ROTHAMSTED RESEARCH

The Park Grass Plots at Rothamsted 1856 -1949

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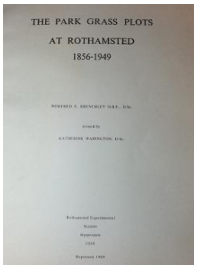

Chapter III. General Effect of Individual and Combined Manures

Rothamsted Research

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CHAPTER I

INTRODUCTION

Manurial experiments on grassland have been carried on continuously at Rothamsted since 1856. About 7 acres of the Park, with a silt-loam soil overlying clay with flints were then divided into twenty plots* varying in area from ½ to 1/8 acre. Two of these received farmyard manure, two were left unmanured, and the others received different combinations and amounts of inorganic fertilizers. In general, the same manurial treatments have been continued on each plot, but any changes that have been made are indicated in the appropriate section. A plan of the field showing the treatments is given on the front page. The area had been under grass for some centuries, and at the beginning of the experiment, therefore, the herbage was a natural one and quickly responded to the fertilizers used. After several years some of the plots began to show signs of lime deficiency, and in November 1883 fresh burnt lime at the rate of 2000 lb. per acre was applied to the west half of each plot. Four years later, in 1887, a similar dressing was given to the east halves except on plot 5, on which the second dressing was postponed till 1896. On plots 11^1 and 11^2, which showed much lime deficiency, a dressing of 4000 lb. per acre was put on the east halves in 1887, and also 2000 lb. on the west halves; the same amount of lime was applied to plot 5 in 1896. Thus ultimately every plot received a similar amount of lime over its whole area. In 1903 a fresh system of liming was introduced to demonstrate the effect of long continued lime starvation. 2000 lb. per acre of lime was then applied to the south half of most plots, the application being repeated once every four years, except in 1911 and 1919 when it was omitted. In 1920, 2500 lb. was given to compensate for the omission in 1919 and after this the application of 2000 lb. per acre was resumed once every four years. In the same year, a special scheme of liming was introduced on plots 18, 19 and 20, the details of which are given in the sections dealing with these plots. The hay from the limed and unlimed areas has always been harvested separately.

* Three of these plots 4, 5 and 11 have since been subdivided.

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Until 1872 the aftermath was usually fed off with sheep penned on to each area. On several plots the animals suffered, and as in addition their use introduced factors other than those associated with fertilizers, grazing was discontinued and the second crop was cut, made into hay whenever weather permitted, or else carted green and the equivalent quantity of hay calculated.

The results of the experiments for the first twenty years were exhaustively worked out by Lawes, Gilbert and Masters[1a, b, c] in their classical memoirs, and certain of these plots, still unlimed, were later dealt with by A.D. Hall [2].

Further detailed examinations of the flora were carried out in 1914 and 1919 by W.E. Brenchley and the results published as a monograph [3a]. Here the influence of the different fertilizers was traced from 1862 or earlier up to 1919, and that of additional lime from 1903. During the next thirty years (1920-1949), botanical analyses of the hay were continued on a number of selected plots, and the results are incorporated in the present volume as an extension of the 1924 monograph. The effect of lime has been specially dealt with elsewhere, [Brenchley 3[b,c,d] (1925, 1930, 1935)].

Since the start of the experiment, detailed visual records have been made on the herbage, and from 1920 at least two such field surveys have been carried out each year. These have been used as a source of additional information, but all numerical data are derived from the hay analyses only. For the sake of continuity, the original nomenclature, with the exception of Festuca ovina, (which has been more accurately termed F.rubra) has been retained. The equivalents in the new classification based on "Flora of the British Isles" Clapham, Tutin and Warburg (1952) are given below:-

NOMENCLATURE

As used in this and earlier publications	Clapham,Tutin and Warburg 1952.
Gramineae	
Agrostis vulgaris	Agrostis tenuis
Aira caespitosa	Deschampsia caespitosa
Arrhenatherum avenaceum	Arrhenatherum elatius
Avena flavescens	Trisetum flavescens
Avena pubescens	Helictotrichon pubescens

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Leguminosae

Ononis arvensis	Ononis repens
Trifolium minus	Trifolium dubium

Miscellaneous Species

Carex praecox	Carex caryophyllea
Conopodium denudatum	Conopodium majus
Epilobium angustifolium	Chamaenerion angustifolium
Potentilla tormentilla	Potentilla erecta
Scabiosa arvensis	Knautia arvensis
Spireae ulmaria	Filipendula ulmaria
Stachys betonica	Stachys officinale
Taraxacum vulgare	Taraxacum officinale

The numbers attached to the names of the species in Tables 2-6 are for convenience of reference only and carry no significance.

In 1940, a number of large trees were felled on the north side of the field adjacent to the unlimed halves of plots 5-13. This may have some influence on the flora in this area, but so far no definite changes have been observed.

1. (a) Lawes, J. B. & Gilbert, J. H. (1880). Agricultural, botanical and chemical results of experiments on the mixed herbage of permanent grassland, conducted for many years in succession on the same land. Part I. Phil. Trans. R. Soc. 171, 289-416.

   (b) Lawes, J. B., Gilbert, J. H. & Masters, M. T. (1882). ibid. Part II. Phil. Trans. R. Soc. 173, 1181-1413.

   (c) Lawes, J. B. & Gilbert, J. H. (1900) ibid. Part III. Phil. Trans. R. Soc. 192, 139-210.

2. Hall, A. D. (1905). Experiments upon grassland mown for hay every year. The Rothamsted Experiments. Chapter 9, pp. 150-159.

3. (a) Brenchley, W. E. (1924). Manuring of grassland for hay. (The Rothamsted Monographs on Agricultural Science). 144 pp.

   (b) Brenchley, W. E. (1925). The effect of light and heavy dressings of lime on grassland. J. Minist. Agric. Fish. 32, 504-512.

   (c) Brenchley, W. E. (1930). The varying effect of lime on grassland with different schemes of manuring. J. Minist. Agric. Fish. 37, 663-673.

   (d) Brenchley, W. E. (1935). The influence of season and of the application of lime on the botanical composition of grassland herbage. Ann. appl. Biol. 22, 183-207.

   (e) Brenchley, W. E. (1935). Park Grass plots. Rep. Rothamsted exp. Stn for 1934, 138-159.

4. Cashen, R. O. (1947). The influence of rainfall on the yield and botanical composition of permanent grass. J. agric. Sci., Camb. 37, 1-10.

5. Warren, R. G. & Johnston, A. E. (1964). The Park Grass Experiment. Rep. Rothamsted exp. Stn for 1963, 240-262.

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METHODS OF SAMPLING AND ANALYSIS

Handfuls of grass were taken at regular intervals from every swathe of the cutting machine. Each sample was then sub-sampled until a weight of approximately 12-20 lb. was obtained. The bundles of grass were transferred the same day to the laboratory and at once spread out to dry under cover, and the weight of the resulting hay determined. Provided the grass was turned frequently and carefully during drying, little breakage or loss of colour occurred, both important points for facilitating the subsequent botanical separation.

Two alternative types of analyses were carried out (a) complete, in which every species was determined and (b) partial, in which the herbage was divided into three groups, Gramineae, Leguminosae and Miscellaneous. Complete separations were made of the hay from all plots at five-year intervals from 1862-1877, of certain plots in 1903 and again of all plots in 1914 and 1919. After this date they were made as seemed desirable, but all plots were included in one of the final two years 1948 and 1949. Many of the earlier analyses were carried out by A.G. Willis, but from 1914 to 1949 they were under the direction of W.E. Brenchley.

MANURING, YIELD AND pH VALUES OF THE SOIL

The manurial treatment given to each plot and the average yields over ten-year periods throughout the experiment are given in Table 1. The figures are for the first crops only. A statistical analysis of the influence of rain fall on yield and botanical composition of the plots was made by R.O. Cashen in 1947[4]. pH values of the soil were determined on most plots in 1945 and the results given as item (a) in the descriptive features of each plot. The figures are approximate only as slight variations, particularly on the limed areas, are to be expected.

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CHAPTER II

FLOWERING PLANTS AND MOSSES

Flowering Plants

A characteristic feature of grassland herbage is the large number of species that occur. During the ninety three years of the experiment i.e. up to 1949, certain changes have taken place, although fundamentally the orders and genera represented have remained practically the same both in number and in kind. During the first years certain species disappeared completely. All of these were originally present in very small quantity and in most cases occurred on a single plot, Carduus arvensis being the only one found on several plots.

The species which have disappeared are:-

Gramineae	None
Leguminosae	Lotus major
	Trifolium minus
	Trifolium procumbens
	Vicia cracca
Miscellaneous	Alchemilla vulgaris
	Carduus arvensis
	Daucus carota
	Galium aparine
	Orchis morio
	Ornithogalum umbellatum
	Plantago media
	Ranunculus auricomus
	Ranunculus repens
	Sonchus oleraceus
	Stellaria holostea
	Veronica officinalis

In 1949, the flora at the first cut of hay (which has been the standard of comparison throughout the experiment) consisted of 65 species, contained in 37 genera and 21 natural orders, little change having taken place since 1919. Their response to the different manures is the subject of chapter V.

A few species occur which do not usually appear in the hay samples, and

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RANUNCULUS ACRIS ET BULBOSUS

Occur on all plots, occasionally in fair amount, R.acris being the more important of the two species.

QUANTITY

Variable (1.0 - 9.8 percent)

Plots	6, 7, 8	Minerals with and without potash
	19, 20	F.Y.M. with and without minerals and nitrate of soda

Small (under 1 percent)

Plots	2, 3, 12	Unmanured
	4^1	Super
	5^1, 5^2	Unmanured or minerals after ammonium salts till 1897
	13	F.Y.M. and fish guano alternately
	15	Minerals
	16, 17	Nitrate of soda with and without minerals

Almost or entirely suppressed

Plots 1, 4^2, 9, 10, 11^1, 11^2, 14, 18.

Ranunculus spp. encouraged by:-

(a) Minerals
(b) Starved soils
(c) F.Y.M.

Ranunculus spp. suppressed by:-

(a) Ammonium salts

LIMED

QUANTITY

Increased

Plots	1	Ammonium salts
	2, 3	Unmanured
	4^1, 7	Minerals
	13, 19LL	F.Y.M. with and without fish guano
	17	Nitrate of soda

Decreased

Plot	8	Minerals without potash

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RUMEX ACETOSA Fig. 22.

Rumex acetosa occurs on all plots. It is usually fairly plentiful where manuring is incomplete, but less so in the presence of heavy dressings of ammonium salts or nitrate of soda. Lime usually increases it when applied with ammonium salts and super or minerals, but decreases it if given with minerals alone or with F.Y.M. Its prevalence varies greatly with season and the following grouping is approximate only.

UNLIMED

QUANTITY

Fairly large

Plots	1	Ammonium salts
	2, 3, 12	Unmanured
	4^1	Super
	5^2	Minerals after ammonium salts till 1897
	6, 7, 8	Minerals with and without potash
	13, 20	F.Y.M. with fish guano or with minerals and nitrate of soda
	18	Minerals without super and ammonium salts

Small

Plots	4^2	Super and ammonium salts
	5^1	Unmanured after ammonium salts till 1897
	$9, 10, 11^2$	Minerals and ammonium salts
	14, 16, 17	Nitrate of soda with and without minerals
	15	Minerals
	19	F.Y.M. after minerals and nitrate of soda

Trace or absent

Plot	11^1	Minerals and heavy ammonium salts

Rumex acetosa encouraged by:-

(a) Minerals
(b) Ammonium salts
(c) Organic manures
(d) Starved soils

Rumex acetosa not encouraged by:-

(a) Sodium nitrate
(b) Heavy nitrogenous manures

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LIMED

QUANTITY

Increased

Plots	4^2	Super and ammonium salts
	10	Minerals without potash and ammonium salts

Decreased

Plots	7	Minerals
	13	F.Y.M. and fish guano alternately
	18	Minerals without super and ammonium salts
	20	F.Y.M., minerals and nitrate of soda

Plots with Rumex acetosa among the three chief species of the whole herbage.

	Unlimed			Limed		
	First	Second	Third	First	Second	Third
1919	-	5^1,5^2,6,7,9,18	4^2,13,15,19	-	1	8
1948 or 1949	-	-	-	-	-	10

Rumex acetosa in Plant Communities

Occurs in a great variety of associations, of which Festuca rubra is always a prominent member when Rumex is plentiful.

SCABIOSA ARVENSIS (Knautia arvensis)

As it flowers late, little is usually found in the hay samples and data are chiefly obtained from observations on the aftermath.

UNLIMED

QUANTITY

Usually present

Plots	2, 3, 5^1, 12	Unmanured
	5^2, 6, 7, 8	Minerals

Occasional

Plots	1	Ammonium salts
	13	F.Y.M. and fish guano alternately
	20	F.Y.M., minerals and nitrate of soda

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