LINCOLN COLLEGE

(CANTERBURY AGRICULTURAL COLLEGE)

School of Agriculture

University of New Zealand

INVESTIGATIONS into the Production of SUBTERANNEAN-CLOVER PASTURES on Ashley Dene 1939-1946

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1. INTRODUCTION

Prior to the commencement of this investigation subterranean clover was used to a very limited extent as a pasture plant in New Zealand. The clover had been recorded in various districts but was regarded more as one of the volunteer weed clovers than as a useful pasture plant.

Following the outstanding success which accompanied the discovery of suitable methods of management of pastures of subterranean clover in Australia a few farmers in New Zealand and some in Canterbury had imported seed from Australia and tried it out as early as 1930. Up to 1935 many pastures were sown with Australian seed. But because of lack of knowledge of the management of the clover under New Zealand conditions, many failures were recorded and farmers were losing interest in it. The first published record of its successful use as a pasture plant in New Zealand was by Hewlett and Neave in 1937 (1). These authorities recommended allowing it to flower freely in the first season and giving annual application of superphosphate. Professor E. R. Hudson was primarily responsible for the enthusiastic expansion in the use of subterranean clover from 1937 onwards. He had had considerable experience with the clover in Australia and after studying the soil and climatic conditions in Canterbury was confident that it could be used with advantage on much of the light land. The College owns "Ashley Dene," a farm of 878 acres of light land near Burnham. The development of this farm through the extensive use of subterranean clover pastures over a period of ten years has been recorded by R. H. Bevin (2).

In the first year of the work it was realised that many problems would arise concerning the fertiliser requirement and the grazing management of subterranean clover pastures. In order to be able to answer some of these problems an investigation was planned. The Department of Scientific and Industrial Research provided the initial cost and met the annual costs of the investigation; the College provided the land and supervised the work.

As the work progressed the results of the investigation have been made known to the farming community through field days, lectures to farmers, radio broadcasts, newspaper articles and articles in publications circulating among farmers. The practices relating to the quantities of lime and superphosphate which have been adopted on the

Ashley Dene farm and described by Bevin (1) were based largely on the early results of the work. The success which has followed the use of pastures of subterranean clover in Canterbury can, in some measure, be credited to the results of the investigation.

11. THE PRESENT INVESTIGATION

The system of farming on the light plains land is based on a ewe flock producing wool and lambs. A proportion of the lambs are fattened off the mothers and the balance are fattened on specially grown crops, generally rape, or sold as "stores." Southdown rams are used on halfbred or Corriedale ewes. In this investigation it was decided to measure the production of the new subterranean clover pasture by means of the grazing animal. So that ewe lambs could be kept to maintain the ewe flock over a period of years a line of Corriedale ewes put to Corriedale rams was used.

Grazing management was designed to utilise as completely as possible all herbage produced. The fertiliser treatments were replicated six times and this permitted a system of controlled grazing based on the amount of herbage on each replicate and on the thrift of the sheep.

The productivity of the different fertiliser treatments was measured in terms of live weight of the sheep, in weight of wool produced and in terms of carrying capacity.

The field chosen for the investigation was a block of 80 acres of old pasture, run out to hair grass *(Vulpia bromoides)*, sorrel *(Rumex acetosella)*, catsear *(Hypochaeris radicata)*, and other low-fertility weeds. In February, 1937, the surface was lightly scuffled and subterranean clover introduced by drilling four pounds of seed with one cwt. of superphosphate on the scuffled surface. A satisfactory re-establishment occurred by February, 1938. Although the clover had not formed a complete cover it was uniformly distributed over the whole area and was considered suitable for the purpose of the investigation.

1. OBJECTIVES

(A) The primary objective was to investigate the differential effect of fertiliser treatments applied to subterranean clover pastures on

(a) the live weight increase of a self-maintaining flock of Corriedale ewes producing lambs on each of the four treatments.

(b) the weight of wool produced by each of the four flocks.
(c) the carrying capacity in terms of ewes, producing lambs, per acre.

(B) A second objective was to provide conditions for the development of any cumulative effect of prolonged feeding on subterranean-clover herbage on succeeding generations of sheep.

(C) A third objective was to examine, in the light of variations in seasonal production, the problem of feed supply for ewes fed entirely on subterranean clover pastures.

2. SOIL AND CLIMATE

The Ashley Dene farm is situated on the north side of the Selwyn River about six miles west of Springston, two miles north-west of Ellesmere and three miles south-east of Burnham. The soil type on the area is typical light plains land of low carrying capacity, ranging from three-quarters to one ewe per acre under the common system of farming practised.

Mr C. S. Harris, Senior Pedologist of the Soil Bureau of the Department of Scientific and Industrial Research has surveyed the area and classified it as follows:

"The greater part is very nearly flat, with a slight fall towards the sea. A line drawn from the north west corner of B1 to the south east corner of C6 gives a rough division of the plots into two soil types. Eighty per cent. of the area lies to the north of this line and consists of Eyre shallow stony loam, while twenty per cent. lies to the south and consists of Springston shallow stony loam.

"(1) Eyre shallow stony loam is almost flat but has several slight depressions ('dongas') lightly etched into the surface. These 'dongas' retain moisture a little better than their surroundings. The profile is:

4 inches light brown stony silt loam
1 inch to 5 inches bright orange yellow, stony silt loam on greywacke stones.

Some profiles are an inch or two deeper than this and some a little shallower, but the above can be taken as an average. It is probable that before settlement the topsoil was much deeper and that losses by wind erosion have occurred since farming commenced. Plot B1 has in places only two inches of topsoil.

In Canterbury there are 80 square miles of this soil type, much of which has been eroded, but addition of

closely related types probably requiring the same manurial treatment, brings the total to over 100 square miles. Until further research is carried out it is impossible to say whether the Burnham (Lismore soil series) type of land, which occupies about 250 square miles of Canterbury, also requires the same treatment.

(2) Springston shallow stony loam lies slightly below the general level of the Eyre type. A deep donga cuts across plots D5 and A5 and the surface as a whole is less even than that of Eyre. The profile is:—

4 inches dull grey stony silt loam

2 inches to 4 inches pale greyish-yellow to ash grey stony silt loam, iron mottled in places, on greywacke stones.

Moisture retention is patchy due to the uneven surface but as a whole the Springston stony silt loam retains moisture in winter and dries out more slowly in the summer. There is very little of it in Canterbury."

The soils are generally shallow, overlying a shingle subsoil with the shingle coming to the surface in many places. As a result the soils dry out very easily in dry weather. The country is good, dry sheep land and is usually run in large blocks of about 1000 acres.

The amount and distribution of rainfall is the most important climatic factor determining pasture growth. Table 1 shows the monthly rainfall during the course of the investigation and the mean monthly rainfall for the Ashley Dene farm over the period of the investigation.

TABLE 1

Monthly Rainfall at Ashley Dene for the Seasons 1939-1946 and mean monthly rainfall.

	1939	1940	1941	1942	1943	1944	1945	1946	Avge.
January	0.50	4.02	1.24	2.19	2.34	0.87	1.80	1.31	1.78
February	0.63	1.57	1.60	1.32	3.04	3.72	2.50	1.07	1.92
March	1.14	0.91	5.15	1.99	1.98	1.26	1.47	1.25	1.89
April	0.33	3.31	2.78	0.72	0.52	3.21	1.15	1.34	1.67
May	1.35	6.10	1.72	7.02	1.34	5.41	5.19	5.76	4.25
June	1.71	1.10	3.09	0.36	5.84	1.55	1.50	4.69	2.48
July	4.47	2.11	0.93	2.34	1.64	2.11	2.73	1.21	2.19
August	3.31	0.93	9.31	0.98	1.74	1.44	4.61	2.22	3.07
September	1.16	4.91	2.19	1.73	4.52	2.03	1.12	4.75	2.80
October	0.92	0.78	1.35	1.76	2.14	1.71	2.80	3.20	1.83
November	1.63	1.64	0.74	1.89	0.72	2.39	0.75	3.17	1.62
December	5.65	0.68	1.74	1.57	0.34	5.61	4.78	1.48	2.73
Total inches	22.80	28.06	31.84	23.95	26.16	31.31	30.40	31.45	28.23

Another climatic factor which influences production is the prevalence in the late spring and early summer (October to December) of hot dry winds from the north-west, lasting for weeks on end in some seasons. These winds reduce the effectiveness of spring rains and may dry up the herbage over a period of two or three days.

3. THE CHARACTERISTICS OF THE PASTURE ON THE EXPERIMENTAL AREA DURING THE COURSE OF THE INVESTIGATION.

Subterranean clover was the main constituent of the pastures. The plant is a winter annual which germinates in the autumn, normally survives the winter and starts to flower in early October. Seeds are produced by mid-November and as the seed ripens the seed heads are normally pushed down into the surface soil. With good moisture-conditions in the soil, flowering and seeding will continue throughout the summer and early autumn. With the advent of dry weather the plants dry off and the seed lies dormant in the soil. It germinates readily when the surface soil becomes moist. Early autumn rains will therefore ensure a good establishment before the winter while late autumn rains result in late establishment with risk of loss by frost-lift and poor growth in the winter. Spring rains are also important in promoting vigorous growth as the temperature rises. With adequate moisture, maximum growth occurs in October and early November. Thereafter the clover begins to dry off—rapidly or slowly according to the rainfall and to the incidence of nor'-west winds. The dried-off herbage provides good milk-producing and fattening feed but much is lost through the trampling of the brittle leaves. As a result, the amount of feed is lessened. When the rainfall is light in the spring months (August and September), growth in October and November is restricted.

The behaviour of the pastures in the different seasons is outlined below:

1st Grazing Season (August 1939-February 1940)

The very dry autumn and spring of 1939 were unfavourable to the establishment and growth of the subterranean clover. The grazing of the plots was commenced in August 1939. During the early spring a strong growth of hair grass *(Vulpia bromoides)* developed and a mob of hoggets was brought in to help eat this down. They were grazed from September 9th to October 9th. By the end of

December the ewes and lambs had bared the herbage and a chaff supplement of 1lb per day for each ewe and ½lb per day for each lamb was fed till mid-February.

2nd Grazing Season (March 1940-February 1941)

A fair strike of clover had established in the autumn though it was too late to provide any appreciable quantity of feed during the winter. The ewes and hoggets were wintered off the experimental area. They were returned to the plots on August 6th. By the middle of September the growth was beginning to get ahead of the sheep and one block (Block VI) was shut up at the beginning of October, the intention being to cut this for hay. During October there was as much as three to four inches of dense herbage on the grazed plots. In early November a prolonged period of hot dry nor'-west winds dried off the herbage. The sheep subsisted on this natural hay from mid-November to the end of March. There was very little rain over the period. The block intended for hay was used for grazing. A good shower in February caused a strike of subterranean clover seedlings, many of which survived the subsequent dry period.

3rd Grazing Season (March 1941-February 1942)

A good soaking rain towards the end of March revived many of the plants which had germinated in February and promoted another dense strike of seedlings. However the rain came too late for good autumn establishment as a prerequisite to winter growth. As a result it was necessary to supplement the winter grazing with chaff for two months, in July and August. In the spring, following nine inches of rain in August, the growth of the clover was good and Block VI was again closed for hay. A crop of good quality hay was cut and baled in December, averaging one and a half tons per acre.

4th Grazing Season (March 1942-February 1943)

The autumn (1942) was very dry, especially in April when only 0.5 inches of rain fell and only a moderate establishment of clover resulted. The winter was mild and only half the hav saved was used. The rainfall in August was only .69 inches and the growth of herbage throughout the remainder of the season was affected by the late spring start. No hay was saved but a carry-over from the previous season ensured a supply of winter feed.

5th Grazing Season (March 1943-February 1944)

Following three inches of rain in February, the autumn establishment of clover was fair. Subsequent hot dry

weather resulted in the loss of a high proportion of seedlings. A later germination towards the end of March gave a fair cover for the winter. Feeding with hay commenced on June 5th and continued until August 15th. There was little growth on the plots. Following a relatively late spring growth of clover, heavy rains in September and early October caused abundant growth and Block VI was again shut up for hay. A light crop of good quality hay was cut and baled in December. Starting in early November a three months' drought ensued and the growth on the plots dried off.

6th Grazing Season (March 1944-February 1945)

The sixth grazing season was the best experienced in the course of the investigation. An excellent establishment of clover occurred following four inches of rain in February. Growth continued during March and April. A mild winter was experienced and a considerable bulk of herbage was produced on each of the treatments. As a result, for the first time it was possible to winter the ewes and hoggets on the experimental area without the aid of supplementary feed. Hay had been soved from Block VI but it was not necessary to use any of this. A good distribution of rain throughout the spring and early summer and the absence of the usual hot dry winds, maintained growth to the end of November. There was no need to save hay owing to a carry over from the past season and surplus growth was utilised by bringing in 500 hoggets which grazed BlocksI, II and III over a period of four weeks (October 19th to November 17th).

7th Grazing Season (March 1945-February 1946)

An excellent establishment of clover occurred in February following five inches of rain, with a further two inches in March. This season the method of measurement of production was changed to sheep-grazing-days. Dry ewes grazed the autumn growth from April to May. The plots were not grazed from June to September and from mid-October to mid-February (four months) they were grazed by ewe hoggets. Four inches of rain in August gave the clover an early start but September was very dry and delayed the commencement of spring grazing. A very dry November caused the herbage to dry off but a recovery occurred following four inches of rain in December. The latter half of January and early February were very dry and the hoggets grazed the available herbage reasonably bare.

8th Grazing Season (March 1946-November 1946

The eighth season was very good for growth. An excellent establishment occurred in February 1946, and was followed by a wet spring and early summer which produced a liberal supply of feed. This was grazed by hoggets until the end of November when the herbage dried off and the sheep were finally removed after shearing on November 29th.

This marks the end of the present investigation. The experimental area is now being used to investigate the place of special purpose pastures—cocksfoot, *Phalaris tuberosa,* alone and in combination with lucerne, perennial ryegrass and short rotation ryegrass, all in association with subterranean clover. The basis of measurement is carrying capacity in terms of grazing days under a system of grazing management judged suitable for the particular species.

4. DESIGN AND METHODS

A. THE DESIGN OF THE EXPERIMENT

The field was subdivided into 24 three-acre plots with roadways providing access to each plot. Four fertiliser treatments were selected for investigation and these were arranged in six randomised blocks (Fig. 1). Each plot was of three acres and water was laid on to each.

B. THE FERTILISER TREATMENTS

Experience in Australia had shown that applications of superphosphate were essential for the successful utilisation of subterranean clover as a pasture plant. The few growers who had pioneered the clover in Canterbury were also getting good results from superphosphate. Some were applying one cwt. per acre, others two cwt. per acre. Those who were not using fertiliser were getting very poor results. Lime was just beginning to be used on an increasing scale for pasture topdressing on the better class of land where red and white clover were the main legumes. The effect of lime on subterranean clover, particularly on the light plains land was unknown. Likewise no information was available on the effect of potash on light land.

The four fertilising treatments which were originally planned were designed to give (A) a light and (B) a heavy application of superphosphate, (C) a heavy application of superphosphate with lime and (D) a heavy application of superphosphate and lime with potash.

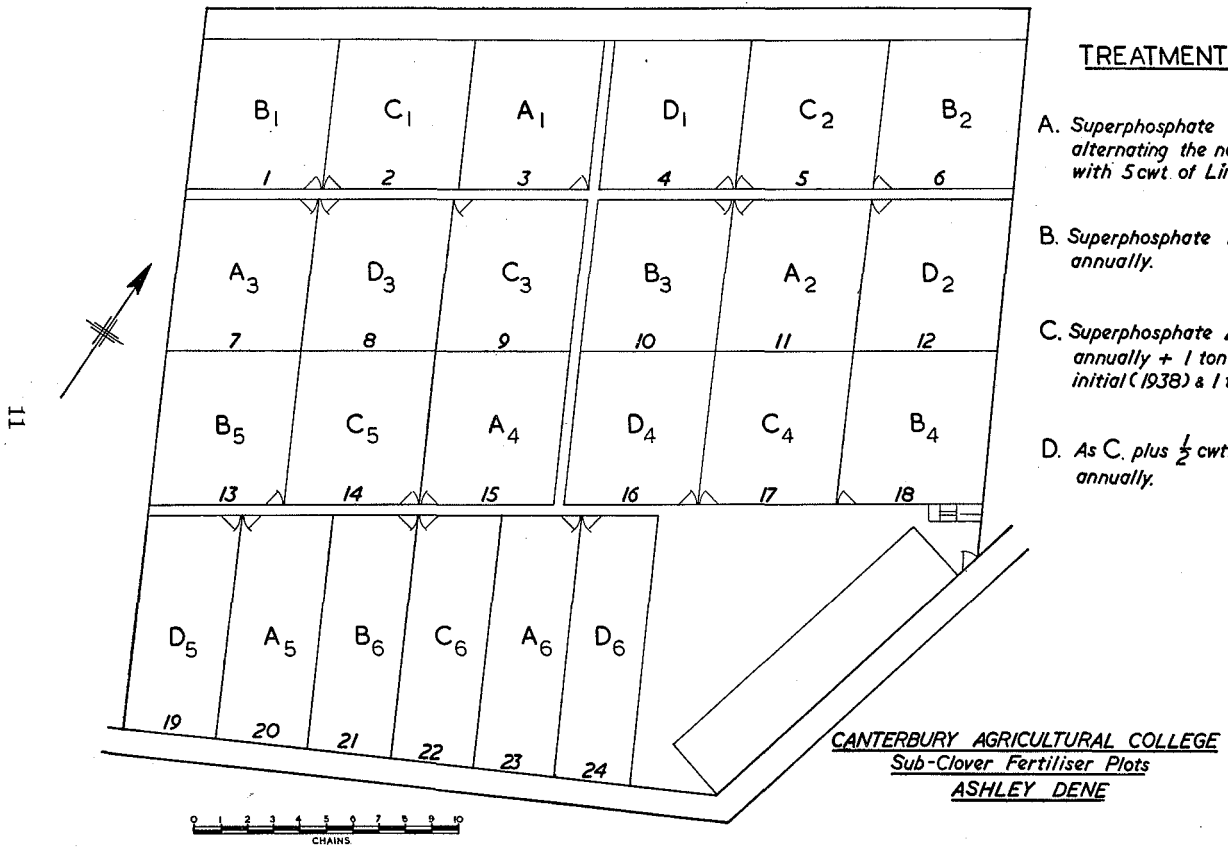


Fig. 1. The arrangement of the Four Fertiliser Treatments in Six Randomised Blocks.

A control treatment was not included as it was known that subterranean clover would not thrive in the absence of superphosphate. In a small trial on another area a control treatment was included and in this trial in the first four years, two cwt. of superphosphate resulted in an increased production of dry matter of about 37 per cent. whereas two cwt. of superphasphate plus one ton of lime (initial) gave an increase of about 62 per cent over control. This difference of 25 per cent between two cwt. of superphosphate without and with lime is similar to the difference of 27 per cent. recorded in Table XXVI. When comparisons are made throughout the text Treatment B (two cwt. of superphosphate annually) is used as the control and one may be justified in assuming that this treatment is about 37 per cent. better than no fertiliser treatment.

The treatments originally adopted were as follows:—

Treatment A.—Superphosphate, 1cwt. annually.

Treatment B.—Superphosphate, 2cwt. annually.

Treatment C.—Superphosphate, 2cwt. annually plus an initial dressing of 1 ton of lime per acre.

Treatment D.—Superphosphate, 2cwt. annually plus an initial dressing of 1 ton of lime per acre plus ½cwt. of 40% potash salts annually.

These fertilisers were first applied in February 1938. The growth during the following winter and spring periods was fair and the establishment of the clover was considered satisfactory enough to proceed with the subdivision fencing and with the water reticulation. To keep the herbage under control the whole field was grazed by a flock of ewes from August 1938 to February 1939.

In February 1939 the second annual application of fertiliser was applied with one modification of the original plan. The modification was introduced to Treatment A as a result of observations on an independent series of small plots where different fertilisers and lime, alone and in various combinations, had been applied. These plots showed that wherever lime and superphosphate were used together the clover grew much more vigorously in the first year of the application than when either was used alone. As a result Treatment A was altered from one cwt. of superphosphate annually to an application of one cwt. of super alternating yearly with five cwt. of lime. This is equivalent to an annual application of half a cwt. of superphosphate and two and one half cwt. of lime.

The four fertiliser treatments have been applied in the autumn of each year until 1946. The total quantities used, including the one cwt. of superphosphate drilled with the seed in 1937 are shown in Table II.

TABLE II.

The Quantity of Lime and Superphosphate Applied per acre to each of the four Treatments from 1937 to the Autumn of 1946

	Treatment A		Treat. B	Treatment C		Treatment D		
Year	Super	Lime	Super	Super	Lime	Super	Lime	Potash
1937	1 cwt.	—	1 cwt.	1 cwt.	—	1 cwt.	—	—
1938	1 cwt.	—	2 cwt.	2 cwt.	1 ton	2 cwt.	1 ton	½ cwt.
1939	—	5 cwt.	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1940	1 cwt.	—	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1941	—	5 cwt.	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1942	1 cwt.	—	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1943	—	5 cwt.	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1944	1 cwt.	—	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1945	—	5 cwt.	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
1946	1 cwt.	—	2 cwt.	2 cwt.	—	2 cwt.	—	½ cwt.
Total	6 cwt.	1 ton	19 cwt.	19 cwt.	1 ton	19 cwt.	1 ton	4½ cwt.

In the winter of 1946 the pH value of the soil on all the plots was determined to get some measure of the comparison between the effect of one ton of lime applied as an initial application eight years previously (Trial C) with one ton applied in four treatments of five cwt. per acre every second year (Treatment A) and with no direct application of lime (Treatment B). The results are presepted in Table III.

TABLE III

The pH value of the soil in each of the 3-acre plots as determined in the winter of 1946.

	Treatment A	Treatment B	Treatment C	Treatment D
Plot No. 1	5.54	5.27	5.44	5.68
„ „ 2	5.85	5.50	5.70	5.84
„ „ 3	5.87	5.48	5.62	5.70
„ „ 4	5.95	5.56	5.81	5.74
„ „ 5	5.68	5.57	5.84	6.01
„ „ 6	5.95	5.74	5.97	5.85
Average	5.806	5.523	5.73	5.803

Treatment A in which one ton of lime had been used in four applications of five cwts. per acre every second year, had a pH higher than Treatment B where no lime had been applied, and higher than Treatment C where one ton had been applied eight years previously. The pH of Treatment D was about equal to that of Treatment A but higher than that of Treatment C. It appears that the addition of potash has had the effect of maintaining the pH of the soil at a higher level than where no potash was used.

These results, associated with evidence discussed in Section 5A (C) or reduced superiority in production or Treatments C and D over that of Treatment A led to the decision to apply another one ton of lime per acre to Treatments C and D in the winter of 1946.

C. THE MANAGEMENT OF THE GRAZING ANIMALS

A flock of four-tooth Corriedale ewes was taken over for the investigation. The ewes were ear-tagged with temporary numbers and weighed at weekly intervals over a period of five months, from tupping in March to lambing in August.

Four separate flocks were then constituted on the basis of similar ewe weights and growth rates so that as far as possible all flocks were comparable.

The particulars of the four flocks when they were first put on the plots at the commencement of the first grazing season are shown in Table IV.

TABLE IV

The Average Weight of Ewes and Lambs and the Number in each flock at the commencement of the first grazing season in August, 1939.

Treatment	No. of Ewes	Avge. Weight in August	No. of Lambs	Avge. Weight in August
A	18	109.0 lb.	18	12.6 lb.
B	24	108.6 lb.	24	13.1 lb.
C	30	108.4 lb.	33	11.7 lb.
D	30	106.9 lb.	31	12.4 lb.

Permanent eartags were fitted in August 1939. They were lettered with the Treatment to which the ewe belonged, the year she was introduced to the Treatment and a number. Each flock was branded with a different colour.

As far as possible the sheep were managed as an ordinary ewe flock. Four rams were turned out each year with ewes in April. These were changed round twice a week to minimise variation due to heredity differences which the rams might possess. Lambing took place in

August and September. The lambs were ear-tagged and weighed at birth. The ewes and ewe hoggets were shorn in November and the weight of each fleece was recorded.

The wether lambs were cleared as soon as they reached a live weight of 75 pounds. All other lambs were weaned in December or January depending on the amount of feed available. The store wether lambs and cull ewe lambs were then cleared from the plots. The ewe lambs which were to be kept for maintenance of the ewe flock were fitted with permanent eartags. They were shorn towards the end of January and run as separate flocks of hoggets on their own treatments till after the mating rams had been out. They were then run with the ewe flocks.

D. MANAGEMENT OF THE GRAZING AND THE FEED SUPPLY

The grazing management of the pasture was designed as far as possible (i) to give complete utilisation of all herbage produced and (ii) to maintain the sheep on the herbage produced on the particular treatments.

The first aim was satisfactorily achieved. Owing to the fluctuation in seasonal growth there are periods when the sheep cannot cope with all growth—particularly in the spring months—and likewise there are periods when growth is inadequate for stock requirements. The surplus growth was dealt with in three ways:—

(a) In the second, third and fifth grazing seasons one of the replicated blocks was closed to provide a hay crop. The second season's crop was not cut owing to the advent of dry weather but the dried off herbage was utilised as deferred grazing. The third season's cut of hay provided supplementary feed for the two following winters. The fifth season's cut was not needed in the following winter and was held over.

(b) In almost every season one or more of the replicated blocks was saved for deferred grazing in the form of dried-off herbage.

(c) On two occasions, in the spring of the first grazing season when the hair grass content of the pasture was too high to justify saving a hay crop, and again in the sixth grazing season when a supply of hay carried over was in hand, surplus growth was controlled by grazing brought-in sheep for a month in mid-spring.

Those periods of the year when pasture growth was normally below stock requirements were met by three methods:

(i) By feeding chaff at one and a half pounds per acre per day in the first grazing season from December 24th to February 14th and again in the third grazing season from July 1st to August 20th.

(ii) In the second grazing season all sheep were removed from the plots and fed on the Ashley Dene farm from June 1st to August 1st.

(iii) In the fourth and fifth grazing seasons the ewes were wintered on subterranean clover hay produced on the particular treatment.

In the first three grazing seasons, i.e., in the development years before the clover had formed a dense cover, it was necessary to supplement the feed on all four Treatments from outside the Treatment, but in the last three seasons when the cover was complete and the seasons were favourable the plots provided adequate grazing and supplementary feed. In the sixth season there was an unusual surplus.

When considering the feed position at the beginning of each grazing season in relation to adjustment of stock numbers, the grazing season can conveniently be divided into four periods with the following characteristics:

Autumn (March, April, May)

The clover establishes in this period—early or late according to the rainfall. An early establishment is associated with high production during the growing season and vice versa. So far as autumn feed is concerned, ewe requirements are light at this period and there is usually little difficulty in maintaining live weights on the autumn growth or on dred off herbage carried over from the spring and summer period.

Winter (June, July, August)

This is normally a dormant period of growth and supplementary winter feed had to be provided in all except the sixth season. Hay produced on the plots was available in the last three seasons.

Spring (September, October, November)

This is the period of maximum growth. Usually the growth was greater than the sheep could cope with and the surplus was conserved as hay or as deferred grazing. At this season food requirements for ewes are high as they are supporting lambs. The sheep carried through the autumn and winter can usually be easily catered for in this period.

Summer (December, January, February)

The growth in this period is entirely dependent on summer rains. In dry seasons the lambs must be weaned early and in wet seasons they can be carried on till the end of January. After weaning, the feed requirements of the ewes are very small and care must be taken to prevent them from getting too fat.

E. THE ADJUSTMENT OF STOCK NUMBERS

One of the problems of the investigation was to adjust stock numbers on each treatment at the beginning of each season. The adjustment involved (a) an estimate of the feed position throughout the coming season (Ref.: Management of Grazing and Feed Supply) and (b) a study of the growth rates of the sheep in the previous season. It was possible to forecast fairly accurately the number of stock to be carried from the nature of the autumn establishment and the amount of winter feed available.

The average live-weight increase of all sheep grazed on the area during the six seasons is shown in Table V. This table indicates that the stock adjustments made in the different seasons resulted in variations in planes of nutrition—high in the second, third and sixth seasons and low in the first, fourth and fifth seasons. In all seasons it was at a reasonable level. The table also shows that, in a favourable season with the ewes on a high plane of nutrition, they will gain weight and make up for low weight-increase recorded when on a low plane of nutrition, e.g., the gain in weight of the ewes from the fifth to the sixth season of over 30 pounds per head.

The fifth grazing season provided the lowest plane of nutrition judging by the weight of the hoggets (105.6lb.) and the lambs (65.5lb.). The hoggets, however, were nearly as heavy as the original ewes with which the investigation started and the lambs were heavier than the first season's lambs (61.5lb.). By the sixth season the hoggets had increased to 148.9 lbs as two-tooth ewes, the lambs to 136.7lb as hoggets.

In addition to an assessment of the feed position the adjustment of sheep numbers on the different treatments involved a comparison of the thrift of the sheep. The adjustments which were made in each of the six grazing seasons are discussed below:—

First Grazing Season (August 1939-February 1940)

It was necessary to make the first estimate of the number of ewes the pastures would carry on an examination of

TABLE V.

(a) Average Live Weight Increase per head per year of all Ewes of different Ages in each of the Six Grazing Seasons.

(b) Average Live Weight of Lambs and Hoggets in each Season.

(c) Of all Sheep at the end of the Ewe Grazing Period in November, 1944.

	Ewes Original 108.2 lb.	Ewes 1939 Progeny	Ewes 1940 Progeny	Ewes 1941 Progeny	Ewes 1942 Progeny	Hoggets 1943 Progeny	Hoggets 1944 Progeny	Lambs	Ewe Hoggets
1st Season ending Feb., 1940	7.4 lb.	61.5 lb.	—	—	—	—	—	61.5 lb.	—
2nd „ „ „ 1941	26.4 lb.	60.6 lb.	74.6 lb.	—	—	—	—	74.6 lb.	122.1 lb.
3rd „ „ „ 1942	11.6 lb.	25.4 lb.	57.3 lb.	84.1 lb.	—	—	—	84.1 lb.	131.9 lb.
4th „ „ „ 1943	0.5 lb.	0.7 lb.	4.2 lb.	50.2 lb.	74.7 lb.	—	—	74.7 lb.	134.3 lb.
5th „ „ „ 1944	(Culled)	2.9 lb.	5.9 lb.	1.3 lb.	30.8 lb.	65.5 lb.	—	65.5 lb.	105.5 lb.
6th „ „ Nov., 1944	—	30.4 lb.	31.5 lb.	36.7 lb.	43.4 lb.	71.2 lb.	54.2 lb.	54.2 lb.	136.7 lb.
At termination of ewe grazing, Nov., 1944:									
Average Weight ..	153.1 lb.	181.5 lb.	173.5 lb	172.3 lb.	148.9 lb.	136.7 lb.	54.2 lb.		
Age in months (avge.)	—	63	51	39	27	15	3		

the pastures alone. The clover had not developed a complete cover and the autumn establishment was only fair. The number of ewes put on the four treatments and the live-weight increase of the ewes and lambs to the end of the grazing season (February 1940) are given in Table VI.

TABLE VI.

The Number of Ewes and the Average Live Weight Increase in each treatment in the first grazing season.

		No. of Ewes	Average Live Weight increase of Ewes	Average Live Weight increase of Lambs
Treatment	A	18	12.0 lb.	69.0 lb.
„	B	24	4.4 lb.	60.0 lb.
„	C	30	2.3 lb.	56.4 lb.
„	D	30	11.0 lb.	60.8 lb.

Second Grazing Season (March 1940-February 1941)

In the second grazing season ewe hoggets were available for addition to the flock. It was decided to add all that were available in order to build up the flock as quickly as possible with ewes bred on the treatment. The addition of the hoggets required some change in the relative numbers of ewes. In the first season Treatments B and C were apparently on a lower plane of nutrition than Treatments A and D. The number of ewe hoggets, the adjustment in ewe numbers and the consequent live weight changes on the different treatments are given in Table VII.

TABLE VII

The Number of Sheep on the four Treatments and the Average Live Weight Increase in the Second Season March 1940-February 1941)

		Original Ewes		1939 Progeny Hoggets		1940 Prog. Lambs
		Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.
Treatment	A	21 lb.	18	60.3 lb.	9	74 lb.
„	B	32.7 lb.	18	59.2 lb.	6	80.7 lb.
„	C	31.8 lb.	27	62.8 lb.	12	69.5 lb.
„	D	20.1 lb.	30	60.2 lb.	12	74.3 lb.

The Third Grazing Season (March 1941-February 1942)

In the second grazing season there were no striking variations in the plane of nutrition. For the third grazing season the proportion of sheep on the different treatments was kept approximately the same as for the second season except that, owing to the appearance of the herbage, A

and D were increased slightly over B and C. The number of the different classes of sheep on each treatment and the average live weight increases are given in Table VIII.

TABLE VIII.

The number of sheep on the four treatments and the average live weight increases in the third season (March 1941-February 1942)

	Original Ewes		1939 Progeny 2-Tooth		1940 Progeny Hoggets		1941 Prog. Lambs
Treatment	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.
A	10.7 lb.	14	18.3 lb.	9	54.7 lb.	8	83.4 lb.
B	16.7 lb.	12	31.6 lb.	6	65.4 lb.	6	87.8 lb.
C	10.2 lb.	14	29.0 lb.	10	56.0 lb.	12	84.8 lb.
D	9.0 lb.	22	22.8 lb.	12	53.1 lb.	12	80.4 lb.

The Fourth Grazing Season (March 1942-February 1943)

The results of the third season suggest that Treatment B was on a slightly higher plane of nutrition than the other three. The season promised to be a good one and stock numbers were increased, but during the season it was realised that an over-estimate had been made and some ewes were culled from each of the treatments. During the season ewes with poor teeth and those which were over fat, and later, those which were affected with pregnancy toxaemia were culled. When ewes were culled, the live-weight gained up to the time of culling was credited to the treatment. The number of ewes and the average live-weight increase are given in Table IX.

The Fifth Grazing Season (March 1943-February 1944)

In the fourth season though the plane of nutrition was obviously lower than in the past two seasons, the lambs and hoggets made good weights. Again the four treatments were on a reasonably similar plane. The autumn establishment was very late and a season of low production was predicted. Ewe numbers were considerably reduced. This coincided with the decision to cull all the original ewes which had produced four crops of lambs on the treatments. They were culled at the end of December 1942 after the lambs had been weaned. The number of sheep carried and their average live-weight increase in the fifth season are given in Table X.

TABLE IX

The number of sheep on the four treatments and the average live weight increases in the fourth season (March 1942-February 1943)

	Original Ewes		1939 Progeny 4-tooth		1940 Progeny 2-tooth		1941 Progeny Hoggets		1942 Prog. Lambs
	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.
Treatment A	1.6 lb.	14	2.4 lb.	9	7.3 lb.	8	51.6 lb.	13-12	75.4 lb.
„ B	-5.2 lb.	12-11*	1.3 lb.	6	2.5 lb.	6-5	47.5 lb.	6	75.5 lb.
„ C	2.8 lb.	14-13	2.8 lb.	10-8	5.5 lb.	12-9	49.2 lb.	10	78.1 lb.
„ D	-1.3 lb.	22-15	3.8 lb.	12-11	1.7 lb.	12-9	52.6 lb.	19-11	70.0 lb.

* In Tables IX, X and XI the two numbers signify that the season started with the first number which was reduced by culling to the second number during the season.

TABLE X

The number of sheep on the four treatments and the average live weight increase in the fifth season (March 1943-February 1944)

	6-Tooth 1939 Progeny		1940 Progeny 4-Tooth		1941 Progeny 2-Tooth		1942 Progeny Hoggets		1943 Progeny Lambs
	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.	No.	Av. L.W.I.
Treatment A	6.1 lb.	9	0.9 lb.	8	-10.6 lb.	11-6	26.7 lb.	15-14	63.5 lb.
„ B	-4.4 lb.	6	-5.4 lb.	5-4	-2.6 lb.	6-5	34.3 lb.	16	65.7 lb.
„ C	-1.8 lb.	8	13.2 lb.	10-9	6.0 lb.	10-8	32.6 lb.	14	64.3 lb.
„ D	11.8 lb.	11-9	15.0 lb.	9	12.5 lb.	11-9	29.8 lb.	15-13	68.5 lb.

TABLE XI

The number of sheep on the four treatments and the average live weight increase in the sixth season (March 1944-November 1944)

		1939 Progeny 8-th.		1940 Progeny 6-th.		1941 Progeny 4-th.		1942 Progeny 2-th.		1943 Progeny Hoggets		1944 Progeny Lambs
		Av. L.W.I	No.	Av. L.W.I	No.	Av. L.W.I	No.	Av. L.W.I	No.	Av. L.W.I	No.	Av. L.W.I.
Treatment	A	32.3 lb.	9	34.7 lb.	8-6	41.3 lb.	6	41.6 lb.	14–13	69.6 lb.	11	56.4 lb.
„	B	28.5 lb.	6-4	40.3 lb.	4-2	32.7 lb.	5–3	47.6 lb.	16–13	76.6 lb.	6	52.0 lb.
„	C	41.8 lb.	8-5	24.4 lb.	9-7	37.7 lb.	8	50.0 lb.	14–13	72.9 lb.	6	54.2 lb.
„	D	26.1 lb.	9-8	26.7 lb.	9-7	35.1 lb.	9–8	44.6 lb.	13	65.8 lb.	10–9	54.3 lb.

TABLE XII

The average live weight of lambs on each treatment in each of the six seasons, and their relative weight compared with treatment B=100

		1st Season		2nd Season		3rd Season		4th Season		5th Season		6th Season	
		Weight lb.	Relative B=100	Weight lb.	Relative B=100	Weight lb.	Relative B=100	Weight lb.	Relative to B=100	Weight lb.	Relative to B=100	Weight lb.	Relative to B-100
Treatment	A	69.0	115	74.0	92	83.4	95	75.4	100	63.5	97	56.4	109
„	B	60.0	100	80.7	100	87.7	100	75.5	100	65.7	100	52.0	100
„	C	56.4	94	69.5	86	84.8	97	78.1	103	64.3	98	54.2	104
„	D	60.8	107	74.3	92	80.4	92	70.0	93	68.5	104	54.3	104

The Sixth Grazing Season (March 1944-November 1944)

In the fifth grazing season the plane of nutrition was again low and all treatments were reasonably comparable. The autumn establishment in the sixth grazing season was the best experienced and a good cut of hay had been saved. As a result the ewe numbers were increased considerably over those of the fifth season. The numbers carried and the live weight increases are given in Table XI.

From an examination of the average live-weight increase of the ewes in each season, it will be clear that the adjustment of the sheep numbers so that each treatment provided a similar plane of nutrition was not achieved with precision. Nevertheless, in most seasons a reasonable degree of similarity was secured, as is shown in Table XII by the weight and growth rate of lambs.

5. RESULTS

A. LIVE-WEIGHT PRODUCTION

(A) The Live Weight of the Sheep

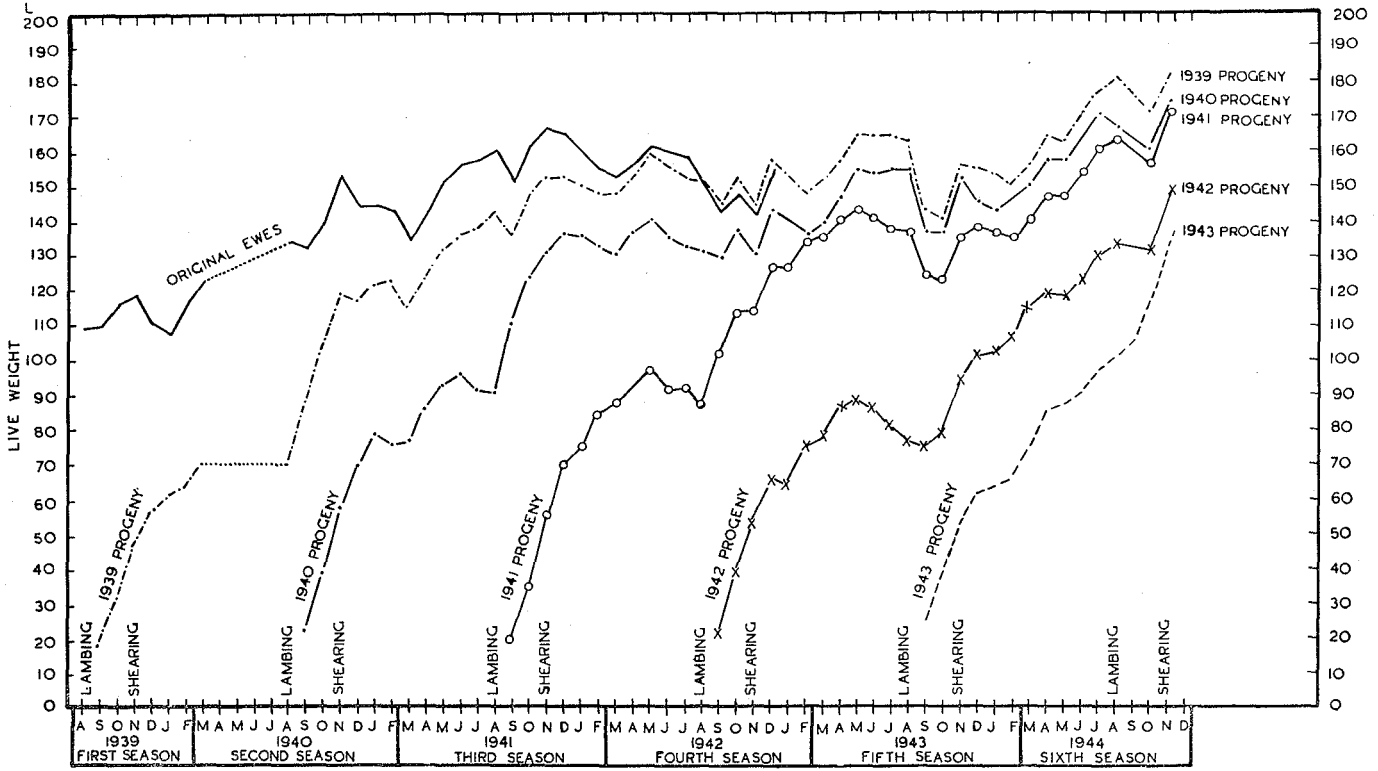
The sheep were weighed twice a month throughout the six grazing seasons and the average of the two weighings was recorded as the month's average weight. The monthly weights of each flock and the average weights of the different generations on each treatment are presented in the Appendix. The average weight of the different generations on the four treatments are also presented in the form of a growth curve in Graph (I) which shows the following features:—

(1) The original ewes which were taken over at an average weight of 109lb show a fluctuating increase in weight up to 165lb in November of their third grazing season. Thereafter a fluctuating fall in weight to approximately 154lb in December of their fourth grazing season. They were then removed from the experiment.

(2) The growth curves of the 1939, 1940 and 1941 progeny show that ewes bred on the treatment reached mature weight at three years of age when they approached their second lambing.

Thus the 1939 progeny caught up in weight to that of the original ewes (150lb) in August of their third grazing season when they were three years old. These sheep maintained the highest weights throughout the course of the experiment.

The 1940 progeny approached within 8lb of the 1939 progeny which now weighed 164lb in August of their third



GRAPH I

The Growth Curves of the Original Ewes and Five Successive Generations.

grazing season and maintained an average weight of about 8lb below them throughout the remainder of the investigation.

The 1941 progeny approached within 2lb of the 1940 progeny (166lb) in August of their third grazing season and caught up with them in December of that season.

(3) The growth curves also provide evidence that there was no apparent harmful effect on the growth of ewes reared on subterranean clover for four and five generations.

Thus the 1942 progeny were the fourth generation of ewes reared on the area and were two years and two months old when the ewes were removed from the investigation. They weighed approximately 149lb which compares favourably with the weight of the other generations at a similar age, e.g., 1939 progeny—152lb; 1940 progeny 130lb; 1940 progeny 136lb.

The 1943 progeny were the fifth generation of lambs reared on the area and all were from ewes reared on the area also. They were one year and two months old when they were removed from the investigation and had approached a weight of 137lb. This is the highest weight recorded for any of the generations of this age, the next highest being the 1940 progeny which weighed 136lb.

(4) The fluctuations in the growth curve in each season generally show two periods of rising live-weight and two periods of falling live-weight.

(a) The spring period of rise. This usually starts in September and continues through November or December. It follows immediately after lambing and is associated with the spring flush of subterranean clover.

(b) The summer period of falling weights. This usually starts in November or December and continues through to February or March. Part of the fall in weight is a result of shearing and part is associated with the drying-off of the subterranean clover on the advent of the dry period.

(c) The autumn period of rise. This usually starts in February or March and continues through to May or June. It is associated with the autumn flush of feed following the germination and establishment of subterranean clover with autumn rains.

(d) The winter period of falling weights. This usually starts in May or June and continues through to August or September. It includes the drop in weight following lambing in August and is further associated with the low growth of subterranean clover during the winter months.

As would be expected there is considerable variation in the degree of rise and fall in weight and in the duration of these four periods. The general trends however are demonstrated in most seasons and they can be interpreted in some measure by the seasonal behaviour of the clover growth discussed in Section 3.

(b) The Live Weight Production on each of the four Treatments.

The total live-weight production of all the sheep on a particular treatment is considered as a measure for the purpose of comparing the productivity of the four treatments. The total live-weight increase over the six grazing seasons and the increase relative to Treatment B as 100 are given in Table XIII.

TABLE XIII

The Total Live-weight Production of all sheep on each of the four Treatments over a Period of six Seasons; and the relative increase to Treatment B as 100

	Live Weight Increase	Relative to B=100
Treatment A	13,570.5 lb.	120
„ B	11,278.0 lb.	100
„ C	14,929.9 lb.	132
„ D	17,282.6 lb.	154

Treatment A, consisting of the equivalent of an annual application of ½cwt. of superphosphate and 2½cwts. of lime per acre has given a 20% increase in live weight production over Treatment B which receives 2cwt. of super per annum.

Treatment C, consisting of an initial dressing of 1 ton of lime per acre and an annual application of 2cwts. of superphosphate per acre. has given a 32% increase over Treatment B. Treatment D, consisting of an initial dressing of 1 ton of lime per acre and an annual application of 2cwts. of superphosphate and ½cwt. of 30% Potash salts, has given a 54% increase over Treatment B.

The combination of lime and superphosphate has given consistently higher increases than superphosphate alone. This was one of the important findings of this investigation. The reaction of lime and superphosphate together is so marked that even small applications of both,

as in Treatment A, have given greater increases in live weight on this class of land than the relatively heavy applications of superphosphate alone, as in Treatment B. Table XIV gives the live weight production of each class of sheep in each of the six seasons and the seasonal total live weight increase.

TABLE XIV

Total live weight production of each class of sheep in each of the six grazing seasons on the four treatments.

Season	Orig. Ewes lb.	1939 Progeny lb.	1940 Progeny lb.	1941 Progeny lb.	1942 Progeny lb.	1943 Progeny lb.	1944 Progeny lb.	Total lb.
				TREATMENT A				
1939-40	180	1202	—	—	—	—	—	1382.0
1940-41	203.1	470.7	1166.2	—	—	—	—	1840.0
1941-42	151.8	164.7	437.6	1876.2	—	—	—	2630.3
1942-43	22.4	21.6	58.4	611.2	2095.7	—	—	2786.9
1943-44	—	54.9	7.2	124.6	382.3	1246.9	—	1564.7
1944-45	—	290.7	249.8	247.8	572.7	765.6	1240.0	3366.6
								13570.5
				TREATMENT B				
1939-40	96.0	1512.0	—	—	—	—	—	1608.0
1940-41	342.6	383.2	1228.7	—	—	—	—	1954.5
1941-42	200.4	189.6	392.4	1344.6	—	—	—	2126.6
1942-43	68.1	7.8	13.0	285.0	1833.3	—	—	2071.0
1943-44	—	-26.4	-1.6	-23.2	548.8	720.6	—	1218.2
1944-45	—	148.2	123.6	139.6	542.7	549.6	886	2299.7
								11278.0
				TREATMENT C				
1939-40	81.0	1838.1	—	—	—	—	—	1919.1
1940-41	526.6	762.2	1588.8	—	—	—	—	2877.6
1941-42	167.4	290.0	672.0	1652.0	—	—	—	2781.4
1942-43	28.7	37.8	62.7	492.0	1931.1	—	—	2550.3
1943-44	—	-14.4	120.8	487.9	456.4	1049.4	—	1612.2
1944-45	—	302.3	218.0	301.6	681.0	437.4	1247.0	3187.3
								14927.9
				TREATMENT D				
1939-40	237.0	1875.0	—	—	—	—	—	2112.0
1940-41	294.7	738.9	2122.3	—	—	—	—	3155.9
1941-42	229.4	273.6	637.2	2522.7	—	—	—	3663.5
1942-43	-22.0	-31.8	22.6	665.3	2521.5	—	—	3155.6
1943-44	—	138.7	135.0	117.8	386.8	1088.9	—	1867.2
1944-45	—	225.5	229.3	308.0	579.6	628.0	1358	3328.4
								17282.6

(c) Seasonal Variation in Total Live-weight Production

The total live-weight production in any season is dependent on the growth of the pasture and we have already seen that the first, second and fifth seasons were low-producting ones, while the third, fourth and sixth were high-producing ones. This is confirmed by the figures for total live weight. In Table XV where the seasonal totals have been expressed relative to the first season equalling 100, the maximum difference of 84% occurs between the fifth and sixth seasons. Such wide variation in production calls for the provision of reserves of feed to tide over the low-producing seasons.

TABLE XV

Total Live Weight Production for each Treatment in each of the six Seasons; and relative to First Season = 100

	1939-40 lb.	1940-41 lb.	1941-42 lb.	1942-43 lb.	1943-44 lb.	1944-45 lb.
Treatment A	1382.0	1840.0	2630.3	2786.9	1564.7	3366.6
„ B	1608.0	1954.5	2126.6	2071.0	1218.0	2299.7
„ C	1919.9	2877.6	2781.4	2550.3	1612.2	3187.3
„ D	2112.0	3155.9	3663.5	3755.6	1867.2	3328.4
TOTAL -	7021.9	9828.0	11201.8	10563.8	6262.1	12182.0
Relative to 1939-40 = 100	100	140	157	150	89	173

A comparison between the total live-weight produced on each treatment in the different seasons can be seen in Table XVI and Graph II. Here it can be seen that Treatments C and D are well above Treatments A and B in the first season with Treatment D ahead of Treatment C. In the second season the advantage has increased still further in favour of C and D. In the third season the live-weight of D continues to increase, while that of C begins to fall in relation to B. In the fourth season D falls, but not to such a low level as C, and then during the fifth and sixth seasons maintains a high level. Treatment C, after the first drop in the third season, maintains that level below D and finishes up in the sixth season about the same degree below D as it was in the first and second seasons. This suggests that the initial dressing of 1 ton of lime on treatments C

and D, and the 2cwt. of superphosphate annually is capable of giving a considerable increase in live-weight production in the first few years after the application of lime. The maximum effect occurred two years (TreatmentC) and three years (Treatment D) after the applications.

It also suggests that the potash applied to Treatment D is having the effect of increasing yield by about 15% and in addition is holding the beneficial effect of the lime in Treatment D into the third, fourth and fifth seasons, whereas the effect of the lime in Treatment C has lost its first flush advantage in the third season.

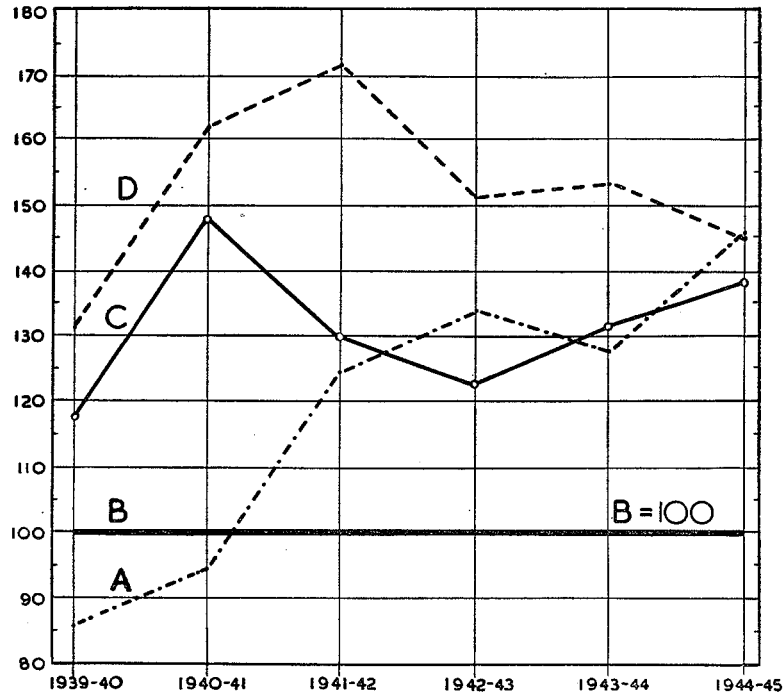
Treatment A shows an interesting trend. In the first and second seasons live weight production falls below that of B. In the third season the production rises more than 20% above that of B and nearly equals that of C. In the fourth and sixth seasons Treatment A is higher than that of Treatment C, in fact in the sixth season it is just higher than Treatment D. There are the seasons when superphosphate is applied to Treatment A whereas in the fifth season—the season when lime is applied—the production of A falls below that of C.

It would appear that the lime status of the soil in Treatment A in the fourth season (1942-43) by which time 10cwts. had been applied—5cwts. in 1941—was higher than that of Treatment C which had had 20cwts. applied in 1938. One cwt. of superphosphate was able for the first time to give higher production in Treatment A than the 2cwts. in Treatment C. This was repeated again in the sixth season when 1cwt. of superphosphate was again applied to Treatment A. Another 5cwts. of lime had been applied to A in 1943 and this appears to have had the effect of bringing the lime status of the soil in A up to that of D, for in the sixth season 1cwt. of superphosphate applied on A just surpassed the live-weight production of Treatment D.

TABLE XVI

Relative Live-weight Production of the four Treatments in each of the six Grazing Seasons. Treatment B = 100.

	1st Season	2nd Season	3rd Season	4th Season	5th Season	6th Season	
	1939-40	1940-41	1941-42	1942-43	1943-45	1944-45	Average
Treatment A	86	94.5	124	134	128	146	120
„ B	100	100	100	100	100	100	100
„ C	118	148	130.5	123	132	139	132
„ D	132	162	172	152	154	145	154



GRAPH II.

The Relative Live-Weight Production of the four Treatments in each of the six Grazing Seasons. Treatment B = 100.

B. WOOL PRODUCTION

The ewes and hoggets were shorn in November each year. The ewe lambs which were kept for addition to the breeding flocks were shorn in January. Each fleece was weighed and the average weight of wool produced by each class of sheep was recorded.

(a) Average Wool Production

The average wool produced by the ewes on the four treatments in each of the six seasons is an index of the plane of nutrition. In Table XVII the average weights and the weights relative to Treatment B as 100 are given. While the weights vary from season to season, the variations between the four treatments in each season are reasonably small and indicate a comparable plane of nutrition in all four treatments, as was shown in the case of average weight of lamb produced by the ewes (Table XII).

TABLE XVII

Average Weight of Wool Produced by the Ewes on Each Treatment in Each of the Six Seasons and the Relative Weight in Relation to Treatment B = 100.

	1939-1940		1940-1941		1941-1942		1942-1943		1943-1944		1944-1945	
	Wt. lb.	Relative	Wt. lb.	Relative	Wt. lb.	Relative	Wt. lb.	Relative	Wt. lb.	Relative	Wt. lb.	Relative
Treatment A	8.0	102	9.45	107	9.5	97	7.8	94	9.2	99	11.65	107
„ B	7.8	100	8.80	100	9.8	100	8.3	100	9.3	100	10.90	100
„ C	8.2	105	8.80	100	9.1	93	8.25	99	8.65	93	11.45	105
„ D	8.1	104	9.50	108	9.3	95	8.45	102	9.15	98	11.95	110

(b) Total Wool Production

The total productivity of the four treatments over the six seasons is given in Table XVIII. The relative productivity is of the same order as was shown to exist in the case of live-weight increase (see Table XIII). In the case of wool production Treatment A has given a total wool production of 24%, Treatment C, 38% and Treatment D 66% greater than Treatment B.

TABLE XVIII

Total Wool-production of all sheep on each of the four Treatments over a period of six Seasons, and Relative Weights to Treatment B = 100

	Total Weight lb.	Relative Weight B = 100
Treatment A -	1992.0	124
„ B -	1577.7	100
„ C -	2181.2	138
„ D -	2623.1	166

In Table XIX the total wool produced by each class of sheep on each of the four Treatments in each of the six seasons is given.

TABLE XIX

Season	Original Ewes	1939 Progeny	1940 Progeny	1941 Progeny	1942 Progeny	1943 Progeny	Total
			TREATMENT A				
1939-40	144.4	37.1	—	—	—	—	181.5
1940-41	179.8	70.3	34.5	—	—	—	284.6
1941-42	137.8	90.3	72.3	49.8	—	—	350.2
1942-43	106.7	71.6	63.6	89.1	53.3	—	384.3
1943-44	—	86.9	74.6	50.3	76.5	39.6	327.9
1944-45	—	113.9	75.0	66.9	140.7	67.0	463.5
							1992.0

TABLE XIX (Continued.)

Season	Original Ewes	1939 Progeny	1940 Progeny	1941 Progeny	1942 Progeny	1943 Progeny	Total
			TREATMENT B				
1939-40	179.4	27.1	—	—	—	—	206.5
1940-41	158.6	50.2	28.5	—	—	—	237.3
1941-42	118.1	67.6	62.1	23.2	—	—	271.0
1942-43	92.7	59.9	52.2	47.3	58.3	—	305.4
1943-44	—	56.3	40.9	42.1	98.0	19.8	257.1
1944-45	—	45.1	21.8	33.3	139.8	60.4	300.4
							1577.7
			TREATMENT C				
1939-40	243.0	68	—	—	—	—	311.0
1940-41	221.9	85.5	47.2	—	—	—	354.6
1941-42	129.6	88.9	98.2	38.5	—	—	355.2
1942-43	106.5	79.3	77.6	77.4	56.2	—	397.0
1943-44	—	71.0	74.7	70.7	81.6	21.0	319.0
1944-45	—	58.1	69.7	96.7	154.0	65.9	444.4
							2181.2
			TREATMENT D				
1939-40	242.7	55.1	—	—	—	—	297.8
1940-41	285.0	101.2	54.5	—	—	—	440.7
1941-42	205.2	121.3	102.0	70.4	—	—	498.9
1942-43	157.4	102.3	86.5	76.7	52.5	—	475.4
1943-44	—	107.1	82.9	74.8	79.3	35.0	379.1
1944-45	—	102.8	87.6	91.3	149.3	100.2	531.2
							2623.1

(c) Seasonal Wool Production

The ewes were shorn in November. Consequently the wool-growing season extends from December to November inclusive. The grazing season over which the live-weight increases were recorded extended from March to February inclusive. For this reason variations in seasonal production of weight of wool do not correspond very closely with seasonal variation in live-weight increases. The wool weights include growth in the last three months (December, January and February) of the previous grazing season and are short of the same three months in the current grazing season.

In Table XX the total weight of wool produced on each treatment in each of the six seasons is given and the seasonal totals are expressed relative to the first season as 100. By comparing Table XX with Table XV it will be seen that the variations in seasonal production of wool are similar to but of a slightly different order from those of seasonal live-weight increases.

TABLE XX

Total Wool Weight for Each Treatment in Each of the Six Seasons and Relative to First Season = 100.

	1939-40 lb.	1940-41 lb.	1941-42 lb.	1942-43 lb.	1943-44 lb.	1944-45 lb.
Treatment A	181.5	284.6	350.2	384.3	327.9	463.9
„ B	206.5	237.3	271.0	305.4	257.1	300.4
„ C	311.0	354.6	355.2	397.0	319.0	444.4
„ D	297.8	440.7	498.9	475.4	379.1	531.2
TOTAL -	996.8	1317.2	1475.3	1562.1	1283.1	1739.9
Relative to 1939-40 = 100	100	131	147	156	128	174

In Table XXI and Graph III the total weights of wool produced each season on each Treatment have been related to Treatment B = 100.

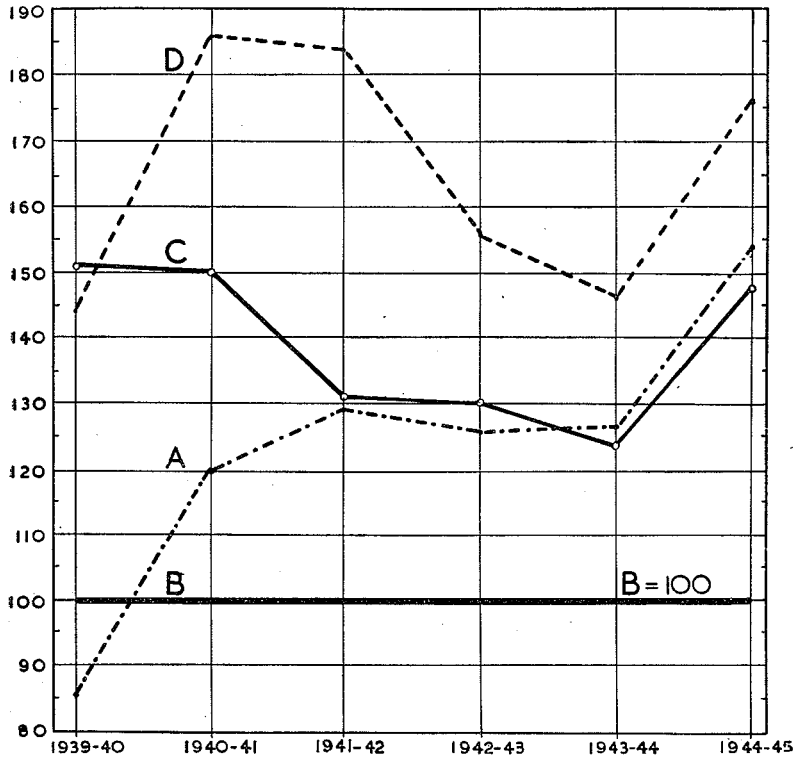
Similar phenomena occur with regard to wool production as were shown to exist with regard to live weight (Graph II) but the curves are not identical for the reason that the wool-growing season differs from the grazing season.

From the second season, Treatments C and D parallel one another, with D consistently higher by an average of 33%. Treatment A, which starts off below Treatment B, rises to just below Treatment C in the third and fourth seasons and slightly above it in the fifth and sixth seasons. From the second season Treatments A and C average about 33% greater than Treatment B.

TABLE XXI

Relative Production of Wool of the Four Treatments in each of the six Grazing Seasons. Treatment B =100.

	1939-40	1940-41	1941-42	1942-43	1943-45	1944-45	Average
Treatment A	86	120	129	126	127	154	124
„ B	100	100	100	100	100	100	100
„ C	151	150	131	130	124	148	138
„ D	144	186	184	156	147	176	166



GRAPH III

Relative Wool Weights of the Four Treatments in each of the six grazing seasons. Treatment B = 100

C. CARRYING CAPACITY

The carrying capacity, in terms of ewes per acre, during the first six seasons was calculated on the basis of breeding ewes and allowing for a hogget as two-thirds of a ewe. In the last two seasons the plot areas were grazed with dry ewes in the autumn and with hoggets in the spring and summer. The number of grazing days on each treatment was recorded and the figures converted to the equivalent of ewes per acre by allowing for the hoggets as three-quarters of a ewe at the time of the year they were on. The number of grazing days and the equivalent carrying capacity for the two seasons are given in Table XXII.

TABLE XXII

Number of Grazing Days and the Equivalent Carrying Capacity on Each of the Four Treatments in the 7th and 8th Seasons

	7th Season 1945-46		8th Season 1946-47	
	Grazing Days	Carrying Capacity Ewes per acre	Grazing Days	Carrying Capacity Ewes per acre
Treatment A	19624	2.2	15507	1.77
„ B	18429	2.1	12142	1.38
„ C	19203	2.2	16687	1.94
„ D	22946	2.58	17695	2.02

Four flocks were used and these were moved round the six replications of each treatment. The grazing management was designed to keep the herbage on each treatment in a similar condition and by the end of the season to secure complete utilisation of all herbage produced. The herbage was not grazed too short nor was it allowed to grow too rank.

Under the conditions of complete utilisation of all herbage produced and reasonable uniformity of thrift of the sheep on each treatment, the productivity of the four treatments may be compared on the basis of carrying capacity. In Table XXIII the carrying capacity of each of the treatments over a period of eight seasons is given.

In table XXIV the carrying capacity is relative to Treatment B at 100 and the relative figures are shown in graph form in Graph IV.

TABLE XXIII

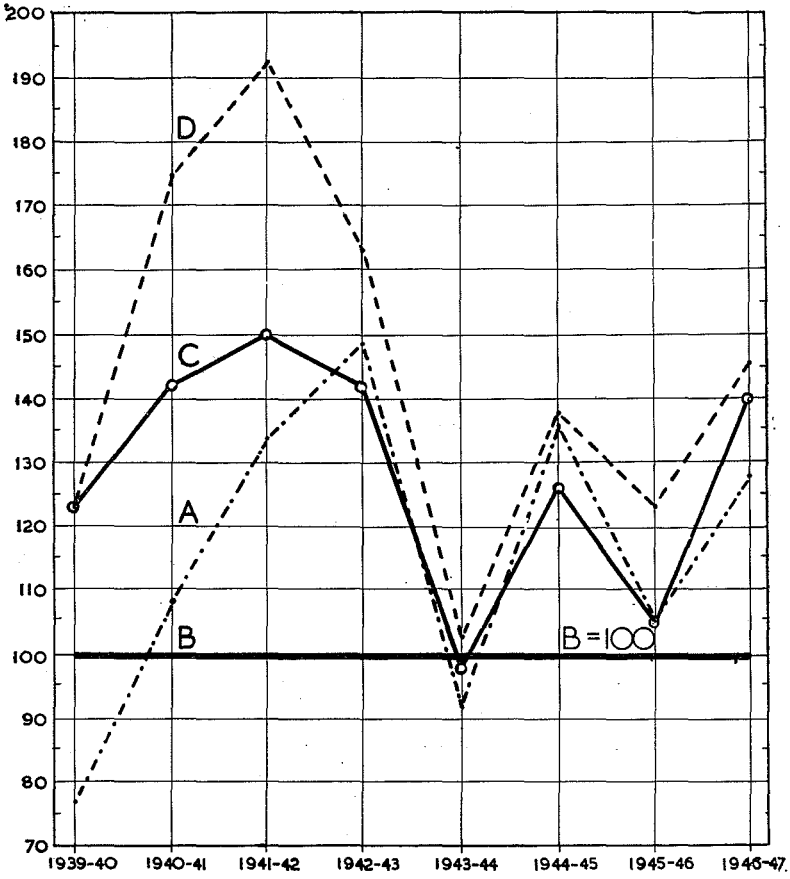
Carrying Capacity, in Terms of Equivalent of Ewes per acre, on Each of the Four Treatments over a Period of Eight Seasons.

	1st Season 1939-40	2nd Season 1940-41	3rd Season 1941-42	4th Season 1942-43	5th Season 1943-44	6th Season 1944-45	7th Season 1945-46	8th Season 1946	Average
Treatment A	1.0	1.3	1.6	2.15	1.60	3.15	2.2	1.77	1.846
„ B	1.3	1.2	1.2	1.44	1.73	2.31	2.1	1.38	1.582
„ C	1.6	1.7	1.8	2.05	1.70	2.92	2.2	1.94	1.990
„ D	1.6	2.1	2.3	2.35	1.78	3.20	2.58	2.02	2.241

TABLE XXIV

Carrying Capacity on Each of the Four Treatments over a Period of Eight Seasons Relative to Treatment B = 100 in Each Season.

	1st Season 1939-40	2nd Season 1940-41	3rd Season 1941-42	4th Season 1942-43	5th Season 1943-44	6th Season 1944-45	7th Season 1945-46	8th Season 1946	Average
Treatment A	77	108	134	149.5	92.5	136	105	128	116
„ B	100	100	100	100	100	100	100	100	100
„ C	123	142	150	142	98.0	126.5	105	140.5	128
„ D	123	175	192	163	103	138	123.5	146.0	145



GRAPH IV

Showing the Relative Carrying Capacity of the four Treatments in each of the eight Seasons. Treatment B = 100.

As with live-weight production and wool weights, Treatments C and D were superior to A and B in the first three seasons. Treatment D though fluctuating in relation to B, remains at a higher level throughout. Treatment C, in the fifth and seventh seasons, is little better than B and is inferior to Treatment A in the fourth and sixth seasons when superphosphate is applied to the A Treatment. In the seventh season Treatments A and C have lost their early superiority over B. It was at this stage that one ton

of lime per acre was applied to Treatment C and D. The eighth season was not a highly productive one, yet Treatment C and D as well as Treatment A (which received 1cwt. of superphosphate) increased considerably over Treatment B. Treatment C again attained superiority over Treatment A. This reaction has confirmed the opinion previously expressed that Treatments C and D had lost the initial big advantage over Treatment B and were able to recover it, in part, within six months of the application of 1 ton of lime. It appears as though the effect of the application of 1 ton of lime on this class of land will persist at a high level for about four seasons.

D. DRY-MATTER PRODUCTION

The dry-matter production was measured in three seasons, 1941-42, 1943-44 and 1944-45. Three quadrats each of a square metre were placed on each of the six replicates on each Treatment.

In the first season the herbage was trimmed at the beginning of August and the quadrats placed in position. From October 7th, three quadrats on one plot of each

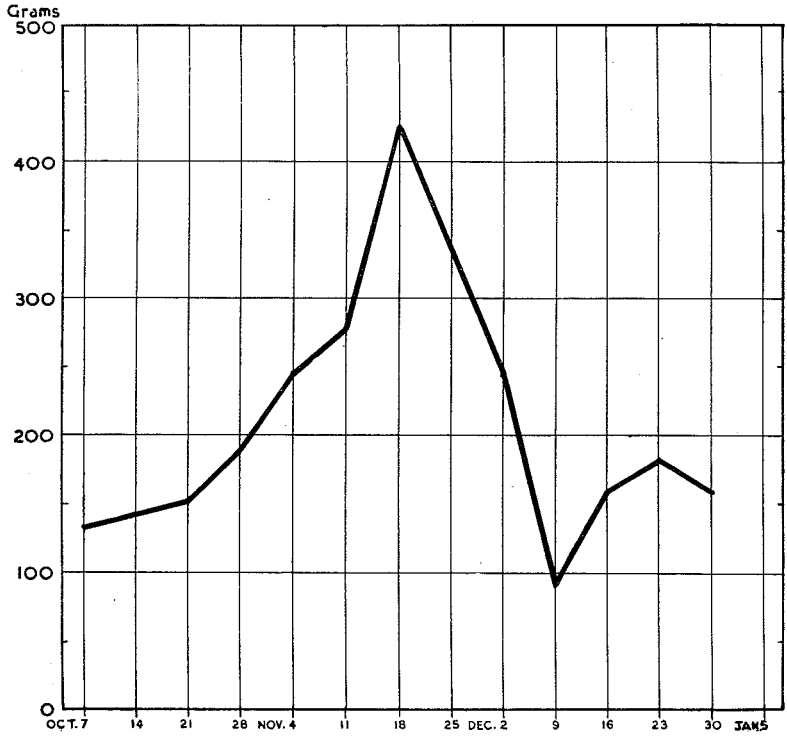
TABLE XXV

Weekly production of Dry Matter in grams per 3 square metres from October 7, 1941, to December 30, 1941.

Date	Weeks of Growth	Treatment A	Treatment B	Treatment C	Treatment D	Total of 4 Treatments 12 sq. mets.	Av. Weekly Production on 12 sq. mets.
Oct. 7	9	392	134	346	333	1205	133.9
„ 14	10	345	207	505	366	1423	142.3
„ 21	11	411	238	616	402	1667	151.5
„ 28	12	587	496	587	594	2264	188.7
Nov. 4	13	1032	572	430	1144	3178	244.4
„ 11	14	862	915	1139	961	3877	277.0
„ 18	6	671	403	626	835	2535	422.5
„ 25	—	—	—	—	—	—	
Dec. 2	7	421	482	475	335	1713	244.7
„ 9	7	118	112	166	243	639	91.3
„ 16	7	322	222	494	69	1107	158.1
„ 23	7	397	83	73	711	1264	180.6
„ 30	7	300	151	159	406	1106	158.0
Total 18 sq. metres		5858	4015	5616	6480		

treatment were cut close to ground level at weekly intervals. The first cut represented nine weeks' early spring growth, the second cut ten weeks' growth and so on. After each cut the quadrats were removed to a new trimmed site. The sixth plot was cut on the sixth week after which the cutting was resumed on the first plots which by now had six weeks' growth on them. The weekly growths of dry matter in the first season are given in Table XXV. Cutting ceased on December 29th when the clover dried off and growth for the remainder of the season was insufficient to collect.

By taking the average weekly production of the four treatments combined, the seasonal growth curve of subterranean clover pastures in the 1941-42 season can be drawn. This is shown in Graph V. Growth started slowly in the spring and during November a high peak of produc-



GRAPH V

The Weekly Production of Subterranean Clover Pastures at Ashley Dene from October 7th to December 30th, 1941

tion was reached. With the advent of dry weather in early December, growth declined but a recovery accompanied December rain. At the end of December growth ceased.

Seasonal growth was measured only in the one season and the growth curve presented shows the general behaviour in the spring and the dependence on rainfall for growth in the late spring and summer months.

In the 1943-44 and 1944-45 seasons the quadrats were placed on trimmed sites at the beginning of March and the herbage was allowed to grow throughout the season. One cut was taken at the end of the following February, i.e., the total season's growth was taken in one cut. The results, together with the total herbage cut in the 1941-42 season, are given in terms per acre in Table XXVI.

TABLE XXVI

Dry-matter Production in Pounds per Acre Obtained on the Four Treatments in Three Seasons

	Treatment A	Treatment B	Treatment C	Treatment D
Season 1941-42	2750	1900	2650	3050
„ 1943-44	2870	2440	3340	3150
„ 1944-45	4780	4550	5450	5700
TOTAL -	10,400	8890	11,440	11,900
Relative to B = 100	113	100	127	134

The table also shows the dry-matter productivity of the four treatments in the three seasons in relation to Treatment B = 100. The order of productivity is similar to that recorded for live-weight wool production and carrying capacity though on a lower scale.

III. DISCUSSION

Subterranean clover seed was surface-introduced into the run-out pasture by drilling 4lb. of seed with 1cwt. of superphosphate on a scuffled surface in the autumn of 1937. It was three or four years before a complete coverage developed. The first grazing season of these trials (March 1939-February 1940) commenced two years after the in-

troduction of the clover. After the second grazing season the herbage was dominantly subterranean clover and it has remained so throughout the course of the investigation.

The original old run-out pasture was able to provide a little grazing from annual weed grasses and herbs in the spring and early summer months. The carrying capacity of the area would probably be less than a quarter of a ewe per acre. On this class of land the average carrying capacity of a farm of about 1,000 acres would range between three quarters of a ewe and one ewe per acre. This would be possible by growing say 100 acres of turnips for winter feed, an equivalent area of oats for greenfeed and chaff, 60 or more acres of rape for lamb fattening and 60-100 acres of new grass sown down each year. This grass would probably give good production for two years and would then run out to weed grasses and herbs, arriving at the condition of the experimental area at the time subterranean clover was introduced.

The new subterranean clover pasture effected a considerable improvement in carrying capacity. After surface introduction, there was a gradual improvement in the density of the clover. Within three years an average of 1.4 ewes per acre were carried and within five years with the addition of some supplementary feed in the winter an average of 1.7 ewes per acre were carried. The carrying capacity in the fourth, fifth and sixth seasons was 1.99, 1.70, and 2.89 ewes per acre respectively, and this without any supplementary feed other than subterranean clover hay made from the particular treatment on which the sheep were grazing.

The seasonal production of subterranean clover pasture fits in well with the requirements of ewes producing fat lambs. The clover is an annual which germinates in the autumn and produces a greater or less amount of autumn and winter feed according to the earliness of autumn re-establishment which is determined by autumn rains. Maximum production occurs in the spring months—October and November—when the ewes are supporting big lambs. With good spring and early summer rains the lambs may be fattened off the mothers by early January, but should the herbage dry off in early November the ewes will continue to produce milk on the dried-off herbage while it lasts. However, this does not last as long as growing herbage and the lambs may have to be weaned before they are fat. For this reason it is preferable to produce early-maturing lambs. In the late summer and autumn period when the subterranean clover is dormant, the feed require-

ments of ewes are very small and they can usually get sufficient grazing from the dried-off herbage and a certain amount of burr until the autumn growth starts.

The total production which influences the carrying capacity is influenced by rainfall at two seasons of the year and by the advent of hot drying nor-west winds in spring and summer which dessicate the soil and cause the herbage to dry off. In this state the herbage still provides valuable grazing. Early autumn rainfall is necessary for good autumn establishment. If autumn rains come late, winter growth is limited and a high loss of seedlings may occur through frost lift. Spring rains, particularly in August, are probably the most important single climatic factor determining total production. With a good autumn establishment the clover makes continuous growth into the spring and early summer. Even with poor autumn establishment, good August rains will cause early spring germination and give satisfactory growth. Following a combination of favourable climatic conditions, the sixth season of the trial was the highest producing one experienced, while following late autumn establishment, a dry August, and the early advent of hot dry winds and fifth season was one of the lowest.

The original ewes were used for four seasons and successive generations of ewe lambs were reared on subterranean clover without any evidence that the health of the sheep was adversely affected by grazing almost pure subterranean clover herbage. The live-weight increases were continuous and the ewes were turned off the area at the completion of the investigation at the following weights—

Hoggets	136 lb.
2-tooth ewes	149 lb.
Mature ewes	149-181 lb. (See Table V)

There was no suggestion of any abnormality in lambing percentages. While pregnancy toxaemia occurred in all seasons, there was no difference between any of the treatments, nor was the incidence any greater than in an average flock on this class of land. There was no sign of scouring, even on the most succulent clover. In fact, both ewes and lambs throve exceedingly well on the diet of almost pure subterranean clover over the whole period of six grazing seasons.

One of the main objectives of the investigation was to determine the effect of different fertiliser treatments and one of the earliest findings was the superiority of lime and superphosphate in combination over superphosphate alone. This was not anticipated in the first grazing season

and Treatment B was stocked more heavily than Treatment A. From the second season onwards all three treatments, where lime and superphosphate were applied, gave consistently higher returns than where superphosphate was applied without liming.

In the first two grazing seasons the initial application of 1 ton of lime per acre with 2 cwts. of superphosphate (Treatment C) gave a marked superiority over Treatment A. But by the third grazing season, by which time Treatment A had received 10 cwts. of lime in two applications of 5 cwts. per acre and in addition had received a total of 3 cwts. of superphosphate, the superiority of Treatment C had almost disappeared. Treatment C had received 1 ton of lime and 9 cwts. of superphosphate per acre. The lime had been applied to Treatment C in 1938 and apparently the soil in Treatment C was beginning to lose the advantage of a high lime status. The application of 5 cwts. of lime per acre to Treatment A in 1939 and again in 1941 had apparently built up the lime status sufficiently to take full advantage of the application of 1 cwt. of superphosphate. In the succeeding seasons there was a tendency for the production of Treatment A to rise above that of Treatment C in the years when 1 cwt. of superphosphate was applied to A. This points to the probability that the lime status of A was being maintained at a higher level than that of C. In the eighth season when another 1 ton of lime was again applied to Treatment C it recovered its superiority over Treatment A.

From the analysis it would appear that an initial application of 1 ton of lime is desirable to bring the production to a high level in the first year and that thereafter smaller applications at frequent intervals are desirable to maintain the lime status—say, 5 cwts. every second year. It also appears that when the lime status of the soil is at a satisfactory level, a light dressing of superphosphate, say 1 cwt. per annum will give a satisfactory level of production.

The effect of the addition of ½ cwt. of potash to the application of 1 ton of lime as an initial application and 2 cwts. of superphosphate per annum (Treatment D) is to give increased production throughout over Treatment C. The potash appears to prolong the advantage of lime and superphosphate into the third season, i.e., it appears to act by maintaining the effectiveness of the lime for a longer period in the early years. In the latter years the superiority of Treatment D over Treatment C has been maintained but at a lower level.

IV. SUMMARY

This bulletin records the production of subterranean clover pastures under different fertiliser treatments. Measurements of production were made by means of the grazing animal. The trial was carried out over the years 1939 to 1946.

1. Subterranean clover was introduced to an old run-out pasture by surface introduction.

2. Four fertiliser treatments were applied to each of six three-acre plots. The fertiliser treatments were:

A 1cwt. of superphosphate applied every second year with 5cwt. lime applied in the alternate years.

B 2cwt. of superphosphate annually.

C 1 ton of lime (initial) and 2cwt. superphosphate annually.

D As for C with the addition of ½cwt. of potash annually.

3. From 1939 to 1944 the treatments were grazed by flocks of pure-bred Corriedale ewes, and the ewe lambs were used for replacement and increase of the flocks. In 1945 and 1946 dry sheep were used.

4. Measurement of production was made in terms of live-weight increase, wool weight, carrying capacity and dry matter production.

5. Treatment B was the lowest producing one throughout the course of investigation. In an adjacent trial Treatment B was 37% better than no fertiliser application. Treatment D gave highest production throughout the period—an average over Treatment B of 53% in terms of live weight, 65% in terms of wool weight and 45% in terms of carrying capacity.

Treatment C gave an average increase over Treatment B of 32% in terms of live weight, 39% in terms of wool weight and 28% in terms of carrying capacity. .. Treatment A gave an increase over Treatment B of 19% in terms of live weight, 24% in terms of wool weight and 16% in terms of carrying capacity.

6. There has been a gradual build-up in the productivity of the pasture as shown by the fact that the average carrying capacity for the first three years (all treatments) was 1.55 ewes per acre and in the last three years was 2.39 ewes per acre.

7. Lime and superphosphate in combination gave consistently better results than superphosphate alone.

8. Relatively light applications of lime and superphosphate (equal to ½cwt. superphosphate and 2½cwt. lime

per annum, Treatment A were equal in production in the third season to heavy applications (Treatment C).

9. Potash gave a marked advantage in the first three seasons only.

V. ACKNOWLEDGMENTS

Acknowledgment is made here to the Department of Scientific and Industrial Research which has provided the finance for the investigation.

The author wishes to thank Mr W. A. Hines, Manager of the Ashley Dene Farm for his willing help and co-operation throughout all stages of the work.

The initial shepherding and the development of the system of marking, weighing and recording were the responsibilities of the late Mr O. H. Banks who was killed in action in Egypt in 1943. His work was later carried on by Messrs I. Miller and W. Brydone whose assistance is acknowledged.

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VII. APPENDIX

The monthly weights in pounds, of sheep on each of the four treatments together with the average weight of the four treatments.

I. Original Ewes.

		Treatment A	Treatment B	Treatment C	Treatment D	Average of the four treatments
Aug.	1939	109	109	108	107	108
Sept.	„	111	109	108	110	109
Oct.	„	115	117	113	116	115
Nov.	„	118	116	117	117	117
Dec.	„	110	109	108	111	109
Jan.	1940	109	106	104	110	107
Feb.	„	121	113	111	118	116
Mar.	„	124	119	118	122	121
Aug.	„	134	134	131	132	133
Sept.	„	133	132	133	126	131
Oct.	„	141	140	138	133	138
Nov.	„	155	152	154	146	152
Dec.	„	145	145	147	136	143

I. Original Ewes (continued)

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Jan.	1941	145	144	144	140	143
Feb.	„	142	146	142	138	142
Mar.	„	135	137	134	128	133
Apr.	„	143	146	142	137	142
May	„	152	155	149	143	150
June	„	158	158	155	148	155
July	„	158	161	156	148	156
Aug.	„	161	165	156	153	159
Sept.	„	150	154	154	143	150
Oct.	„	158	170	161	153	160
Nov.	„	163	173	169	157	165
Dec.	„	161	171	166	157	164
Jan.	1942	156	166	159	154	159
Feb.	„	153	162	153	147	154
Mar.	„	151	160	151	146	152
Apr.	„	155	163	157	150	156
May	„	160	170	161	152	161
June	„	159	168	161	150	159
July	„	155	165	155	147	158
Aug.	„	152	157	151	145	151
Sept.	„	142	145	140	140	142
Oct.	„	149	151	151	139	147
Nov.	„	141	147	145	132	141
Dec.	„	154	157	155	147	153

II. 1939 Progeny.

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Sept.	1939	16	16	16	15	16
Oct.	„	30	30	27	28	29
Nov.	„	48	47	42	45	46
Dec.	„	58	57	51	55	55
Jan.	1940	63	61	54	60	60
Feb.	„	69	60	56	61	62
Mar.	„	76	68	63	67	69
Aug.	„	74	66	66	68	69
Sept.	„	89	87	83	86	86
Oct.	„	106	101	100	100	102
Nov.	„	125	119	113	117	119
Dec.	„	124	117	114	113	117
Jan.	1941	128	117	117	121	121
Feb.	„	129	119	119	121	122
Mar.	„	122	112	112	113	115
Apr.	„	128	123	121	122	124
May	„	136	132	128	126	131
June	„	143	136	133	131	136
July	„	141	140	137	133	138
Aug.	„	147	146	138	135	142
Sept.	„	140	132	138	132	136
Oct.	„	148	146	149	146	147
Nov.	„	151	151	155	150	152
Dec.	„	151	151	154	150	152

II. 1939 Progeny (continued)

		Treatment A	Treatment B	Treatment C	Treatment D	Averag
Jan.	1942	150	151	151	149	150
Feb.	„	148	151	148	144	148
Mar.	„	147	151	148	144	148
Apr.	„	151	155	153	151	153
May	„	157	163	159	155	159
June	„	155	160	156	148	155
July	„	153	159	151	145	152
Aug.	„	154	157	147	146	151
Sept.	„	140	152	143	145	145
Oct.	„	147	159	155	147	152
Nov.	„	140	152	147	142	145
Dec.	„	155	161	161	154	158
Feb.	1943	150	152	151	140	148
Mar.	„	147	158	152	147	151
Apr.	„	157	163	160	153	158
May	„	164	170	167	160	165
June	„	167	171	164	157	165
July	„	164	171	167	156	165
Aug.	„	165	170	165	157	164
Sept.	„	140	156	141	138	144
Oct.	„	144	140	142	136	141
Nov.	„	158	156	158	157	157
Dec.	„	157	152	159	155	156
Jan.	1944	160	147	156	153	154
Feb.	„	156	148	149	152	151
Mar.	„	159	154	154	160	157
Apr.	„	167	161	165	165	165
May	„	169	163	163	162	164
June	„	178	170	176	160	171
July	„	182	175	185	169	178
Aug.	„	191	170	190	175	182
Oct.	„	180	162	179	167	172
Nov.	„	188	176	191	178	183

III. 1940 Progeny.

		Treatment A	Treatment B	Treatment C	Treatment D	Averag
Sept.	1940	19	25	21	20	21
Oct.	„	35	42	36	37	38
Nov.	„	55	62	54	56	57
Dec.	„	—	73	65	68	69
Jan.	1941	78	85	71	78	78
Feb.	„	74	81	70	74	75
Mar.	„	76	82	72	75	76
Apr.	„	84	93	81	82	85
May	„	91	101	87	88	92
June	„	94	103	91	91	95
July	„	89	100	85	89	91
Aug.	„	90	103	86	80	90
Sept.	„	108	121	105	104	110
Oct.	„	119	134	119	118	123
Nov.	„	127	142	126	126	130
Dec.	„	131	148	130	133	136

III. 1940 Progeny (continued)

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Jan.	1942	130	149	129	133	135
Feb.	„	129	146	126	127	132
Mar.	„	127	142	123	128	130
Apr.	„	131	145	132	134	136
May	„	136	151	136	137	140
June	„	131	147	131	130	135
July	„	128	145	127	127	132
Aug.	„	128	142	127	125	131
Sept.	„	124	139	128	126	129
Oct.	„	132	147	136	132	137
Nov.	„	126	139	126	129	130
Dec.	„	140	152	140	138	143
Feb.	1943	136	149	131	129	136
Mar.	„	135	153	134	135	139
Apr.	„	145	159	144	141	147
May	„	151	168	150	147	154
June	„	152	167	147	147	153
July	„	150	172	150	147	155
Aug.	„	151	169	150	150	155
Sept.	„	137	144	133	133	137
Oct.	„	137	143	136	133	137
Nov.	„	149	156	150	151	152
Dec.	„	133	148	149	148	145
Jan.	1944	142	140	147	144	143
Feb.	„	137	143	144	144	142
Mar.	„	143	156	149	152	150
Apr.	„	151	163	161	157	158
May	„	154	168	158	152	158
June	„	157	173	166	154	163
July	„	168	178	169	164	170
Aug.	„	170	163	167	165	166
Oct.	„	154	167	157	160	160
Nov.	„	172	184	169	171	174

IV. 1941 Progeny.

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Sept.	1941	21	18	22	20	20
Oct.	„	35	33	38	35	35
Nov.	„	55	54	57	55	55
Dec.	„	70	70	71	68	70
Jan.	1942	76	76	75	74	75
Feb.	„	83	88	85	80	84
Mar.	„	87	92	86	85	88
May	„	93	107	102	85	97
June	„	86	101	98	82	92
July	„	86	102	96	83	92
Aug.	„	84	97	91	78	88
Sept.	„	99	111	102	93	101
Oct.	„	111	123	116	105	114
Nov.	„	109	122	113	111	114
Dec.	„	124	132	128	123	127

IV. 1941 Progeny (continued)

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Jan.	1943	126	132	127	124	127
Feb.	„	135	135	134	133	134
Mar.	„	135	136	134	133	135
Apr.	„	137	142	138	141	140
May	„	141	142	144	145	143
June	„	140	143	139	142	141
July	„	134	139	139	139	138
Aug.	„	130	143	137	138	137
Sept.	„	115	135	127	122	125
Oct.	„	121	125	128	122	124
Nov.	„	128	134	142	140	136
Dec.	„	128	140	142	144	139
Jan.	1944	129	135	141	146	138
Feb.	„	124	133	140	146	136
Mar.	„	131	140	142	152	141
Apr.	„	138	145	153	156	148
May	„	140	148	149	153	148
June	„	144	153	160	158	154
July	„	152	155	169	167	161
Aug.	„	157	154	171	173	164
Oct.	„	151	150	163	163	157
Nov.	„	166	165	178	181	173

V. 1942 Progeny.

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Sept.	1942	22	20	22	19	21
Oct.	„	40	37	40	35	38
Nov.	„	53	53	54	50	53
Dec.	„	67	67	71	59	66
Jan.	1943	65	67	64	59	64
Feb.	„	75	76	78	70	75
Mar.	„	79	79	85	69	78
Apr.	„	84	89	94	79	87
May	„	87	93	94	83	89
June	„	87	90	90	81	87
July	„	79	86	85	75	81
Aug.	„	75	83	80	70	77
Sept.	„	71	82	77	68	75
Oct.	„	76	86	83	71	79
Nov.	„	88	99	99	89	94
Dec.	„	96	106	108	94	101
Jan.	1944	100	105	108	93	102
Feb.	„	102	110	111	100	106
Mar.	„	111	121	121	113	117
Apr.	„	106	127	127	115	119
May	„	113	126	123	113	119
June	„	121	128	133	115	124
July	„	128	132	139	122	130
Aug.	„	134	126	141	129	133
Oct.	„	129	134	139	126	132
Nov.	„	144	147	161	144	149

VI. 1943 Progeny.

		Treatment A	Treatment B	Treatment C	Treatment D	Average
Sept.	1943	23	25	27	23	25
Oct.	„	36	34	37	35	36
Nov.	„	51	54	51	52	52
Dec.	„	58	63	60	61	61
Feb.	1944	64	66	64	68	66
Mar.	„	72	73	73	78	74
Apr.	„	—	83	87	88	86
May	„	85	86	88	93	88
June	„	89	85	93	95	91
July	„	95	92	100	99	97
Aug.	„	98	97	104	104	101
Sept.	„	104	107	111	107	107
Oct.	„	114	123	120	116	118
Nov.	„	133	142	137	134	137