disc	2.10	1.54

	Arkell - 5 yr. Rotation - Hay Tons/Acre		
Treatment	1st yr. Hay	2nd yr. Hay	3rd yr. Hay
Moldboard Plow	1.74	1.74	1.48
One-way Disc and Disc Plow	1.83	1.75	1.81
One-way Disc and Moldboard Plow	1.66	1.64	1.37
T. N. T. Plow	1.49	1.73	1.40
Disc Plow	1.71	1.40	1.35
One-way Disc	1.49	1.68	1.53
Rototiller	2.24	1.56	1.42
Cultivator	2.44	1.51	1.47

Bronte 4 yr. Rotation (Poor)

Hay Yield in Tons/Acre	
Moldboard Plow	1.88
Disc Plow	1.26
Rototiller	1.38
One-way Disc	1.46

Bronte - 6 yr. Rotation - Hay Yield Tons/Acre

	Hay Following Wheat	Hay Following Oats	Hay Following Hay
Rotovator	2.04	1.92	2.01
One-way Disc and Moldboard Plow	1.71	1.53	1.92
Rototiller	1.92	1.54	2.02
Moldboard Plow	1.55	1.57	1.75
One-way Disc	2.19	1.50	1.90
Disc Plow	1.74	1.50	1.67

2. Effect of Deep Tillage Machinery on Crop Yields on Haldimand Clay Soil

G. L. Byers, (Ag. Eng.)

R. P. O. Ag. Eng. 18
Location: Nye Farm, Kohler, Haldimand County.
Objectives: 1. To compare the effect on crop yield of two deep tillage implements.
2. To study the economics of using these machines.
Procedure: Three tillage treatments, namely: (A) Moldboard Plow, (B) Deep Tillage Cultivator (C) Sub-soiler; were followed by conventional moldboard plow. Each tillage plot was sub-divided to provide three levels of fertility with four replications for all treatments. Deep Tillage plots were cultivated four times with a cultivator. Sub-soiling done to a depth of 26" every 26" on the surface. Basic Rotation: wheat, hay, hay, corn, oats.

Fertility treatments were as follows:

No. 1 Lime 4 tons/acre
Superhposphate 550 lbs./acre
3-18-9 150 lbs./acre

Ammonia Nitrate 150 lbs./acre
No. 2 3-18-9 150 lbs./acre
No. 3 No fertilizer

Results: The area was seeded to fall wheat in 1952. Hay production data will be collected in 1953 for the first time.

3. Cropping Systems Study

Ketcheson, J. (Soils)

R.P.O. S.F. 74
Objective: The objective of the project is to study the influence on soil productivity of various proportions of soil building to soil depleting crops under two different management practices.
Procedure: This project was started in 1952 and is to be continued for twelve years (1964). The five cropping systems to be compared are:

1. Six-year rotation with four years grass-legume sod.
2. Four-year rotation with two years grass-legume sod.
3. Six-year rotation with two years grass-legume sod.
4. Three-year rotation with one year grass-legume sod.
5. Continuous corn.

Each system will be used at two levels of management: (a) Minimum fertility level using residues of manure only, and (b) Adequate fertility level according to soil tests, using commercial fertilizers in addition to residues or manure.

This project is located on the S.A.E. Farm, Guelph. The design is fashioned after Golden's Standard Rotation Plan. Corn and hay are to be used as indicator crops. Plots are arranged to bring such crops from the various rotations adjacent in one block. The number of replications of the various systems varies from two for a six year rotation to twelve for continuous corn. Each crop of each system occurs each year.

Results: This experiment has not been running long enough for differences due to cropping to show up. However, hay yields were taken on June 1, 1953 from Block 10 (the hay block for 1953) to compare hay production under the two levels of fertility management. Yields from the plots on the unfertilized half of the block averaged 1.26 tons per acre, while yields from the plots on the fertilized half averaged 1.22 tons per acre (15% moisture). A starter fertilizer (170 lbs./ac. of 2-12-10) was applied to the fertilized plots when the oats (seeded down) were sown in the Spring of 1952, and in addition the fertilized half of the block received a top dressing of 200 lbs. of muriate of potash on August 19, 1952. No response to this fertilizer was evident in the yields taken on June 1, 1953. The soil is high in phosphorus but low in potash.

4. Fertility of Major Soil Types as Indicated by Response of Crops to Applied Fertilizer Material

Caldwell, A.G. (Soils)

R.P.O. S.F. 22
Objective: The objective of this study is to determine the fertility requirements of major Ontario soil types for various crops (including hay).
Procedure: This project was started in the Spring of 1952 and is to continue for possibly eight years (1960). Fertilizer treatments were applied in an N-P-K factorial design to field plots on eight different soil types in Grey, Waterloo, and Wellington Counties. Treatments were laid down cooperatively with farmers on privately owned farms. Plots were laid out and fertilizer treatments applied broadcast by the Department of Soils. Planting operations were conducted by the farmer.

Oats (seeded down) were sown in the Spring of 1952. Fertilizer (500 lb./ac. of 4-16-8) was applied broadcast and worked in the soil before sowing. Oat yields were taken in 1952 and hay yields were obtained in 1953 on six of the eight locations.

Results: There was no significant effect of fertilizer application on yield of hay. It is felt that a large part of the Spring of 1952 fertilizer additions, particularly N and K, was taken up by the oat crop, and if the new seeding had been top-dressed in the Spring of 1953 with additional fertilizer, some response might have been obtained. Future work on this project will folfow this assumption.

5. Phosphorus and Potassium Response of Burford Loam

Ketcheson, J. and Smith, J. (Soils)

R.P.O. S.F. 54
Objective: The objective of this study is to determine response to adequate levels of phosphorus and potassium in the presence of other nutrients on the growth of several crops including grass-legume hay.
Procedure: This project was started in 1951 to continue for at least three years (1954). The experiment is located on the S.A.E. farm, Guelph. A "paired-plot" design is being used. Complete N-P-K treatments are placed adjacent to N-P and N-K treatments only. Plots are .025 acres in size and treatments are replicated four times.

Results: (1952) One cutting of the first-year hay plots was made on

June 19, 1952. No response to either P and K was noted. This was possibly due to severe drought conditions. The hay was short and parched.

Table 1 - Yield of First Year Hay - 1952

Treatment	Yield (Tons/Ac. -10% Moisture)
Complete NPK	1.37
No P	1.41
1/3 P	1.34
2/3 P	--
Complete NPK	1.35
No K	1.23
1/3 K	1.72 (1 rep. only)
2/3 K	1.35

(1953) Two cuttings of first-year hay were made in 1953, on June 1st and July 15th. Total yield of hay was increased by 0.33 ton per acre (10%) by additions of 50 lb. per acre of P_2O_5. Original soil tests showed soil phosphorus levels to be H to VH. Total yield of hay was increased by 1.14 tons per acre (56%) by addition of sufficient K_2O to bring the soil test up to an adequate potash level. Yields given are on a 15% moisture basis. The N-P-K plots received 120 lb. of K_2O in the Spring of 1951 and either 100 or 200 lbs. of K_2O in the Spring of 1953, depending on the soil test.

Table 2 - Yield of First Year Hay - 1953

	Yield (Tons/Ac. - 15% Moisture)		
Treatment	1st Cut	2nd. Cut	Total
Complete NPK	2.07	1.34	3.41
No P	1.75	1.32	3.07
1/3 P	1.85	1.30	3.15
2/3 P	1.81	1.17	2.99
Complete NPK	1.92	1.24	3.16
No K	1.13	.89	2.02
1/3 K	1.58	1.08	2.66
2/3 K	1.65	1.23	2.88

6. Use of Rock Phosphate as Soil Treatment

Ketcheson, J. (Soils)

R. P. O. S.F. 61

Objective: The objective of this project is to study the place of rock phosphate in a soil fertility program.

Procedure: This project was started in 1952 and is to continue for twelve years (1964). African rock phosphate and Florida rock phosphate are being compared as single treatments, and as combined treatments with superphosphate, as to effect on productivity of a Burford loam soil (pH 7.0-7.3). N and K are being applied in all treatments. The rotation of crops consists of wheat (seeded) and two years of grass-legume hay. Each crop appears each year. Two replications of the treatments are made. Plot size is 0.046 acres.

Results: No results are available to date due to catch failures on wheat in the Fall of 1952 and again in the Spring of 1953. This study has been extended to Haldimand Clay soil (pH 5.2) on the S. A. E. farm, Cayuga, where the rotation is Oats (seeded), hay, corn or wheat. No results are available to date.

7. Lime, Potash, and Borax Response of Burford Loam

Ketcheson, J. (Soils)

R. P. O. S. F. 60

Objective: The objective of this project is to study effects of agricultural limestone on near neutral soil on growth of certain crops.

Procedure: This project was started in 1951 to continue for five years (1956). The location of this experiment is at the S. A. E. farm, Guelph. Agricultural limestone was applied at three rates as sub-plot treatments on six combinations of potash and borax treatments. Plot size is 0.028 acre. Treatments were applied in 1951, fall wheat was sown, and alfalfa was seeded on the wheat in the Spring of 1952.

Results: Yields of alfalfa hay were taken on June 2, 1953. The average yield from all plots was 1.14 tons per acre on a 15% moisture basis. Neither limestone nor borax had any effect on yield. The plots receiving potash (200 lbs. /ac. of K_2O in 1951) averaged about 0.25 ton per acre more than plots receiving no potash. While the potash soil test for this soil in general is low, a considerable part of this project area shows a very high level of exchangeable potash due to the piling of manure over winter a few years previous. The stand on this area in general was rather poor.

8. Lime Requirements on Lockport Clay Loam

Willis, A. L. (Soils)

R.P.O. S.C. 34
Objective: The objective of this project is to study lime requirements of Lockport clay loam (pH 5.2) as reflected in crop growth, effect on pH and base saturation of the soil.
Procedure: This project was started in 1952 to continue for possibly three years (1955). Increments of dolomitic limestone were applied in the Spring of 1952 to small scale plots on a privately owned farm in Halton County. The treatments were replicated four times. Oats seeded to alfalfa and fertilizer were sown in the Spring of 1952.

Results: Oat yields taken in 1952 showed no response to lime additions. Soil samples taken in August 1952 were tested for pH and ranged from 6.2 to 6.6 depending upon rate of application. A fair stand was obtained in 1952. This wintered quite well and was left in 1953. No yields were taken. The most significant result of this project was the establishment of a fair stand of alfalfa following heavy applications of limestone (6 to 10 tons per acre) on another part of the same field where seedings had failed the two years previous following lighter, more normal applications of limestone (1 to 5 tons per acre).

9. Lime Requirements on Various Soil Types

Caldwell, A.G. (Soils)

R.P.O. S.F. 22
Objective: The objectives of this study were to determine the amount of limestone required to raise the pH of various soil types to a desired level, and to assess the effect (if any) of this rise in pH on the yield of different crops.
Procedure: This project was started in 1952 in the greenhouse and is completed. Seven soil types were brought into the greenhouse and put into one-gallon pots. These were all heavy-textured soils, as follows: Brookston clay (pH 5.4), Caistor clay (pH 5.8), Chinguacousy clay (pH 5.8), Haldimand clay (pH 5.7), Jeddo clay (pH 6.0), Peel silty clay loam (pH 6.7), Perth clay (pH 7.3). Sufficient $CaCO_3$ was added to certain pots in each soil type to bring the pH up to approximately 7.0. The amounts of $CaCO_3$ added in lbs. per acre were for Brookston clay 5650, Caistor clay 3900, Chinguacousy clay 5000, Haldimand clay 5200, Jeddo clay 4400, Peel clay 1500, Perth clay nil. Barley seeded to sweet clover was sown in each pot.

Results: A significant response in yield of sweet clover to liming to pH 7.0 was obtained on the Brookston, Caistor, Chinguacousy, and Haldimand soils.

10. Livestock Manure Study

Ketcheson, J. (Soils)

R.P.O. S.F. 73
Objective: The objective of this project is to study suitable systems of management of livestock manure from the standpoint of its application to various crops of a four-year rotation of corn, oats (seeded), and two years of grass-legume hay.
Procedure: This project was started in 1952 to continue for eight years (1960). The location of this experiment is at the S.A.E. farm, Guelph.

Results: The project has not been underway long enough to afford comparisons on hay yields between the various manure treatments.

11. Minor Element Studies

Willis, A. L. (Soils)

R.P.O. S.C. 72
Objective: The objective of this project is to study minor element requirements of soils for growth of legume crops.
Procedure: This is a current project started in 1952 and is to continue for an indefinite period. This experiment is located on the S.A.E. Farm, Guelph. In the Spring of 1952 a series of plots were laid out on old alfalfa sod. Five minor elements: Mn, Zn, Cu, B and Mo were added singly, and in combination, as a top dressing. Spray applications were also made. Each treatment was replicated three times.

Results: Yields were taken on the first hay cutting. No response to treatment was obtained.

This project is being continued on an adjacent area on which efforts were made to establish a stand of red clover in 1953.

12. Studies on the Operation of Machines Used in the Seeding of Grasses and Legumes

G. L. Byers, and J. Ketcheson (Ag. Eng. & Soils)

R.P.O. A. Eng. 11
Objective: The objective is to investigate the ability of certain farm

machines to place small grass and legume seeds suitably for germination.
Procedure: Four methods of seeding and two rates of seeding are being used, utilizing a randomized split-plot design with four replications. The nurse crop is oats. The test is located at the S. and A. E. farm.

Methods of Seeding are:

A. All seeds mixed in drill box. Roll after seeding.
B. Standard Disc Drill. Brome mixed with oats, remainder broadcast from grass seed box. Harrowed with levelling harrows-rolled.
C. Seeds placed as in (b) followed by cultipacker.
D. Cultipacker Seeder.

Rates of Seeding are: Full rate and one-half rate.

Results:

	Hay Yield	Tons/acre - 15% Moisture			
Rate	A.	B.	C.	D.	Mean
x	1.28	1.74	1.76	1.80	1.67
y	1.31	1.69	1.54	1.75	1.57
Mean	1.29	1.71	1.65	1.82	

L.S.D. - 1% - .285
- 5% - .21

x - Full rate of seeding   y - One-half rate of seeding

13. Methods of Preparing the Seedbed and Seeding Grasses and Legumes

Byers, G. L. and Fulkerson, R. S. (Ag. Eng. and Field Husb.)

R. P. O. A. Eng. 22 and Field Husb. 33-6
Objectives: To investigate the ability of certain machines to place small seeds, and the effect of the type of seedbed on this placement.
Procedure: Three methods of seedbed preparation as follows were used.

A. Disc harrow.
B. Spring tooth harrow.
C. Rotary tiller.

Three methods of seeding were compared on each method of seedbed preparation. These were: 1. Single Disc Grain Drill: Brome and orchard grasses mixed with oats. Remainder broadcast from the grass seed box, followed by smoothing harrows.
2. Seeds placed as in (1) but followed by cultipacker.
3. All seeds (other than oats) placed with a cultipacker seeder.

A split-plot design with methods of seedbed preparation as main plots was used. The oat companion was clipped with a forage harvester and the residue returned directly to the plots. The trial was seeded on the S. and A. E. farm in 1953.

Results: Plant counts were taken in the fall of 1953. The data are summarized in Table 1.

Table 1. Plants per Square Foot in Fall of Seedling Year, 1953.

Species	Methods of Seeding	Soil Preparation			
		Tandem Disc	Field Cultivator	Rototiller	Method Means
Red Clover	1	13.2	14.8	14.9	14.3
	2	14.3	15.2	15.8	15.1
	3	19.3	9.8	11.6	13.6
Alfalfa	1	5.8	7.3	6.1	6.4
	2	7.6	5.9	6.8	6.8
	3	8.5	8.9	6.5	8.0
Total Legume	1	19.0	22.1	21.0	20.7
	2	22.0	21.2	22.5	21.9
	3	27.8	18.7	18.2	21.6
	Mean	22.9	20.6	20.6	21.4
Orchard Grass*	1	5.9	5.8	6.0	-5.9
	2	5.8	4.7	7.5	-6.0
	3	13.0	8.9	11.3	-11.0
Bromegrass*	1	2.5	3.0	2.1	2.5
	2	2.1	2.4	2.8	2.4
	3	2.4	1.0	1.2	1.6
Timothy	1	3.4	3.3	4.4	3.7
	2	5.4	3.4	4.0	4.3
	3	4.9	2.5	2.4	3.3
Total Grass	1	11.8	12.0	12.5	12.1
	2	13.3	10.5	14.3	12.7
	3	20.3	12.4	14.9	15.9
	Mean	15.2	11.6	13.9	13.6
Total Legume and Total Grass	1	30.9	34.1	33.5	32.8
	2	35.3	31.6	36.8	34.6
	3	48.1	31.1	33.1	37.4
	Mean	38.1	32.3	34.4	34.9

*L.S.D. at .05 for methods over all soil preparation for orchard is 2.8 and for brome is 0.8

14. Seed Quality in Relation to Emergence and Early Seedling Vigor in Smooth Bromegrass

Tossell, W.E. (Field Husbandry)

R.P.O. F.H. 33-5

Objectives: In spite of the wide adaptability of smooth bromegrass, some difficulty in obtaining satisfactory seedling stands has been reported. Various environmental factors including depth of seeding, moisture conditions, temperature, soil fertility, light, and disease incidence have been investigated in regard to stand establishment in this and other grass species. There is, however, little information on the importance of strain or seed lot as a factor in stand establishment. This study was undertaken to (1) compare commercially available strains of bromegrass in regard to ability to establish, (2) investigate the relationship of seed quality to seedling establishment, (3) evaluate the possibilities for developing, by breeding methods, a strain of bromegrass with superior ability to establish.

Procedure: Sixteen strains, 10 polycross progenies, and open-pollination progenies from 100 individual plants of diverse origin were studied in a series of greenhouse and field trials. In all greenhouse studies an experimental unit consisted of 50 seeds seeded in a 3" pot. A randomized block design with 3 replicates was used. In the field studies, an experimental unit consisted of 100 seeds seeded in a 2' row. A split-plot design with four replicates was used for both field trials summarized in this report.

Two depths of seeding, 0.25 and 1.5 inches, were used in the main group of trials to investigate a possible seed lot x depth of seeding interaction. Data collected included rate of emergence, maximum stand, height and vigor.

Results: Only part of the data are included in this report since the project will be summarized for publication. The main results are:

1. Preliminary trials indicated that soil type, soil temperature, soil moisture and depth of seeding, all affect seedling stands and vigor. Only the last showed an interaction with seed lot. Hence seed lot performance under one set of conditions might have a wide application. This coupled with the good agreement found between greenhouse and field trials suggests the feasibility of conducting tests for seed quality and early seedling vigor in the greenhouse.

2. Depth of seeding is important in relation to seedling stand and vigor. In 1952 the 1/4 inch seeding gave an establishment of 87 percent where the 1 1/2 inch seeding gave an establishment of 39 percent as

shown in Table 1. The vigor of the seedlings was greater at the 1/4 inch planting. Soil moisture was adequate in this test.

Table 1: Seedling Stand Counts and Vigor Rating from Three Seed Lots of Bromegrass at 21 Days from Seeding in the Field at O. A. C. in 1952.

Depth of Seeding in Inches	Stand Counts (%)				Vigor*			
	Martin	Sel.** 22	Sel. 14	Depth Means	Martin	Sel. 22	Sel. 14	Depth Means
1/4	91	80	90	87	9.9	9.6	9.1	9.5
3/4	87	72	79	79	9.0	9.0	7.7	8.6
1 1/2	57	44	19	39	4.4	3.2	1.1	2.9
Sel. Mean	80	66	64		7.8	7.3	6.0	

* vigor index of 10 (good) to 1 (poor)
** open-pollination seed lot from the indicated plant selection.

3. A strain x depth interaction was found (Table 1) indicating that certain strains are more able to withstand deep seeding than others. Martin and Selection 14 had similar establishment percentages, 91 and 90 respectively, at 1/4 inches but differed widely, 57 and 19 respectively, at the 1 1/2 inch depth of seeding.
4. Strains differed in ability to establish. Martin had a mean vigor rating of 9.1 while Lancaster had a low rating of 4.2 (Table 2).
5. Seed weight is a major factor affecting seedling establishment as shown in Table 3. Seed lots with high seed weights tended to be high in the factors of establishment - rate of emergence maximum stand, height and vigor.

Similarly seed weight classes within a seed lot differed in percentage stand and vigor (Table 4). However, certain progenies similar in seed weight were different in the factors of establishment indicating that not all of the differences found among progenies can be ascribed to seed weight.

Table 2 Eleven Strains of Brome Grass in the Field at Guelph in 1953.

Strain	Stand Counts at 14 days (%) Actual 1950*	Actual 1952*	Transformed 1950	Transformed 1952	Vigor at 35 days** 1950	1952	Mean	D. M. in mgs. from 25 plants at 35 days 1950	1952	Mean
Martin	50	67	58	50	8.8	9.5	9.1	4.1	3.3	3.7
Can. Common	28	59	44	41	8.5	8.8	8.6	4.6	4.2	4.4
Manchar	50	47	48	45	8.2	9.0	8.6	3.8	3.7	3.8
Elsberry	43	48	46	42	7.2	6.8	7.0	4.2	3.8	4.0
Fisher	28	70	49	45	8.8	9.5	9.1	4.5	3.7	4.1
Achenbach	28	55	42	40	7.2	9.0	8.1	4.9	4.2	4.5
Lyon	45	62	54	47	6.5	9.2	7.9	3.7	4.0	3.8
Lincoln	24	57	40	39	3.5	6.2	4.9	3.7	4.2	3.9
Lancaster	16	46	31	33	3.2	5.2	4.2	4.6	3.5	4.0
S-4088		47				10.0				3.8
Parkland		52				3.0				2.7
Mean	35	57	42	42	6.9	8.1	7.4	4.2	3.8	4.0
L.S.D. .05			3.9				1.8			0.4
L.S.D. .01			5.3				2.4			
C.V.			10.7				14.2			22.5

* seed under test was from 1950 and 1952 seed crops respectively.

** vigor index 10 (good) to 1 (poor)

Table 3: Effect of Seed Weight on Seedling Establishment of Bromegrass Grown in the Greenhouse. Data 28 days from Seeding.

Seed Weight Group* or Strain	Rate of Emergence++	Stand %		Vigor+		Height in Cms.	
	1/4	1/4	1 1/2	1/4	1 1/2	1/4	1 1/2
431**	69	94	88	8.9	6.7	23.7	20.7
375	61	96	88	8.6	6.1	24.2	20.8
325	58	92	82	8.3	5.5	21.6	18.3
281	43	92	76	7.5	4.3	20.3	17.2
Martin	64	92	90	9.0	7.7	24.6	22.0
Can. Common	45	86	80	8.8	7.0	23.6	21.3

* mean of 10 0. P. seed lots
** mean seed weight of 100 seeds in mgms.
++ stand at 6 days from seeding as percent of maximum stand.
\+ vigor index 10 (good) to 1 (poor)

Table 4: Effect of Seed Weight on Seedling Establishment of Bromegrass Grown in the Greenhouse. Date 26 Days from Seeding at Depth of 3/4 inches.

Progeny Number or Strain	100-Seed Weight in mgms.	Rate of Emergence*	Stand %	Vigor**
99	447	100	99	9.3
	360	97	98	7.2
	228	93	89	4.5
76	410	78	93	6.7
	315	50	78	3.5
	203	33	41	1.0
Can. Common	445	96	97	8.7
	314	89	92	6.2
	233	61	58	3.7

* stand at 8 days as percent of maximum stand.
** vigor index 10 (good) to 1 (poor)

6. Correlation studies indicated that rate of emergence was related directly to height and vigor and associated to a low degree with maximum

stand. The latter was correlated with height and vigor. Height was associated with vigor, dry matter weight per seedling, and leaf width and hence is useful as an index of general seedling vigor. Among maternal plant characters investigated, plant seed yield was the only one associated with each of the characters of establishment - rate of emergence, maximum stand, height and vigor. From these studies it would appear that tall, coarse plants high in fertility, seed yield and seed weight would, on the average, produce progenies highest in ability to establish.

Certain individual plant open-pollination progenies were superior to Martin, the best commercial strain tested, although the percentage of superior progenies was small. This indicates that improvement in seed quality and early seedling vigor is possible but this study will, at best, be only moderate. Since testing for seed quality and seedling vigor in the greenhouse was found satisfactory, it would seem both worthwhile and feasible to conduct such tests on all selected breeding materials during the course of the breeding program.

15. Rate of Seeding Alfalfa Grown Alone and with Timothy or Brome Grass

Tossell, W.E., and Fulkerson, R.S. (Field Husbandry)

R.P.O. F.H. 33-4

Objectives: 1. Alfalfa seed is relatively expensive in comparison with a seed such as timothy. Hence, it is particularly important to establish a seeding rate which is satisfactory for stand establishment, hay yield and hay quality, but not wasteful of seed.

2. Evidence is accumulating which indicates that brome makes a good grass in a mixture with alfalfa. Information is needed on seeding rates of alfalfa when grown with brome.

3. Critical data are needed comparing brome and timothy as grasses to grow with alfalfa.

Procedure: A test including 5 seeding rates of alfalfa alone 3 or alfalfa in a mixture with timothy, and 4 of alfalfa in a mixture with brome was seeded in 1950. A duplicate test was seeded in 1951 in the Field Husbandry plot area. Two crops of hay were removed each year. Botanical separations were made on the first cut hay in 1952 and 1953 to measure the percentage of alfalfa in each mixture. Separations on the second cut were made only on the mixtures including 9 lbs. of alfalfa.

Prior to and after each cutting treatment the alfalfa plants per square foot were counted using a 24" x 6" quadrat with six counts stratified throughout each plot. During the first crop year of the 1950 seeding the number and size of stems of the alfalfa plants were taken for the first and second cut hay crops of the pure stands. Thirty plants were picked at random in each plot. The stems of each plant were counted and one average stem was measured in centimetres approximately six inches above the crown.

Results: This experiment will be completed and summarized in 1955. The data collected thus far are summarized in tables 1 to 4. As indicated by the data in Table 1, the establishment was dissimilar in the two years. The 1950 season was fair for seedling establishment while the 1951 season was excellent for establishment. The stands were good in each year but the general level differed widely being 5.0 plants per square foot in 1951 from the 1950 seeding and 11.6 in 1952 from the 1951 seeding.

In general, alfalfa, alfalfa-timothy and alfalfa-brome mixtures gave similar yields of dry matter per acre (tables 2 and 3). Although brome grass-alfalfa mixtures were not significantly higher yielding than timothy-alfalfa mixtures in aftermath production, the aftermath of the former contained a higher percentage of grass (table 4) than the latter. This higher proportion of grass would be valuable in an alfalfa pasture to reduce the bloat hazard, No differences in yield among the seeding rates were indicated except in the aftermath of the 1950 seeding in 1952 (table 3). Even then no clear cut trend is evident. Hence there does not appear to be a close relationship between seeding rate and dry matter yield.

Additional agronomic data are shown in table 5. The number of plants per square foot was not related to hay yield. However, measurements of culm size and number of culms per plant at each seeding rate show that as the plant population increased the number of culms per plant and culm size decreased. These relationships would account for the fact that hay yield was not related to seeding rate. Smaller culm size results in hay of higher feeding value. The intermediate rate of seeding such as 9 lbs. of alfalfa per acre would seem preferable for

(1) good hay quality.
(2) good level of yield.
(3) stand assurance.

Table 1. Alfalfa Plants per Square Foot in May at Guelph

Rate of Seeding lbs./acre		1950 Seeding			1951 Seeding		
		1951	1952	1953	1951	1952	1953
Alfalfa	3	2.8	2.6	2.3	8.2	7.6	3.7
	6	4.7	4.3	2.8	17.0	12.1	6.2
	9	5.9	5.3	3.2	25.0	15.7	6.8
	12	6.4	5.4	3.2	26.7	17.6	8.1
	15	7.5	6.8	4.1	36.2	20.7	8.6
Alf-timothy	3-2*	3.4	3.1	2.4	8.4	5.3	4.5
	6-2	3.9	3.8	3.0	13.0	8.3	5.6
	9-2	5.6	4.2	3.1	19.3	10.8	6.3
Alf-brome	3-8**	4.2	3.4	3.2	7.3	7.3	4.3
	6-8	4.3	3.7	2.2	14.1	8.8	6.1
	9-8	4.4	4.5	2.6	18.7	11.9	5.9
	12-8	7.0	6.4	3.3	28.1	13.0	5.9
Mean		5.0	4.4	2.9	19.1	11.6	6.0
L.S.D.* -0.05		1.9	1.3	1.0	4.9	2.3	1.1
C.V.		26.5	20.8	24.0	14.6	17.1	16.1
Mean of 3, 6 and 9 rates							
Alfalfa		4.5	4.1	2.8	16.7	11.8	5.6
Alf-timothy		4.3	3.7	2.8	13.6	8.1	5.5
Alf-brome		4.3	3.9	2.7	13.4	9.3	5.4

** 3 lbs. alfalfa + 8 lbs brome
* 3 lbs. alfalfa + 2 lbs timothy
\+ July count in year of establishment

Table 2. Total D. M. in Tons per Acre from the Alfalfa and Alfalfa-Grass Mixtures at Guelph

Rate of Seeding lbs. /acre		1950 Seeding			1951 Seeding	
		1951	1952	1953	1952	1953
Alfalfa	3	2.80	3.63	----	3.08	5.17
	6	2.99	3.43	----	2.94	6.43
	9	3.02	3.14	----	3.00	5.38
	12	2.88	3.02	----	3.04	5.06
	15	3.20	3.85	----	3.01	5.14
Alf-timothy	3-2*	3.19	3.78	4.10	3.76	5.36
	6-2	2.92	3.45	3.57	3.12	5.22
	9-2	3.06	3.38	3.80	3.24	5.42
Alf-brome	3-8**	2.90	3.59	3.65	3.07	4.97
	6-8	3.14	3.53	3.78	3.16	5.20
	9-8	3.06	3.32	3.39	3.32	5.14
	12-8	3.09	3.46	3.54	3.09	5.20
Mean		3.02	3.47	----	3.15	5.22
L.S.D. - 0.05		N.S.	N.S.	N.S.	0.35	N.S.
C.V.		8.9	10.6	11.9	9.7	6.0%
Mean of 3, 6 and 9 rates						
Alfalfa		2.94	3.40	----	3.01	5.66
Alf-timothy		3.06	3.54	3.82	3.37	5.33
Alf-brome		3.03	3.48	3.61	3.18	5.10

* 3 lbs. alfalfa + 2 lbs. timothy
** 3 lbs. alfalfa + 8 lbs. brome

Table 3. Aftermath Production in Tons D. M. per Acre from the Alfalfa and Alfalfa-Grass Mixtures at Guelph

Rate of Seeding lbs./acre		1950 Seeding			1951 Seeding	
		1951	1952	1953	1952	1953
Alfalfa	3	1.31	1.23	----	0.99	1.90
	6	1.26	1.10	----	0.95	1.95
	9	1.19	0.98	----	0.95	1.94
	12	1.24	0.97	----	0.95	1.76
	15	1.35	1.33	----	1.01	1.93
Alf-timothy	3-2*	1.32	1.09	1.35	1.08	1.95
	6-2	1.20	0.87	1.01	0.90	2.01
	9-2	1.17	0.97	1.25	0.90	1.98
Alf-brome	3-8**	1.29	1.10	1.13	0.87	1.87
	6-8	1.37	1.11	1.21	0.95	1.87
	9-8	1.31	1.03	1.06	1.02	1.93
	12-8	1.35	1.01	1.10	0.93	1.88
Mean		1.28	1.07	----	0.96	1.91
L.S.D. - 0.05		N.S.	0.23 tons	N.S.	N.S.	N.S.
C.V.		9.5	14.6	20.6	11.5	7.44%
Mean of 3, 6 and 9 rates						
Alfalfa		1.25	1.10	----	0.96	1.93
Alf-timothy		1.23	0.98	1.20	0.96	1.98
Alf-brome		1.32	1.08	1.13	0.95	1.89

* 3 lbs. alfalfa + 2 lbs. timothy
** 3 lbs. alfalfa + 8 lbs. brome

Table 4. Percent of Alfalfa in Mixtures with Timothy or Brome at Guelph

Association	Rate of Seeding in lbs. per acre	1950 Seeding 1952 Hay	1950 Seeding 1953 Hay	1951 Seeding 1953 Hay	1951 Seeding Aftermath
Alfalfa - Timothy	3-2*	51	41	81	
	6-2	52	41	84	
	9-2	60	38	72	90
Alfalfa - Brome	3-8	76	42	65	
	6-8	66	42	50	
	9-8	72	50	56	61
	12-8	64	58	55	
Mean 3, 6and 9 rates					
Alf-Timothy		53	40	79	
Alf-Brome		71	51	57	

* 3 lbs. alfalfa + 2 lbs. timothy per acre

Table 5. Selected Data from Study on Rate of Seeding Alfalfa Grown Alone and in Association with a Grass at the O. A. C.

Rate of Seeding Alfalfa lbs./ac.	1950 Seeding				1951 Seeding	
	Alfalfa Plants Per Sq. Ft.	Tons D.M./acre June, 1951*	No. Culms Per Plant June, 1951	Culm Size in mm. June, 1951	Alfalfa Plants Per Sq. Ft.	Yield in Tons D.M./acre June, 1952
3	2.8	1.49	10.9	3.2	8	2.09
6	4.7	1.73	7.0	3.2	17	1.99
9	5.9	1.82	6.6	3.0	25	2.05
12	6.4	1.64	6.2	2.6	27	2.09
15	7.5	1.86	8.0	2.5	36	1.99

* no significant difference among treatments.

16. The Effect of Seed Treatment With Fungicides on Seeding Establishment

Fulkerson, R.S. (Field Husb.)

R.P.O. F.H. 33-1
Objectives: Difficulty is experienced in establishing stands of forage seedlings, especially legumes, in certain areas of Ontario. The problem is most important on the heavy clay soils and on light soils.

Research on the effect of fungicides on the establishment of grass and legume seedlings was carried out in greenhouse studies prior to 1953. Some of these data have been published. From these studies the following general conclusions were drawn.

1. Some fungicides were more effective in controlling damping-off organisms when used as a seed treatment than others.
2. Soils from different areas were found to have different effects upon the establishment of seedlings.
3. Soils obtained within a field where good and poor stands of grass and legumes were present, gave a similar establishment picture under greenhouse conditions.

Procedure: Field studies were established at Guelph and Barrie in 1953 with red clover. Similar tests were seeded in 1951 and 1952 but failed due to weather conditions. The plot size was 6' x 6'. The design of the tests was a randomized block with 4 replications. Establishment counts were made from 25 to 33 days after seeding when the new seedlings were about 2-1/2 inches high. The mean of the number of plants from three square foot counts was used as the plot establishment value.

Results: The results obtained from the three studies conducted are given in Table 1.

Table 1: Number of Red Clover Plants Established per Sq. Ft., 1953

Treatment	Guelph I Seeded Apr. 30	Guelph II Seeded July 31	Barrie I Seeded May 14
Arasan	29.5	31.4	47.6
Leytosan P	38.0	40.7	47.6
Ceresan M	35.6	31.6	41.6
Leytosan P Excess	41.4	36.8	45.2
Phygon	31.5	31.2	31.0
Check	16.8	27.8	33.2
L.S.D. - 0.05	9.0	6.3	9.3
- 0.01	12.5	8.7	12.9
C.V.	18.7	12.6	15.0

In the first test at Guelph all treatments gave significant increases in establishment above the check. In the second Guelph test Leytosan P gave the best results. In the study at Barrie, Arasan and Leytosan P gave good establishment. In all cases the seedlings produced from the treated seed were more sturdy and grew faster for the first three or four weeks, after which the check seedlings seemed to catch up and soon no further differences in seedling vigor could be noticed. This vigor difference was particularly striking in the Barrie study.

A field demonstration was also carried out in the Barrie area. The farmers' seed was treated at seeding time with Phygon, Arasan, and Leytosan P at .5% by weight. Acre blocks of a mixture of Timothy 3, Red Clover 5, and Alfalfa 10, were broadcast seeded by the farmer. Counts made 25 days later as well as in the fall are given in Table 2. Each figure is the mean of 13 counts.

Table 2: Number of Legume Plants per Square Foot at Barrie Location in 1953

Treatment	Total Legume Count June 8	Fall Count - Oct. 16		
		Red Clover	Alfalfa	Total Legume
Leytosan P	20.2	5.0	5.5	10.5
Arasan	17.6	4.8	4.8	9.6
Phygon	15.5	4.2	4.2	8.4
Check	13.5	7.7	0.7	8.4

From the counts on June 8, Arasan and Leytosan P were particularly effective in producing better stands of legumes. By fall however, this difference had narrowed considerably. The fall counts also showed that, in the treated strips, there were the same number of plants of red clover and alfalfa per unit area, though twice as much alfalfa had been seeded. Also, in the check area the alfalfa was almost a complete failure. From this it would appear that alfalfa is more difficult to establish in the area than red clover.

17. Antibiotics in Relation to Seedling Establishment and Crop Yields

Fulkerson, R.S., and Tossell, W.E., (Field Husb.)

R.P.O. 33-2

Objectives: Treatment of alfalfa seed with penicillin produced changes in foliage colour of alfalfa in Haldimand county in 1952. This observation, along with reports in the literature of growth stimulation following treatment of the seed with certain antibiotics, suggested an experiment to evaluate the use of such materials as aids to seedling establishment.

Procedure and Results:

a. Greenhouse Studies

During the winter of 1953, preliminary work was initiated to ascertain the effect of antibiotics when used as a seed treatment on establishment and seedling vigor. In greenhouse studies aureomycin, penicillin and terramycin were applied at rates based on cost per acre. One hundred seeds were used as a unit and planted in soil at a depth of 3/4 of an inch in 4 inch plots immediately following treatment. A randomized complete block design with 4 replications was used.

The effect of the treatments on emergence is shown in Table 1. A repeat test was run on alfalfa to see if the first results could be duplicated, but damping-off organisms attacked some pots and the results were not too satisfactory. Heavier concentrations of the antibiotics were also tried with red clover, the results of which are shown.

In all tests the treatments did not significantly affect establishment. After the plants were about 4 weeks old vigor differences were noted and these differences became more pronounced as time progressed. When the seedlings were 10 weeks old some treatments had plants over twice as tall and more sturdy than the plants from the untreated seed.

Red clover showed moderate responses in vigor to the antibiotics. Alfalfa showed by far the greatest response whereas timothy showed no response in vigor to any of the antibiotics used.

Alfalfa responded more to aureomycin than to penicillin or terramycin. Within each antibiotic, rates of application had a definite effect on growth. Light rates gave the greatest response with some antibiotics whereas heavier rates responded more with others. Heavy applications of 4 and 8 grams per bushel had no effect on establishment with red clover and retarded growth in all cases.

Table 1. The Effect of Antibiotic Seed Treatments on Establishment in Percent in the Greenhouse in 1953.

Treatment	Red Clover	Alfalfa	Timothy	Alfalfa Repeat	Red Clover High Concentrations
2 grams penicillin	70.2	65.3	90.8	48.3	4 gms. 60.1
1/2 grams penicillin	57.1	62.3	89.6	61.1	8 gms. 58.8
1/8 grams penicillin	57.3	57.0	80.1	57.5	
1/32 grams penicillin	60.1	58.8	92.6	67.3	
2 grams aureomycin	63.8	60.1	90.2	58.8	4 gms. 56.1
1/2 grams aureomycin	60.7	63.8	93.2	66.1	8 gms. 61.1
1/8 grams aureomycin	64.3	58.2	90.2	56.1	
1/32 grams aureomycin	60.4	60.9	94.5	63.4	
2 grams terramycin	64.5	56.1	83.1	56.4	4 gms. 64.8
1/2 grams terramycin	65.1	62.3	87.6	49.3	8 gms. 59.5
1/8 grams terramycin	65.1	65.8	89.6	37.7	
1/32 grams terramycin	64.3	63.3	92.2	69.0	
Check	61.6	61.4	93.4	50.9	58.8
L.S.D.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.	6.1	10.0	8.2	21.5	7.8

b. Field Studies

Antibiotics were used as seed treatment in broadcast seedings with alfalfa and red clover. The rates of treatment used were those which had given the best results in the greenhouse tests. Each test was a randomized block design with 4 replications. The plot size was 5' x 22'. The plots were seeded without a companion crop on May 9th, and the data collected on July 3rd.

Plant counts were made on 4 square foot samples taken in each plot area. These counts were meaned for analysis. In addition, 25 plants from each plot were harvested, dried, and the dry weight used as an index of vigor. The results of these determinations are given in Table 2.

Table 2. The Effect of Antibiotics on Establishment and Vigor of Alfalfa and Red Clover in the Field at Guelph in 1953.

Treatment	Alfalfa		Red Clover	
	Plants per sq. ft.	Dry Weight 25 plants	Plants per sq. ft.	Dry Weight 25 plants
1/2 gram aureomycin	25.4	74.2	39.7	55.2
1/2 gram penicillin	28.8	79.2	35.2	56.2
1/8 gram terramycin	24.9	84.0	39.7	55.0
Check	24.0	82.5	37.2	57.8
L.S.D.	N.S.	N.S.	N.S.	N.S.
C.V.	8.3	10.7	18.0	14.9

From the results shown it will be noted that no significant differences were obtained with alfalfa or red clover in establishment or seedling vigor in this field study.

The effect of antibiotics as a seed treatment on row plantings was carried out with alfalfa, red clover, birdsfoot trefoil, brome grass and reed canary. The seed of each species was treated and counted one day and planted the next. A randomized block design with four replications was used. The seed was planted in rows 2 feet long and 6 inches apart at a uniform depth of 3/4 inches. Increased concentrations were used with the two grasses as no differences had be noted in a greenhouse test with timothy at the lower concentrations. One hundred seeds were seeded per row or plot. Analyses on establishment were run on transformed data. The results of these tests are given in Table 3 for the legumes, and Table 4 for the grasses. Included in the repeat studies with alfalfa and red clover was a fungicide and a fungicide-antibiotic combination treatment.

Table 3. The Effect of Antibiotics Upon the Establishment and Vigor of Alfalfa and Red Clover in the Field at Guelph in 1953.

Treatment	Alfalfa Seeded May 5th Percent	Alfalfa Seeded Aug. 17th			Red Clover Seeded May 5th Percent	Red Clover Seeded Aug. 17			Birdsfoot Trefoil Seeded May 5th Percent
		Trans-formed	Actual %	Vigor Index		Trans-formed	Actual %	Vigor Index	
1/32 gram aureomycin	29.7	43.5	47.4	2.3	33.5	22.9	15.1	3.8	41.5
1/8 gram aureomycin	21.0	40.5	42.2	2.5	35.0	23.2	15.5	2.8	43.4
1/2 gram aureomycin	27.6	42.8	46.2	2.5	39.3	25.6	18.7	3.0	40.4
2 gram aureomycin	31.7	38.9	39.4	2.5	41.8	30.9	26.4	2.8	38.6
1/32 gram penicillin	35.5	35.4	33.5	2.8	37.6	27.2	20.9	3.0	37.2
1/8 gram penicillin	28.4	42.8	46.2	2.8	35.0	26.1	19.4	3.2	35.7
1/2 gram penicillin	25.1	42.6	45.8	2.5	53.0	30.5	25.8	3.2	41.0
2 gram penicillin	25.3	41.8	44.4	2.0	43.9	28.8	23.2	3.0	48.4
1/32 gram terramycin	24.6	40.9	42.9	1.5	44.6	22.2	14.3	3.5	45.3
1/8 gram terramycin	37.1	39.4	40.3	1.8	44.4	31.1	26.7	2.5	40.5
1/2 gram terramycin	30.1	43.4	47.2	2.8	43.7	30.5	25.8	2.5	40.3
2 gram terramycin	31.3	42.7	46.0	2.8	38.4	26.6	20.1	3.2	37.6
Leytosan P		50.8	60.1	2.5		35.6	33.9	1.8	
Leytosan P+1/2 gram Aureomycin		47.8	54.9	2.3		28.0	22.0	2.3	
Check	27.6	43.5	47.4	2.8	38.1	21.4	13.3	3.2	39.3
L.S.D. .05	N.S.	7.2			N.S.	7.2			N.S.
C.V.	17.5	12.0			12.4	18.6			12.0

Table 4. The Effect of Antibiotics Upon the Establishment and Seedling Vigor of Brome and Reed Canary Grass in the Field at Guelph in 1953.

Treatment	Brome Grass I			Brome Grass II				Reed Canary Grass I		
	Trans-formed	Actual %	Weight 25 Plants	Trans-formed	Actual %	Weight 25 Plants	Field Vigor Score	Actual %	Weight 25 Plants	Field Vigor Rating
1/32 gram aureomycin	56.1	68.9	6.44	48.2	55.6	4.82	3.0	51.7	6.04	2.2
1/8 gram aureomycin	52.5	62.9	5.97	46.4	52.4	6.35	1.8	49.7	5.09	2.8
1/2 gram aureomycin	51.7	61.6	8.74	48.0	55.2	6.36	1.5	47.7	7.04	1.5
2 gram aureomycin	50.8	60.0	7.65	42.9	46.3	5.24	3.0	50.5	5.36	3.5
4 gram aureomycin	55.2	67.4	6.10	48.2	55.6	5.24	1.5	47.6	5.66	2.5
1/32 gram penicillin	55.0	67.1	6.32	51.8	61.7	6.31	2.2	51.4	5.37	3.0
1/8 gram penicillin	54.3	65.9	7.98	44.6	49.3	5.94	2.0	49.5	5.30	3.0
1/2 gram penicillin	51.4	61.1	6.68	46.3	52.3	5.30	3.2	46.0	6.02	2.5
2 gram penicillin	50.7	59.9	8.97	44.8	49.6	5.22	2.5	43.9	8.06	2.2
4 gram penicillin	55.1	67.3	7.25	49.8	58.3	5.42	1.2	52.6	6.57	1.8
1/32 gram terramycin	44.2	48.6	7.49	51.7	61.6	5.32	2.8	44.4	5.62	2.2
1/8 gram terramycin	49.5	57.9	6.36	51.7	61.6	4.74	2.2	51.4	5.54	2.5
1/2 gram terramycin	51.7	61.6	7.58	47.5	54.4	5.13	2.8	47.2	5.90	2.5
2 gram terramycin	48.3	55.7	6.52	41.8	44.4	4.85	3.5	39.4	5.78	3.2
4 gram terramycin	44.2	48.6	6.60	41.9	44.6	4.76	3.0	47.4	5.92	2.2
Check	54.4	66.1	7.50	43.7	47.7	5.40	3.2	50.5	5.48	2.5
L.S.D. .05	6.9		N.S.	6.9		N.S.	N.S.	N.S.	N.S.	N.S.
C.V.	9.4		21.6	10.4		22.2	48.1	14.4	24.1	50.5

From Table 3 it will be noted that no significant differences in establishment were obtained with alfalfa, red clover or birdsfoot trefoil seeded in the spring. Vigor indexes were not taken in these tests as rabbits ate off most of the plots when they were about 3 weeks old. Although they did recover, vigor differences were not visible.

In August a repeat test with alfalfa and red clover was made. The alfalfa established quite well but the red clover did not. Differences in establishment were significant at the 5 percent level. In the alfalfa test only Leytosan P. increased the establishment. This treatment was also the highest in red clover. Several of the antibiotics also gave higher establishment with red clover than the check. Vigor was indexed in these two tests, but no analysis was completed due to the variability between replications with some treatments.

In the tests with brome grass and reed canary (Table 4) unfavourable weather following treatment delayed planting. With Brome I, 6 days elapsed between treatment and planting, with Brome II, 2 days, and with Reed Canary, 1 day. This may have affected the results.

Differences in establishment between treatments were more prevalent in the second test with brome than in the first. Some antibiotics increased the establishment over the check in the second study. With reed canary grass there were no significant differences in establishment. The weight of 25 plants as a vigor index showed no significant differences in all three studies. Field vigor indexes showed very high variability.

18. Effect of Rate of Seeding and Row Spacing of an Oat Companion Crop upon Forage Seedling Establishment

Fulkerson, R.S. (Field Husb.)

R.P.O. F.H. 33-3
Objectives: This phase of the seedling establishment project was undertaken to study the effect of an oat companion crop on forage seedling establishment considering number of plants established and the vigor of those plants. As a result it should be possible to select the seeding rate and row spacing for the oat crop which will assure a satisfactory forage seedling stand and at the same time, provide reasonably good returns from the oat crop.
Procedure: The mixture used was alfalfa 6, red clover 4, timothy 2, orchard 3 and brome 5. Simcoe oats were seeded at rates varying from 0 to 4 bushels per acre at 1/2 bushel intervals. In addition 1, 2, 3 and 4 bushel rates were seeded in 14 inch rather than 7 inch drills. The oats were seeded with a V-belt seeder, the grass seed by hand followed by cultipacking. Each plot consisted of 9 rows, 7 inches apart and 20 feet

long. A modified split plot design with 6 replications was used. The oats were seeded on April 24th, the grass seeded on April 29th.

Results: The establishment of both oats and new seeding was very good but unfortunately some oat plots lodged when they were in the shot blade. Lodging continued until harvest time, being severe over most of the test and making it impossible to harvest. Plots that went down early killed the young seedlings completely. Later lodging also had severe effects on the young grasses and particularly the legumes. Only a few plots were harvested for grain to give an indication of what the yields were (Table 1) and stand counts were made on early, medium and late lodge areas (Table 2).

Table 1. Representative Oat Yields in the Companion Crop Study at Guelph in 1953

Row Spacing in inches	Seeding Rate bu. /acre	Oat Yields bu. /acre
7	1/2	99
	1	92
	2-1/2	115
14	1	85
	4	86

Table 2. Effect of Time of Lodging and of No Companion Crop On Legume Establishment at Guelph, 1953

Time of Lodging	No. Red Clover Plants/Sq. Ft.	No. Alfalfa Plants/Sq. Ft.
Early	0.5	1.5
Medium	7.2	3.2
Late	12.5	16.0
No Companion Crop	0.3	2.0

Highest oat yields were obtained from plots that showed little lodging or those which lodged late. Early lodging decreased yields of grain and also was very severe on the new seeding. Though only the legumes were counted, the grass seedlings were thinned drastically under early lodged grain, and to a moderate extent, on medium lodged plots, though not as severely affected as the legumes. On plots where no companion crop was used the legumes seemed to be thinned by the excessive growth of the grasses. Many of the grasses headed and the plots produced a good crop of hay. If they had been clipped or grazed the thinning of the legumes might have been appreciably less.

19. Soil Conditions in Relation to Forage Seedling Establishment

Webber, L. R. and Fulkerson, R. S. (Soils and Field Husb.)

R. P. O. S. P. -71

Objectives: The objectives of this study were to determine the effect of stabilization of the seedbed against crusting, on the emergence of small seedlings from a heavy textured soil (Haldimand clay). In addition, the possible interactions of lime, fertilizer and conditioner were evaluated.

Procedure: The location of this experiment was on the S. A. E. farm, Cayuga. The treatments were replicated three times. Lime was applied to certain plots at the rate of 4.5 tons/ac. and mixed into the surface inch of soil. Fertilizer (250 lbs./acre of 10-10-10) was broadcast and mixed into the surface inch of soil. Conditioner treatments included, (a) Monsanto #6 at 50 lbs./ac. mixed into top 1/2 inch of soil, (b) liquid (Monsanto) at 67-1/2 gal./ac. applied after grass-legume seeding.

The mixture was seeded on June 23rd with a cultipacker-seeder. On June 24th the plots were irrigated with 1.2 inches of water and another application of 0.20 inches on July 10th.

Results: The results may be summarized as follows:

1. Liquid conditioner was better than the check regardless of lime-fertilizer treatment.

2. Liquid conditioner was better than dry conditioner except when neither lime nor fertilizer was applied.

3. Dry powder conditioner was not significantly better than check (no conditioner).

4. No significant increase in stand was caused by either lime or fertilizer or a combination of the two, with or without conditioner.

Table 1. Legume Stand Counts

	Number of plants per square foot (mean of 3 reps) according to Conditioner Treatment		
Treatment	No Conditioner	#6 Powder	Liquid
Lime	10.7	11.3	19.3
Fertilizer	11.3	11.0	18.7
Lime + Fertilizer	13.7	9.7	19.0
No Lime or Fertilizer	9.3	13.7	17.0

L.S.D. (.05) 5.2 Plants

20. Evaluation of Species and Mixtures of Grasses and Legumes for Hay

Tossell, W.E. and Fulkerson, R.S. (Field Husbandry)

R.P.O. F.H. 29-1

Objectives: (1) to evaluate 5 grasses and 3 legumes as components of hay-pasture mixtures.

(2) to compare pure stands, simple mixtures, and complex mixtures.

Consideration is given to D. M. yield, seasonal distribution of production, hay and pasture quality, and effect on the succeeding crops.

Procedure: The grasses, legumes and mixtures used (Table I) were seeded in a randomized block design at Guelph in 1950. A crop of hay was removed at the regular hay stage, then two aftermath clippings were taken in each of the 3 years to simulate aftermath grazing management.

Results: The data have not been completely compiled. Selected data are shown in Tables 1 to 3. The following summary includes some of the major results:

(1) Legume-grass mixtures were much superior to pure stands of grasses in both yield and forage quality.

(2) Under these management conditions complex mixtures on the average gave slightly higher yields than simple mixtures. Certain simple mixtures were superior to the complex types. It would appear that the legumes are not crowded out as quickly in simple mixtures when only one grass is included. Hence simple mixtures would be expected to be superior under conditions of management which favour each component.

(3) Alfalfa is superior to ladino as a hay plant.

(4) Orchard grass did not perform as well as timothy at the hay stage in June, but its value in a pasture mixture was indicated by the aftermath production data, especially the July data.

(5) Brome grass made hay with the best appearace of all the grass hays.

(6) Legumes were more subject to injury by frequent clipping than grasses.

(7) Reed canary grass performed well in simple mixtures where it was the only grass, but was not able to compete well in mixtures with the more aggressive grasses such as orchard or brome.

Table 1. Total D.M. Production in Tons/Acre of 49 Combinations of Legumes and Grasses Over a Three Year Period (1951-1953) at Guelph

Combination	Hay	Aftermath	Hay + Aftermath
Kentucky Blue*	3.78	1.67	5.45
Timothy*	6.30	1.06	7.36
Orchard*	4.68	1.54	6.22
Brome*	4.08	1.35	5.43
Meadow Fescue*	4.90	0.92	5.82
Reed Canary	3.66	1.64	5.30
Alfalfa*	6.89	3.43	--
Ladino*	3.78	2.66	6.44
Alfalfa + Timothy*	8.27	4.62	12.90
+ Orchard*	7.77	4.84	12.61
+ Brome*	7.46	4.89	12.35
+ M. Fescue*	8.28	5.54	13.82
+ R. Canary *	7.40	4.94	12.34
Ladino + Timothy*	7.05	3.06	10.11
+ Orchard*	6.61	3.74	10.35
+ Brome*	6.07	2.99	9.06
+ M. Fescue*	6.51	3.29	9.80
+ R. Canary*	6.51	3.28	9.79
Alfalfa + Ladino + Timothy	7.52	4.58	12.10
+ Orchard	7.44	4.38	11.83
+ Brome	6.83	4.71	11.54
+ M. Fescue	6.25	4.27	10.52
+ R. Canary	6.60	4.44	11.04
Alf. + Lad. + Tim. + Orch.	7.64	4.10	11.74
+ Tim. + Brome	8.23	4.94	13.16
+ Tim. + M. Fesc.	7.25	4.18	11.42
+ Tim. + R. Canary	8.74	4.70	13.45
+ Orch. + Brome	7.59	4.94	12.52

Table 1. Total D.M. Production Tons/Acre of 49 Combinations of
(cont'd)
Legumes and Grasses Over a Three Year Period
(1951-1953) at Guelph

Combination	Hay	Aftermath	Hay + Aftermath
Alf. +Lad. +Orch. +M. Fesc.	7.89	4.84	12.73
+Orch. +R. Canary	7.22	4.72	11.94
+Brome+M. Fesc.	6.58	4.14	10.71
+Brome+R. Canary	7.18	4.16	11.35
+M. Fesc. +R. Canary	6.99	4.34	11.32
Alf. +Lad. +Tim. +Orch. +Brome	8.01	4.97	12.98
+Tim. +Orch. +M. Fesc.	8.32	4.88	13.20
+Tim. +Orch. +R. Canary	7.72	4.14	11.86
+Tim. +Brome+M. Fesc.	7.36	4.48	11.84
+Tim. +Brome+R. Canary	7.64	4.86	12.50
+Tim. +M. Fesc. +R. Canary	6.87	4.01	10.88
+Orch. +Brome+M. Fesc.	7.85	4.47	12.32
+Orch. +Brome+R. Canary	7.51	4.50	12.01
+Orch. +M. Fesc. +R. Canary*	8.69	4.72	13.42
+Brome+M. Fesc. +R. Canary	7.22	4.50	11.73
Alf. +Lad. +Tim. +Orch. +Brome+M. Fesc.*	8.24	4.15	12.39
Alf. +R. Clover+Tim. +Orch. +Brome	7.60	3.93	11.54
Alf. +Lad. +R. Clover+Tim. +Brome	7.86	4.12	11.98
Alf. +R. Clover+Tim. +Brome	8.49	3.98	12.47
Red Clover+Timothy*	7.62	2.39	10.00
Kentucky Blue+W. Dutch*	6.80	2.60	9.40
Mean	7.01	3.88	10.90
L.S.D. .05	0.96	0.30	1.59
.01	1.26	0.39	2.10
C.V.	14.4	14.8	11.4

* Department of Nutrition is analyzing samples for crude protein, Ca. and P.

Table 2. Hay Mixture Trial. Comparison of Types of Mixtures. Total Yield of D. M. in Tons per Acre

Combination	Hay 1 yr.	Hay 2 yr.	Hay 3 yr.	Aftermath 1 yr.	Aftermath 2 yr.	Aftermath 3 yr.	Hay + Aftermath 1 yr.	Hay + Aftermath 2 yr.	Hay + Aftermath 3 yr.
Kentucky Blue	0.82	1.56	3.78	0.56	0.76	1.67	1.38	2.33	5.45
Pure Stand grasses	1.42	2.29	4.72	0.42	0.77	1.30	1.84	3.07	6.03
Pure Stand legumes	1.92	3.31	5.34	1.64	2.60	--	3.55	5.91	--
Alfalfa	2.11	4.42	6.89	1.98	3.43	--	4.09	7.85	--
Ladino	1.72	2.20	3.78	1.29	1.78	2.66	3.01	3.97	6.44
Alfalfa + 1 grass	2.50	4.85	7.84	1.70	3.21	4.97	4.20	8.06	12.80
Ladino + 1 grass	2.25	3.45	6.55	1.45	2.07	3.27	3.70	5.52	9.82
Alfalfa + Ladino + 1 grass	2.42	4.12	6.93	1.63	2.79	4.48	4.05	6.90	11.41
Alfalfa + Ladino + 2 grasses	2.62	4.51	7.53	1.65	2.80	4.51	4.27	7.31	12.03
Alfalfa + Ladino + 3 grasses	2.72	4.68	7.72	1.68	2.86	4.55	4.40	7.54	12.27
Alfalfa + Ladino + 4 grasses	2.97	4.97	8.24	1.65	2.64	4.15	4.63	7.60	12.39
Mixtures containing Red Clover	3.01	4.95	7.98	1.59	2.56	4.01	4.60	7.51	12.00
Red Clover + Timothy	2.91	4.63	7.62	1.51	2.02	2.39	4.42	6.65	10.00
Kentucky Blue + White Dutch	1.94	3.86	6.80	0.98	1.38	2.60	2.92	5.24	9.40

Table 3. Hay Mixture Trial. Comparison of Red Clover & Ladino as Components of a Hay-Pasture Mixtures D. M.

Production in Tons per Acre

Combination	Hay 1 yr.	Hay 2 yr.	Hay 3 yr.	Aftermath 1 yr.	Aftermath 2 yr.	Aftermath 3 yr.	Hay + Aftermath 1 yr.	Hay + Aftermath 2 yr.	Hay + Aftermath 3 yr.
Red Clover + Timothy	2.91	4.63	7.62	1.51	2.02	2.39	4.42	6.65	10.00
Ladino + Timothy	2.33	3.64	7.05	1.56	2.04	3.06	3.90	5.68	10.11
Alfalfa + Timothy	2.52	5.05	8.27	1.66	3.04	4.62	4.17	8.09	12.90
Alfalfa + Red Clover + Timothy + Brome	3.17	5.54	8.49	1.62	2.74	3.98	4.79	8.27	12.47
Alfalfa + Ladino + Red Clover + Timothy+Brome	2.88	4.76	7.86	1.63	2.57	4.12	4.51	7.33	11.98
Alfalfa + Ladino + Timothy + Brome	2.96	4.98	8.23	1.71	3.04	4.94	4.67	8.02	13.16
Alfalfa + Red Clover+Timothy+Orchard+Brome	2.99	4.56	7.60	1.52	2.37	3.93	4.51	6.93	11.54
Alfalfa + Ladino +Timothy +Orchard+Brome	2.72	5.03	8.01	1.68	3.09	4.97	4.40	8.12	12.98

21. Nutrient Content of Forage Crops

Motzok, I. (Nutrition)

R. P. O. Nut. 4-1
Procedure: In the project on the evaluation of species and mixtures of grasses and legumes for hay, conducted by the Department of Field Husbandry, the Department of Nutrition is analyzing samples of forage for crude protein, calcium and phosphorus. The following 22 mixtures indicate (*) in Table 1 of F.H. 29-1 are involved.

Mixture #3
- Ladino 4 lbs.
- Timothy 4 lbs.

Mixture #7
- Red Clover 11 lbs.
- Timothy 4 lbs.

Mixture #11
- Ladino 4 lbs.
- Brome 32 lbs.

Mixture #13
- Alfalfa 12 lbs.
- Reed Canary 8 lbs.

Mixture #18
- Ladino 4 lbs.
- Meadow Fescue 19 lbs.

Mixture #19
- Ken. Blue 2 lbs.
- White Dutch 1 lb.

Mixture #25
- Alfalfa 12 lbs.
- Meadow Fescue 19 lbs.

Mixture #26
- Ken. Blue 2 lbs.

Mixture #28
- Brome 33-2/3 lbs.

Mixture #30
- Ladino 4 lbs.
- Reed Canary 8 lbs.

Mixture #31
- Reed Canary 10-2/3 lbs.

Mixture #35
- Alfalfa 12 lbs.
- Brome 32 lbs.

Mixture #37
- Alfalfa 20 lbs.

Mixture #38
- Timothy 4 lbs.

Mixture #39
- Meadow Fescue 20 lbs.

Mixture #40
- Orchard 8-2/3 lbs.

Mixture #42
- Alfalfa 12 lbs.
- Timothy 4 lbs.

Mixture #44
- Ladino 6-2/3 lbs.

Mixture #46
- Alfalfa 7 lbs.
- Ladino 2 lbs.
- Orchard 3 lbs.
- Meadow Fescue 6 lbs.
- Reed Canary 2-1/2 lbs.

Mixture #47
- Alfalfa 12 lbs.
- Orchard 8-1/2 lbs.

Mixture #49
- Alfalfa 6 lbs.
- Ladino 2 lbs.
- Timothy 5 lbs.
- Orchard 4 lbs.
- Brome 5 lbs.
- Meadow Fescue 3 lbs.

22. Redional Uniform Forage Strain Trials

Tossell, W. E. (Field Husb.)

R. P. O. F. H. 28

Objectives: A number of forage strains are available which have looked promising for Ontario. However, these have not been widely tested in Ontario with the result that critical comparative data are not available. Such data are required as a basis for strain recommendations.

Procedure: In 1953 a series of strain trials was seeded at each of 3 locations - Ridgetown, Guelph and Kemptville. A similar series will be seeded at Ottawa in 1954. The same group of strains is included at each location, and the testing technique is relatively uniform at all locations. The strains under test are those (1) which have shown some promise in previous yield or observation trials at one or more locations and (2) for which seed could be made commercially available in quantity in a reasonable length of time.

Strains Seeded in Regional Uniform Forage Strain Trials, 1953

Legumes	Alfalfa	Red Clover	Birdsfoot Trefoil
	Grimm	Ottawa	Viking
	Ladak	Dollard	Empire
	Ranger	LaSalle	Common
	Rhizoma	Redon	
	Vernal	Common	
	Narragansett	Pennscott	
	DuPuits		

Grasses	Timothy	Orchard	Brome	Fescues
	Climax	Hercules	Achenbach	Ensign
	Milton	Oron	Fisher	Mefon
	Medon	Danish	Common	Ottawa 39
	S-48	S-26		Common
	Common	Common		

Results: The Kemptville trials were seeded without a companion crop. Growth was so rapid that the legume plots were clipped twice. Hence, the yield data in Table 1 are for the year of establishment. These data provide a measure of relative vigor in the year of establishment and may indicate the performance of the strains in the first harvest year.

Table 1. D. M. in Tons per Acre from Uniform Forage Strain Trials at Kemptville in 1953.

Strain	First Cut July 30	Second Cut Sept. 2	Total
Alfalfa			
Ladak	1.84	1.09	2.93
Rhizoma	1.72	1.15	2.87
Du Puits	1.56	1.22	2.78
Vernal	1.48	1.16	2.64
Narragansett	1.41	1.16	2.57
Grimm	1.55	1.16	2.71
L.S.D. - .05	0.26	N.S.	N.S.
- .01	0.35	8.1	
C.V.	11.0		9.3
Red Clover			
Pennscott	1.54	0.83	2.37
Dollard	1.53	0.69	2.22
La Salle	1.56	0.66	2.23
Ottawa	1.36	0.75	2.10
Redon	1.33	0.76	2.09
Common	1.64	0.85	2.49
L.S.D. - .05	0.15	N.S.	0.26
- .01	0.20		
C.V.	6.6	12.5	7.6
Birdsfoot Trefoil			
Viking	1.55	0.47	2.02
Empire	1.48	0.16	1.64
Common (European)	1.62	0.70	2.32
L.S.D. - .05	N.S.	0.08	0.28
- .01		0.12	0.43
C.V.	9.0	10.0	8.3

23. Emergency Hay Crops

Fulkerson, R.S. and Tossell, W.E. (Field Husb.)

R.P.O. F.H. 31

Objectives: This study was undertaken to evaluate a number of crops and crop mixtures as supplementary hay and pasture. This report considers only the hay phase. Data from three years are desired in the first step in this study which involves screening the possible crops and mixtures. Data from two years are available.

Procedure: The crops and mixtures listed in Table 1 were seeded in a randomized block design in plots 6' x 20' in size at Guelph in 1950, 1951 and in 1953.

Results: The data obtained are shown in Table 1. The 1953 seeding made unfavorable growth because of drought and was discarded.

1. Oats and peas gave the best performance over the two year period considering total D. M. yield and quality. Total yield was high. In addition it is a legume-grass mixture hence in superior in quality to a pure grass hay such as the millets.

2. Empire was the best millet tested considering D.M. yield, leafiness and fineness of stem.

Table 1. Yield of Hay in Tons D. M. per Acre of Several Emergency Hay Crops Grown at Guelph

Crop	Total 1950	Total 1951	Two Year Mean
Sudan grass	2.65	2.88	2.76
Sudan and beaver oats	2.70	2.53	2.61
Sudan and munroe soybeans		2.80	
Sudan and hubam	2.39*	2.61	
Hubam	2.88	2.44	2.66
Hubam and beaver oats	3.07	3.06	3.06
Hubam and perennial rye	2.59*		
Beaver oats and O. A. C. #181 peas	3.93	3.00	3.46
Beaver oats and biennial sweet clover	3.18	2.91	3.04
Beaver oats and annual vetch		3.12	
Beaver oats and munroe soybeans		2.60	
Munroe soybeans		2.00	
Empire millet	3.64	2.21	2.92
Crown millet	2.74	2.38	2.56
Hansens white siberian proso	3.25	2.33	2.79
Teff grass			
Crimson clover and Italian Rye		2.23	

* 1 replication only.

24. Economics of Crops, Cultural Practices, Machines and Methods on Livestock Farms in Ontario

MacGregor, M.A. & Caldwell, H.W.

R.P.O. Ag. Economics 10
Objectives: The study land use, farm practices and methods in producing cereal and forage crops to determine:
1. Economics of selected harvesting machines (baler, forage harvester, hayloader etc.);
2. Costs of alternative methods of handling hay (silage, chopped, baled, loose);
3. Relative costs of production of cereals and forages;
4. Yields of various cereal and forage crops as related to cultural practices and methods.

Procedure: Three areas in which to collect the information were chosen, one in Western Ontario, one in Central Ontario and one in Eastern Ontario. Records were taken by personal interview on the farms where forage harvesters, balers and hay loaders were found. A minimum of 15 usable records on each machine were established for each of the three areas. It was hoped that a similar number of records might be taken on farms where "hand methods" only were used but it was difficult to find many farms with none of the forage harvesting machines. Before going to the field the questionnaire was pre-tested and some revisions were made.

The field work began on this project about July 15 and continued until Sept. 20. In total 205 records were taken. The number of records on each method of Handling forage was as follows:

Baler	57
Forage Harvester	64
Hayloader	55
Hand	16
Buck Rake	13

The analysis of data requires considerable detailed work. Since September 1953 to date two to three clerks have been employed in the analysis of data plus two staff member intmittently.

The method, machine and crop costs are being calculated as:

1. costs per acre;
2. costs per ton;
3. costs per 100 lbs. T.D.N. (Morrison Standards)

Labour requirements are being calculated on a per acre, per ton and per 100 lbs. of T.D.N. basis according to machines and methods used.

Results: The main results are not in clear enough focus to present at this time.

25. Basic Drying Experimentation

Theakston, F. H. and Hedlin, C. P. (Ag. Engineering)

R. P. O. A. Eng. 29

Objectives: To make a preliminary investigation of the relative efficiency of drying various thicknesses of hay.

It is important in drying to make the greatest possible use of the potential of air to remove water. The amount of water that can be removed from hay by through circulation of air depends on the following variables.

1. Psychrometric condition of the air supplied.
2. Psychrometric condition of the leaving air which in turn depends on:

(a) Moisture content of the hay and the stage in the drying process which affects the relative humidity of the leaving air.

(b) Length of time during which air is in contact with material being dried. If the length of time is excessively short the air may not be able to reach the equilibrium relative humidity.

(c) Amount of heat added to or removed from the air during passage.

Removal of moisture depends on the evaporation of water. The process of evaporation requires approximately 1060 b.t.u. per pound of moisture. The entire drying process for hay takes place in what is known as the "falling rate period". The air cannot reach a saturated condition. It is not possible for it to reach a moisture content higher than that corresponding to the equilibrium relative humidity which is determined by the type and moisture content of the hay and temperature of the air. In the initial stages of drying, the air can remove relatively large amounts of moisture because the equilibrium relative humidity is at a maximum.

The air reaches the equilibrium relative humidity in a short distance of travel through the hay and passes through the remainder of the hay with very little change in condition. Thus drying tends to occur in a band of hay. As drying progresses, the hay nearest the point of supply becomes partially dried. In this condition it does not supply moisture to the air as quickly as in the intial stages and the air must pass farther through the hay before reaching equilibrium relative humidity. In time, the entire thickness is partially dried with the result that the air on leaving has a lower relative humidity than in the initial stages of drying and each pound does not remove as much moisture.

An attempt has been made to determine the condition of air at a number of points along its path as drying progresses. A knowledge of the rate of change in air condition occurring at various stages in drying will allow a determination of the relative efficiency of drying for different thicknesses of hay and velocities of air flow.

In two different dryers, thermocouples were placed at measured intervals along the path of the air flow to determine where evaporation was taking place and where the air reached a condition of maximum moisture content. It was assumed that the thermocouples registered the dry bulb temperature of the air. The temperatures were recorded by a recording potentiometer.

First Dryer (1 ton size)

Fig. 1 indicates the temperature change occurring in the air as it passed through the bottom two feet of a dryer holding 1 ton of hay. The initial moisture content of the hay was approximately 45%. The hay was cut in lengths of approximately 3 inches. The first five thermocouples were placed at 3-inch intervals and the next three were at 4-inch intervals. During the initial stages (5.00 PM) the air required approximately 6 inches of travel to come to equilibrium relative humidity. This is evidenced by the fact that the temperature was constant for the remainder of the hay thickness. The drying band increased in width as the drying process continued and at 4.00 PM the next day it appeared to be wider than the thickness of hay under observation.

Second Dryer (50 pound size)

Owing to the difficulty experienced in getting a large uniform sample of hay for the above type of test, a small dryer was constructed. This dryer consisted of a box 2 feet square and 2 feet high. It had a screened false floor with a plenum chamber below. Hay was chopped into lengths of approximately 1 inch and was placed on the dryer. The moisture content was 40.5%. The hay was compacted initially by placing 90 pounds of weights on the upper surface of the hay. The weight was evenly distributed by a wire screen. The purpose of the initial compaction was:

1. To prevent a decrease in hay volume as drying proceeded.
2. To provide a standard of compaction which might be approximated in future tests.

After the placement of the hay, thermocouples were put in the hay. In the bottom 12 inches of the dryer, the thermocouples were placed at 1 inch intervals. Above 12" the interval was increased to 1-1/2 inches.

Drying air was supplied at a constant rate by a Canadian Blower and Forge (2E) fan. No attempt was made to control the condition of the air with the result that it varied with the outside conditions.

The speed of air flow through the hay was determined approximately by blowing smoke into the hay at the inlet and measuring the length of time required to pass to the top of the hay. This method was not altogether satisfactory because there was likely to be a small time lag between the emergence of the smoke and its detection. A series of 20 timings was taken. The time varied from 4.0 to 5.1 seconds and averaged 4.5 seconds. The hay thickness was 20 inches and the air speed was therefore approximately 22.2 feet per minute.

Fig. 2 shows the change in temperature of the drying air in passage through the hay. The figure shows that during the initial stages (5.30 PM) of drying, the air reached the equilibrium relative humidity after passing through approximately 4 inches of hay. By 9.00 PM the drying band had lengthened to approximately 8 inches. The temperature curve became increasingly irregular as drying progressed. It is thought that this is a result of the method of placing the thermocouples which caused some bunching of the hay. The placement was effected by forcing a 1 inch copper tube into the hay, passing the thermocouple inside it and then removing the tube over the wire leaving the thermocouple in place.

Efficiency of Drying

One of the objectives of this experiment was to determine the efficiency of drying for various thicknesses of hay.

The efficiency with which air is used in drying can be represented in several ways.

1. It may be represented by the ratio of the amount of sensible heat associated with each pound of air that was used to evaporate moisture to the sensible heat in the air as it starts through the drying process.

Total available heat associated with each pound of air

$$= (t1 - tDP)\ 0.24 + (h_2 - h_1) \qquad (1)$$

t_1 = inlet dry bulb temp. ^{o}F
t_{DP} = dew point temp. of inlet air ^{o}F
.24 = specific heat of air
h_2 = total heat content of air leaving the hay - b t u per pound
h_1 = total heat content of entering air b.t.u./pound

Total heat used in drying

$$= (t_1 - t_2)0.24 + (h_2 - h_1) \qquad (2)$$

t_2 = outlet dry bulb temp. ^{o}F

$$\text{efficiency} = \frac{(t_1 - t_2)0.24 + (h_2 - h_1)}{(t_1 - t_{DP})0.24+(h_2 - h_1)} \qquad (3)$$

The performance ratio is the same except that the dew point temperature is replaced by the wet bulb temperature.

For an adiabatic drying process, the efficiency can be expressed as follows:

$$e = \frac{t_1 - t_2}{t_1 - t_{DP}} \qquad (4)$$

t_1 = inlet dry bulb temp. ^{o}F
t_2 = outlet dry bulb temp. ^{o}F
t_{DP}=dew point temp. ^{o}F

This equation gives an approximate answer when used in connection with hay drying because the drying process is not adiabatic.

(a) Heat is added to the hay to raise the temperature as it dries.

(b) Heat may be added to the air by "heating" of the hay.

It does, however, give an approximate answer and was used to compare the efficiency of drying of different thicknesses of hay based on temperatures recorded at various points as described earlier.

The following is a table of efficiencies calculated on the basis of Equation (4) and Fig. 2

Table 1

Hay Thickness inches	2	4	6	8	10	12	15	18
Efficiency	.25	.28	.26	.22	.35	.38	.35	.43

If the air had been adiabatically saturated at all times during the drying process, the efficiency would have been 0.70. If the air had reached the equilibrium relative humidity at all times throughout the drying process, the efficiency would have been approximately 0.60.

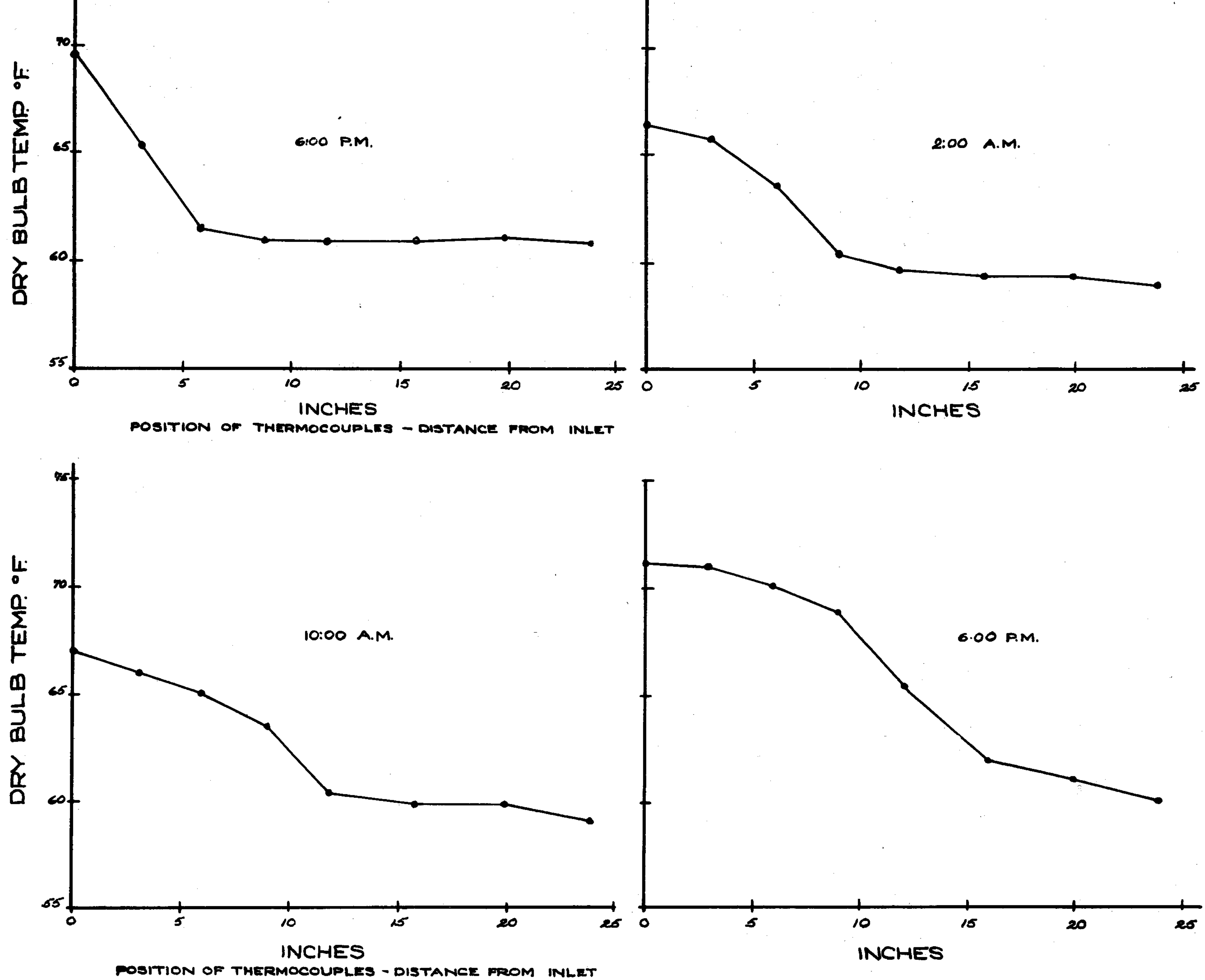
The efficiency increased with the thickness of the hay and it seems probable that the efficiency curve would approach asymptotically to the maximum attainable efficiency (in this case .60) as the hay thickness was increased.

Recording of Inlet and Outlet conditions of Air in Exhaust Flue System

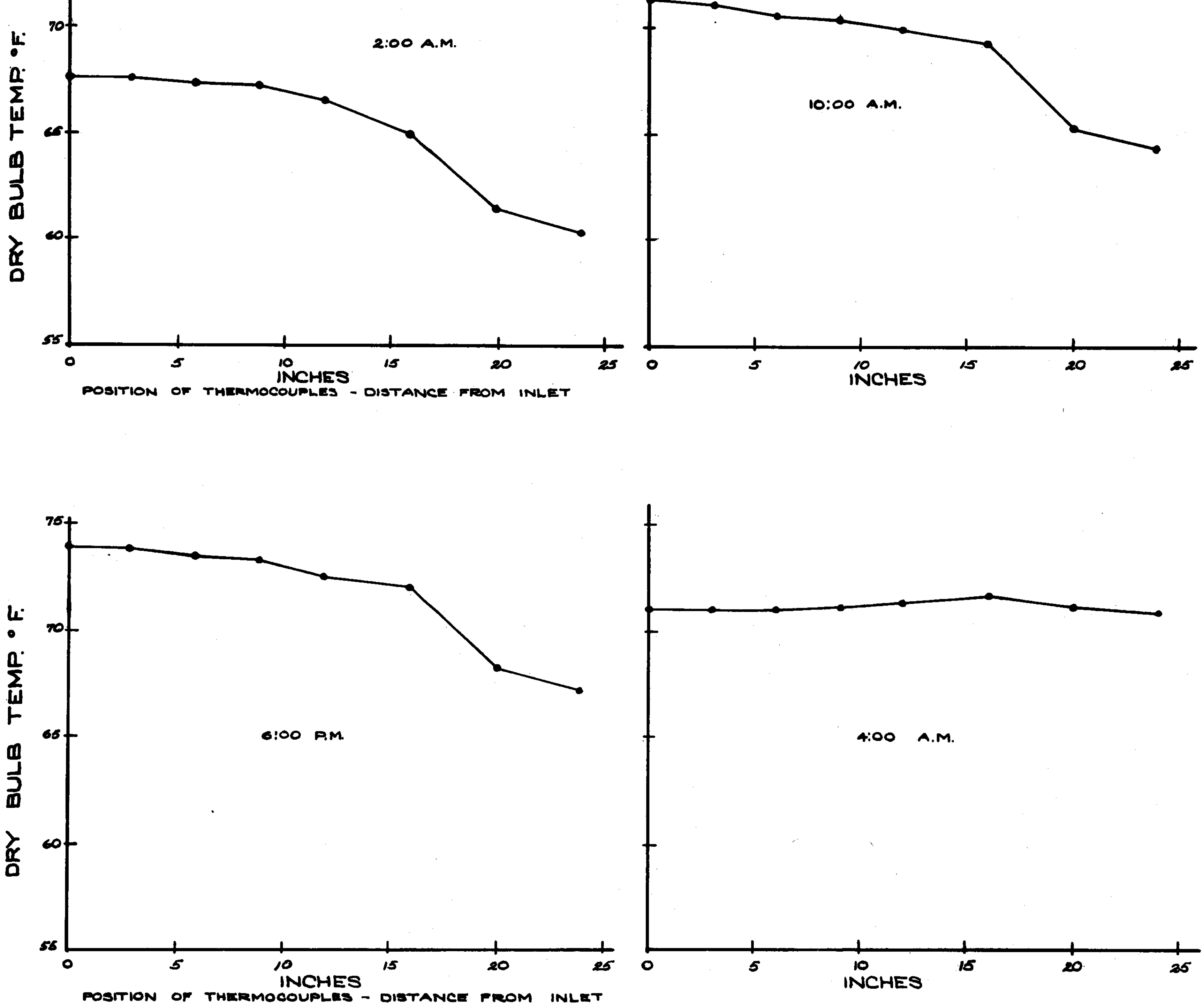
A recording potentiometer was used to record the inlet and outlet condition of the air in the mow with the exhaust flue system. The relative humidity of the entering and exhaust air is presented in Fig. 3. The change in moisture content and total heat content is also placed on the same graph. There was no time during the first three days at which rehydration occurred. On the fourth day (July 14) rehydration began at approximately 9.00 PM when the outside relative humidity was approximately 73%. Drying began the next morning at 6.00 AM when the relative humidity was 77%.

More hay was added to the mow on July 15 bringing the total hay depth to 15 feet. Drying continued uninterruptedly until 8.00 PM July 18. Drying began again at 8.00 AM on the morning of July 19. Drying was interrupted on the morning of July 20 but began again at 8.30 AM (Relative humidity 86%). Drying stopped at 11.00 PM (relative humidity 70% and began at 9.00 AM July 21 (relative humidity 62%). From then on drying was intermittent and the hay was found to be dry.

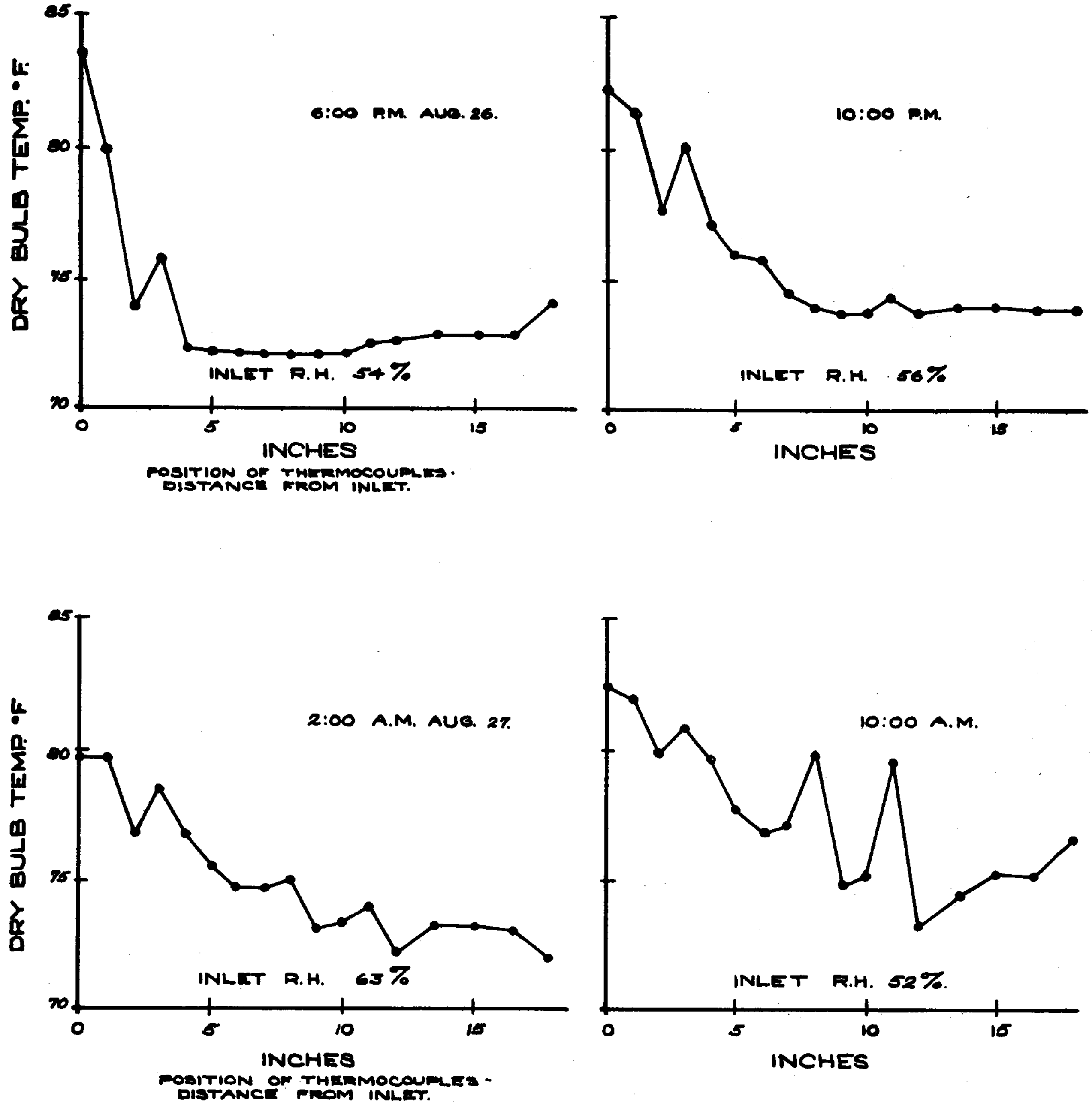
This years results coupled with those of last year indicated that drying occurs without interruption for the first 3 or 4 days if the hay has a moisture content of about 45%. After that drying usually occurs from



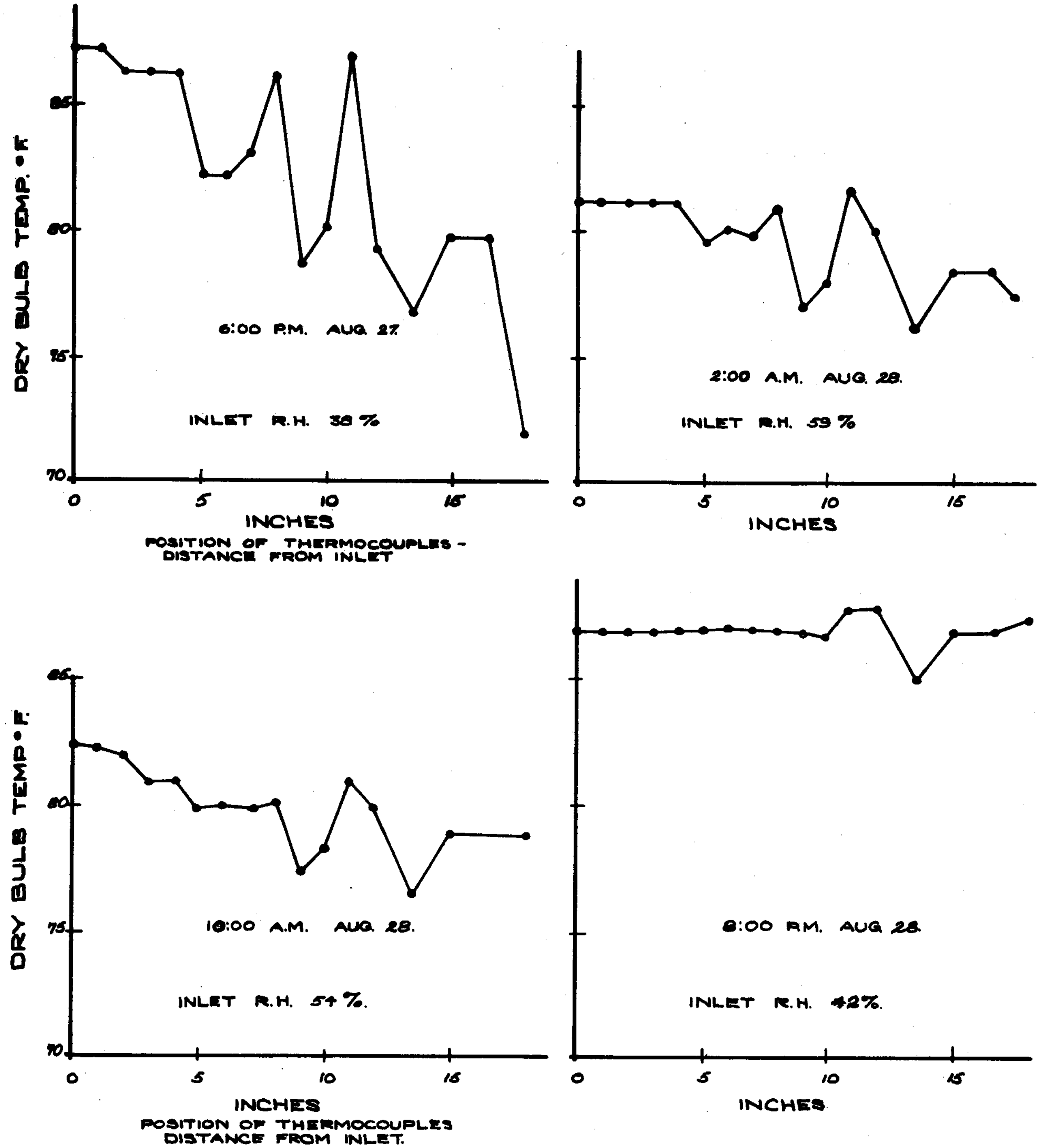
TEMPERATURE CHANGE -
AIR PASSING THROUGH HAY
- 1 TON DRIER



TEMPERATURE CHANGE
AIR PASSING THROUGH HAY
-1 TON DRIER

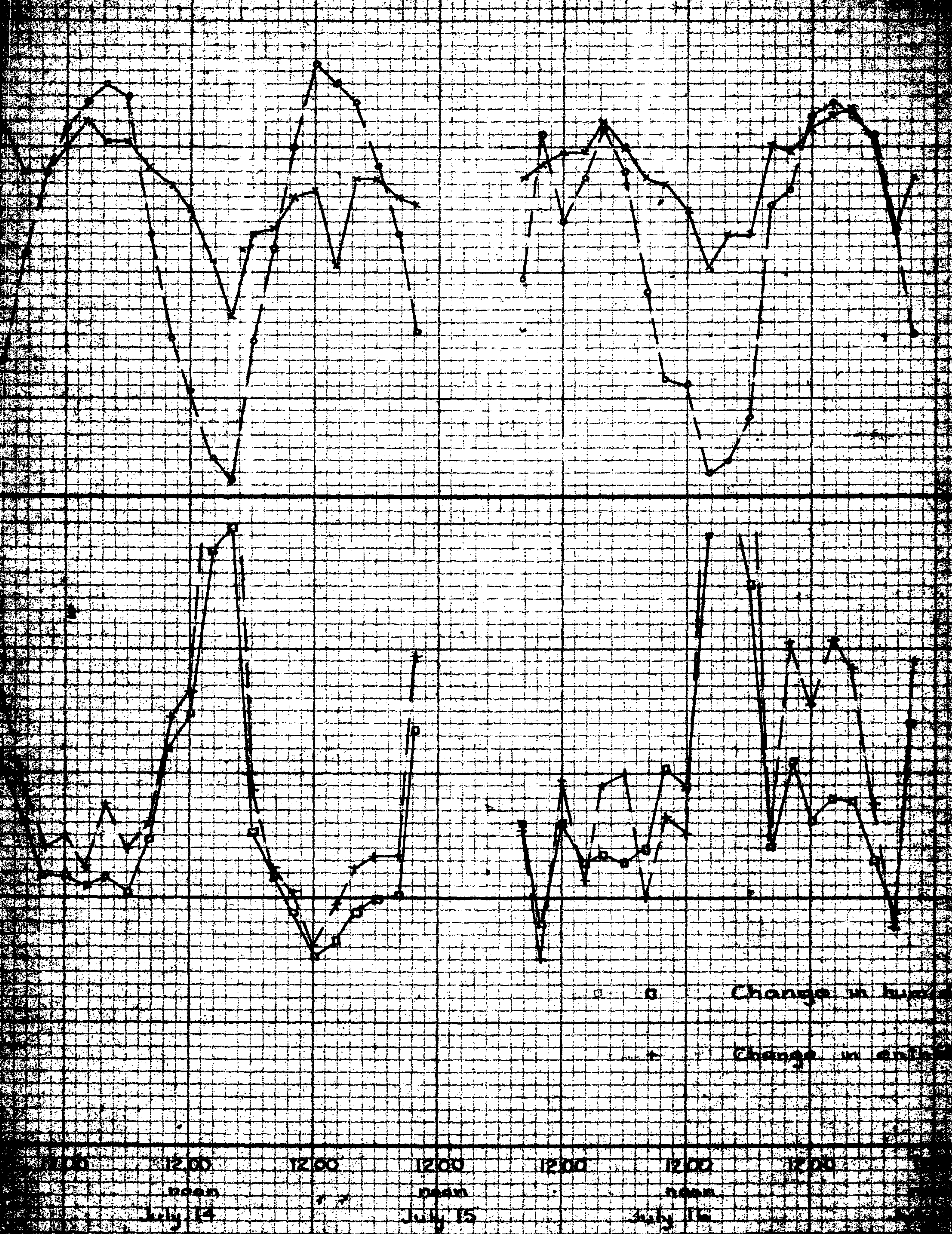


TEMPERATURE CHANGE -
AIR PASSING THROUGH HAY
-50 POUND DRIER

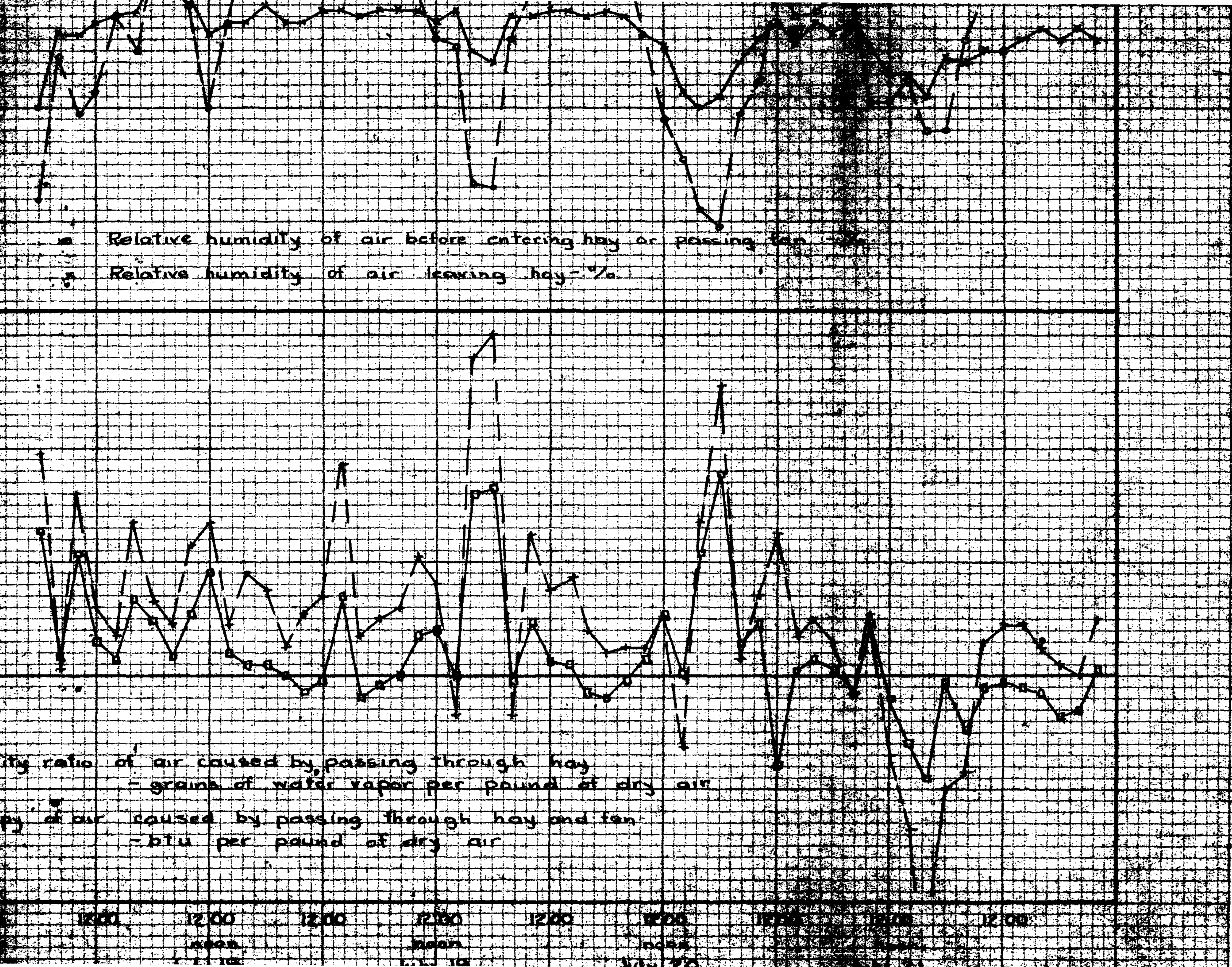


TEMPERATURE CHANGE -
AIR PASSING THROUGH HAY
- 50 POUND DRIER


% Relative humidity
90
80
70
60
50
40
30
Enthalpy change btu/pound
Humidity ratio change grains/pound
6.0
60.0
4.0
40.0
2.0
20.0
0.0
0.0
-2.0
-20.0
removed from air
added to air
12:00
12:00
noon
12:00
12:00
noon
12:00
July 11
July 12



Changes in Drying Air Used in Exhaust



Relative humidity of air before entering hay or passing fan
Relative humidity of air leaving hay - %
ity ratio of air caused by passing through hay
- grains of water vapor per pound of dry air
py of air caused by passing through hay and fan
- btu per pound of dry air
12:00
12:00
noon
12:00
12:00
noon
12:00
12:00
noon
12:00
12:00
12:00
12:00

6.00-8.00 AM until about 9.00 PM.

The humidity ratio increase was determined for each of the two hour intervals used in plotting Fig. 3. The average increase in humidity ratio was 10.8 grains per pound of air for the whole drying period. Similarly the average increase in total heat content of the air was calculated to be 1.73 b.t.u. per pound. This appears to be excessively high.

In 1952 similar work was done and the following results were obtained.

Mow	Avg. Humidity Ratio Inc. gr./#	Enth. Inc b/#
Beef Bam Deep System	+ 5.457	+ .6033
Kemptville baled hay	+ 0.894	+ .3402
Kemptville chopped hay	+ 1.643	- .354

26. Investigation of Static Pressure Losses in Hay Driers

Theakston, F.H. and Hedlin, C.P. (Ag. Engineering)

R.P.O. A. Eng. 28

Static pressure is required to force air through an air distribution system and through hay on a drier. Static pressure losses occur through friction on duct work and shock due to changes in speed or direction. While losses are certain to occur, proper design will reduce the amount of the loss and therefore will reduce the pressure against which the fan must work.

Objectives: To determine the magnitude of losses occurring in duct work used in a hay dryer and to design and use a hay dryer with reduced pressure losses.

The magnitude of loss occurring in the distribution system depends on the velocity of air flow through the duct work and on the abruptness of change in velocity due to changes in cross sectional area of the duct or changes in direction of flow. The magnitude of the loss occurring in passage through the hay depends on the thickness of the hay, the amount of compaction that has taken place and the velocity of air flow through the hay.

The losses occurring in the duct work and in the hay can be determined by the application of well known mathematical formulae. A knowledge of the physical dimensions of each part of the duct work for which the loss is to be determined is necessary. A detailed description of the losses occurring in the duct work is contained in the progress report for the project.

Value of decreasing static pressure requirements

By decreasing the static pressure losses, the volume of air supplied by a given fan operating at a given speed will increase. If the static operator problem as other farmers have no difficulty using the same machines.

An attempt was made to determine the actual power cost per ton for curing hay. In many instances the installation of a hay curing system involved changing the farmers Hydro classification. Where this occurred the additional cost of power was charged to hay drying

The following Table gives the cost per ton computed on this basis.

Farmer	Hydro Before	Classification After	Cost per ton Dollars
H. Cressman	F - 35	F - 50	1.14
F.A. Stock	F - 50	F - 50	0.40
Big Four Jersey Farm	F - 35	F - 50	1.13
B. Topp	F - 35	F - 35	0.43
D. Henderson	F - 35	F - 50	1.07
E. Bowman	F - 35	F - 50	0.63
F. Stager	F - 50	F - 50	0.22
		Ave.	0.72

NOTE: These costs are for electrical power only and do not include equipment or wiring costs.

6.00-8.00 AM until about 9.00 PM.

The humidity ratio increase was determined for each of the two hour intervals used in plotting Fig. 3. The average increase in humidity ratio was 10.8 grains per pound of air for the whole drying period. Similarly the average increase in total heat content of the air was calculated to be 1.73 b.t.u. per pound. This appears to be excessively high.

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Value of decreasing static pressure requirements

By decreasing the static pressure losses, the volume of air supplied by a given fan operating at a given speed will increase. If the static pressure losses are decreased sufficiently, it may warrant the purchase of a fan with lower pressure characteristics. At the present time, it is common to purchase a fan to supply air at a pressure of 3/4 of an inch W. G. Following is a table in which are indicated the characteristics of the three most commonly used fans.

Table 1

Make	HP	S. P.	Vol.	S. P.	Vol.	S. P.	Vol.	No.
Sheldons	5.0	.75	19,600	.50	20,800	.25	21,900	36" Type 86
Aerovent	"	.75	19,200	.50	20,400	.25	21,750	3650
Aerovent	"	.75	22,000	.50	24,200	.25	26,400	4280
Aerovent	"	.75	21,000	.50	22,200	.25	23,500	4240
Robbins & Myers	"	.75	16,800	.50	19,000	.25	21,000	36E
"	"	.75	18,400	.50	21,200	.25	24,100	42D

From tables of fans with lower pressure characteristics, the following figures were obtained.

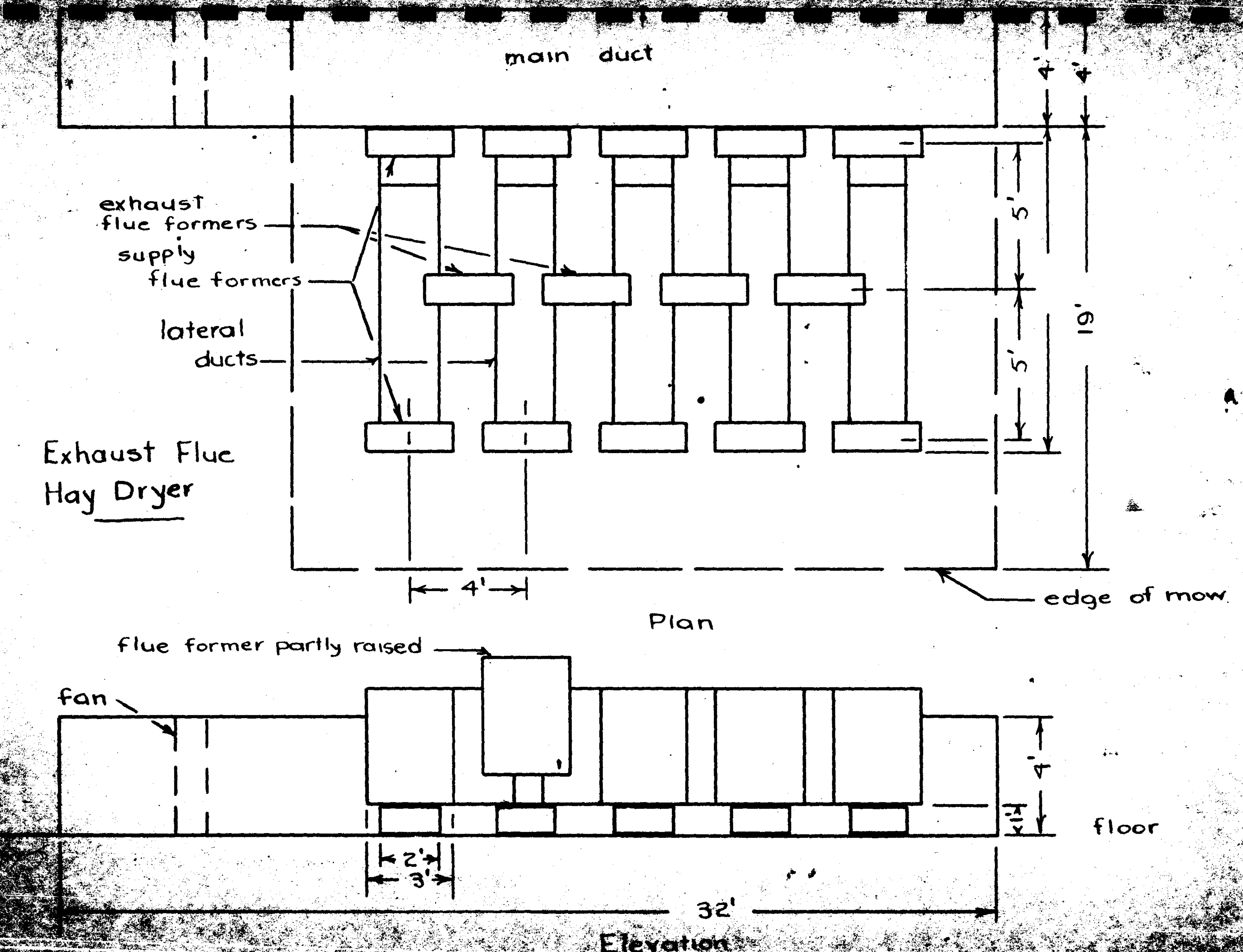
Make	HP	S. P.	Vol.	HP	S. P.	Vol.	HP	S. P.	Vol.	Size & Type
Sheldons	3.17	.25	21,200	3.22	.375	19,700	3.25	.50	17,900	42"
"	1.01	.25	11,600	.98	.375	7,900	1.06	.50	5,100	Type 74 & 78
Robbins &	3	.25	21,000	3	.375	19,200	3	.50	17,000	42 C
Myers	1	.25	12,000	1	.375	7,750	1	.50	900	42 P

By improved dryer design which results in reduced static pressure requirements, a smaller motor can be used to do the same work as a larger motor which has to work against higher static pressure.

Exhaust flue system

The flue system dryer used in 1952 was not considered entirely satisfactory. The design of the dryer was such that it appeared unlikely that air would circulate through the hay at the centre and bottom of the mow. Drying that occurred there would probably result from migration of moisture from the areas of wet hay and high vapor pressure to the drying air flowing vertically through the flues. It seems that this type of drying is likely to be slow if the moisture has to move through approximately two feet of hay. There were some reports of good success with this type of dryer, however.

The existing system is a modification of the original flue system and is as indicated in Fig. 1. The modification was made with a view to obtaining air flow horizontally through the hay so that there would be no "dead" spots where air flow did not occur. It was also designed with a view to minimizing the static pressure losses.


main duct
4'
4'
exhaust
flue formers
supply
flue formers
lateral
ducts
5'
5'
19'
Exhaust Flue
Hay Dryer
4'
edge of mow
Plan
flue former partly raised
fan
4'
1 1/2'
floor
2'
3'
32'
Elevation

Static pressure readings were taken with an Alnor velometer before and after loading the mow with hay and at various stages in the loading.

The following table indicates the approximate depth of hay and the static pressure reading.

Date	App. Hay Depth	S. P. in W. G.
Before loading	no hay - flue formers removed	0.23
July 7/53	5 feet 4 flue formers raised about 1 foot	0.65
July 10/53	9 feet	0.34
July 11	10 feet flue formers raised too high	0.27
July 15	15 feet	0.25
July 18	15 feet	0.32

These readings were taken approximately 13 feet down the duct from the fan at a point between the second and third lateral ducts. It was taken here rather than at the fan because of the difficulty experienced in getting consistent readings near the fan. This pressure represents all the losses occurring between the main duct and the outlet from the hay.

The readings indicate that most of the pressure loss occurs in the distributing system and not in flow through the hay. The static pressure with no hay in place and with the flue formers removed was 0.23 in.W.G. when the mow was completely loaded, the loss was 0.25 to 0.32 in. W.G.

27. Air Distribution Tests

Hedlin, C.P., Theakston, F.H., and Garland, J.W. (Ag. Engineering)

R.P.O. Ag. Eng. 26

Procedure: One of the objectives was to investigate the ratio between the rate of air flow through the side of the mow and the top of the mow for a slatted floor dryer. The purpose was to determine the most desirable ratio between hay depth and the distance from the edge of the slatted floor with a view to obtaining good air distribution.

A slatted floor dryer in the Harrison Barn was selected for use in the project. Baled hay was piled in such a way that bales extended beyond the edge of the slatted floor by a predetermined amount. In one part of the mow the bales extended 4 feet from the slatted floor. At another point the edge of the hay was 6 feet horizontally from the slatted floor and at a third point it was 8 feet from the slatted floor.

Additional air distribution investigation

In addition to work at the Harrison Barn, the air distribution of a flue system was investigated in the beef barn. The results are given in Fig. 2. It will be noted that the velocity of the air near the top of the mow is very much less than it is near the floor.

The average velocity of air emerging from the hay 12.5 feet above the floor is 2.56 f.p.m.; 10 feet above the floor it is 4.48 f.p.m.; 7.5 feet above the floor it is 8.30; 5 feet above the floor it averages 7.34 f.p.m.; and 2.5 feet above the floor it averages 11.60 f.p.m.

Air distribution tests were made at the completion of loading the mow during the drying process.

Results: It was hoped that it would be possible to obtain an average air velocity through the top of the mow, also an average velocity of air flow through the side of the mow at which the bales extended 8 feet past the slatted floor and average velocities from the side of the mow where the bales extended 6 and 4 feet past the edge of the slatted floor. It was hoped that by using these results it would be possible to obtain information as to the most desirable ratio between the depth of hay and the distance from the edge of the slatted floor to the edge of the hay.

The results from the test were not conclusive. The hay depth was approximately 14 feet and the average air velocity through the top of the mow was approximately 0.4 f.p.m. as compared to approximately 1.0 f.p.m. through the sides indicating the desirability of using either a great side distance or a smaller depth.

Investigation of Typical Farm Hay Drying Installations

During the Summer of 1953 several hay curing installations were visited while in the process of loading and after loading. Kilo-watt hour meters were installed on these systems to determine the power consumption. In addition, air distribution tests were made. Table 1 gives the farms visited and other data collected.

The moisture content of the hay was checked at each visit during loading. However, it was not possible to get a sufficient number of moisture determinations to be of value. Of the moisture tests take the range was from 25% to 55% with the majority of the hay going in at about 40%.

The majority of the hay put on these driers was too mature.

The loading of these mows, generally speaking, was not too desirable. In nearly all cases the mows were loaded too high. It appears that central duct systems should have a depth of hay over the duct of less than the distance from the duct to the side of the mow in order to get good air distribution.

Some farmers had difficulty with their harvesters and blowers plugging when the hay was cut using two knives. This seems to be an operator problem as other farmers have no difficulty using the same machines.

An attempt was made to determine the actual power cost per ton for curing hay. In many instances the installation of a hay curing system involved changing the farmers Hydro classification. Where this occurred the additional cost of power was charged to hay drying

The following Table gives the cost per ton computed on this basis.

Farmer	Hydro Classification Before	After	Cost per ton Dollars
H. Cressman	F - 35	F - 50	1.14
F. A. Stock	F - 50	F - 50	0.40
Big Four Jersey Farm	F - 35	F - 50	1.13
B. Topp	F - 35	F - 35	0.43
D. Henderson	F - 35	F - 50	1.07
E. Bowman	F - 35	F - 50	0.63
F. Stager	F - 50	F - 50	0.22
		Ave.	0.72

NOTE: These costs are for electrical power only and do not include equipment or wiring costs.

Table 1.

Name of Farmer	Type of System	Ratio-depth over duct or slatted floor to distance to side	Tons of Hay	Baled or Chopped	Ave. vel. thru top of mow	Ave. vel. thru side of mow	Static Pressure	KWH per ton
H. Cressman	Central duct with A Frame	1.1	41	Chopped 2 Knives	4.7	11.3	0.3	35.2
F. A. Stock	Central duct with A Frame	1.1	30	Chopped 4 Knives	below 0.5	approx. 15.	0.5	30.0
Big Four Jersey Farm	A Frame	0.9	35	Chopped 2 Knives	3.3	7.5	0.55	26.0
B. Topp	Central duct	0.8	27	Chopped 1 Knife	4	5 (one reading only)	0.5	31.6
D. Henderson	Central duct with flues	2.0	41	Chopped 2 Knives	0.5	8.5	0.87	37.3
E. Bowman	Central duct with A Frame	1.2	60	Chopped 2 Knives	0	4.1	Not Taken	12.7
F. Stager	Slatted Floor	2.0	60	Baled	2.0 between bales	1.4 between bales	0.7	16.1
							Ave.	27.0

28. Effect of Hay Handling Methods & Moisture Content on Nutrient Loss

Hedlin, C. P., Byers, G. L. and Evans, E. V.

R.P.O. Ag. Eng. 27 and Nut. 13-1.
Objectives: To study possible shatter losses with different rakes used with a crop at various moisture contents.
Procedure: Two types of rake were used: a finger wheel rake and a side delivery rake. A field of mixed hay consisting of approximately 90% legumes was chosen for the experiment. It was planned to use each rake on the hay at moisture contents of 60%, 50%, 40%, 30% and 20%, with 4 replicated plots on each treatment using a randomized block design.

The whole field was mowed at one time, and moisture tests were conducted at intervals on samples from the plots by the rapid tractor-attachment moisture tester. When such tests indicated that the moisture content had reached the intended level, the appropriate plots were raked. Samples for laboratory analysis of moisture, crude protein, crude fiber and ash were taken from adjacent locations in each plot prior to and immediately after raking. The sampling and analyses were conducted by the Department of Nutrition. The hay on all plots was baled at one time, when the rapid test indicated a moisture content of approximately 20%, the yields of baled hay from individual plots being recorded.

The experiment was performed twice in 1953, using the first and second crops from the same area. In the former case the initial sampling was done immediately after mowing (i.e. fresh crop) and in the second case the initial sampling was done immediately before the raking operation on each plot. This was the only procedural variation between the two experiments, but climatic complications entered into the first trial since heavy rain fell on the hay in all plots after the first two raking and sampling operations (intended 60% and 50% moisture levels) had been completed. This introduced a possible adverse influence on the three later rakings. A further very heavy rainfall following the completion of raking and before the baling of the hay invalidated the observations on the bales in this first experiment.

Results: In practice the exact pattern of intended moisture levels at raking was not achieved, largely as a result of variations in moisture content between samples from replicate plots and perhaps the unavoidable time lag between the taking of the sample for the rapid moisture test and the actual performing of the raking and the collecting of laboratory samples. As a consequence, there was a wide variation in the moisture observations on the replicate plots, and even the mean of the observations for these replicates varied considerably from the intended level.

The best method for handling and assessing the analytical data obtained is therefore not easy to ascertain. It is not justifiable to conduct the analysis of the data according to the originally intended pattern, because of the fact that raking was not done at the specified moisture levels, and the replicated plots were raked actually at different moisture contents.

Pending a decision on the handling of the data, and, if possible a statistical evaluation of it, the actual detailed analytical results are being recorded here. These are shown in Tables 1, 2 and 3.

One suggested method for evaluating the results is to consider them on the basis of the actual moisture levels rather than the intended levels, discarding the original pattern of replication. To this end, Tables 4, 5 and 6 have been prepared showing the plot sample data listed in order of decreasing moisture content. Although the two types of rake have not been separated in these listings, the data for the different rakes could be handled separately in the same way.

Some information may be obtained from the data in the tables by comparing the results for different moisture ranges. Such comparisons might be applied to various moisture ranges. Table 7 shows one possibility where the 16 samples of highest moisture content are compared with the 16 samples of lowest moisture content.

The results for protein only have been analyzed statistically, and the findings are summarized below:

First Cut: Difference between "High" and "Low" is highly significant ($P=0.01$)

Second Cut: After raking: Difference between "High" and "Low" is approaching significance for $P=0.05$

Second Cut: Baled: Difference between "High" and "Low" is significant ($P=0.05$)

Second Cut: High Moisture: Difference between the hay after raking and after baling is significant (P less than 0.05)

Second Cut: Low Moisture: Difference between the hay after raking and after baling is not significant for $P=0.05$ (but significant for $P = 0.10$)

It is obvious from the foregoing results that raking at the lower moisture levels causes a greater degree of shattering and hence loss of protein than does raking at the higher moisture levels. The more pronounced loss in the first experiment is very probably a consequence of the heavy rainfall and the consequent prolonged exposure.

The observation that there is an appreciable difference in composition between the samples before and after baling is of considerable interest. In other work the question has been raised as to the possibility of loss of leaf material when fully cured hay is baled. This is one indication that this possibility is a real one.

Table 1. Results of Analysis - First Cut

Rake	Intended Moisture Content at Raking %	Plot No	Actual Moisture Content % Fresh Cut	Actual Moisture Content % at Raking	% Protein (M. F. B.) Fresh Cut	% Protein (M. F. B.) After Raking	% Crude Fibre (M. F. B.) Fresh Cut	% Crude Fibre (M. F. B.) After Raking	% Total Ash (M. F. B.) Fresh Cut	% Total Ash (M. F. B.) After Raking
S D	60	5	76.7	58.8	17.3	18.1	28.0	26.2	7.90	7.70
		20	67.7	55.5	16.9	16.6	28.4	28.1	7.31	7.12
		27	76.1	63.3	16.1	16.2	29.8	28.3	7.06	7.19
		40	71.6	49.2	15.7	18.4	29.9	29.6	7.06	6.69
		Ave	73.0	56.7	16.5	17.5	29.0	28.0	7.33	7.18
S D	50	7	77.2	50.5	14.2	15.5	32.2	29.7	7.18	7.40
		15	73.1	37.7	16.8	15.9	29.3	28.2	7.49	7.16
		23	71.6	38.8	16.9	15.1	28.0	28.6	6.89	6.96
		35	71.3	44.4	16.8	16.3	28.5	27.7	6.95	7.08
		Ave	73.3	42.9	16.2	15.7	29.5	28.6	7.13	7,15
S D	40	9	71.6	36.4	18.7	14.8	26.9	29.0	7.68	7.57
		17	77.4	42.7	16.8	13.5	29.3	32.7	7.49	6.86
		29	61.1	38.5	17.6	16.5	26.9	28.7	8.17	7.24
		37	73.8	43.5	14.9	15.1	31.9	31.6	6.24	6.61
		Ave	70.9	40.3	17.0	14.9	28.8	30.5	7.40	7.07
S D	30	10	75.5	20.0	18,1	17.8	28.0	30.1	7.40	6.62
		19	75.3	22.5	15.7	15.1	27.1	31.0	7.36	6.33
		26	76.4	27.2	16.8	15.1	30.8	33.2	7.11	6.05
		36	72.4	22.6	15.9	14.1	30.0	34.5	6.54	6.18
		Ave	74.9	23.0	16.6	15.5	29.0	32.2	7.10	6.29
S D	20	1	79.4	28.8	16.0	14.0	31.7	33.8	7.18	6.21
		18	75.5	18.2	15.7	14.5	28.7	33.9	6.94	6.43
		28	74.7	27.8	17.4	16.3	27.8	31.9	7.24	5.98
		34	73.8	29.6	16.8	16.4	27.6	31.7	7.35	6.81
		Ave	75.9	26.1	16.5	15.3	29.0	32.8	7.15	6.36

Table 1. Results of Analysis - First Cut (Continued)

Rake*	Intended Moisture Content At Raking %	Plot No	Actual Moisture Content % Fresh Cut	Actual Moisture Content % At Raking	% Protein (M. F. B.) Fresh Cut	% Protein (M. F. B.) After Raking	% Crude Fibre (M. F. B.) Fresh Cut	% Crude Fibre (M. F. B.) After Raking	% Total Ash (M. F. B.) Fresh Cut	% Total Ash (M. F. B.) After Raking
F W	60	8	77.7	67.2	15.5	15.7	30.5	28.6	7.34	7.37
		16	66.1	65.0	15.1	15.6	29.9	29.9	7.33	6.93
		30	72.2	57.2	17.3	16.7	29.3	28.5	8.39	7.34
		32	75.0	67.2	15.9	17.4	30.7	28.5	6.71	7.38
		Ave	72.8	64.2	16.0	16.4	30.1	28.9	7.44	7.26
F W	50	3	78.0	51.8	15.7	15.4	30.1	30.1	6.86	7.02
		13	78.0	48.3	17.1	15.7	28.2	30.7	7.68	7.13
		25	71.1	41.3	17.1	15.7	26.9	28.9	7.47	6.71
		31	75.5	46.4	15.6	17.4	30.3	28.5	6.72	7.38
		Ave	75.7	47.0	16.4	16.1	28.9	29.6	7.18	7.06
F W	40	4	75.7	37.5	17.1	16.3	28.4	27.8	7.27	7.81
		12	76.8	43.8	15.4	14.2	31.1	32.9	7.03	6.29
		22	73.8	46.1	17.8	14.4	28.8	31.0	7.36	6.69
		39	70.7	33.6	17.0	16.4	28.8	27.8	7.32	7.33
		Ave	74.3	40.3	16.8	15.3	29.3	29.9	7.25	7.03
F W	30	6	76.1	29.6	17.3	14.2	28.6	34.9	7.76	6.83
		11	76.8	24.8	17.3	15.0	31.7	35.1	7.24	6.56
		24	73.0	26.4	17.8	14.2	28.3	34.3	7.27	5.93
		38	71.6	15.0	16.4	16.7	28.5	32.9	6.64	6.10
		Ave	74.4	24.0	17.2	15.0	29.3	34.3	7.23	6.36
F W	20	2	77.4	19.2	16.2	12.9	30.4	34.9	6.95	6.07
		14	77.7	13.2	17.0	14.3	30.3	33.6	7.97	6.68
		21	75.5	24.4	17.4	15.0	29.3	33.5	7.20	6.26
		33	72.4	11.8	15.8	14.0	30.2	34.7	7.38	5.85
		Ave	75.8	17.2	16.6	14.1	30.1	34.2	7.38	6.22

* - S D refers to Side Delivery Rake.
- F W refers to Finger-Wheel Rake.

Table 2. Results of Analysis - Second Cut

Rake	Intended Moisture Content At Raking %	Plot No	Actual Moisture Content %		% Protein (M. F. B.)		% Crude Fibre (M. F. B.)		% Total Ash (M. F. B.)	
			Before Raking	After Raking	Before Raking	After Raking	Before Raking	After Raking	Before Raking	After Raking
S D	60	5	48.7	47.7	16.3	16.0	27.9	27.3	6.57	6.88
		20	43.0	39.2	16.0	17.6	29.8	26.6	5.71	6.26
		27	49.1	47.7	16.6	15.6	26.9	29.8	6.81	6.18
		40	47.4	45.2	17.2	16.9	30.8	27.5	7.22	6.56
		Ave	47.1	44.9	16.5	16.5	28.9	27.8	6.58	6.47
S D	50	7	43.1	43.6	16.7	16.7	28.3	28.7	6.07	6.06
		15	48.8	43.3	15.9	17.0	30.3	26.7	6.48	6.73
		23	42.4	41.8	16.8	16.8	28.4	26.6	5.63	5.69
		35	44.4	42.7	17.7	17.1	28.1	25.6	6.51	6.48
		Ave	44.7	42.9	16.8	16.9	28.8	26.9	6.17	6.23
S D	40	9	35.7	21.8	17.2	16.9	30.8	27.5	7.22	6.56
		17	29.2	31.1	15.2	16.9	28.0	26.3	6.04	6.30
		29	36.2	32.7	15.6	17.1	28.5	28.1	6.44	6.49
		37	31.7	28.6	17.7	16.0	28.9	29.1	6.59	6.34
		Ave	33.2	28.6	16.4	16.7	29.1	27.8	6.57	6.42
S D	30	10	22.5	21.6	15.4	15.7	29.2	27.5	6.57	5.90
		19	24.7	7.2	18.2	18.2	24.2	26.2	6.34	6.33
		26	28.8	16.7	14.5	15.3	29.9	29.4	6.22	6.54
		36	18.3	21.1	17.5	15.3	30.7	28.1	5.81	6.75
		Ave	23.6	16.7	16.4	16.1	28.5	27.8	6.24	6.38
S D	20	1	17.3	10.5	16.8	15.1	24.2	29.2	6.97	6.36
		18	29.0	15.8	16.5	19.1	29.5	27.7	6.33	6.45
		28	20.0	20.0	16.5	17.1	26.6	27.7	6.47	6.77
		34	19.3	20.4	17.0	15.9	29.7	30.3	6.74	6.46
		Ave	21.4	16.7	16.7	16.8	27.5	28.7	6.63	6.51

Table 2. Results of Analysis - Second Cut (Continued)

Rake	Intended Moisture Content At Raking %	Plot No	Actual Moisture Content % Before Raking	Actual Moisture Content % After Raking	% Protein (M. F. B.) Before Raking	% Protein (M. F. B.) After Raking	% Crude Fibre (M. F. B.) Before Raking	% Crude Fibre (M. F. B.) After Raking	% Total Ash (M. F. B.) Before Raking	% Total Ash (M. F. B.) After Raking
F W	60	8	48.3	45.5	17.0	16.0	28.6	29.3	6.25	6.39
		16	43.1	44.0	15.6	15.9	28.4	30.5	6.01	5.93
		30	51.3	48.2	18.1	17.8	28.6	29.5	7.63	6.95
		32	47.6	43.7	17.0	16.3	26.7	29.5	6.26	6.26
		Ave	47.5	45.4	16.9	16.5	28.1	29.7	6.54	6.38
F W	50	3	38.8	40.7	16.2	16.3	30.7	28.4	5.57	5.87
		13	44.4	38.5	16.1	16.5	29.2	29.0	5.30	5.77
		25	44.0	43.6	17.0	17.2	27.0	26.9	6.18	6.58
		31	34.4	41.7	16.1	16.3	28.4	28.6	5.83	5.85
		Ave	40.4	41.1	16.4	16.6	28.8	28.2	5.72	6.02
F W	40	4	30.8	34.2	17.0	15.2	26.2	32.0	6.79	6.50
		12	33.0	30.8	15.0	15.7	31.0	29.3	5.59	5.71
		22	37.5	37.2	16.1	16.7	29.6	28.4	6.09	5.98
		39	32.5	27.0	16.7	16.7	28.3	28.9	6.07	6.42
		Ave	33.5	32.3	16.5	16.1	28.8	29.7	6.14	6.15
F W	30	6	20.5	22.4	12.9	15.4	32.2	31.2	5.61	5.73
		11	20.8	21.1	15.2	13.5	27.4	28.9	6.44	6.15
		24	21.7	21.3	12.0	16.0	32.8	28.3	8.89	5.88
		38	22.2	22.0	18.2	14.4	25.2	28.3	6.05	6.07
		Ave	21.3	21.7	14.6	14.8	29.4	29.2	6.75	5.96
F W	20	2	20.0	17.7	16.7	14.8	28.5	30.9	6.37	6.04
		14	16.6	16.6	16.2	15.5	27.9	32.3	6.50	6.37
		21	15.5	7.3	16.3	13.6	27.3	28.3	6.08	5.88
		33	17.1	21.6	18.2	16.9	25.6	30.2	6.52	5.81
		Ave	17.3	15.8	16.9	15.2	27.3	30.4	6.37	6.03

Table 3. Results of Analysis - Second Cut - Baled Hay

Rake	Intended Moisture Content At Raking	Plot No	% Protein (M.F.B.)	% Crude Fibre (M.F.B.)	% Total Ash (M.F.B.)
S D	60	5	16.0	27.3	6.83
		20	16.3	30.1	6.58
		27	14.1	30.0	6.30
		40	18.5	28.8	7.51
		Ave	16.2	29.1	6.81
S D	50	7	16.4	26.7	6.07
		15	17.0	26.7	6.73
		23	17.1	29.4	6.50
		35	16.0	29.0	6.50
		Ave	16.6	28.0	6.45
S D	40	9	16.3	29.5	6.19
		17	14.2	32.3	6.19
		29	15.7	27.9	7.17
		37	11.7	31.7	5.81
		Ave	14.5	30.4	6.34
S D	30	10	12.9	32.0	5.87
		19	15.5	29.1	6.43
		26	14.5	29.9	5.69
		36	14.5	32.7	5.81
		Ave	14.4	30.9	5.95
S D	20	1	16.0	31.0	6.13
		18	13.9	33.0	5.69
		28	16.5	26.6	6.47
		34	16.3	29.2	6.56
		Ave	15.7	30.0	6.21
F W	60	8	16.8	28.5	6.45
		16	14.8	28.7	5.35
		30	15.0	28.2	6.51
		32	16.3	29.0	6.03
		Ave	15.7	28.6	6.09
F W	50	3	16.5	28.5	6.45
		13	14.2	29.9	5.20
		25	16.0	29.0	6.50
		31	13.6	29.0	5.47
		Ave	15.1	29.1	5.91
F W	40	4	15.9	31.1	6.23
		12	13.2	29.9	5.20
		22	15.8	30.4	5.46
		39	17.2	29.4	6.46
		Ave	15.5	30.2	5.84

Table 3. Results of Analysis - Second Cut - Baled Hay (Cont'd)

Rake	Intended Moisture Content At Raking	Plot No	% Protein (M. F. B.)	% Crude Fibre (M. F. B.)	% Total Ash (M. F. B.)
F W	30	6	14.3	31.3	6.20
		11	14.6	31.6	6.06
		24	16.0	29.4	6.61
		38	-	-	-
		Ave	15.0	30.8	6.29
F W	20	2	12.6	35.0	5.34
		14	14.1	31.0	6.13
		21	15.5	29.2	6.05
		33	15.0	27.6	6.80
		Ave	14.3	30.7	6.08

Table 4. First Cut - Analytical Results Arranged in Order of Decreasing Moisture Content

Plot No	Rake	Actual Moisture Content At Raking	Composition after Raking (M.F.B.) % Protein	% Crude Fibre	% Ash
8	F W	67.2	15.7	28.6	7.37
32	F W	67.2	17.4	28.5	7.38
16	F W	65.0	15.6	29.9	6.93
27	S D	63.3	16.2	28.3	7.19
5	S D	58.8	18.1	26.2	7.70
30	F W	57.2	16.7	28.5	7.34
20	S D	55.5	16.6	28.1	7.12
3	F W	51.8	15.4	30.1	7.02
7	S D	50.5	15.5	29.7	7.40
40	S D	49.2	18.4	29.6	6.69
13	F W	48.3	15.7	30.7	7.13
31	F W	46.4	17.4	28.5	7.38
22	F W	46.1	14.4	31.0	6.69
35	S D	44.4	16.3	27.7	7.08
12	F W	43.8	14.2	32.9	6.29
37	S D	43.5	15.1	31.6	6.61
17	S D	42.7	13.5	32.7	6.86
25	F W	41.3	15.7	28.9	6.71
23	S D	38.8	15.1	28.6	6.96
29	S D	38.5	16.5	28.7	7.24
15	S D	37.7	15.9	28.2	7.16
4	F W	37.5	16.3	27.8	7.81
9	S D	36.4	14.8	29.0	7.57
39	F W	33.6	16.4	27.8	7.33
34	S D	29.6	16.4	31.7	6.81
6	F W	29.6	14.2	34.9	6.83
1	S D	28.8	14.0	33.8	6.21
28	S D	27.8	16.3	31.9	5.98
26	S D	27.2	15.1	33.2	6.04
24	F W	26.4	14.2	34.3	5.93
11	F W	24.8	15.0	35.1	6.56
21	F W	24.4	15.0	33.5	6.26
36	S D	22.6	14.1	34.5	6.18
19	S D	22.5	15.1	31.0	6.33
10	S D	20.0	17.8	30.1	6.62
2	F W	19.2	12.9	34.9	6.07
18	S D	18.2	14.5	33.9	6.43
38	F W	15.0	16.7	32.9	6.10
14	F W	13.2	14.3	33.6	6.68
33	F W	11.8	14.0	34.7	5.85

Table 5. Second Cut - Analytical Results Arranged in Order of Decreasing Moisture Content

Plot No	Rake	Actual Moisture Content At Raking %	Composition after Raking (M. F. B.) % Protein	%Crude Fibre	% Ash
30	F W	48.2	17.8	29.5	6.95
27	S D	47.7	15.6	29.8	6.18
5	S D	47.7	16.0	27.3	6.88
8	F W	45.5	16.0	29.3	6.39
40	S D	45.2	16.9	27.5	6.56
16	F W	44.0	15.9	30.5	5.93
32	F W	43.7	16.3	29.5	6.26
25	F W	43.6	17.2	26.9	6.58
7	S D	43.6	16.7	28.7	6.06
15	S D	43.3	17.0	26.7	6.73
35	S D	42.7	17.1	25.6	6.48
23	S D	41.8	16.8	26.6	5.69
31	F W	41.7	16.3	28.6	5.85
3	F W	40.7	16.3	28.4	5.87
20	S D	39.2	17.6	26.6	6.26
13	F W	38.5	16.5	29.0	5.77
22	F W	37.2	16.7	28.4	5.98
4	F W	34.2	15.2	32.0	6.50
29	S D	32.7	17.1	28.1	6.49
17	S D	31.1	16.9	26.3	6.30
12	F W	30.8	15.7	29.3	5.71
37	S D	28.6	16.0	29.1	6.34
39	F W	27.0	16.7	28.9	6.42
6	F W	22.4	15.4	31.2	5.73
38	F W	22.0	14.4	28.3	6.07
9	S D	21.8	16.9	27.5	6.56
10	S D	21.6	15.7	27.5	5.90
33	F W	21.6	16.9	30.2	5.81
24	F W	21.3	16.0	28.3	5.88
36	S D	21.1	15.3	28.1	6.75
11	F W	21.1	13.5	28.9	6.15
34	S D	20.4	15.9	30.3	6.46
28	S D	20.0	17.1	27.7	6.77
2	F W	17.7	14.8	30.9	6.04
26	S D	16.7	15.3	29.4	6.54
14	F W	16.6	15.5	32.3	6.37
18	S D	15.8	19.1	27.7	6.45
1	S D	10.5	15.1	29.2	6.36
21	F W	7.3	13.6	28.3	5.88
19	S D	7.2	18.2	26.2	6.33

Table 6. Bales From Second Cut

Analytical Results Arranged in Order of Decreasing Moisture Content At Raking

Plot No	Rake	Actual Moisture Content At Raking %	Composition After Raking % Protein	% Crude	% Ash
30	F W	48.2	15.0	28.2	6.51
27	S D	47.7	14.1	30.0	6.30
5	S D	47.7	16.0	27.3	6.83
8	F W	45.5	16.8	28.5	6.45
40	S D	45.2	18.5	28.8	7.51
16	F W	44.0	14.8	28.7	5.35
32	F W	43.7	16.3	29.0	6.03
25	F W	43.6	16.0	29.0	6.50
7	S D	43.6	16.4	26.7	6.07
15	S D	43.3	17.0	26.7	6.73
35	S D	42.7	16.0	29.0	6.50
23	S D	41.8	17.1	29.4	6.50
31	F W	41.7	13.6	29.0	5.47
3	F W	40.7	16.5	28.5	6.45
20	S D	39.2	16.0	27.3	6.83
13	F W	38.5	14.2	29.9	5.20
22	F W	37.2	15.8	30.4	5.46
4	F W	34.2	15.9	31.1	6.23
29	S D	32.7	15.7	27.9	7.17
17	S D	31.1	14.2	32.3	6.19
12	F W	30.8	13.2	30.1	7.81
37	S D	28.6	11.7	31.7	5.81
39	F W	27.0	17.2	29.4	6.46
6	F W	22.4	14.3	31.3	6.20
38	F W	22.0	16.0	27.5	5.95
9	S D	21.8	16.3	29.5	6.19
10	S D	21.6	12.9	32.0	5.87
33	F W	21.6	15.0	27.6	6.80
24	F W	21.3	16.0	29.4	6.61
36	S D	21.1	14.5	32.7	5.81
11	F W	21.1	14.6	31.6	6.06
34	S D	20.4	16.3	29.2	6.56
28	S D	20.0	16.5	26.6	6.47
2	F W	17.7	12.6	35.0	5.34
26	S D	16.7	14.5	29.9	5.69
14	F W	16.6	14.1	31.0	6.13
18	S D	15.8	13.9	33.0	5.69
1	S D	10.5	16.0	31.0	6.13
21	F W	7.3	15.5	29.2	6.05
19	S D	7.2	15.5	29.1	6.43

Table 7. Comparative Analyses of Samples of Hay Raked at High and at Low Moisture Content

Samples	Constituent	Composition on Moisture-free Basis: High Moisture*	Low Moisture**
1st Cut After Raking	Protein %	16.1	14.9
	Crude Fiber %	29.3	33.4
	Ash %	7.08	6.31
2nd Cut After Raking	Protein %	16.6	15.8
	Crude Fiber %	28.2	28.8
	Ash %	6.28	6.27
2nd Cut Bales	Protein %	15.9	14.9
	Crude Fiber %	28.5	30.5
	Ash %	6.33	6.13

* 16 samples. Range of moisture contents at raking:
1st cut - 67.2 to 43.5%
2nd cut - 48.2 to 38.5%

** 16 samples. Range of moisture contents at raking:
1st cut - 29.6 to 11.8%
2nd cut - 22.0 to 7.2%

29. Does it Pay to Barn Dry Hay?

Campbell, D.R. (Ag. Economics)

R.P.O.
Objectives: 1. To ascertain the extra costs involved in barn drying hay as compared to field curing hay.
2. To ascertain the extra recovery, nutritive qualities and feeding value of barn-dried hay over field cured hay.
3. To compute the extra revenue (if any) of barn dried hay over field cured hay.
4. To ascertain "break-even points" based on size of mow, and price of milk, at which it would pay to barn dry rather than field cure hay.
Procedure: In 1952-3, 26 farmers provided information on costs, and opinions as to extra value of mow-cured hay on 31 barn driers in operation in 1952. Records were obtained from the O. A. C. and other government institutions where driers were installed, but these costs were usually unrealistic because the systems were designed for experimental and demonstrational work, and were often more elaborate than necessary.

Results: Results to date are indicated in the Extension Release - "The Economics of Barn-Drying Hay", of May 1953. Further cost records were obtained in 1953-4 on five additional systems, and seven of the systems covered the previous year. These data indicate about the same findings as in 1952-3.

30. Comparison of the Feeding Value of Hay Subjected to Different Methods of Curing

Rennie, J.C.

R.P.O. An. Husb. -1
Objectives: To determine if there is any significant difference in the feeding value of hay measured in terms of milk production when the hay is harvested by the following methods:

1. Field cured-loose, harvested with hay loader
2. Field cured-baled
3. Barn cured-baled
4. Field cured-chopped, harvested with forage harvester.

Importance: Since the machinery required for some of these methods of harvesting is quite expensive, it is desirable to know how the feeding value of hay produced by means of this equipment compares with that of hay harvested by the older and more conventional methods. It has been reported that with the feeding of chopped hay, a significant drop in butterfat test is detected. This fact warrants considerable investigation.

Experiment A

This experiment compares hay of the following types:

1. Field cured-loose, harvested with hay loader
2. Field cured-baled
3. Barn cured-baled

Two feeding trials have been conducted in successive years involving these three types of hay.

Trial 1. This trial was conducted during the early winter of 1953 with hay harvested in the summer of 1952. The hay used in this trial was from the same field and consisted of approximately 40% legume and 60% grass. The hay was fairly mature at the time of harvesting. The barn cured hay was stored without having been exposed to rain, whereas, the other two types received one shower during the field curing period.

This feeding trial was divided into three equal feeding periods of three weeks' duration. Twelve dairy cows, (nine Holsteins, three Ayrshires) were divided into four equal groups, arranged as closely as possible as to age of cow, stage of lactation, level of production and breed. Four cows were fed each type of hay during each period, utilizing a double change-over system as outlined by Cochran et al (1941).

Protein and carotene analyses were conducted on replicate samples from a lot of hay mid-way through the feeding period.

The cows consumed 30 pounds of a mixture of corn and grass silage and 10 pounds of 16% concentrate daily on the average regardless of the type of hay being fed. The concentrate mixture consisted of the following:

1,000 lbs.	rolled oats,
500 lbs.	bran
200 lbs.	oilcake
150 lbs.	corn gluten feed
100 lbs.	molasses
30 lbs.	high grade feeding bonemeal
20 lbs.	iodized cobaltized salt.

A summary of results of this trial is shown in table #1 along with the analytical* data on the hay.

As indicated in Table #1, the cows produced on the average .3 lbs. and 1.7 lbs. of milk per cow per day more on the barn cured-baled hay than when fed the field cured-baled, and the field cured-loose hays respectively. Production on the field cured-baled hay was greater than that on the field cured-loose hay by 1.4 lbs. of milk per cow per day. These differences are not statistically significant.

Table 1. Results of Trial 1 - Experiment A

Type of Hay	Protein Content % M. F. B. *	Carotene Content mgs/lb. M. F. B. *	Hay Consumed per Cow Daily (lbs.)	Milk Produced per 100 lbs. of Hay Consumed**	Milk Produced per Cow Daily (lbs.)
Field cured - baled	11.7	4.6	16.7	22.5	37.4
Barn cured - baled	11.6	13.3	20.7	18.2	37.7
Field cured - loose	10.3	3.3	20.0	18.0	36.0

* protein and Carotene analysis determined at time of feeding trial.

** silage and grain were consumed at the same rate regardless of the type of hay being fed.

Table 2. Results of Trial 2 - Experiment A

Type of Hay	Protein Content % M. F. B. *	Carotene Content T mgs/lb. M. F. B. *	Hay Consumed per Cow Daily (lbs.)	Milk Produced per 100 lbs. of Hay Consumed**	Milk Produced per Cow Daily (lbs.)
Field cured-baled	14.8	3.2	20.0	20.6	45.8
Barn cured-baled	14.0	14.8	22.4	22.9	46.1
Field cured-loose	12.9	4.1	22.5	20.4	45.9

* protein and Carotene analysis determined at time of feeding trial.

** silage and grain were consumed at the same rate regardless of the type of hay being fed.

Table 3. Results of Trial 1 - Experiment B

Type of Hay	Protein Content % M. F. B. *	Carotene Content mgs/lb. M. F. B. *	Hay Consumed per Cow Daily (lbs.)	Milk Produced per 100 lbs. of Hay Consumed**	Milk Produced per Cow Daily (lbs.)
Field cured - baled	14.8	3.2	16.0	16.0	38.6
Field cured - chopped	13.9	3.1	15.8	23.4	37.0
Field cured - loose	12.9	4.1	16.5	16.5	38.3

* protein and Carotene analysis determined at time of feeding trial.

** silage and grain were consumed at the same rate regardless of the type of hay being fed.

* Analyses for protein and carotene conducted by Nutrition Dept., O. A. C.

Trial #2. This feeding trial was conducted during the winter of 1954 using hay harvested in the summer of 1953. The hay used in this trial was from new seeding and was composed of 70% legume and 30% grass. The barn cured-baled hay was stored without having been exposed to rain. The other types of hay received a heavy rain when it was almost ready for storing and as a consequence a period of five days elapsed before these hays were stored.

The design of this feeding trial was the same as in trial #1 excepting that only six cows were used and the trial was conducted for a period of six weeks. Due to a shortage of cows and time these changes in the design were necessary. The cows consumed 30 lbs. of corn silage and 11.8 lbs. of concentrate daily (the same concentrate mixture as fed in trial #1) on the average regardless of the type of hay being fed.

Table #2 presents a summary of the results of this trial along with the analytical data on the hay. The cows produced .3 lbs. and .2 lbs. of milk per cow per day more while on the barn cured-baled hay than while being fed the field cured-baled and the field cured-loose hay respectively. Production on the field cured-loose hay was .1 lbs. of milk per cow per day greater than that on the field cured baled hay. These differences are not statistically significant.

Experiment B

Trial #1. This feeding trial involved the following three types of field cured hay: baled; loose, (harvested with hay loader); and chopped, (harvested with a forage harvester). These hays were taken from the same field and harvested at the same time as the hays used in trial #2 of experiment A. The design of this trial which was conducted in the early winter of 1954 was the same as in experiment A trial 1, with twelve cows, (nine Holsteins and three Ayrshires) being used over a period of nine weeks. Silage was consumed at the rate of 28 lbs. per cow per day and 16% daily concentrate at the rate of 12 lbs. per cow daily, (on the average), regardless of the type of hay being fed.

The field cured-baled hay was superior to the other two types although the differences were not statistically significant. The cows produced 1.6 and .3 pounds of milk per day more on the field cured-baled hay than when fed the chopped and loose hays respectively. Production on the loose hay was greater than that on the chopped hay by 1.3 pounds of milk per cow daily. The cows consumed on the average less chopped hay than either of the other two types.

There was no significant decrease in the butterfat test of the cows on the chopped hay when compared with the other two types of hay. It may be reasoned that the chopped hay fed in this trial was too long (4-5 inches) to cause a drop in butterfat test as reported by other investigators when feeding chopped hay.

Summary:

1. In all three feeding trials the difference obtained in terms of pounds of milk production on the different hays were not statistically significant.

2. The differences between the protein contents of the hays at time of feeding do not appear to account for the differences in terms of pounds of milk.

3. It is realized that a very adequate amount of silage and grain was fed to the cows on test, however, it was fashioned after recommended feeding practices as carried out on the average dairy farm.

4. The production on barn cured-baled hay was greater than that on field cured-baled hay in both experiments. Production on field cured-baled hay was greater than that of field cured-loose hay in two of the three trials.

5. Consumption of field cured-baled hay was less than that of field cured-loose hay in all three feeding trials and less than the barn cured-baled hay in both trials where a comparison could be made. The cows consumed a smaller quantity of the field cured-chopped hay than they did of any of the other three types.

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31. The Effect of Mow Drying Hay from Different Moisture Contents on Nutritive Value

Kennedy, W. O., Stringam, E. W. (Animal Husbandry)

R. P. O. An. Husb. 7

Objectives: The object of this project was to investigate the comparative nutritional value of five batches of hay brought into the mow dryer at different moisture content.

Procedure: The hay for this project was cut on July 9th, 1953. It was a mixture of alfalfa - 6 pounds, red clover - 4 pounds, timothy - 2 pounds, orchard - 3 pounds, brome - 5 pounds and ladino - 1 pound, and was the first cutting from new seeding. This was a very heavy catch with the hay being coarse due to heavy fertilizing.

The first batch was raked and baled on July 10th and had a moisture content of between 55 to 60 per cent. This was placed on the dryer on July 10th and all of the air from the fan was directed through the catch. Care was taken to pack the hay so that there was as little leakage of air as possible.

The second batch was raked and baled on July 11th and was put on the dryer at a moisture content of between 35 to 40 per cent. This was extremely well packed and again all of the air from that fan was directed through these two batches. Unfortunately, we had rain on the rest of the hay and it discoloured it quite a lot. The third batch was raked and placed on the dryer at 25 to 30 per cent moisture on July 13th, and the fourth lot was put on the dryer at 21 per cent moisture.

The fifth batch was field cured and was placed in the barn at about 18 per cent moisture.

Results: The results of this work up to the time of taking these lots off the dryer were wholly observational. The observations made were:-

1. The 55 to 60 per cent moisture barn cured hay was very heavy to handle with manual labour and required nearly twice the labour to load in the field and store on the dryer.
2. The 35 to 40 per cent also required extra labour.
3. It was necessary to operate the fan several days longer on the hay of 55 to 60 per cent moisture than on the hay of 35 to 40 per cent moisture.
4. All of this hay dried very well with only one bale being mouldy in the first group.
5. The 55 to 60 per cent moisture hay was surprisingly good in quality.

Other observations were that the 25 to 30 per cent hay retained its leaf almost as well as the 55 to 60 per cent hay, although it had .5 inches of rain. This hay was scored on our score card and the following scores were made:

A - 90%
B - 88%
C - 85%)
D - 82%) These three had the .5 inches of rain and were scored
E - 80%) lower in colour and aroma.

Samples of these have been taken to the Department of Nutrition for chemical analysis.

Feeding Trial: The second part of this project is the feeding trial of this hay to sixty Western Lambs.

Procedure: The five samples of hay were fed to ten lots, each of six lambs, each sample or treatment being thereby replicated. The lambs were first allocated to five average groups on a weight basis and each group was then split with the six lighter lambs in one group and the six heavy lambs in the replicate. Each replicate contained 4 wether lambs and 2 ewe lambs.

Hay from each sample was fed adlibitum, as much as each lot would clean up in a day, and was carefully weighed into each feed. Grain was fed at the rate of 1.4 lbs. per lamb per day in two feeds. The lambs were weighed at the beginning and end of the trial and throughout the period.

Results:

	Lot I (Control) Hay 18% Moisture	Lot II Mow Cured Hay 21% Moisture	Lot III Mow Cured Hay 25-30% Moisture	Lot IV Mow Cured Hay 35-40% Moisture	Lot V Mow Cured Hay 55-60% Moisture
Average Daily Gain	.334	.332	.336	.335	.344
Hay Consumed Daily Per Lamb	7.54	8.31	8.40	8.12	8.33
Hay Per lb. Gain	3.76	4.12	4.18	3.82	4.10

No significant difference was observed in the average daily gain between treatments.

The same story was apparent in the consumption of hay per day per lamb. The average differences shown in the table were not significant. Efficiency of hay conversion presents a similar picture. In analysis it was found that in both of the latter cases the replicate of heavier lambs ate less per day and used hay more efficiently than the lighter lambs as there was a highly significant difference between replicates for both of these items.

Very little waste was noted in the hay fed, also the hay with 50 to 60 per cent had a slight burnt odour to it.

DEPARTMENT OF PUBLIC RELATIONS

J.D. MACLACHLAN, B.A., A.M., PH.D.
PRESIDENT

GUELPH, CANADA

Extension Release

May 1953

THE ECONOMICS OF BARN-DRYING HAY

(This extension circular is to be of limited circulation in order to prevent misinterpretation of the findings of one year's research)

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Guelph Canada.

This circular is intended to be no more than a progress report which may be of some guidance to farmers who are considering the installation of a barn-drier. It is based on only one year of investigation (1952) and may therefore be subject to change as information from 1953 and subsequent years is obtained.

Appreciation is expressed to 26 farmers who provided information as to costs of constructing and operating 31 barn-driers used in 1952. It is believed that most, though not all, of the driers used in Ontario in 1952 were included.

Appreciation is also expressed for the co-operation of the Departments of Agricultural Engineering, Animal Husbandry, and Nutrition at O.A.C., and those concerned at Ridgetown, Kemptville, and New Liskeard.

TYPES OF BARN DRIERS

The main types of barn driers are appraised as to advantages and disadvantages discovered in 1952. Details of construction are to be found in Circular 113, or obtained from the Department of Agricultural Engineering, O.A.C.

1. SLATTED FLOOR. Of the 31 farmer-owned driers, 12 were Slatted Floors, and of these, 7 used baled hay, 4 used chopped, and 1 used long hay. Advantages claimed were that spoilage was limited and quality was high. One farmer dried 6000 bales, indicating that with the proper fan and power unit, capacity is high.

Disadvantages are that the bales are heavy to place in the mow. A bale of dry hay (20% moisture) weighing 50 lbs. becomes 67 lbs. when the moisture content is 40%. Making looser bales reduces the weight but makes them more likely to fall apart after drying. Constructing the slatted floor in sections makes it easier to remove the hay from a large mow because the sections may be stacked as uncovered during feeding.

2. CENTRAL DUCT. Of the 31 farmer-owned driers, 12 were Central Ducts, and all 12 used chopped hay. The ducts were rectangular or triangular and covered with slats or wire mesh. This system is relatively cheap and easy to construct.

The chief disadvantage is a tendency to have some spoilage directly over the duct. The hay is usually blown in through a window or door at the end of the duct, and the heavy material tends to pack over the duct. Also air escapes more easily by flowing along the stems of hay which lie horizontally, and thus the air is more likely to flow horizontally to the edges of the mow than rise directly above the duct. Attempts to meet these disadvantages have been by blowing the chopped hay at the roof or by putting someone at the hood in order to distribute the hay more evenly. However it may be hard to find an extra person during haying season. Many maintain that walking over the hay to distribute it by fork as required results in spoiled pieces where packed by the feet.

Another disadvantage is that the duct must be covered by hay before drying can be begun. Thus there may be packing and some heating at floor-level especially if there is any delay in filling up the mow.

Removing the hay from the mow during the feeding period may be complicated by the large duct which usually is placed down the centre of the mow. This disadvantage may be partially overcome by constructing the duct in sections which can be removed as convenient during the winter.

3. Flue System

Of the 31 farmer-owned driers, 6 were flues, and all used chopped hay. Advantages claimed are the small amounts of spoilage and the large capacity which reduces cost per ton. The chief disadvantage is the extra construction cost and the labour of moving the flue-formers periodically

4. Variations in driers

(a) Lateral Ducts - There was one such system.

(b) Hot air - At the Ridgetown Agricultural School, a Seed Corn Drier was used to provide supplementary heat. This system would be feasible only for those who already have a drier or who might have a lucrative market for large quantities of barn-dried hay.

A portable Drier using heat was in operation for demonstration purposes during Farmers' Week at O. A. C. and at New Liskeard, but no records could be taken. Its disadvantages are that as it is used outside the barn, the hay must be piled on it, dried and then put in the barn, which involves considerable labour; the bales are likely to disintegrate with all this handling, especially after drying; the whole system is outside and vulnerable to weather; it is limited to about 10 tons to be dried in a 10 - 12 hour period.

The greatest advantage of using heated air is being free from dependence on favourable drying weather. Also more hay can be dried for any given size of motor when heated air is used.

(c) Slatted floor (of fence rails) and central duct (of bales) - One system which seemed to be satisfactory in spite of the fact that there was practically no cost of installation, dried about 4500 round bales. These bales were laid so as to make the walls of the duct, with planks and rails thrown across for ceiling. The inner rows of bales were placed on fence rails to allow the air to move toward the edge of the mow as in a slatted floor system. The two outside rows of bales were on the floor itself.

(d) Slatted floor of fence rails, no central duct - This was a small system using a centrifugal-type fan and a 2HP electric motor to drive air via a tin duct (about 8" high) into the mow. The outside two rows of bales were placed on the floor, the remainder on fence rails in order to allow circulation of air. This produced excellent hay at negligible cost.

POWER UNITS

Of the 34 farmer-owned power units studied, 19 were electric motors, 8 were gasoline motors, and 7 were tractors. There seemed to be more difficulty with power units in 1952 than with any other part of the installation - this may have been a coincidence or the power required may have been under-estimated. Whatever the cause, failure of the power unit when one has a mow full of green hay is a serious matter. Tractors operated satisfactorily, but of course, were unable to be used in the fields at the same time. Some farmers put their tractors on the fan in late afternoon, poured in enough has to last for six or eight hours and let them run. This utilized the tractor at a convenient time but had the disadvantage of operating at a time when the air blown through the system was more cool and moist and therefore less able to dry the hay.

Electric motors have the advantage of convenient housing within the barn, safety switches, and low operating costs, but have the disadvantage of fairly heavy initial cost and the possibility of an expensive programme of re-wiring with heavier wire.

Stationary internal combustion engines require no wiring but have high initial and operating costs. Danger of fire is fairly well overcome by leading the exhaust to a pail or milk-can some distance from the barn. See circular 113 for details as to power units and requirements.

FANS

Fans were either propeller type, usually purchased new; or centrifugal, always purchased second-hand. Centrifugal fans are quiet and efficient and can sometimes be purchased cheaply from city factories which are altering their ventilation systems. See Circular 113 for details as to desirable fans.

COSTS OF BARN DRYING

1. Investment in motors and fans (plus pulleys etc.) as valued by farmers.

	Number Used	Average Value	Range in Value
Electric Motors (5 H P)	16	$ 296.00	$ 150.00 - $ 385.00
Extra Electric Wiring	11	270.00	50.00 - 500.00
Gas and Diesel Stationary Motors	8	709.00	300.00 - 977.00
36" Prop. Fan	17	263.00	130.00 - 329.00
42" Prop. Fan	10	319.00	260.00 - 382.00
Centrifugal Fan	6	86.00	25.00 - 120.00

There were 3 electric motors in addition to the 16 of 5 HP; and one 48" propeller fan.

2. Fixed Charges. Rates of depreciation, repairs and interest charged in calculating the annual fixed charges:

	Depreciation	Repairs	Interest
Drier System	7%	3%	4.5%
Power Unit	5%	1%	4.5%
Fan	3%	1%	4.5%
Wiring and Controls	5%	2%	4.5%

In addition $5.00 as a flat fee for housing was charged for each permanent system. Whenever the power unit or any other equipment was used for other work, the charge to barn-drying was pro-rated.

3. Operating Charges. Operating charges consisted of electricity or gasoline consumed and were taken at the "going" rate, and of extra labour as in those cases where an extra man was stationed at the hood of the blower-pipe. Further labour involved in handling the hay (due to extra weight) was not included. Thus operating expenses may be too low.

4. Costs by different sizes of driers.

Size of Drier	Average No. of tons	Fixed Cost per ton	Operating Cost per ton	Total Cost per ton
Small	32	$2.62	$1.02	$3.64
Medium	73	1.41	.64	2.05
Large	161	1.14	.40	1.54

It is obvious that increasing size results in decreasing costs per ton. This is further brought out by the line AB in the diagram on page 8.

BENEFITS OF BARN-DRYING

1. Less Exposure to Weather. The value of nutrients lost from rain damage is difficult to estimate, but we can estimate the proportion of June-cut hay likely to be rain damaged. Over the 20 years 1932-51 there were 600 June days: at Guelph 86 of these June days, or 14% had rain* the following day; 11% had one day clear before the next rain; 9% had two days clear; 8% had three days; and 58% had more than three days before the next rain. If we assume that three days are required between cutting and storing and that equal amounts of hay are cut every day, 42% of the June-cut hay over the past 20 years would have been rained upon.

*"Rain" includes only days with greater than .2 inches precipitation.

2. Time Saved. Barn drying may save time by making the haying operations more flexible. Without a drier one can haul in hay only when it is "fit"; with a drier one can start earlier in the morning and work later, depending on the drier to take out the extra moisture. While most authorities advocate that hay for the drier should be drawn in at about 40% moisture (20% is safe for field-cured hay) a practical farmer will use that ideal only as a near-maximum. What comes in early in the morning may be 40-45%, by noon it may be 35% and by mid-afternoon it may be 25% or lower depending on the day. Cutting hay early in the season and hauling it in as rapidly and as soon as possible are of higher priority than having precisely the recommended moisture content.

3. Hay recovered. Field-cured hay is subject to considerable loss of leaves - the most valuable part of the hay - because it must be stored at a moisture content of 20%, whereas hay with a higher moisture content retains the leaves. At the O.A.C. side-by-side swaths were baled as field-cured and barn-dried hay. The bales from each swath were marked and the areas measured carefully. Some months later all bales were weighed. The recovery per acre through barn-drying was an extra 200 lbs. or about 5% of the hay.

4. Nutrition Analyses:

Marked bales from these two swaths were retrieved from the mow after storage for nine months and samples from these bales were analysed for protein and carotene by the Department of Nutrition. The results are shown below, the figure representing the average of the analyses on six bales in each case.

	% Protein	Carotene Milligrams per lb.
Barn-dried	11.6	13.3
Field-cured	11.7	4.6

These results, on a moisture-free or dry-matter basis, indicate no difference in protein retention in this particular trial, but do show less loss of carotene in the barn-drying than in the field-curing.

Bales on one farmer's large slatted-floor system were sampled and tagged as they were being placed in the mow. The same bales were retrieved and analysed in February 1953. The results show that little or no protein had been lost. The average protein content of samples from six bales when placed in the mow, was 15.4% of the dry matter, and the average protein content of samples from the same bales in February was 15.1% of the dry matter.

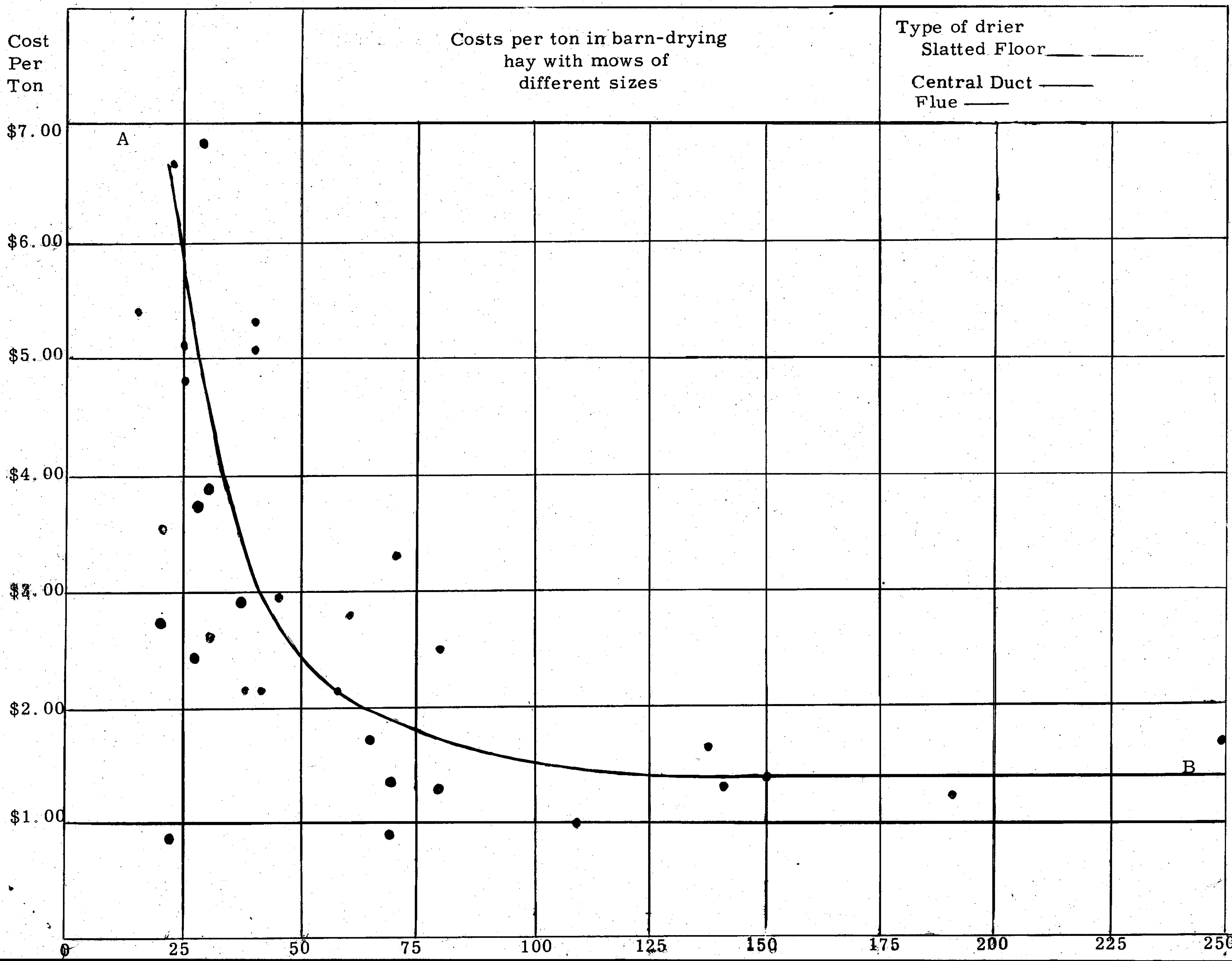
5. Farmers' Opinions. In February 1953, a questionnaire was mailed to the 26 farmers whose costs had been obtained during the previous summer. Twenty farmers replied indicating that in general they were quite satisfied with their barn-dried hay. Seven of the twenty stated that if they had it to do over again, they would change their systems: two were dissatisfied with their power units; one would expand his capacity; and four intended modifications in favour of flues. Of these four, three had central duct systems and one a central duct with laterals.

6. Feeding-test on Dairy Cows. The Department of Animal Husbandry, O.A.C., ran a full-scale feeding test on twelve dairy cows in the winter and spring of 1953. These cows were matched in three groups of four cows each, each group being about the same as to average age, weight, stage of lactation, stage of gestation, and previous production. Each group was fed grain (1 lb. grain to 4 lbs. milk), silage, and hay. The hay fed was

(a) barn-dried baled,
(b) field-cured baled and
(c) long loose hay.

All this hay had been taken from the same field and cut the same day. The feeding of hay was rotated to provide a sound comparison of results, and the cows were fed all they could eat. Unfortunately this hay was cut rather late in the season and was not of as high a quality as might be desired.

The results of this test have not yet been analysed. A similar test is to be conducted next year when, it is felt, two years' results will provide more reliable information as to the actual feeding value of barn-dried hay.


Cost
Per
Ton
Costs per ton in barn-drying
hay with mows of
different sizes
Type of drier
Slatted Floor
Central Duct
Flue
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
A
B
0
25
50
75
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125
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175
200
225
250