Report for 1935

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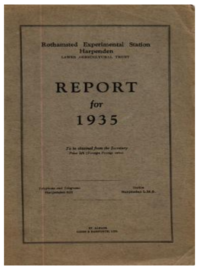

Thirty Years' Work in the Botanical Depatment 1906-1936

Rothamsted Research

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invited to give their experiences and the Rothamsted staff and other experts also read papers. The proceedings are then published cheaply as booklets.

(*b*) by lectures to farmers' organisations This falls largely on Mr Garner, but the senior members of the staff including the Director regularly give a certain number. Field demonstrations are arranged at outside centres wherever the experimental results are suitable: this is usually done by Mr. Garner or Dr. Crowther, in association wherever practicable, with the County Organiser. Articles for the technical press are frequently written.

(*c*) by demonstrations at the Rothamsted Farm, usually by Mr. Garner, Captain Gregory and Mr. Moffatt. The numerous visitors to the laboratories are dealt with by Messrs. Garner and Gregory and a group of rota guides, which includes selected voluntary workers and all members of the scientific staff other than Heads of Departments. The number of visitors increases every year.

In addition there is a fair amount of visiting of farms when the owner not infrequently brings together a little group of neighbours for discussion.

THIRTY YEARS' WORK IN THE BOTANICAL DEPARTMENT. 1906-1936.

WINIFRED E. BRENCHLEY, D.Sc.

During the early years of Rothamsted the laboratory work was entirely concerned with matters arising from the field plots, chiefly chemical in nature, and this was carried on by a chemist and a few laboratory assistants under Sir Henry Gilbert. No regular botanist was needed, but when occasion arose a trained man was engaged temporarily to supervise the botanical separation of Park-grass Hay, this work being carried on later by Mr. J. J. Willis. By 1906 the scientific work of the institution was widened, and sub-division into departments gradually became necessary. The James Mason laboratory, erected in that year, served to house the various young biological departments until the general extension of the laboratories began about 1912. During that period the foundations of a botanical department were laid down, and the work was ready for fuller development when increased accommodation and working facilities became available.

In the early days of this century the question of the "strength" of wheat was receiving much attention, and the first problem dealt with in the new department was the possibility of associating the varying strength of wheat with cytological differences in the developing grain, but no such differences could be detected ([1]). Analyses made at three day intervals from flowering to maturity showed that at each stage the endosperm is filled by uniform material, possessing always the same ratio of nitrogenous to non-nitrogenous material and ash, this ratio being determined by such factors as variety, soil and season ([2]). With barley, as with wheat,

(1) W. E. Brenchley—"On the Strength and Development of the Grain of Wheat (Triticum vulgare). Ann. Bot., 1909. Vol. XXIII, pp. 117-39.

(2) W. E. Brenchley and A. D. Hall—"The Development of the Grain of Wheat." J. Agric. Sci., 1909. Vol. III, pp. 195-217.

the weight of the whole plant increases steadily until desiccation sets in, after which it falls; the fall is greater for barley, which is cut dead ripe, than for wheat, which is cut when maturation changes are only beginning. With wheat from Broadbalk the manuring had very little effect on the composition of the grain or straw, whereas with barley from Hoos Field the effect of phosphoric acid starvation was reflected in the results obtained. (3). Later work on the phosphate requirements of barley emphasized the great importance of adequate supplies in the early stages of growth. Normal development and maximum dry weight are attained if phosphate is supplied for the first few weeks even if it be entirely withheld afterwards, though the actual amount of phosphate absorbed continues to increase steadily if the supply is maintained. On the other hand the absence of phosphate during early growth seriously hinders development, even though an adequate amount is given after short periods of deprivation. (4). Parallel experiments, as yet unpublished, indicate a somewhat similar response with regard to potash, maximum dry weight being attainable after a few weeks' initial supply, but with nitrogen, increase of dry weight continues with nitrogen supply up to a relatively short time before maturity.

The first work on plant physiology at Rothamsted was concerned with the action of various substances, especially plant poisons, on growth. It had been supposed that all substances deleterious to plant growth act as stimulating agents if they are available only in exceedingly minute quantities, and in 1907 investigations were begun in water cultures to test this hypothesis. Salts of manganese, copper, zinc, arsenic and boron were studied, but, while toxic effects were always produced by relatively small amounts, minute traces did not always have a stimulating action under the conditions of experiment. Arsenious acid and arsenites were far more toxic than corresponding doses of arsenic acid and arsenates. (5).

Boron is less toxic than the other elements tested, but it was not till 1921 that a chance observation drew attention to a far more important question—the possibility that boron might be an essential element for plant growth. Attempts to grow beans in water cultures had always failed, and it so happened that they had never been tested in solutions containing boron till 1921, when a series of *Vicia faba* plants were grown for entomological purposes with various elements in addition to the usual nutrient salts. This was followed up by Miss K. Warington, and it was conclusively established that a trace of boron is absolutely essential for the growth of many plants, and that in its absence the meristematic tissues are adversely affected and death ultimately occurs. In *Vicia* the cambium cells are greatly enlarged in the absence of boron, and breaking down of the vascular tissues proceeds from the stem apex downwards.

(3) W. E. Brenchley—" The Development of the Grain of Barley." Ann. Bot. 1912. Vol. XXVI., pp. 903-28; W. E. Brenchley—" The Development of the Flower and Grain of Barley." J. Inst. Brew. 1920. Vol. XXVI, pp. 615-32.

(4) W. E. Brenchley—" The Phosphate Requirement of Barley at Different Periods of Growth." Ann. Bot. 1929. Vol. XLIII, pp. 89-110.

(5) W. E. Brenchley—" The Influence of Copper Sulphate and Manganese Sulphate upon the Growth of Barley." Ann. Bot., 1910. Vol. XXIV, pp. 571-83; W. E. Brenchley—" On the Action of Certain Compounds of Zinc, Arsenic, and Boron on the Growth of Plants." Ann Bot. 1914 Vol. XXVIII, pp. 283-301; W. E. Brenchley—" Inorganic Plant Poisons and Stimulants" (Cambridge Univ. Press), Second Edition, 1927, pp. 134.

Deficiency of boron also adversely affects nodule production by inhibiting the development of the vascular strands which supply the carbohydrate material needed as a source of energy for the bacteria. The latter become parasitic, attacking the protoplasm of the host cell, and the ultimate result is abnormal nodules which are only capable of fixing very small amounts of nitrogen, less than one-tenth of that fixed in normal plants.

The need for boron was at first thought to be specific to leguminous plants, but it has since been shown to be essential for other species, although the requisite amount may be less. The chemical combination in which it is presented to the plant is immaterial, but no other element, out of over fifty tested, has proved capable of replacing it. Boron deficiency symptoms appear more slowly during spring and autumn than in the summer months, the delay being controlled more by the shorter length of day than by the lower temperatures. The symptoms are similar under both long and short day conditions, though they are less pronounced and their progress is retarded with short days. In no circumstances, however, did shortening the day when boron was supplied produce degeneration effects similar to those induced by a lack of boron. ([6]). Though the need for boron is fully recognised, its function is still undetermined. It may be connected with the uptake or utilisation of other nutrients, but though some indications were obtained of an association between boron and calcium, the evidence was not conclusive and the search continues.

This question of boron deficiency is proving to be one of considerable economic importance, as it is now found that certain obscure "physiological" diseases of important cultivated crops, *e.g.*, heart-rot of sugar beet, brown heart of turnips and certain tobacco diseases, can be cured by the application of from 12-20 lb. of borax per acre. In Sumatra boron compounds take a regular place in the manuring of the tobacco crops, and wherever sugar beet is grown watch is being kept for heart-rot and boron amelioration is being attempted. The subject is being further studied. ([7]).

During recent years much attention has been directed to the importance of these "minor" elements in plant nutrition, and to the possibility of utilising them in agricultural practice for crop improvement. Before this can be done, however, full information on the action of the various elements is needed, and the botanical department endeavours to supply this. Claims are frequently made of heavy crop increases due to the use of certain elements, such as titanium, copper, etc., and these are as far as possible investigated both in soil and water cultures. It seldom happens that the benefit

(6) K. Warington—"The Effect of Boric Acid and Borax on the Broad Bean and certain other Plants." Ann. Bot., 1923, Vol. XXXVII, pp. 629-72; K. Warington—"The Changes induced in the Anatomical Structure of *Vicia faba* by the Absence of Boron from the Nutrient Solution." Ann. Bot., 1926, Vol. XL, pp. 27-42; W. E. Brenchley and H. G. Thornton—"The Relation between the Development, Structure and Functioning of the Nodules on *Vicia faba*, as influenced by the Presence or Absence of Boron in the Nutrient Medium." Proc. Roy. Soc. B., 1925, Vol. 98, pp. 373-99; W. E. Brenchley and K. Warington—"The Rôle of Boron in the Growth of Plants." Ann. Bot., 1927, Vol.XLI, pp. 167-87; K. Warington—"The Influence of Length of Day on the Response of Plants to Boron." Ann. Bot., 1933, Vol. XLVII, pp. 429-57.

(7) K. Warington—"Studies in the Absorption of Calcium from Nutrient Solutions, with Special Reference to the Presence or Absence of Boron." Ann. Bot., 1934, Vol. XLVIII, pp 743-76; E. Rowe—"A Study of Heart-rot in young sugar beet plants grown in culture solutions." Ann. Bot. (In press).

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claimed can be substantiated under experimental conditions, but the possibility always exists, and it is of the greatest importance that all available information shall be obtained on the action of various elements on different types of soil and under different growth conditions.[8].

From time to time an agricultural outlet is sought for by-products in industry. Attempts were made to use iodine compounds (of which there are considerable potential supplies) as a partial sterilisation agent to improve the germination of tomatoes in " sick " soils, and as a preventive of " damping off," but with little or no success. Stronger doses of iodine added to the usual manures were definitely harmful to the germination of barley and mustard, if the seeds were sown directly after treatment. This toxic action gradually decreased and later sown seeds were not affected. Although occasional examples of stimulation were observed in mustard, the results failed to justify any recommendation of an extended use of iodine for agricultural purposes. [9].

The large percentages of silicon present in certain crops, especially cereals, had long attracted attention and suggested that silicon could partially replace phosphorus in the economy of the plant. Experiments in water cultures indicated that under normal conditions of nutrition, with available phosphate present, silicon is ineffective in improving growth, though in the entire absence of phosphate it may produce a slight increase in dry weight. Crops vary in their response to silicate on different types of soil, a certain improvement being obtained chiefly when potash or phosphate is deficient. The benefits, however, were insufficient to justify the addition of silicates to the usual manures.[10]

The action of certain organic compounds on growth has been studied in view of their use as fumigants or sterilising agents. When supplied through the roots, prussic acid and cyanides are extremely poisonous ; 1 part in 100,000 proved fatal to peas, and barley was slightly more resistant, but no sign of stimulation has been observed with any concentration down to 1 part in 1,000,000,000. The phenols behave similarly in their general effects, though the individual substances exert their specific action at somewhat different concentrations. High concentrations are fatal, and somewhat lower strengths have a paralysing effect at first, seriously checking growth for some time. This inhibition gradually wears off, and the affected plants may ultimately make as good growth as the controls. This type of temporary inhibition is rarely seen with inorganic poisons, and may be due to a weakening of the organic toxic material by oxidation or other chemical change. [11]

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(8) W. E. Brenchley—" The Action on the Growth of Crops of Small Percentages of certain Metallic Compounds when applied with Ordinary Artificial Fertilisers." J. Agric. Sci., 1932, Vol. XXII, pp. 705-35 ; W. E. Brenchley—" The Effect of Rubidium Sulphate and Palladium Cloride on the Growth of Plants." Ann. Appl. Biol., 1934, Vol. XXI, pp. 398-417 ; W. E. Brenchley —" The Essential Nature of certain Minor Elements for Plant Nutrition." Bot. Rev., 1935. Unpublished work on Copper, Nickel and Cobalt.

(9) W. E. Brenchley—" The Effect of Iodine on Soils and Plants." Ann. Appl. Biol., 1924, Vol. XI, pp. 86-111.

(10) W. E. Brenchley, E. J. Maskell and K. Warington—" The Inter-relation between Silicon and other Elements in Plant Nutrition." Ann. Appl. Biol., 1927, Vol. XIV, pp. 45-82.

(11) W. E. Brenchley—" Organic Plant Poisons. I. Hydrocyanic Acid." Ann. Bot., 1917 Vol. XXXI, pp. 447-56 ; W. E. Brenchley—" Organic Plant Poisons. II. Phenols." Ann. Bot. 1918, Vol. XXXII, pp. 259-78.

Alcohol, absorbed by the roots, is definitely toxic in fairly high concentrations, ethyl alcohol being more poisonous to barley than methyl alcohol. The difference in toxicity is not merely one of degree, but of kind, as with ethyl alcohol ear development was found to begin early, with a corresponding early death of superfluous leaves, whereas with methyl alcohol active vegetative growth continued much longer and ear development was delayed. ([12]). A general review of the resistance of plants to poisons and alkalies, covering a wide field, was recently presented at the Third International Congress for Comparative Pathology at Athens. ([13])

During the course of these inquiries various physiological problems arising out of the methods of technique were studied. Early work with solutions extracted from various Rothamsted soils indicated that within wide limits the rate of growth of a plant varies with the concentration of the nutritive solution, irrespective of the total amount of plant food available. Later on, in standardising the solutions to be used for water cultures, it was again found that the concentration of the nutrient solution, up to a comparatively high strength, has a great effect upon the rate and amount of growth and that starvation effects, due to insufficient nutriment, are obtainable in much stronger concentrations than was usually recognised. ([14])

The harmful effect of overcrowding plants is usually attributed to competition for food and water in a limited area of soil. The importance of aerial competition for light, essential for photosynthesis, was shown by growing barley plants in individual bottles to eliminate competition for food and water, but so closely crowded together that serious shading occurred. The crowded plants suffered drastic reduction in development and ear production, whereas corresponding plants, given ample space, tended to produce a standard type in which the relation between the number of tillers and ears, dry weights, and ratios of root to shoot approximated in some degree to a constant standard.

Although the water culture work is carried on in a roof greenhouse, with minimum interference with the available light, the effective experimental period during the year is limited by light conditions, and as a general rule, few experiments can be carried on during the winter months. On the other hand, cereals fail to grow well if sown too late, and the usual plan is to start cereal experiments during February or March at the latest, and when a later crop is required to utilise other plants, as broad beans or peas, which will develop successfully from summer sowings. Depression of growth during very hot sunny weather was traced to high temperatures at the roots associated with strong and prolonged sunshine, though the two factors acting individually cause much less

(12) A. N. Puri—" Effect of Methyl and Ethyl Alcohol on the Growth of Barley Plants." Ann. Bot., 1924, Vol. XXXVIII, pp. 745-52.

(13) W. E. Brenchley—" The Resistance of Plants to Poisons and Alkalies." Rapp. 3rd Inter. Cong. Pathol. Comp., Athens, 1936, pp. 3-23.

(14) A. D. Hall, W. E. Brenchley and L. M. Underwood—" The Soil Solution and the Minera Constituents of the Soil." J. Agric. Sci., 1914, Vol. VI, pp. 278-301 ; Phil. Trans. Roy. Soc. B., 1914, Vol. 204, pp. 179-200 ; W. E. Brenchley—" The Effect of the Concentration of the Nutrient Solution on the Growth of Barley and Wheat in Water Cultures." Ann. Bot., 1916, Vol. XXX, pp. 77-90.

damage. This difficulty was overcome by using sun-blinds and by giving better protection from the direct rays of the sun to the culture bottles, thus keeping the root temperatures at a lower level. [15].

In pot and water culture experiments the ultimate measure of the result is usually that of dry weight, associated with chemical analyses and observations made during growth. The practice has always been to grade the larger seeds used for experiment within close limits of weight, on the assumption that the amount of reserve food in the seed might have an effect upon growth and the final crop. The correctness of this assumption was proved by experiments with peas and barley in which a steady and considerable rise in the dry weight of the plants occurred as the initial weight of the seed increased. Similar results were obtained with either a limited or abundant food supply, and justify the use of large heavy seed for agricultural crops.

With pot cultures the caking of the soil due to surface watering has been overcome by sinking small earthenware pots to their rims in the soil of the experimental pots, and adding the water through the porous pots. Better root development is thus obtained and incidentally much time is saved in watering. [16]

Much of the work of the botanical department is concerned with germination and pot culture tests of manures and other substances requiring investigation, the results of which are frequently incorporated in unpublished reports. With the outbreak of the Great War, fertilisers became increasingly difficult to obtain, and various waste products were examined in the search for substitutes, such as pottery waste, leather waste, flue dust and blast furnace dust containing lead oxide. The conclusion of the War brought a reversal of activities in the attempt to find an outlet for superfluous munitions by converting T.N.T., cordite, etc., into fertilisers and utilising ammonium and potassium perchlorates as weed-killers, as they are too toxic to have manurial value. Germination tests are repeatedly called for, often as a preliminary to further developments if the results prove satisfactory. Large scale pot culture experiments may be carried on for several years before the final report is issued, and frequently a number of soils are imported from various districts in order that tests may be made on different soils under parallel environmental conditions. Superphosphate, mineral phosphate, basic slag, ammonium humate, cyanamide, humunit, sewage sludge, poultry manure, copper sulphate and peat manure are among the substances investigated over a long period, in some cases in association with the chemical department. [17]

The root development of barley and wheat was worked out with

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(15) W. E. Brenchley—"Some Factors in Plant Competition." Ann. Appl. Biol., 1919, Vol. VI, pp. 142-70; W. E. Brenchley—"On the Relations between Growth and the Environmental Conditions of Temperature and Bright Sunshine." Ann. Appl. Biol., 1920, Vol. VI, pp. 211-44; W. E. Brenchley and K. Singh—"Effect of High Root Temperature and Excessive Insolation upon Growth." Ann. Appl. Biol., 1922, Vol. IX, pp. 197-209.

(16) W. E. Brenchley—"Effect of Weight of Seed upon the Resulting Crop." Ann. Appl. Biol., 1923, Vol. X, pp. 223-40; K. Singh—"Development of Root System of Wheat in different kinds of soils and with different methods of Watering." Ann. Bot., 1922, Vol. XXXVI, pp. 353-60.

(17) W. E. Brenchley and E. H. Richards—"The Fertilising Value of Sewage Sludges." J. Soc. Chem. Ind., 1920, Vol. XXXIX, pp. 177-82; E. M. Crowther and W. E. Brenchley. "The Fertilising Value and Nitrifiability of Humic Materials prepared from Coal." J. Agric. Sci., 1934, Vol. XXIV, pp. 156-76.

special reference to the "white" roots produced about the time that tillering begins. Their function is probably to provide the plant with a plentiful supply of water and dissolved nutrients at the time that vigorous growth is setting in, abundant root hairs and an enlarged conducting system forming the necessary mechanism. (18)

A further branch of the department's activities deals directly with field problems. The important question of weeds and their eradication led to a series of surveys of arable land to ascertain how far weed species are associated with particular soils or crops, and to what extent they are of general distribution. Comparatively few individual weeds can be regarded as symptomatic of special types of soils, but groups of weeds are characteristic of clay, chalk and peat while loams tend to be colonised by a greater variety. Information on these points is still being collected with the aid of observers in schools and colleges in various parts of the country. (19)

The harmful effect of weeds in crops appears to be due to direct competition for the essential food, water and light, though the possibility of some toxic effect by root excretions cannot altogether be ruled out. Accurate knowledge of the habits of weeds is essential for devising appropriate methods of eradication, and a considerable amount of work has been devoted to this end. (20)

Direct experiments on eradication have been carried out from time to time, the most noteworthy results being the effective use of perchlorate for ridding paths of weeds, and the possibility of utilising thiocyanates for improving very weedy grassland. The latter experiment is still in hand, and promises considerable success. Sodium chlorate is so effective in keeping down weeds that it is now regularly used in the precincts of the laboratories. Special care is needed to avoid splashing boots and clothes with the solution as chlorates are very inflammable if they dry on to organic material.

The difficulties of weed eradication are intensified by the fact that seeds buried in the soil are able to retain their vitality for long periods, often extending over many years. Living seeds of weeds characteristic of arable land were found in areas that had been under grass for varying times (Laboratory House Meadow, 58 years; Barnfield grass, 40 years; Geescroft, 32 years, New Zealand field, 10 years). More than a dozen species germinated, *Atriplex patula* and *Polygonum aviculare* providing the greatest number of

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(18) W. E. Brenchley and V. G. Jackson—"Root Development in Barley and Wheat under different conditions of Growth." Ann. Bot., 1921, Vol. XXXV, pp. 533-56; V. G. Jackson—"Anatomical Structure of the Roots of Barley." Ann. Bot., 1922, Vol. XXXVI, pp. 21-39.

(19) W. E. Brenchley—"The Weeds of Arable Land in Relation to the Soils on which they Grow." I. Ann. Bot., 1911, Vol. XXV, pp. 155-85; "The Weeds of Arable Land in Relation to the Soils on which they Grow." II. Ann. Bot., 1912, Vol. XXVI, pp. 95-109; "The Weeds of Arable Land in Relation to the Soils on which they Grow." III. Ann. Bot., 1913, Vol. XXVII, pp. 141-66; W. E. Brenchley—"Weeds in Relation to Soil." J. Bd. Agric., 1911-12, Vol. XVIII, pp. 18-24; J. Bd. Agric., 1912-13, Vol. XIX, pp. 20-26; J. Bd. Agric., 1913-14, Vol. XX, pp. 198-205; W. E. Brenchley—"Weeds of Farm Land." Longmans, Green & Co., 1920, pp. 239; W. E. Brenchley—"Yellow Rattle as a Weed on Arable Land." J. Bd. Agric., 1912-13, Vol. XIX, pp. 1005-9.

(20) W. E. Brenchley—"The Effect of Weeds upon Cereal Crops." New Phyt., 1917, Vol. XVI, pp. 53-76 W. E. Brenchley—"The Effect of Weeds upon Crop." J. Bd. Agric., 1917-18, Vol. XXIV, pp. 1394-1400; W. E. Brenchley—"Weeds on Arable Land and their Suppression." J. Roy. Agric. Soc. Eng., 1915, Vol. LXXVI pp. 1-24; W. E. Brenchley—"Spraying for Weed Eradication" J Bath and West & Sou. Coun. Soc., 1924-25, Vol. XIX, pp. 1-20; W. E. Brenchley—"Eradication of Weeds by Sprays and Manures." J. Bd. Agric., 1918-19, Vol. XXV, pp. 1474-82; W. E. Brenchley—"West Country Grasslands." J. Bath and West & Sou. Coun. Soc., 1916-17, Vol. XI, pp. 1-28.

individuals.[21] The undue increase of poppies and black bent (*Alopecurus agrestis*) on Broadbalk field led to a two-year fallow, providing opportunity for making a numerical census of the number of viable seeds in the soil before and during treatment, and of following up the after effects of fallowing on the weed flora. Weed species in general show a definite tendency to germinate at a particular season: the majority germinate chiefly in the autumn, but a few, e.g. *Polygonum aviculare* and *Bartsia odontites*, reach their maximum in the spring. This is of great importance in practice, as weeds are most easily destroyed in the seedling stage, and cultivation during the dormant period of the seeds can do nothing towards their eradication. No adequate explanation of the cause of this seasonal effect is forthcoming, though experiments carried out with seeds kept in constant and in fluctuating daily temperatures indicate that temperature conditions are apparently of great, though not of sole, importance. Fallowing operations do not equally reduce all species, as the range of reduction varies over a wide percentage, while a few species may even be increased. This occurs if the interval between cultivations is too long, as some rapidly-growing species are then able to reach maturity and replenish the soil with seeds. The ultimate re-establishment of weed species is not correlated with the degree of reduction by fallowing, but seems to depend upon the rapidity with which any species can begin to reassert itself. *Alopecurus agrestis* and *Stellaria media* were drastically reduced by fallowing, but within three years they were more plentiful than before treatment, whereas *Papaver rhæas* has remained approximately at the fifty per cent. level to which it was reduced by the fallow.[22]

The results of giving weeds a free hand among the crops is well shown by Broadbalk wilderness, in which the wheat crop of 1882 has reverted to an oak-hazel wood where it is entirely undisturbed, and to a rough meadow where the trees and shrubs are removed yearly.[23]

The dominant species in the weed flora of any area are to a great extent determined by the crop and its type of cultivation, winter wheat, spring barley and root crops presenting quite a different balance in their associated weeds. The cumulative effect of long-continued manuring appears to be of secondary importance except in cases of serious deficiency, such as a lack of nitrogen or exhaustion of minerals induced by a prolonged application of ammonium salts only.[24]

Though weeds are generally regarded as pernicious, they have certain beneficent aspects, and during the War search was made for the various uses to which they could be put as substitutes for essential materials that were difficult to obtain. The range of

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(21) W. E. Brenchley—"Buried Weed Seeds." J. Agric. Sci., 1918, Vol. IX, pp. 1-31.

(22) W. E. Brenchley and K. Warington—"The Weed Seed Population of Arable Soil. I." "Numerical Estimation of Viable Seeds and Observations on their Natural Dormancy." J. Ecol. 1930, Vol. XVIII, pp. 235-72; II. "Influence of Crop, Soil and Methods of Cultivation upon the Relative Abundance of Viable Seeds." J. Ecol., 1933, Vol. XXI, pp. 103-27; III. "The Re-establishment of Weed Species after Reduction by Fallowing." J. Ecol. (In Press); K. Warington—"The Effect of Constant and Fluctuating Temperature on the Germination of the Weed Seeds, in Arable Soil." J. Ecol., 1936, Vol. XXIV, pp. 185-204.

(23) W. E. Brenchley and H. Adam—"Re-colonisation of Cultivated Land allowed to revert to Natural Conditions." J. Ecol., 1915, Vol. III, pp. 193-210.

(24) K. Warington—"The Influence of Manuring on the Weed Flora of Arable Land." J. Ecol., 1924, Vol. XII, pp. 111-26.

possible uses is very wide, but in most cases the value is too low or the costs of collection and manufacture are too great for economic exploitation under normal conditions.(25)

Through all these years of change and progress the original botanical work on Park grass was never neglected. Partial analyses of the herbage were made year by year, by Mr. J. J. Willis, till his death in 1911, after which the work was transferred to the botanical department. In 1914 and 1919 complete botanical analyses of every plot were made by a specially recruited staff of assistants, with Miss G. Bassil as deputy supervisor and Mr. E. Gray as referee for knotty points, in view of his long experience of the plots and methods of separation. These results provided a gauge for estimating the change in the herbage since 1877, when Lawes, Gilbert and Masters had completed a series of four quinquennial analyses. They also demonstrated the effects of the system of liming one half of each plot, instituted by Mr. (now Sir) A. D. Hall, in 1903. Complete and partial analyses of specific plots are still made regularly, and a complete synopsis of the results obtained since the experiment was started in 1856 is now available in published form.(26) The serious lodging that occurs on the heavily-manured plots in some seasons and the comparative rigidity of plants supplied with potassium salts led to an anatomical investigation of *Dactylis glomerata*, and the results seemed to point to the rigidity being due to physiological causes rather than to anatomical strengthening.(27) At one period, when frost had devastated the unlimed area receiving heavy dressings of ammonium sulphate, a heavy invasion of fireweed (*Epilobium angustifolium*) occurred, but in succeeding years it failed to hold its ground, and disappeared from the plots.(28)

On the solitary classical plot (Plot 13) receiving organic manures, liming usually proved detrimental to the crop. From 1920 other plots were treated with light and heavy dressings of lime at four-year intervals, and again it appeared that in conjunction with organic manure, or with such combinations of artificials as nitrate of soda and minerals, liming may cause considerable reduction of yield.(29)

The present practice with regard to Park grass is to conduct botanical analyses over a period of years to elucidate some special point in connection with the effect of certain manurial systems. From 1919 to 1934 attention was concentrated on the influence of season upon the botanical composition of the herbage from year to year, in the presence and absence of lime. With complete fertilisers,

(25) W. E. Brenchley—" Useful Farm Weeds." J. Min. Agric., 1918-19, Vol. XXV, pp. 949-58; W. E. Brenchley—" Uses of Weeds and Wild Plants." Sci. Prog., 1919, Vol. XIV, pp. 121-33; W. E. Brenchley—" Weeds of Farm Land." Longmans, Green & Co., 1920, pp. 187-205.

(26) J. B. Lawes, J. H. Gilbert and M. T. Masters—" Results of Experiments on the Mixed Herbage of Permanent Meadow. II. The Botanical Results." Phil. Trans. Roy. Soc., Part IV, 1882, pp. 1181-1413; W. E. Brenchley—" Manuring of Grass Land for Hay." Longmans, Green & Co., 1924, pp. 146; W. E. Brenchley—" Park Grass Plots." Rothamsted Annual Rep., 1934, pp. 138-159.

(27) O. N. Purvis—" The Effect of Potassium Salts on the Anatomy of *Dactylis glomerata*." J. Agric. Sci., 1919, Vol. IX, pp. 338-65.

(28) W. E. Brenchley and S. G. Heintze—" Colonisation by *Epilobium angustifolium*." J. Ecol., 1933, Vol. XXI, pp. 101-2.

(29) W. E. Brenchley—" Effect of Light and Heavy Dressings of Lime on Grassland." J. Bd. Agric., 1925-6, pp. 504-12; W. E. Brenchley—" The Varying Effect of Lime on Grassland with different Schemes of Manuring." J. Min. Agric., 1925, pp. 504-12.

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including nitrogen and minerals, the relative proportions of the three main groups of species, i.e. grasses, leguminous and miscellaneous plants, are not usually much affected by season, though the individual species vary, but with one-sided fertilisers and on unmanured areas wide fluctuations occur in the percentage of these groups.(30) A new cycle of analyses is now being carried out to determine the effect of potash on the herbage fluctuations from year to year in relation to the supply of nitrogenous fertilisers. The Park grass plots afford a unique opportunity of observing the relations between plant species and seasonal and manurial conditions.

INSECT PESTS AT ROTHAMSTED AND WOBURN, 1935

A. C. Evans

General

A very severe attack of pigmy mangold beetle occurred on Barnfield, the entire crop being lost. Wheat bulb-fly caused much damage on the Alternate Wheat and Fallow and on the Four-Course Rotation experiments. Pigeons completely destroyed the first planting of brussels sprouts on Fosters.

Wheat

Wheat bulb-fly (*Hylemyia coarctata* Fall.) caused much damage on the Alternate Wheat and Fallow and Four Course Rotation experiments, but was slight elsewhere. On Broadbalk, the wheat blossom midges (*Sitodiplosis mosellana* Géhin and *Contarinia tritici* Kirby) are steadily increasing. The following are the figures for the last three years.

	Number of Larvae per 500 ears		
	1933	1934	1935
C. tritici	1,474	3,381	4,289
S. mosellana	319	572	4,221
	Percentage Grain Attack		
C. tritici	0.7	1.5	2.1
S. mosellana	1.4	2.5	18.0

The percentage parasitism found is still low, and so a still further increase in the numbers of the midges is expected in 1936.

Barley

Few gout-fly (*Chlorops taeniopus* Meig.) were present. Several arvæ of a leaf-eating beetle (*Lema melanopa L.*) were found on barley on Hoos field. This species has not yet been recorded in these reports as occurring on the farm.

Oats

A severe attack of eelworm (*Heterodera schachtii* Schmidt) occurred on Long Hoos I. Fortunately the infested area was small.

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(30) W. E. Brenchley—"The Influence of Season and of the Application of Lime on the Botanical Composition of Grass Land Herbage." Ann. App. Biol., 1935, Vol. XXII, pp. 183-207.

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