Rothamsted Experimental Station

By H. L. Walster*

An English squire, John Bennet Lawes, who died in 1900, launched in 1843 the first continuously operated agricultural experiment station in the history of the world. Preliminary experiments began in 1838. Brought up as a country boy in the manor house of Rothamsted in Hertfordshire, England, his early education was at Eton where he prepared for Oxford University by taking chemistry under Dr. Charles G. Daubeny, a chemist interested in the effect of changes in soil and light upon the growth of plants.

Leaving Oxford at the age of 20 without graduating, Lawes threw himself enthusiastically into the study of chemistry in his own home where, he tells us, "It sadly disturbed the peace of mind of my mother to see one of the best bedrooms in the house fitted up with stoves, retorts, and all the apparatus and reagents necessary for chemical research."[1]

Lawes was no test-tube chemist—he was apparently ambitious to become a manufacturer of chemicals on a large scale. The laboratory soon left the bedroom and entered the barn where he successfully made calomel. Incidentally the barn on this old English estate served science until 1855.

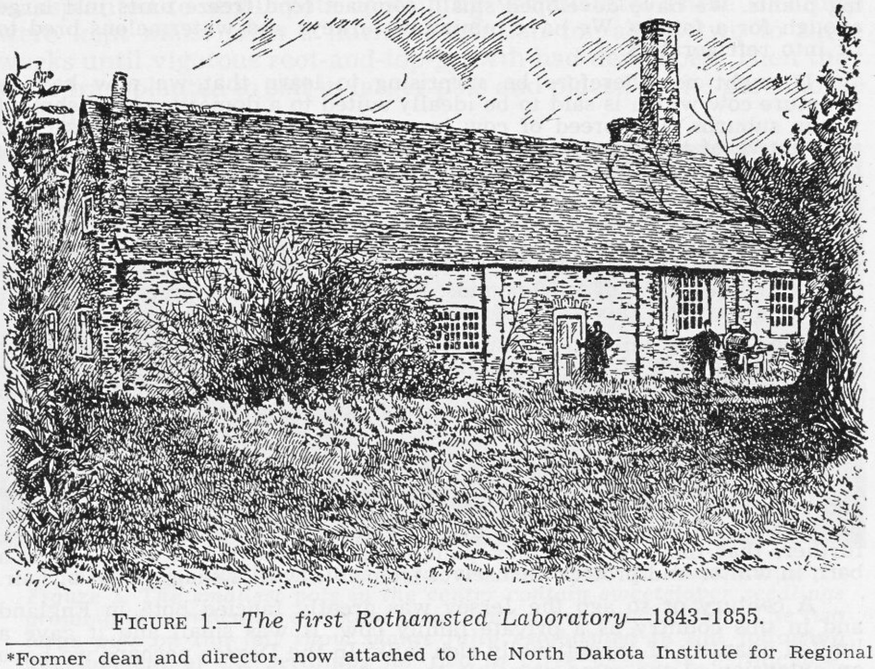

FIGURE 1.—*The first Rothamsted Laboratory*—1843-1855.

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As early as 1837 Lawes became interested in fertilizers. His first experiments consisted in applying different manures to plants grown in pots.[2] Because yields of wheat were falling in England, the English farmer was turning to every kind of waste product for use as manure. Lawes tried charcoal made from animal bones as a fertilizer. He soon found that it had a greater beneficial effect upon his plants when the bone charcoal had been treated with sulphuric acid.

This was no new idea but Lawes carried the idea one step further. As a student of chemistry he knew that bones contained phosphates. The supply of bones was strictly limited. So Lawes turned to treating mineral phosphates with sulphuric acid. He found a supply at hand in the mineral coprolite from Cambridgeshire and Suffolk. The coprolites are the fossilized dung of ancient reptiles and other organisms. Later Lawes obtained his mineral phosphate from Africa.[3] He tried out his product on his Rothamsted farm in 1840 and 1841 and by 1842 patented the process for its manufacture. In the "Biographical Introduction" to The Book of the Rothamsted Experiments, A. D. Hall summed up the importance of the application of this process as follows: "If Sir John Lawes had done nothing more than introduce the manufacture of artificial manures, he would still rank among the greatest benefactors to agriculture."

FIGURE 2.—*The history of planting and harvesting at Broadbalk is also the history of changing times in the use of agricultural labor. Note the manpower used in the harvesting of Broadbalk wheat* 1880, *as shown above.*

But Lawes did something more. In the year in which he built his first factory for making superphosphate (1842) he began his first systematic experiments with fertilizers and farm manure at Rothamsted, thus founding the Rothamsted Experimental Station, now in its 113th year of operation. To the support of this station he dedicated a large part of his fortune. Honors of all kinds came to Lawes including the conferring of a baronetcy by the Queen in 1882.

Lawes supported Rothamsted from his own funds from 1838 to 1899. Shortly before his death in 1900 he created a trust for its perpetuation. Further endowments and government grants have added to its support. Joseph Henry Gilbert (later Sir Joseph), a chemist, began working with Lawes making a scientific partnership which continued until 1900. A. D. Hall became director of Rothamsted Experimental Station in 1901, continuing in that capacity until 1912. Hall was succeeded by E. J. Russell who served until his retirement in 1943. Dr. W. A. Ogg, director of the Macaulay Institute for Soil Research, succeeded Russell in September 1943. Throughout the long history of Rothamsted each of its directors have been scientists with major interest in soils. The centenary of the Experimental Station was celebrated in 1943 while the nation was still engaged in World War II. These men are highly honored the world around and all have been knighted by the English king or queen. Sir E. J. Russell visited the North Dakota Agricultural Experiment Station in 1922 and again in 1927.

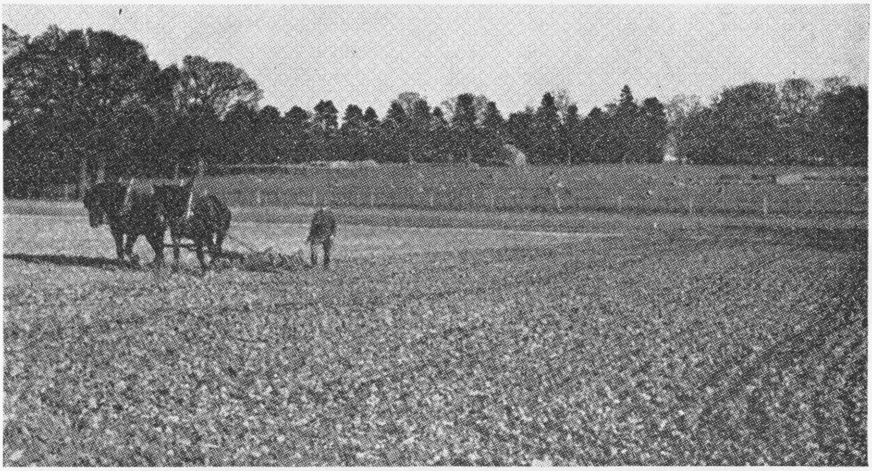

FIGURE 3.—*No event in history has deterred or halted the regularity of annual field trials at the Rothamsted Station. Here, during the war year of* 1939, *ground is prepared for the* 97th *consecutive wheat crop at Broadbalk.*

The establishment of Rothamsted Experiment Station at Harpenden, Hertfordshire, England, furnished a pattern for the great system of American Agricultural Experiment Stations. E. W. Allen, writing an editorial in the Experiment Station Record for

1900 at the time of the death of Lawes, said of the Rothamsted Station that its influence in the United States was "especially strong" for three reasons: First because it was well known with results available in the English language, second because it was practical, and third because English and American methods of agriculture in the early years of its history were similar.

Most of all one must praise the maintenance of the classical field experiments. Of its famous field experiments E. W. Allen said: "The Rothamsted field experiments derive their greatest value from the comprehensive plan in which they were laid out, which has enabled their scope to be continued from time to time so as to include new phases under investigation as they develop; from the systematic and painstaking manner in which they have been continued through long periods, strengthening the confidence in the results; and from the full notes which have been taken at each stage and placed in permanent form."

The North Dakota Agricultural College has a complete file of the bound volumes of the Rothamsted memoirs beginning with volume I covering articles published 1847-1863 and ending with volume XXXI, covering the period 1952-1953.

The most famous of the experiments started by Sir John Lawes, and his long time scientific associate chemist, Sir Joseph Henry Gilbert, are the trials of different fertilizers under continuous winter wheat growing on Broadbalk Field. The most recent summary of the results of these trials was published in 1940.[4] The mean annual yields for the period 1852 to 1925, except as noted, follow:

Yields of Winter Wheat Under Continuous Culture
Broadbalk Field—Rothamsted

Bushels of Grain Per Acre

Plot No.	Treatment	Mean Yield 1852-1925
2A	Farmyard manure	30.0[a]
2B	Farmyard manure	36.2
3-4	Unmanured	12.5
5	Complete minerals, no nitrogen	12.9
6	Minerals plus 43 lbs. of nitrogen in sulphate of ammonia	23.3
7	Minerals plus 86 lbs. of nitrogen in sulphate of ammonia	32.9
8	Minerals plus 129 lbs. of nitrogen in sulphate of ammonia	37.5
9	Minerals and 43 lbs. of nitrogen in nitrate of soda	25.9[b]
10	Sulphate of ammonia containing 86 lbs. of nitrogen, and no minerals	20.3
11	Sulphate containing 86 lbs. of nitrogen and superphosphate	23.0
12	Sulphate of ammonia containing 86 lbs. of nitrogen, superphosphate and sulphate of soda	29.3
13	Sulphate of ammonia containing 86 lbs. of nitrogen, superphosphate and sulphate of potash	31.7
14	Sulphate of ammonia containing 86 lbs. of nitrogen, superphosphate, and sulphate of magnesia	25.6

15	Minerals and two applications of sulphate of ammonia, totalling 86 lbs. of nitrogen, all applied in the autumn	30.1
16	Minerals, and nitrate of soda amounting to 86 lbs. of nitrogen	33.2
17-18	Minerals and sulphate of ammonia containing 86 lbs. of nitrogen, applied in alternate years	30.1
17-18	Minerals only, (Sulphate of ammonia applied in alternate years as above—this average from 17 and 18 with minerals only)	15.1
19	Rape cake containing 86 lbs. of nitrogen	23.5[c]
20	Sulphate of ammonia containing 86 lbs. of nitrogen and sulphates of potash, soda, and magnesia	17.6[d]

[a]Mean of 26 years, 1900-1925.
[b]Mean of 41 years, 1885-1925.
[c]Mean of 33 years, 1893-1925. Rape "cake" is rape seed from which oil has been expelled.
[d]Mean of 18 years, 1906-1925 excluding 1912 and 1914.

Mineral applications were as follows:

Plots 5, 6, 7, 8, 9—392 pounds superphosphate, 200 pounds sulphate of potash, 100 pounds sulphate of soda, and 100 pounds sulphate of magnesia.

Plot 11—392 pounds superphosphate.

Plot 12—392 pounds superphosphate and 366 pounds of sulphate of soda.

Plot 13—392 pounds superphosphate and 200 pounds of sulphate of potash.

Plot 14—392 pounds superphosphate and 280 pounds of sulphate of magnesia.

Plots 15, 16—Same as 5.

Plots 17, 18—Minerals, same as 5 alternate with the nitrogen applications by years.

Plot 20—Same as plot 7 but without superphosphate.

The superphosphate applications varied from 63 to 70 pounds of phosphoric acid (P_2O_5) per acre. The manure applications approximated 200 pounds of nitrogen annually. Farm manure varies in nitrogen content, an average figure is 10 pounds per ton—hence 200 pounds of nitrogen in the annual application are equal to 20 tons of manure per acre.

The Lesson of Broadbalk For Spring Wheat Farmers

Broadbalk's continuous wheat plots are of winter wheat. The harvest is usually removed from the field by August 25 and the next crop of wheat seeded by November 1, leaving a short period in which to get rid of weeds. The annual precipitation for the 50 year period, 1852 to 1901 inclusive, averaged 28.24 inches. Rainfall above the average, and particularly heavy winter rainfall in England causes excessive leaching of soluble plant food, especially of nitrates from the soil, a condition which does not occur in the long cold winter of the Northern Plains in the United States and Canada.

The Broadbalk heavily manured Plot 2B is an effective maintainer of high yields but Plot 8 which receives superphosphate, potash, and other minerals plus a heavy application of nitrogen in the form of sulphate of ammonia, is equally effective. In recent years Broadbalk's continuous wheat plots have suffered from two soil-infecting diseases, "eye-spot lodging" and "take-all". The spring wheat area of the United States is not infected with these organisms, but, as H. L. Bolley[2] pointed out more than 40 years ago, our wheat fields are accumulating a load of root-rotting fungi of other species. Soil-carried insects have not damaged the Broadbalk continuous wheat plots more than wheat under rotation at Rothamsted.

The greatest enemy of wheat throughout the years on Broadbalk's plots has been weeds. So serious did weeds become that, beginning with 1926, all Broadbalk plots have been divided into five sub-plots. Some of these sub-plots are fallowed every year according to a pre-determined pattern of either two-year or four-year fallowing.

In spite of these long periods of fallow, weeds still persist. In a report upon the crop of 1953 on Broadbalk the following notes appear:

"Section I nearest the farm, carrying the second crop after fallow, was a good plant, (that is good stand, H.L.W.) and looked well throughout the season, but in the remaining sections the plant was much thinner than usual, and poppies, buttercup and bent grass were conspicuous.

"Wild oats appeared to be diminishing slightly, thanks to the careful and systematic hand-pulling that has been carried out in Broadbalk for several seasons. On the other hand, leguminous weeds, chiefly trefoil and vetches, were particularly bad on Plot 5, minerals only, where the wheat was practically choked out by them. These weeds are beginning to spread to Plot 6 which receives only a small dressing of ammonium sulphate in addition to the mineral manures."

Russell and Watson, in discussing the effects of fallow, have said: "The occasional fallowing of parts of Broadbalk has had remarkable effects in raising the yields to the initial levels or higher showing that fallowing can completely overcome the deterioration in yield."[5] To the foregoing statement there should be added another quotation from the same source:[6]

"The beneficial effect of the fallow is partly due to the better control of weeds, partly to better seed-bed and general soil conditions and partly to nitrates that have accumulated during the fallow period. A fourth factor that is of prime importance in the great wheat growing countries, the storing up of soil moisture, is hardly likely to operate here, (that is in England, H. L. W.) since the rainfall is already in excess. The amount of nitrate stored up during the fallow is considerable."[7]

[2]Botanist and plant pathologist, retired, formerly with N. D. Agricultural Experiment Station.

Here in the spring wheat area of the United States summer fallow both stores water and accumulates nitrates. The stored nitrates are essential to satisfactory phosphate response on many soils.

References

[1]Hall, A. D. The Book of Rothamsted Experiments 1905.

[2]Ibid—P XXIII "Biographical Introduction."

[3]Gavin, Sir Wm. The Way to Higher Crop Yields: Agriculture: The Journal of the Ministry of Agriculture P106 58: 105-111. 1951.

[4]Russell, E. J. and Watson, D. J. The Rothamsted Field Experiments on the Growth of Wheat. Tech. Communication No. 40, Imperial Bureau of Soil Science 1940.

[5]Ibid P. 62 and 63.

[6]Ibid P. 70.

[7]Report of the Rothamsted Experimental Station for 1953—The Classical Experiments P. 138. Harpenden 1954.

THIS IS THE JUNGLE PRIMEVAL

A six square mile tract of jungle in the Panama Canal Zone contains one of the world's most varied and most concentrated collections of tropical wild life.

This is Barro Colorado island, now administered for the benefit of the world's naturalists by the Smithsonian Institution. The island is an old hilltop, left above water when the Chagres river was dammed to create Gatun lake, an integral part of the Panama canal. Barro Colorado is covered by primeval jungle, much the same today as when Spaniards first crossed the isthmus. It is preserved intact entirely for scientific purposes, and it has been estimated that within half a century it may constitute the only unaltered jungle in that part of the world.

Barro Colorado remains unaltered so far as its living things, from pinhead sized red chiggers to boa constrictors, are concerned. All the ancient ways of jungle life go as they did 10,000 years ago without attempt by man to modify them. It remains natural jungle, ordered as little as possible for the benefit of scientists. There are miles of marked trails for the use of naturalists and native guides familiar with the haunts of most of the wild creatures. Only in one secluded corner is there a small, man made clearing for living, laboratory and library facilities.

The island still contains the mammals, birds, reptiles, amphibians and lower forms of life it had before the white man invaded Panama. To these a few may have been added—jungle creatures that have found a refuge here when life in their former habitats became difficult. Killing or capturing an animal, or even picking a plant, except for approved scientific purposes, is strictly forbidden.

Naturally, life may be somewhat more concentrated than it was in the original jungle. Creatures live at closer quarters to one another. They now have had a quarter of a century to adjust to this condition and appear to have done quite well. The waters of Gatun lake serve as a wall through which few of the land creatures can make their way easily.

Scientists have been exploring the life of Barro Colorado for the last 25 years, since the opportunely created island was first set aside as a preserve at the request of naturalists by order of an interested governor of the Canal Zone. Hundreds of hitherto unknown species have been found here and described to science, most of them, of course, smaller creatures such as insects and small amphibians and reptiles. Many more, it is probable, will be found in the future, as the investigators are far from having reached the ultimate depths of the infinitely varied and infinitely complicated jungle life.