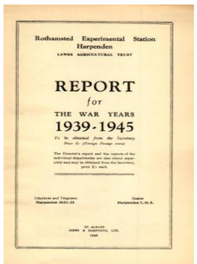
ROTHAMSTED RESEARCH

Report for 1939-45

Full Table of Content


Rothamsted Experimental Station
Harpenden
REPORT
for
THE WAR YEARS
1939-1945

Botany Department

Winifred E. Brenchley

Winifred E. Brenchley (1946) *Botany Department ;* Report For 1939-45, pp 89 - 98 **- DOI: https://doi.org/10.23637/ERADOC-1-87**

DEPARTMENT OF BOTANY

By Winifred E. Brenchley

In the Report for 1935 a survey was made of the work of the Botanical Department since its inception in 1906, and in the 1936-1938 reports certain completed investigations were outlined. It is now proposed to bring the account of the work of the Department up to date, including where necessary investigations that were in progress before war broke out.

Since 1935 the only major changes in the organisation of the Botanical Department have been a recent strengthening of the scientific staff and the provision of more adequate glasshouse accommodation. A new range of houses was completed in 1940 for the bacteriology, botany and chemistry departments, of which four houses with an adjoining potting shed, drying room, weighing room and bird-proof cage were shared by botany and chemistry, the water-culture and bacteriology glasshouses being under separate roofs. A glasshouse, preparation room and stills room are now available for water-culture work, the stills room being isolated to prevent the entry of gas fumes into the glasshouse, the distilled water being conveyed direct to carboys by glass tubes passing through the wall into the preparation room. The chief feature of the glasshouse is a range of shallow tanks 58 ins. by 27 ins. by 7½ ins. running down each side, each with a cold-water inlet and an overflow, providing for the immersion of culture bottles to control root temperatures. When not in use the tanks are covered with sliding wooden covers which make an ordinary bench.

Plant physiology

Work has continued on various minor elements and on other physiological problems. Boron is essential for the normal growth of carrots, and as death soon occurs in its absence it was necessary to grow plants with boron for a few months and then remove it from the nutrient solutions in order to determine the effect of boron deficiency on the flowering stages. Where the original supply of boron was small, deficiency symptoms soon set in, and death of the apices occurred before the formation of flowering shoots. Where more boron had originally been supplied the effect of the shortage was delayed and then flower-bearing shoots were developed, only to die from deficiency before maturing. All plants receiving boron continuously formed normal flowering shoots. Anatomical investigations showed that breakdown of the tissues, particularly those associated with the meristematic and vascular systems, is an invariable concomitant of a deficiency of boron. The type of abnormality appears to be very similar to that described for other plants (1).

At the request and with the financial aid of the Chilean Nitrate Corporation work was begun in 1938 on the physiological importance of the various minor elements that are always present in Chilean nitrate. Although the value of the contained boron was already recognised time was given to compare the effect of the natural nitrate with synthetic nitrate plus boron and other elements. The

Chilean nitrate used was a composite sample drawn from 4,800 bags in one shipment, and spectrographic and chemical analyses were made before use. Boron, iodine and potassium perchlorate were the chief alien substances present in the nitrate. Of these boron proved to be the most critical, being essential for all species tested, whereas the effect of iodine and perchlorate was only evident in a few cases and was not consistent in repeated experiments. Most of the species showed their need for boron by making very little growth in its absence, Chilean nitrate being as effective a source of supply as sodium nitrate with added boric acid. Cereals and grasses, however, do not exhibit boron deficiency in the early stages but may make vegetative growth of an abnormal type, producing no ears as in barley, or may push up to ear as in oats, but fail to develop fertile grain.

The range of plants tested covered various cereals, leguminous crops, roots and leafy plants, giving information relative to most of the types of agricultural crops grown in this country. In all cases death of the growing point in the absence of boron was characteristic, and the development of red colouration or bronzing was noticed in several plants, as cauliflower, mangold and red clover.

While the essential nature of boron was so clear, only occasional evidence was obtained of a definite action of iodine, whether beneficial or otherwise. Sometimes an improvement was noticed in parsley when iodine was supplied, but this was not always seen. In soy bean the perchlorate present in the Chilean nitrate caused slight damage to some of the developing leaves, but no real depression of growth occurred and the dry weight was not affected. Attention was concentrated on an attempt to determine whether iodine is essential to plants, as it is sometimes assumed that because the element is now known to be necessary to animals it must therefore be needed by plants. Twenty-six species were tested, but in the majority of cases the value of iodine proved negative, causing no improvement in dry weight or appearance. Sometimes transient indications of benefit or depression occurred, but disappeared afterwards as growth levelled up. Any variations in dry weight at harvest were usually not much beyond the limits of experimental error. There seems to be little evidence of a beneficial action of iodine over a fair range of plants, but the fundamental difficulty exists that the element is so widely distributed in air as well as in nutrient salts and water, and only experiments that can be carried out in iodine-free air can show definitely whether very minute traces of the element are indeed essential. Attempts were made to grow *Lemna* under such conditions, but as far as the experiments went they provided no further evidence.

Lettuces grown with Chilean nitrate were usually better than those receiving synthetic nitrate reinforced with boron and iodine, and traces of the other minor elements contained in Chilean nitrate were therefore tested, including molybdenum, titanium, strontium, vanadium, chromium and zinc. Of these only *molybdenum* gave very definite results, and plants receiving it were outstanding on account of their deep green colour, large size and relative freedom from disease (2). The importance of these results, if confirmed, from

https://doi.org/10.23637/ERADOC-1-87

the horticultural point of view led to intensive work being undertaken, but the results were variable and it is still impossible to say what conditions enable molybdenum to exercise a beneficial action. Among the factors examined were the range of concentration of molybdenum, the effect of different nutrient solutions, the possible correlation with the presence or absence of other minor elements, and the effects of the variety and the season of the year at which the plants were grown. Variable results were obtained throughout, in some cases improved plants being obtained with molybdenum, whereas in others the controls were just as good (3). The results are now being critically examined in search of any possible clue to this erratic behaviour.

Soil cultures show similarly variable results. Earlier work in the department had shown the toxicity of certain strengths of molybdenum for tomatoes, but in this later work the plants were able to stand heavy dressings without damage, and apparently also without any regular benefit. Further investigation showed that a soil factor is concerned here, as on a series of eight soils tomatoes were killed or seriously damaged on a Fen soil, but were quite healthy on the others. Flax, on the contrary, was seriously injured on five of the soils, while *Solanum nodiflorum* was still more irregular, as duplicates with the same treatment reacted differently, one sometimes being badly poisoned while the other was normal or only slightly damaged. It is hoped to continue this line of work, as it has very suggestive possibilities.

At the request of the Agricultural Research Council experiments were made to determine the effect of minor elements on the growth of flax. The problem of securing an adequate iron supply seems to be the focal point of difficulty in growing flax in water cultures, but very satisfactory growth was obtained with one of van der Crone's solutions.

The need of flax for *boron* is beyond question, but the plant seems to be responsive to very small amounts, which, as with other species, must be available throughout life. One part of boric acid in 100,000,000 parts of nutrient solutions will support healthy growth for a time, but as the plant develops this supply becomes inadequate and deficiency symptoms appear. Signs of toxicity occur when the concentration of boric acid ranges about 1 : 10,000. The question of boron deficiency and toxicity is affected by the amount of boron available at any one time, and also by the total amount presented during the entire life of the plant. This means that a weaker concentration applied frequently may be as effective as a stronger one given at longer intervals, provided the total quantities of boron are equivalent. On the other hand a heavy dose given at one time may have a toxic action, whereas the same quantity given at intervals may have excellent results.

No indication was obtained that *zinc* is essential for the growth of flax, but there was a slight suggestion that toxicity might begin to occur with zinc sulphate about the range of 1 : 5 million concentration.

By the courtesy of the Norfolk Flax Establishment fibre estimations were made of flax plants grown in soil with different manurial combinations and at different rates of sowing. In the soil

https://doi.org/10.23637/ERADOC-1-87

used, nitrogen was the only manure which increased the yield, potash, phosphate and sodium chloride having no such influence when applied singly or together.

In 1943, the fibre content was increased by the use of phosphate especially when combined with potash, whereas nitrogen lowered the percentage. A larger proportion of fibre occurred in the thinner straws from densely sown pots than in the thicker ones from well spaced plants. The next year the same effect of phosphate was obtained, the lowest level of phosphate tested always giving the best result, as heavy dressings caused a considerable drop in the fibre content except where sodium was also present. When nitrogen was applied the fibre content was at a consistently low level, though this might not necessarily hold good on all soils.

X-RAY TREATMENT OF SEEDS

Seeds of wheat and barley, both dry and soaked, which had been treated with hard or soft X-rays were grown and brought to maturity in pot cultures in Rothamsted soil. Preliminary findings in germination tests were borne out by the results of the long-term experiment. Treatment in the dry state had little effect on growth, though there was a suggestion of an approach to the toxic limit with hard X-rays on wheat.

Soaking the seeds renders them much more susceptible to both types of ray, the hard rays being the more harmful, and barley being more adversely affected than wheat. With barley the three highest dosages of both types of ray killed all the seeds, the weakest hard X-rays killed most and depressed the others while the weakest soft X-rays gave variable results, with a general tendency to decreased ear development. Wheat showed a more variable response to treatment, as with the soft rays some plants survived all treatments and developed remarkably well, the weakest dose causing little or no depression. With hard rays the weakest dose had a similar effect, but with higher dosages only one plant developed, adversely affected in development and rate of maturity.

In no case was there any indication of stimulus due to seed treatment, as far as could be told from the green weights. One noteworthy feature of the results was the lack of gradation in the effect of treating soaked seeds, as in nearly all cases such seeds were either killed or left relatively undamaged, very few plants showing injury which increased progressively with the strength of treatment.

The seeds from these first crops were sown the next season, but no definite evidence was obtained that the treatment of seed with X-ray affects the resultant grain in any way that is shown in the succeeding crop. With barley the only suggestion of a beneficial after-effect was with the dosage of 7,000 " r " units of either hard or soft rays on seeds treated dry, the straw being more abundant, but without any corresponding grain increase, but there were insufficient data to decide whether this was really the result of treatment or merely an accidental coincidence. The general conclusion reached was that any harmful effects of X-ray treatment are not passed on to the next generation and that no suggestion of transmitted beneficial action was forthcoming.

Vitality of buried weed seeds

The sectional fallowing of Broadbalk field that was carried on for two-year periods between 1925 and 1929 proved very successful in reducing the weed-seed population of the soil, but with the first year that the whole field returned into crop it became evident that many of the weed species would soon reassert themselves and become as prevalent as they were originally unless some definite method of control were instituted. A cycle of fallowing was therefore started in 1931, in which one of the five sections of the field was fallowed each year in succession, so that the whole field was in fallow for one year in five. After this cycle had been repeated twice the results were worked up for publication, but the benefit was so obvious that the method is still being continued as a matter of farm routine. During the first ten years twenty samples were taken yearly from each of the three plots receiving farmyard manure, minerals and sulphate of ammonia together, and minerals and sulphate of ammonia in alternate years. This yearly sampling was then discontinued, but another series of samples has been taken this year (1945) after harvest to enable a comparison to be made with the position in 1940 at the end of the last five-year cycle.

As before, the samples were reduced in bulk by washing through sieves, and the seedlings that appeared over a period of three years were counted and removed. The numbers of seedlings obtained were grouped to show the reduction in weed-seed population during fallow and the behaviour of the various species during the succeeding years in crop. By this composite grouping several years' results are included in each figure, and the effect of variable seasonal and cultivation factors is greatly reduced.

The buried seeds of most species are reduced by fallow, and increase more or less rapidly during succeeding years, only to be again reduced by a later fallow. Usually this reduction brings the population to a lower level than after the first fallow. Black bent (*Alopecurus agrestis*) varies from year to year more than any other species. Poppy (chiefly *Papaver rhoeas*) was the outstanding exception to the general rule, as, once reduced by fallow, it usually failed to reassert itself and was again reduced by a later fallow. Consequently, this species is no longer the menace that it was in 1925 when the experiment first began, and poppies are now very little in evidence. About ninety per cent. of the total seedlings that germinated consisted of black bent, poppies, lady's mantle (*Alchemilla arvensis*), field speedwell (*Veronica arvensis*) and black medick (*Medicago lupulina*).

The production of weed seeds was much influenced when minerals and sulphate of ammonia were applied alternately. With most species nitrogen encouraged heavier seed production, as was shown by the average number per section compared with those produced with mineral manuring. Field speedwell was the only one of the main species to behave irregularly with the two types of manuring, and black medick was the only one to respond in a reverse direction, being more benefited by minerals than nitrogen.

In the first year after fallowing both crop and weeds were usually able to profit by the stored fertility, and did not appear to come into competition with one another except where farmyard manure was used, when the heavy growth of the crop at first kept the weed-seed population of the soil down to a low level. In later years the crop tended to become less heavy, and the weeds increased to correspond, until the balance was again restored by another fallow.

Field observations have been carried on alongside the laboratory experiments, and have shown a steady improvement in the cleanness of Broadbalk field, confirming especially the reduction of poppies. The various weed species fall into definite groups, according to whether the increase or reduction in numbers induced by fallowing is maintained, or whether there is an irregular increase or decrease in numbers over a term of years (6).

The general conclusion is that the fallowing of one section per year has fully justified itself, as the weed-seed population has not only been kept in check, but has also been decreased during the fifteen years that the system has been applied.

In spite of the periodic fallowing, however, an infestation of wild oats has recently attacked certain parts of Broadbalk field, and is also troublesome on Hoos, threatening to become serious if some means are not found to check it. Several species and varieties of wild oats are involved, and investigations have been put in hand to gain more knowledge of the habits and dormancy of these weeds, with a view to attacking them in the best way, and at the most vulnerable time in their life history. This is bound to take some time and meanwhile various direct methods of attack are being considered. As wild oats are also prevalent at Woburn, on an entirely different type of soil, close contact is being kept with Dr. Mann on the matter.

Grassland

Since the publication of " Manuring of Grassland for Hay " in 1942, a considerable amount of analytical and observational data on the flora of the Park Grass plots has accumulated, some of which have been utilised in various papers. During the war it has not been possible to deal with this material, but it is now hoped to consider it in detail and to bring the ecological history of the plots up to date. Since 1940 complete botanical analysis into individual species has had to be suspended owing to pressure of other work, but will be resumed if required to clear up any points that may arise during the examination of the accumulated material.

In connection with the grazing experiments on High Field, to test the effect of combined slagging and manuring of the pasture as shown by the growth of cattle and sheep, botanical analyses of the herbage have been made each year. Early in the season, before the beasts are put on, a number of cages are distributed on each plot, and kept there till the grass is high enough to be identified easily. Then a two-foot square of grass is cut from each protected piece of herbage, and dried in the shade to keep its colour, afterwards being analysed into its constituent species. A year after the first application of slag there were indications that rather more white clover had been encouraged on the slagged areas, though variations between different parts of the field were very great. Visual observations during the spring of 1939 confirmed this, as it was possible

https://doi.org/10.23637/ERADOC-1-87

for an impartial observer to pick out the slagged areas by the extra growth of white clover on them. Grouped analytical figures from the samples indicated that this increase was maintained when the growing period arrived. An additional dressing of slag was then applied across the original treatments of the plots, and the analyses have been continued year by year, though all the data have not yet been worked up.

Joint investigations

During recent years a considerable amount of work has been done in conjunction with other departments, and accounts of this will be found in the reports of the departments concerned.

During the war, work has been carried on in co-operation with the chemical department in pot cultures with a variety of organic fertilisers, using spinach beet as the chief subject, with some tests on turnips. In this connection a large number of boiling tests were made on potatoes, a special technique being developed for the purpose.

In 1944 the Farm collaborated in a number of small-scale spraying tests with various recognised weed-killers, with the primary idea of ascertaining their effect on different crops, rather than their action on weeds, which was already well known.

Experiments have now been started together with the Crop Physiology Department on the relation between potash and sodium nutrition in sugar beet, using the method of sand cultures. The results of the first year's tests justify carrying on the work if the departmental programmes permit.

PUBLICATIONS

SCIENTIFIC PAPERS

1. Warington, K. 1940. *The growth and anatomical structure of the carrot* (Daucus carota) *as affected by boron deficiency*. Ann. Appl. Biol., 27, 176-183.

Carrots grown in nutrient solution without B were unable to develop normally and exhibited both external and internal deficiency symptoms. The effect of a lack of B on the flowering stage was determined by transferring plants to a B-free solution after they had received an initial supply. The chief deficiency symptoms were :—

(*a*) *External.* The leaves curled back pointing downwards, the laminae often being reduced, and the growing apex of the shoot died. The tap root was small with abnormally thickened laterals and sometimes wart-like excrescences on the outside. If the flowering stage was reached, before the deficiency arose the inflorescences bent over and died, those on the side shoots succumbing first.

(*b*) *Internal.* Most of the tissues of both shoot and root were affected before external deficiency symptoms appeared. Breakdown began in the region of the growing point of the shoot though the meristematic apex was not necessarily first involved. Lesions preceded or accompanied by hypertrophy occurred in the cortex and less frequently in the pith. All components of the vascular bundles were affected, blocking occurring in the xylem and phloem and hypertrophy and breakdown in the thin-walled tissues. The formation of wart-like growths and the thickening of the lateral roots was due to repeated branching and radial extension after elongation and emergence were prevented through death of the apices.

2. BRENCHLEY, W. E. and WARINGTON, K. 1942. *Value of molybdenum for lettuce*. Nature, **149**, 196.

A preliminary note on the beneficial effect of 0·1 p.p.m. Mo as sodium molybdate on lettuce grown in nutrient solution indicated that treated plants were both larger and a richer green colour than the untreated controls, and appeared to be less susceptible to disease.

3. BRENCHLEY, W. E. 1943. *Trace elements in Chilean nitrate*. Manufact. Chem., **14**, 5-6.

Experiments carried out in nutrient solutions have given fresh support to the view that Chilean nitrate is not only valuable as a nitrogenous fertiliser, but also on account of its content of minor elements, especially boron, iodine and molybdenum. This was demonstrated on a wide range of crops, including grasses, legumes, roots and leafy plants. In some cases molybdenum improves the growth of lettuce, but this does not always occur and the necessary conditions are not yet known. There is still no evidence that iodine is essential to plants, but the possibility is suggested that by dressing with Chilean nitrate the iodine content of plants may be increased, to the benefit of animal and human consumers.

4. BRENCHLEY, W. E. 1943. *Minor elements and plant growth*. Biol. Rev., **18**, 159-171.

5. BRENCHLEY, W. E. 1946. *Recent work on minor elements and crop growth*. Bot. Rev. In the press.

These two reviews follow up that published in the Botanical Review in 1936, and attempt to epitomise the chief work on minor elements in relation to plants up to the present time. The voluminous literature on the subject only allows of a bare outline of the work, and the references, selected out of many thousands published, indicate as far as possible where additional information can be obtained by those interested in any special aspects of the subject.

6. BRENCHLEY, W. E. and WARINGTON, K. 1945. *The influence of periodic fallowing on the prevalence of viable weed seeds in arable soil*. Ann. Appl. Biol., **32**, 285-296.

Soil samples were taken annually for 10 years from three plots on Broadbalk permanent wheat field to determine the effect of a sectional cyclic fallowing once in five years on the control of weeds. The plots selected received farmyard manure, minerals and sulphate of ammonia together, and minerals and sulphate of ammonia in alternate years. Most species are reduced by fallow, rise more or less rapidly during succeeding years, and are again reduced by a later fallow, usually to a lower level than the first. *Alopecurus agrestis* showed the greatest variation from year to year. *Papaver rhoeas* was the outstanding exception to the general rule, as, once reduced by fallow, it failed to reassert itself except in a few cases, and was further reduced by the later fallow. These two species, with *Alchemilla arvensis*, *Veronica arvensis* and *Medicago lupulina*, contributed about ninety per cent. of the total seeds.

Alternate manuring with minerals and sulphate of ammonia greatly influenced the production of weed seeds, nitrogen inducing the heavier seed production with most species. *Alopecurus agrestis*, *Alchemilla arvensis*, and usually *Papaver rhoeas* responded thus, *Veronica arvensis* was the only one of the main species to behave irregularly, whereas *Medicago lupulina* showed a reverse response, being more benefited by minerals than nitrogen. The various weed species fall into definite groups, in two of which the reduction or increase in numbers induced by fallowing is maintained, while in the third there is an irregular increase or decrease over a period of years. The general conclusion is that the fallowing of one section per year has fully justified itself, as the total weed seed population has not only been kept in check, but has been gradually decreased during the fifteen years the system has been applied.

TECHNICAL AND OTHER PAPERS

7. BRENCHLEY, W. E. 1937. *Boron and the control of plant disease*. Nature, **139**, 536-537.

https://doi.org/10.23637/ERADOC-1-87

8. BRENCHLEY, W. E. 1942-3. *Botanical investigations at Rothamsted. 2. Minor elements and plant growth.* Proc. Linnean Soc., Session 155, 238-240.

This paper formed part of a symposium on botanical work at Rothamsted given at the Linnean Society in celebration of the Centenary of the Experimental Station.

9. BRENCHLEY, W. E. 1943. *Development of botanical investigations at Rothamsted.* Nature, **152**, 91.

10. WARINGTON, K. 1944. *Boron in relation to plant life.* Article written at the request of the M.O.I. for inclusion in a Russian Technical Journal.

An account is given of the gradual development of knowledge regarding the importance of boron to plant life and its practical application. Starting from the discovery of boron as a constituent of plant ash, scientific investigations are traced through the period when the addition of minute quantities of the element were found to be beneficial up to the discovery that the element is essential for some of the higher plants. Examples are given of the practical application of this discovery in the association of boron deficiency with various crop diseases, the cause of which had previously been unknown. The effect of boron deficiency on the structure and metabolism of the plant is discussed and some references made to the theories as to the function of the element.

11. BRENCHLEY, W. E. 1945. *Trace elements in relation to plant growth.* South Eastern Naturalist & Antiquary, **50**, 6.

Presidential address to the Botanical Section of the South Eastern Union of Scientific Societies, at Rothamsted 1945.

12. BRENCHLEY, W. E. 1937. *Pasture problems.* Nature, **140**, 918-919.

13. BRENCHLEY, W. E. 1938-9. *The vitality of weed seeds.* Proc. Linnean Soc., Session 151, 145-152.

14. BRENCHLEY, W. E. 1940. *The weed problems in non-rotational wheat-growing.* Emp. J. Exp. Agric., **8**, 126-137.

A résumé of the results of fallowing on the weed flora of Broakbalk Wheat Field.

15. BRENCHLEY, W. E. 1940. *Weed seeds in the soil.* Rothmill Quart. Mag., **11**, 177-181.

16. BRENCHLEY, W. E. 1944. *Weed control and the dormancy of weed seeds.* Agriculture, **50**, 452-455.

The above group of papers (13-16) outline various aspects of the vitality of weed seeds in relation to the problem of weed control in agriculture.

17. BRENCHLEY, W. E. 1944. *The behaviour and survival of weed seeds in cultivated land.* School Nature Study, **39**, 2-4.

18. BRENCHLEY, W. E. 1944. *Weed control by chemical methods.* Manufact. Chem., **15**, 426-431.

Although herbicides have for long had a limited use for destroying all vegetation on railway tracks, paths, tennis courts and other areas, the interest which is at present being shown in the subject reflects tendencies in agriculture which have made labour scarce and costly and introduced intensive, mechanised methods of cultivation. The essential difference between the old and the new view of herbicides is that they shall be selective in their action, killing or retarding weeds while leaving crops unharmed, or even directly nourishing them. Each of the chemicals so far used for this purpose has its special merits, limitations and mode of use, and there is coming into being a fairly complex technique of choosing and applying weed control chemicals for their effect on specific crops and in specific conditions.

Reviews, all by W. E. Brenchley.

19. Ellis, C. and Swaney, M. W. 1938. *Soil-less growth of plants*. Pages 155, plus 1 plate. 13/6 net. Nature, **142**, 649-650.

20. Korsmo, E. 1939. *Weed plates, Series* 3, Plates 61-90. With textbook of 140 pages. Nature, **143**, 1,003.

21. Guise, C. H. 1939. *The management of farm woodlands*. (American Forestry Series). Pages 352. (McGraw-Hill Book Co.). Price 20/-. Nature, 1940, **146**, 475.

22. *Hunger Signs in crops*. 1941. Pages 327, illustrated. Published by the American Society of Agronomy and the National Fertiliser Association. Nature, **148**, 330.

23. Robbins, W. W., Crafts, A. S. and Raynor, R. N. 1942. *Weed Control*. Pages 543. (McGraw-Hill Book Co.). Price 35/-. Nature, 1943.

24. Allport, N. L. 1943. *Chemistry and pharmacy of vegetable drugs*. (London. George Newnes, Ltd.). Pages 264. Manufact. Chem., 1944, **15**, 108.

https://doi.org/10.23637/ERADOC-1-87