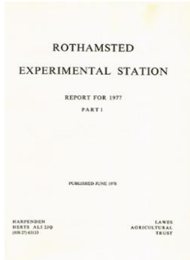
Report for 1977 - Part 1


ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1977
PART 1

Broom's Barn Experimental Station

R. K. Scott

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Introduction

The year 1977 and the growth of our crop. After 3 successive years when disease and drought devastated sugar beet, to give yields which were far below the average of the late 1960s and early 1970s, the industry faced the 1977 season with considerable anxiety. Against the background of heavy investment at the factories and with an annual target of the home production of 1·25 million t of sugar, many farmers were questioning whether they could any longer afford the investment in machinery or face the difficulties that the cultivation of such a bulky, below-ground crop inevitably brings, not only within the 'break' phase of the rotation, but also to the cereal crop which follows.

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Early sowing and bolting. Over the years our experiments have consistently shown that the first essential in obtaining high yields is early sowing. Because yield is invariably lost as sowing is delayed beyond early April, the operation must start as soon as it is possible to prepare a seedbed. Traditionally this could not be done until fertiliser was applied and the tractor wheelmarks left by the operation had been removed. Now that our experiments have shown that for all fertiliser elements except nitrogen, autumn application is a satisfactory alternative for crop nutrition when a maintenance dose is needed, and since we have devised a method of applying nitrogen between the rows at drilling, it is possible to create a seedbed and sow at the first opportunity to get on to the land. Last year was the first of a new series of experiments including very early sowings and already important trends are appearing.

Consistently over the years fewer seedlings have emerged from mid-March than from April sowings. When crops were sown thickly and seedlings hand-thinned the inferior emergence was not important, but with drilling-to-a-stand any factor which reduces emergence is likely to lead to gappy stands and yield loss. In 1977 the first opportunity to sow occurred on 4 March. The plant stand was thinner and more irregular than that of the early April sowing and yield was less. However, the major factor in the substantially smaller yield was the extent of bolting, a feature of many crops in 1977. The weather was cooler than average during March and early April, much of May and the whole of June.

Experiments in controlled environments have this year demonstrated for the first time that cold conditions, even before emergence, can cause bolting. The long period spent in cold soil by early sown seeds, added to their more advanced seedling development relative to later sowings during the cool spring and early summer resulted in extensive bolting. A worrying feature was that many of the bolters set viable seed, a possible source of weed beet. In 1975 (*Rothamsted Report for 1975*, Part 1, 65) it was noted that seed from wild annual beets, introduced as a contaminant of seed produced in Mediterranean countries had contaminated a few fields. Many of the bolters which set seed in 1977 came from seed which itself had been grown in England and, so far as we know, remote from any wild annual types. In one field where such seed had been used a third of the plants bolted and by November each bolter had, on average, set 30 viable seeds.

Experiments previously done at Nottingham University but now to be continued at Broom's Barn, have clearly demonstrated that the temperatures in which the seed crop ripens can, if sufficiently low, predispose the following root crop to bolt. Like all seed crops, sugar beet matured late in 1977 and was subjected to some cold nights while seed was still 'on the straw'. There is a risk that if this seed is used for early sowings in 1978 and the spring and early summer are cool, then bolting could once again be a feature of the national crop. The aim of our research is to predict how seed lots, ripened and harvested under different conditions, will tolerate various types of spring weather without risk of bolting.

During early April it was possible to prepare fine, firm, moist seedbeds and by 18 April 80% of the national crop was sown. Establishment was generally satisfactory and the plant populations were much better than for some years, approaching the target of 75 000 plants ha^{-1}. Although the timely sowing and satisfactory establishment augured well for a high yield, the cool spring and early summer retarded leaf growth and until mid-July roots were no heavier than in 1975, the year when wet soils delayed the start of sowing at Broom's Barn until 21 April, about 5 weeks later than normal.

Herbicides. Soil-applied herbicides were very effective in the moist soils. As well as being cool, May was also windy and a universal problem was to decide whether to wait for calmer conditions to apply post-emergence herbicides and risk that weeds would be too

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far advanced to be susceptible. With many of the plant samples sent in by fieldmen for diagnosis and advice, the suspected cause of poor growth was herbicide damage, either alone or in combination with pests and diseases. There was a clear demonstration of this effect at Broom's Barn. After phenmedipham was applied on 18 May, an extremely bright and breezy day when the air temperature was 15°C, one-fifth of the plants died and the growth of those that remained was severely checked. In the past such damage has usually been temporary and outgrown but this year effects persisted until harvest. The effects of the weather on herbicide activity, the consequences of damage and the inter-relationship with the general pathology of the crop is a subject which demands more of our attention.

Manganese. With the advent of warmer days in June following a prolonged cold spell (the classic conditions for manganese deficiency) many reports came in of plants showing speckled yellows; about 30 000 ha were affected. Recent experiments aiming to provide a starter dose of manganese by incorporating the element within the pellet have given promising results. This enables the seedling to obtain manganese while it is too small to be treated effectively with a spray. This coming year (1978) small trial batches of seed with manganese incorporated within the pellet will be available to interested growers.

Rainfall and irrigation. July was virtually rain-free and whereas the crop on the clay loam soil at the southern end of Broom's Barn farm remained very healthy and vigorous, many plants were wilting on the sandy loam in the N.E. of the farm. This crop received 75 mm of irrigation water during the month. By mid-August it was necessary to apply a further 50 mm of water and all seemed set for a repeat of the disastrous drought of 1976, but with growth considerably retarded; in late July roots were only about half the weight that had been reached by the same date in 1976. The first rains came on 6 August and the total for the month was 130 mm, 81 mm more than the long-term average. Growth, particularly of tops, responded rapidly. The non-irrigated crop grew rapidly during September, maintained unusually high growth rates in October and by December the response to irrigation was smaller (about 1·5 t ha^{-1} roots) than for some years.

The sugar-beet crop continues to concentrate into the hands of fewer growers who operate on an increased scale. This trend is associated with a shift from the heavier soils where wet autumns lead to adverse, even impossible, conditions for sugar-beet harvesting which in turn make it extremely difficult to create satisfactory seedbeds for the cereal crop which follows. Although the lighter soils do not suffer from these problems they more frequently fail to supply sufficient water to maintain growth and several dry seasons during the past few years have increased growers' interest in the possible benefits of irrigation.

Virus yellows. In 1974 more plants were infected than ever before, with 66% showing symptoms by the end of August, and the disease was also important in 1975 and 1976. However, the 1977 crop was remarkably free from virus yellows and nationally, symptoms showed in less than 1% of plants by the end of August, the lowest count ever recorded. Given favourable weather the disease can increase rapidly and it is therefore still one of the most important problems faced by the industry. As a step in developing an effective strategy for control a major research effort is being mounted to seek a better understanding of the mechanisms involved in the various stages of the epidemiology of the disease, particularly the influence of weather on aphids, their natural enemies and the over-wintering of virus sources.

Beet cyst-nematode. An experiment started at Broom's Barn in 1965 comparing yields

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of sugar beet in contrasting crop rotations is described in Part 2 of the Report, pp. 5–13. Until 1977 no viable cysts of *Heterodera schachtii* were found in regular searches on plots which had grown sugar beet each year. However, in October many cysts were found on three of the nine plots with this cropping sequence and on one of these roots of all the plants examined were heavily infested. Evidently the pest has been present in small numbers for several years but appears not to have affected yields significantly, except probably on the most heavily-infested plot in 1977. It seems that 1977 was favourable for nematodes; there were several reports of beet sickness from the factory fieldstaffs and Docking disorder was severe where control measures were not applied.

Several recent developments make it essential that we investigate fully various aspects of crop rotation in relation to beet cyst-nematode. The area of oilseed rape continues to expand; it is a host crop for the nematode and is grown on farms which include sugar beet in the rotation. The relevance of this work is all the more urgent as the old Beet Eelworm Orders have been revoked and the Ministry of Agriculture, Fisheries and Food (MAFF) no longer enforce a satisfactory rotation on infested or 'at risk' fields. The new Beet Cyst Nematode Order, 1977, contains reserve powers to enforce crop rotation only if the national infestation should increase significantly.

Sugar concentration. Although during harvest many growers have expressed disappointment with the size of the roots in relation to the state of the tops which remained unusually vigorous and healthy, apart from a little powdery mildew or rust, the compensation has been the sugar concentration which has been universally high. For example, a ton of sugar beet at 17% sugar is worth about £1.65 more than a ton at 16% and the high sugar concentration also benefits the British Sugar Corporation through lower processing costs. For instance, a 1% overall increase in sugar concentration saves £250 000 on lime used in the factory process alone. Freedom from disease, particularly virus yellows, has been a contributing factor to these high sugar concentrations. Another has been the lack of residual nitrogen after the winter rains. The crop has had to rely on fresh fertiliser N and luxury uptake seems to have been avoided. The presence of more nitrogen within the plant than is needed for growth depresses sugar concentration and extractability. In 1976 nitrogen uptake did not follow the usual pattern in early/mid-season, doubtless because of drought, but the element remained in the soil and when rains came in September much was taken up resulting in the lowest ever sugar percentages. The largest single factor influencing sugar concentration is the amount of autumn rainfall. In 1977 little rain fell in September and October, the soil became very dry and the water content of the storage roots was lowered accordingly.

The future. Perhaps more than with most other crops the ability to predict root yield and sugar concentration would have great advantages. The strategy for the campaign, the amounts of fuel and lime required and the dealings in sugar on the world markets are all greatly influenced by estimates of productivity. Fundamental studies of sugar accumulation in beet are currently being undertaken by the Botany Department on individual plants under controlled-environment conditions. These have provided a better understanding of some of the physiological processes of sugar storage involved in determining sugar concentration. So far these studies have not been extended to interpret changes in sugar concentrations induced by seasons, agronomic treatments, diseases, etc. We now propose to do this within the context of a wider study of the photosynthetic productivity of the field crop.

When the effect of a factor, whether it be site, season, agronomic practice or pathogen, is being investigated, rather than determine an empirical relation or response, physical and physiological analyses will be made of the processes governing, first total dry matter

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production and second the accumulation of sugar in the storage root. The processes involved are those controlling leaf production, expansion and persistence which largely determine how much sunlight a crop intercepts, and those controlling the 'efficiency' with which intercepted light is converted into total plant material (photosynthesis and respiration) and stored sugar. The last, economically important, part of the analysis will require a detailed understanding of the developmental sequences controlling the growth of the shoot and the root. By understanding what controls crop behaviour at different stages we should be able to:

1. Devise experiments which will produce data from which we can generalise and thus reconcile data from more empirical experiments done at different sites in different seasons.
2. Fix yield targets and predict yield given various measured parameters.
3. Devise crop agronomy, pest and disease programmes to achieve realistic output targets in different environments.

Agronomy and Physiology

Plant distribution. The proportion of seeds which produce seedlings in the field is notoriously variable. For example, in experiments made throughout eastern England in 1976 seedling establishment varied from 24 to 89%. Although seeds are uniformly spaced along the row, an irregular distribution of plants is eventually produced. Despite generally good emergence in 1977 irregular spacing was a feature of part or all of many crops including our own at the southern end of the farm. Data from experiments reported previously (*Rothamsted Report for 1973*, Part 1, 272) show that when the crop is grown in rows 50 cm apart, a standard practice, plants adjacent to any gap in the row more than approximately 45 cm long, as happens when seeds in two or three consecutive positions fail, cannot utilise completely the resources in the unoccupied portion of row, and yield is reduced. The yield loss per cm of unoccupied row is not constant, but increases as the gaps lengthen. An attempt was made to predict the length, frequency and effect upon yield of the gaps produced by drilling crops to a stand using different target seed spacings and various levels of percentage establishment.

The predictions were made in two parts; the first gave a description of the plant distribution and the area available to each plant. In the second part an attempt was made to predict the yield of each plant and, by summation, the yield of the crop as a whole. The binomial theorem was used to predict the frequency and length of intra-row distances between plants when seed spacing and the probability that a seed would produce an established plant were varied. The frequency with which any two intra-row distances occurred on either side of a plant was then predicted from the multinomial theorem.

These results were compared with observations made on crops drilled to a stand in which the seed spacing and percentage establishment was varied. The latter was altered by mixing known proportions of living and dead seed. The first stage in the predictions was found to be very accurate.

To predict yield the crop was divided into a series of rectangles each containing a plant. The rectangle occupied by each plant was delineated by half the predicted distance to adjacent plants along the row, and the distance between rows. The area of all possible rectangles was calculated, and the yield of the plants they contained was predicted from the population/distribution data of the experiments referred to above (*Rothamsted Report for 1973*, Part 1, 272) using the yield/plant density relationship of Bleasdale and Nelder (Bleasdale, J. K. A. *Annals of Applied Biology* (1966), **57**, 173–182) making due allowance for the position of the plant within the rectangle. The yield of the crop was then derived

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by summing the yields of the individual plants weighted for the frequency with which each class of plant occurred. This method predicted yields close to those observed.

The next stage was to extend the predictions to cover a wide range of seed spacings and seedling establishment levels. These predictions indicate that, within the range of inter-seed spacings in current use (12–20 cm), yields are reduced whenever the establishment percentage is less than 70%, the situation on all or part of most fields. A move to shorten inter-seed spacings is impractical because today's harvesting machinery is inefficient in recovering roots from plants which are less than 12 cm apart. Closer rows might enable complete compensation across gaps within the row and hence increase yield where seedling establishment is poor. This is being investigated, as is the general validity of the procedure when used to predict the yield of crops drilled to a stand. (Jaggard)

Crop establishment

Seed pretreatment. Sugar-beet seed can be 'hardened' or 'advanced' by holding it imbibed so that cell divisions occur in the embryo. This treatment gives earlier emergence of seedlings which are heavier during the early stages as a consequence. Seed of the cv. Amono, Bush Mono G, Nomo and Sharpe's Klein Monobeet was advanced before pelleting and sown in field experiments at Broom's Barn from 1975 to 1977. The treatment, which increased the rate but reduced the extent of germination by 6% in laboratory tests, gave inconsistent results in the field. In each year's experiments advanced seed gave earlier seedling emergence than untreated seed, but 9% fewer plants. Final yield was positively correlated with numbers of plants. However, in 1976 when drought affected emergence and early growth, advanced seed increased both the final numbers of plants and yield by 3%. (Webb)

Seeds may also be 'primed' by starting germination in a liquid of high osmotic pressure which prevents root extension. As with 'advancing', 'primed' seeds are dried after treatment and sown conventionally. 'Primed' seeds germinate quickly and uniformly and give early seedling emergence. In 'fluid drilling', germination is not interrupted by drying. Seeds which have germinated and produced short roots ('chitted') are removed, and put into a viscous fluid which is extruded into the soil. These three techniques have been compared with conventional seed drilled normally and an experimental programme done in collaboration with National Vegetable Research Station, Wellesbourne, for 3 years at several sites on soil types including loams, sand and peat fen is now complete.

In 1975 advanced, primed and fluid drilled seed all gave earlier emergence, by as much as 8 days. However, they also gave fewer seedlings than the control and treatment yields reflected plant numbers rather than seedling size. In 1976, advancing the seed reduced the time to 50% emergence from 27 to 24 days without impairing establishment and yield was 4% greater than the control. After chitting seedlings emerged in 18 days. However, the final emergence from chitted seed sown in fluid was 30% compared with 56% from untreated seed, and yield was reduced where plant numbers were sub-optimal.

In 1977 only seeds from which the radicle had protruded by 2–3 mm were included and seedling emergence equalled that of the control (62%) but was lower than that of advanced seed (73%). Time to 50% emergence was reduced from 16·5 to 14·9 days by advancing the seed, and to 12·2 days by chitting and sowing in fluid. Plant numbers after singling were large and uniform in all treatments at all sites and, although June growth analysis figures showed that plants from advanced seed and chitted seed sown in fluid were up to 30% heavier than plants from the control seed, at final harvest sugar yield was not significantly affected by any of the treatments.

This work shows that seed treatment can give earlier emergence of sugar-beet seedlings by from about 4 to 10 days. This is often accompanied by a reduction in emergence which

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is difficult to understand, particularly in the case of chitted seed sown in fluid. Differences in emergence date were associated with large differences in seedling and established plant weights, but these differences declined as time passed and by final harvest were either very small or had disappeared altogether. The reasons for these discrepancies need further investigation. (Longden)

Effect of fertilisers on seedling establishment. The results of 73 field experiments, mostly in commercial crops, were used to determine the extent of variation in seedling establishment and to investigate whether fertiliser application practices contribute to poor establishment. The proportion of seeds giving seedlings varied from year to year and site to site from less than 30 to over 80% and from about 23 to 55 days were needed for maximum emergence. The effect of fertilisers depended on the quantity applied, the sowing date, and rainfall between application and sowing. In general, when the recommended amounts of fertiliser were given about two weeks before sowing, superphosphate and potassium or sodium chloride had little effect on the number of seedlings established. However, nitrogen decreased seedling numbers by about 5%. Broadcasting nitrogen fertiliser or sodium chloride immediately before sowing in March retarded emergence and decreased establishment by up to 18%. By contrast, when sodium chloride was applied in the previous autumn, there were small but consistent increases in the number of seedlings. Additional experiments made under controlled conditions confirmed that salts have the greatest detrimental effects at low temperature and in relatively dry soils. Placing intact seeds on filter paper soaked in saturated sodium chloride solution for 28 days decreased subsequent emergence by only 5%. However, contact with much less concentrated solutions was sufficient to dehydrate and kill seedlings. Thus it seems that the adverse effects of fertilisers in the field primarily occur after rather than during germination. Although fertilisers sometimes reduce the numbers of seedlings in field experiments their effects are not large enough to cause the wide variations in establishment mentioned above. (Durrant, Payne and Draycott)

Herbicides. On 18 May, phenmedipham, the most commonly used post-emergence herbicide, was applied at the recommended rate (10 litres 'Betanal E' ha^{-1} in 225 litres water ha^{-1}) in bright conditions when the air was unusually dry. The manufacturers recommend that the dose should be reduced from 10 to 8·5 litres ha^{-1} if the air temperature exceeds 21°C but the temperature did not rise above 15°C during spraying. At spraying half the crop plants had four true leaves. The herbicide was unusually active; *Polygonum convolvulus* L. had grown beyond the cotyledon stage, when it is usually not readily killed, but on this occasion control was complete. Sugar beet was badly scorched and many plants died. Sugar yields were 6·56 t ha^{-1} compared with 8·41 t ha^{-1} for the hand-weeded control. There are three factors which could have contributed to the loss of yield. The plant population was reduced from 95 000 to 75 000 ha^{-1}, growth of those plants which survived was severely checked and many weeds subsequently established to exert competitive effects. Data from other experiments indicate that the fall in plant population recorded would have only a slight effect on yield. Yields from other treatments indicate that the persistence of the check and competition from late-infesting weeds contributed equally to the yield loss. (Jaggard)

Weed beet. The distribution and extent of the problem was revealed by a survey, planned in conjunction with the Statistics Department, of ten sugar-beet fields in each sugar factory fieldman's area; in all 2·5% of the national crop. Very few seedlings were found between the rows during late May but during July, when both weed seedlings and bolters were more easily seen, 15% of the crop was found to be contaminated. In only

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two factory areas were all fields reported free of the problem but in the Cantley area misplaced beet were found in more than 30% of the fields inspected.

Because of the difficulty of controlling these misplaced plants and their potential for seed production it is surprising and worrying that only about one in four farmers are taking action to control them. (Maughan)

Seed production

Temperatures during seed ripening. Much of the sugar-beet seed sown in England is home-produced but a substantial proportion is grown in southern France and Italy. Reports have indicated that seed produced in southern Europe tends to be smaller than that of the same variety produced in N.W. Europe, but that emergence of the root crop is better, bolting less frequent and yields often higher. There is little information on the extent to which environmental conditions during seed production affect seed quality or growth of the root crop and a series of experiments was therefore started at the University of Nottingham School of Agriculture, Sutton Bonington and continued at Broom's Barn which examined the effects of temperature during seed ripening. The aim was to provide information which could be used in conjunction with meteorological records to match the climate of the locality where seed is produced with that of the root crop region, to minimise bolting and improve yields.

Seed plants were ripened in controlled environment rooms at a range of day and night temperatures simulating average conditions occurring in August (20°/12°C), September (16°/8°C) or October (12°/5°C) in E. England; day length was 16 h. Plants were also ripened in alternating temperature regimes (5-day periods at 12°/5° and 16°/8° or at 12°/5° and 20°/12°C) to assess whether the effects of short periods of cold are cumulative or neutralised by intermittent warm spells. Experiments were made using a bolting-susceptible stock from the Plant Breeding Institute, Cambridge in 1974 (root crop test in 1975 and 1976 at Sutton Bonington), and two stocks, one susceptible and one resistant to bolting, from Anglo-Maribo Seed Co. Ltd., in 1976 (root crop tests at Broom's Barn in 1977). Treatment effects were consistent for all stocks. Maturity was progressively delayed with decreasing temperature. Seed plant yields increased in the cooler conditions because fruits were larger rather than more numerous; an effect associated with increased growth of the pericarp, for the true seeds were smaller. Germination and field emergence of seed ripened at 12°/5° was poor. In part this was due to the presence of water soluble inhibitors for there was a marked response to washing. In the field, seed produced at 12°/5°, gave fewer smaller seedlings, earlier and more frequent bolting, and lower sugar yields than seed ripened at 20°/12°. The performance from seed ripened at 16°/8° was intermediate. In 1977 the alternating temperature treatments gave inconsistent results, but in earlier experiments the percentage bolting was related to the amount of cold to which the ripening seed was subjected irrespective of the warm days which were interspersed.

These experiments confirm that low temperatures during seed ripening will either completely vernalise the seed or predispose the seedlings to be very responsive to cold during the following spring. Comparisons at different sowing dates also show that the colder the weather after sowing the greater the frequency of bolters, but that in all cases the level of bolting is dependent on the temperatures during seed ripening. If the summer is sufficiently cool to delay ripening so that seed crops are still in the fields during late September or October, bolting of the succeeding root crop is likely to be increased in proportion to the amount of cold weather while seed is 'on the straw'. Even with bolting resistant material, sugar yields may be adversely affected if sowing is early and the spring cold. (Scott and Longden, with Wood, Botany Department)

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Nitrogen application to the seed crop. Previous work showed that sugar-beet seed-crop yields increased with increases in spring top dressings of nitrogen up to 150–250 kg ha^{-1}, depending on site. Growers are anxious to know when this nitrogen should be applied for optimum effect and also whether the tradition of splitting the application to provide a little nitrogen early and the rest when growth is most rapid can be justified economically in terms of extra yield or quality of seed. Nine field experiments on *in situ* crops have been made since 1970 comparing the effects of single applications during February, March, April or May with equivalent applications split into two over a range of dates during this period.

Yields of seed averaged over years and sites ranged from 4·3 to 4·6 t ha^{-1} and were similar, irrespective of when the nitrogen was given. Although late manured plots often looked green longer, there were no noticeable delays in maturity. Leaf petiole nitrate concentration increased by about a quarter in the month following application, then declined progressively throughout the season. At all times values were large and it seems unlikely that nitrogen ever limited growth in any of the experiments.

The usable proportion of seed from multigerm crops was 35–65%, and from monogerm ones 9–20% but neither was affected by nitrogen treatment except that nitrogen applied in May reduced laboratory germination by about 3% and seedling emergence in the field by about five seedlings per 100 fruits sown. The proportion of single seedlings ('monogermity') was not affected by nitrogen. An attempt to assess seed vigour was made by determining average seedling weight when grown in the field in the year following harvest, but results were inconsistent.

In practice it appears that the spring top dressing of nitrogen for the sugar-beet seed crop in its second year should be made as a single application at the end of February or as soon as possible thereafter. (Longden and Johnson)

Steckling root and shoot pruning. In countries where stecklings are transplanted it is said that the root tips must be removed in order to ensure that all plants produce inflorescences and seed. Tops are also removed and, although this may simply get rid of sources of fungal infection, the practice may also ensure that during clamping the growing point is thoroughly exposed to the low temperature stimulus. Tops could also be removed before winter where crops are grown *in situ*. In England virtually all sugar-beet seed is now grown *in situ* without any root or shoot pruning. Four experiments compared the effects of cutting off the root tips and/or mowing off the tops. All combinations of these treatments were carried out both before and after the main winter cold period. Each plot was harvested on three occasions to test whether treatments affected maturation.

Although air temperatures adjacent to crowns fell as low as −6°C, there were no significant losses of plants. Mowing the tops resulted in a shorter crop but all plants from all treatments bolted simultaneously. Nor were yield, germination or seed size affected. Removal of roots, whether carried out in the autumn, before vernalisation, or in the spring, caused a significant yield reduction. In one experiment germination was reduced by root removal, in one increased and in two there was no effect. The only interaction with harvest date occurred in the experiment in which root removal reduced germination; this treatment significantly delayed optimum harvest and gave smaller seed. (Longden)

Soils, irrigation and plant nutrients

Soil type and sugar-beet yield. Yields of sugar in the United Kingdom vary considerably from place to place and from year to year, the range in commercial practice generally being from 4 to 8 t sugar ha^{-1}. The effects of some of the factors involved have recently been investigated using the yields and responses to fertilisers on 400 fields throughout

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the sugar-beet growing areas from 1957 to 1970 (Paper No. 24). The soil at each experimental site was described and classified by the Soil Survey of England and Wales and the records have now been examined for the first time to determine which properties of the soil influence sugar yield.

Year-to-year variation accounted for 20% of all variation in yield but there was a significant long-term trend of increasing sugar yield from the experiments of 0·042 t ha^{-1} year^{-1}. The experimental yields closely followed national yields each year but were always greater. Yields in Scotland (average 5·23 t ha^{-1}) were approximately 1·4 t ha^{-1} less than in England and Wales, but there were no significant regional differences within England and Wales.

Surprisingly, differences in topsoil texture accounted for little of the variation in yield but subsoil texture had an appreciable effect, the crop on sandy subsoil and chalk or limestone yielding poorly whilst that on silt or peat yielded best. The range of differences in sugar yield due to subsoil texture was almost 2 t ha^{-1}. When the soils were grouped into six drainage classes on the basis of their gley morphology, sugar beet on the moderately-drained soil yielded better than the crop on either well drained or imperfectly drained soil, the maximum difference in sugar yield between drainage classes being 1·0 t ha^{-1}.

Yields were also examined in relation to soil profile. Broad division into major soil groups gave meaningful differences but fine division by soil series was only useful for the 11 series on which at least ten experiments had been made. The crop yielded most sugar on gleyed calcareous soils, peats and humic gleys, and least on rendzinas and brown calcareous soils. Responses to nitrogen and potassium but not to phosphorus were affected by both topsoil and subsoil texture. Nitrogen and potassium both increased yield most on sandy soils and least on fine silts and peats.

Experiments are needed specifically to measure the influence of soil morphology and its chemical, physical and biological properties on crop yield to provide more precise guidance for selecting the best land for the crop. (Draycott and Durrant, with Webster and Hodge, Soil Surveys of England and Wales)

Irrigation. Irrigation of sugar beet has featured in the experimental programme at Broom's Barn since 1965 and results up to 1975 have been examined recently (Paper No. 13) in relation to rainfall, potential transpiration and measured soil moisture deficit. Responses to irrigation in the 19 experiments on sandy loam over sandy clay loam soil at Broom's Barn were also compared with results of 36 irrigation experiments with sugar beet reported by other workers in the United Kingdom since 1947. Irrigation at Broom's Barn, applied to prevent soil moisture deficit from exceeding 40 mm, increased average yield from 7·6 to 8·3 t sugar ha^{-1} and in 6 of the years significantly increased yield by more than 1 t sugar ha^{-1} (15%). Studies of root growth and use of soil moisture by the crop showed that, at Broom's Barn, sugar beet often utilises water stored in the subsoil to a depth exceeding 150 cm. Hence the rather small response even in dry years. Responses at other centres, where soils were generally sandier, were slightly greater than at Broom's Barn. The experiments also tested plant density, nitrogen, harvest date and time and amount of irrigation. Without irrigation, maximum sugar yield was from a density of 74 000 plants ha^{-1} but larger densities gave slightly more yield when irrigated. Irrigation affected the magnitude of response to nitrogen but 100 kg N ha^{-1} gave the most profitable yield increase, both with and without irrigation. Yield increases of about 1 t sugar ha^{-1} (15%) between early and late harvesting were also independent of irrigation. Early irrigation of 25 mm and 50 mm in June and July respectively increased yield in 4 of the last 5 years but in no year did applications in late summer increase sugar yield. Irrigation in June was particularly effective at Broom's Barn as it aided rapid establishment of complete leaf cover and improved root shape and yield. This is an important finding

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because at present growers do not irrigate sugar beet early in the season so full benefits may therefore not be obtained. (Draycott and Messem)

Root quality. In field experiments with sugar beet it is necessary to measure the effect of treatments not only on sugar concentration and yield but also to estimate the proportion of sugar which can be recovered from the roots. Sugar concentration is readily and simply measured polarimetrically but the amount of white sugar that can be extracted in the factory is determined from root juice purity which can only be measured after a tedious clarification procedure. In the factory process, each unit increase in juice purity, defined as the percentage of sugar to total soluble solids, allows 2% more sugar to be crystallised. Three of the major impurities, sodium, potassium and α-amino-nitrogen, are relatively easy to measure in a root extract. Roots from fertiliser experiments made at Broom's Barn and on growers' fields during 1964–72 were analysed both for juice purity and for concentrations of these three impurities. The results have been examined to determine how the impurities are related, individually and together, to juice purity. The α-amino nitrogen concentration usually gave the best individual estimate of juice purity whilst summing α-amino nitrogen and sodium or potassium concentrations improved the estimate. The three impurities were also summed in a regression equation. This equation gave a value of juice purity which in most cases was very similar to juice purity measured directly, the regression accounting for up to 90% of the variance, but in a few experiments the regression gave a poor estimate of juice purity. It is suggested that when it is not possible to measure juice purity directly the three impurities should be examined individually, because an increase in any of them is likely to depress sugar extraction in the factory process. (Last and Draycott)

Sodium. Despite evidence that sodium is essential for sugar-beet growth, it is still not used in all fields where it would improve yield. One reason for this is the fear expressed by some growers that this element may affect soil structure. It is known that sodium damages structure when the concentration reaches about 15% saturation of the exchange capacity, a condition found, for example, after sea-water flooding, but there has been little research on the possible effects of smaller amounts of sodium. It has been suggested that applications for sugar beet may delay sowing by increasing soil moisture retention. Recent studies at Broom's Barn in field and lysimeter experiments have determined how winter cultivations and rainfall affect soil sodium concentration and movement. With a knowledge of how sodium moves in the soil, it would be possible to predict what range of sodium concentrations could be expected in a particular soil and the effects of these on soil structure. Detailed soil sampling and analysis was made on three field experiments in 1977. The accuracy of the soil sampling was much improved this year by the use of equipment with which cores, 1 m in length, were extracted and sectioned into 10 cm horizons before analysis. Plots receiving 300 kg Na ha^{-1} in autumn were compared with untreated plots in January and March on three soil types.

The autumn and winter of 1976/77 were wetter than average and soils returned to field capacity earlier than usual. In the field and lysimeter experiments, half or more of the applied sodium, depending on soil type, was still to be found in the soil in March when leaching ceased. With twice the currently-recommended dressings of sodium fertiliser applied in autumn and ploughed in, sodium accounted for no more than 2·1% of the saturation exchange capacity and moisture measurements on soils from the lysimeters showed that five times the recommended dressing of sodium was needed to significantly increase the quantity of water retained by the soil. Results so far suggest that autumn application of sodium is unlikely to affect either the physical properties of the soil or delay seedbed preparation.

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Sodium as the chloride is an inexpensive fertiliser and on most fields greatly improves yield of sugar. Other experiments are therefore being made to determine whether even greater increases in yield would arise from larger applications of the element than used now and to discover whether different amounts should be advised for autumn and spring application. Eighteen field experiments have been completed, with a further six being harvested in 1977, with the same treatments as detailed in *Rothamsted Report for 1976*, Part 1, 66. In 1975, on average, the largest application of 300 kg Na ha^{-1} yielded significantly more sugar than any other rate tested. This is of considerable interest as the amount was approximately twice the present recommendation of 150–200 kg Na ha^{-1}. Yields in 1976 from spring application of 150 kg Na ha^{-1} were better than those from 300 kg ha^{-1} because application of the latter dressing in the dry spring reduced plant population. As in 1975, the largest yield from autumn application was from 300 kg Na ha^{-1}. Results so far indicate that the current recommendation appears correct as regards spring application but it may be possible to recommend increasing the dressing for autumn application when results of further experiments are available. Averaged over all experiments, time of application had little effect on yield. On some fields, spring application was slightly better, perhaps because autumn applied sodium was not readily accessible, and on others autumn application was better because, in dry springs, sodium given before sowing decreased plant population. Growth analyses at Broom's Barn have confirmed the importance of sodium for early leaf growth so a sufficiency of sodium during early spring is important. Further work will be directed to optimising sodium concentrations in soil at this stage so that maximum benefit is gained from the element without loss of plant stand.

Recent dry summers have renewed interest in the water needs of the crop. At present less than 10% of the sugar-beet area in England is irrigated. Especially on sandy soil, crops which cannot be irrigated might benefit from agronomic treatments that alleviate the effects of drought or enhance the crop's tolerance to water stress. Sodium fertiliser may be such a treatment. Leaves of plants given this nutrient have been shown to contain more water and it has been claimed they wilt less readily. Measurements in 1974 and 1975 indicated an interaction between sodium fertiliser and soil moisture on plant-water status, growth and yield. In both years sodium increased leaf area index early in the growing periods, the water content of leaves and the final yields of root dry matter and sugar. In 1974 it increased the relative water contents and diffusive conductances of leaves in August when there was a moderate soil moisture deficit but not in June or September when deficits were small. Similarly, in June 1975 there was again no effect when the soil moisture deficit was small, but later, when there was a severe drought, sodium decreased water leaf potential. Further evidence of an interaction between sodium and soil moisture was obtained from results of other field experiments made between 1968 and 1972 which showed that, on average, giving sodium halved the response to irrigation. However, sodium did not completely replace the need for irrigation, nor irrigation the response to sodium as both were needed for maximum yield. Reappraisal of other field experiments between 1965 and 1976 suggested that the greatest responses to sodium (about 20% more sugar) were obtained in the 1967, 1971–73 and 1975 growing seasons in which intermediate responses to irrigation (10–40%) were obtained. This study suggests that sodium gives greater sugar yields through at least two different physiological mechanisms; it improves the interception of radiation by increasing leaf area early in the season and it improves the efficiency of leaves under conditions of moderate water stress. (Allen, Cormack, Draycott and Durrant, with Milford, Botany Department)

Manganese deficiency and seed pelleting. The conventional method for controlling the deficiency is to spray the leaves with an aqueous solution of manganese sulphate soon

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after deficiency symptoms appear. Recent experiments measuring the effect of deficiency on yield suggest that a shortage of the element is most damaging when the plants are small; also many crops recover later in the year without further treatment. At the seedling stage, spraying is not very practicable because the seedlings have little leaf area to intercept the spray, and more than one spray is often needed to prevent reappearance of symptoms.

Experiments have therefore been made testing manganese incorporated in the coating of pelleted seed as an alternative to foliar spraying (see Paper No. 17). Of several compounds tested in the greenhouse, manganese sulphate incorporated in the seed pellet was the most effective in supplying seedlings with manganese, but decreased seedling establishment in slightly acid soils. Manganese as oxide (MnO) in the seed pellet was less available than manganese as sulphate but was never harmful, and was therefore acceptable as a pellet additive. In standard laboratory germination tests, seed pelleted with material containing 50% w/w manganous oxide germinated quicker than seeds pelleted with material containing no manganous oxide. In the greenhouse and in the field, pellets containing manganous oxide gave more seedlings more quickly than pellets containing none. In fields where untreated sugar beet suffered from manganese deficiency, incorporating 50% w/w manganous oxide in the pellet improved establishment and size and vigour of the plants, decreased the proportion with manganese-deficiency symptoms and decreased the severity of deficiency on plants where symptoms remained. Although assessments of the proportion of plants with deficiency symptoms indicated that an early foliar spray had a slight advantage over manganous oxide in the seed pellet, yields showed little difference between the two treatments. In Fens around Peterborough where the organic topsoil is only 30–50 cm deep and there is a clay subsoil the manganese in the pellet was sufficient to meet the seedlings' need until roots penetrated the clay and no spray was needed. On Isleham Fen, where the organic soil overlays sand, symptoms developed and persisted unless a spray was applied as well. (Farley and Draycott)

Magnesium. Sugar-beet growers on light soils where magnesium deficiency causes loss of yield are now regarding and using magnesium as a major plant nutrient like nitrogen, phosphorus and potassium. This is proving to be the correct approach as severe magmagnesium deficiency is rarely encountered following several applications of magnesium fertiliser for previous sugar-beet crops. On severely deficient fields, kieserite (magnesium sulphate) is the best quick-acting form of the element presently used in fertilisers. On fields where a maintenance dressing of magnesium is needed, calcined magnesite is a promising and less expensive alternative. The study of calcined magnesite as an alternative magnesium source to kieserite began at Broom's Barn in 1969. Since then laboratory, greenhouse and field experiments have led to great improvements, mainly resulting from closer control of calcining temperatures in the production process which has increased the availability of magnesium from calcined magnesite. Work is continuing as further improvements are possible. Commercially produced samples of calcined magnesite are being tested in field experiments and laboratory produced samples tested in pot and soil incubation experiments. One group of field experiments completed in 1976 measured the long-term effects of various magnesium fertilisers, including calcined magnesite. The experiments began in the autumn of 1972 on four fields and tested the effects of 100 kg Mg ha^{-1} as kieserite and as calcined magnesite applied at various times during the rotation. Sugar beet was grown in 1973 and 1976. Soil analyses each year showed that the kieserite initially gave the larger increase in exchangeable magnesium but, by 1976, the values were similar to those on plots given calcined magnesite. This indicates that calcined magnesite may be effective for longer than kieserite and therefore more suitable for use as a maintenance dressing. (Hutchison, Durrant and Draycott)

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Pests and diseases

Insecticide seed treatment. Trials in each of 15 sugar factory areas and at Broom's Barn concluded the series testing insecticides, incorporated with the seed during pelleting, to control seedling pest damage. Methiocarb, bendiocarb and dieldrin were compared, using ethylmercury phosphate steeped Amono seed, 'Filcoat' pelleted by Germains. On average, none of the treatments significantly affected seedling establishment in the absence of pest damage. Methiocarb incorporated in the pellet has been tested by us since 1971 at rates from 0·05 to 6·4% w/w of seed before pelleting. It can give considerable benefit where pest damage occurs and, at 0·2% w/w, has been gradually replacing dieldrin as the standard insecticide treatment for sugar-beet seed; the replacement of dieldrin was requested by MAFF. The British Sugar Corporation have decided that all beet seed will be treated with methiocarb in 1978. Because manganous oxide may in future be incorporated in pellets for use in manganese deficient soils, it was tested with and without the 0·2% methiocarb treatment at the 16 sites. On average manganous oxide had no significant effect on seedling establishment although in two trials significant decreases occurred when it was used. (Winder, Dunning and Thornhill)

Wood mice taking seed. Year to year variation in population density at the time of sowing may contribute to the great fluctuations found in the severity of damage caused by wood mice. A pilot survey of mouse numbers on fields immediately prior to sowing was carried out with the help of BSC field staff; cartons which recorded the tracks of mice which entered them were used to obtain an index of population density in 21 fields throughout the beet growing areas. The estimated densities of mice on the fields in March were uniformly low and little damage was recorded subsequently despite early sowing which in previous seasons has increased the damage (*Rothamsted Report for 1976*, Part 1, 54). Further tests are planned with a view to forecasting severe damage.

Experimental poisoning of mice on 15 sugar-beet fields with three or six chlorophacinone baits per hectare confirmed the effectiveness of this technique in reducing mouse numbers and probably controlling damage (*Rothamsted Report for 1976*, Part 1, p. 54).

A two-and-a-half-year live-trapping study of a wood mouse population on arable land was concluded and the results analysed. The population fluctuations and their causes were found to have many features in common with those of deciduous woodland populations studied by other workers (*Rothamsted Report for 1975*, Part 1, 56). Variations in mortality during the winter (non-breeding period) and at the onset of breeding in March–April are responsible for year to year differences in mouse density at the time of sowing sugar beet.

Birds grazing seedlings. The factors affecting the numbers and diet of birds grazing on sugar-beet fields were investigated. Feeding birds were counted, their diet analysed and the availability of some important foods measured on 13 fields. The density of skylarks on these fields was found to increase with the abundance of weed seeds in the soil but to be unaffected by the density of weed or crop seedlings. Skylarks were found to feed selectively on weed seeds and beetles, reducing their consumption of seedling leaves when the preferred foods were abundant. This result is consistent with the findings of a study of seasonal variations of skylark diet, concluded in 1977, which showed that skylarks select feeding areas and foods mainly on the basis of the rate at which energy can be obtained from them. Grazing seedlings is one of the skylark's least profitable feeding methods from this point of view. (Green)

Aphicides: time of spraying. Three trials compared seven different times of spraying with a mixture of demeton-S-methyl and pirimicarb (244 and 140 g a.i. ha^{-1}) at approxi-

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mately 12-day intervals from late May until August. Because there were few aphids and very little yellows only one outside trial and some treatments at Broom's Barn were harvested. Sugar yield was unaffected, even where all seven sprays were applied following aldicarb (840 g a.i. ha^{-1}) in the seed furrow.

Aphicides: method of spraying. Although *Myzus persicae* can be effectively controlled by direct interception of organophosphorus sprays such as demeton-S-methyl and demephion, resistant strains may survive the residual systemic action of certain of these insecticides at standard rates of application. Conventional crop spraying covers mainly the upper leaf surface and control of aphids on the under surface relies on systemic action. In an endeavour to get better cover of the leaf-under-surface a cooperative project was started with Mr. R. Sharpe (National Institute of Agricultural Engineering). A prototype nozzle arrangement with leaf-lifting devices was tested in the field at Broom's Barn comparing the same volumes of spray applied conventionally from above the foliage with application from both above and below, using a systemic (demeton-S-methyl, 244 g a.i. ha^{-1}) versus a contact insecticide (permethrin, 100 g a.i. ha^{-1}).

A fluorescent pigment, Saturn Yellow, suspended in the spray liquid showed that some improvement in spray distribution on both the undersides of the leaves and the heart leaves was obtained by the 'above and below' nozzles. Infestations of wingless green aphids were very slight and only the decrease in numbers obtained by the permethrin treatment was statistically significant. Virus yellows incidence was very low and was unaffected by treatments. (Dunning and Winder)

Predator/aphid dynamics. Our previous observations on sugar beet have suggested that predators resident in fields, especially Arachnida and Coleoptera, may be important in controlling the development of aphid populations on plants early in the season and a better understanding of the role of aphid predators may help to improve the integrated control of virus yellows. The species and numbers of predators present are affected by soil type. An investigation was started with field observations made on two 150 m^2 plots of beet, cv. 'Nomo' on Flint Ridge and The Holt. The low natural infestation of aphids, especially *M. persicae*, necessitated some artificial infestation. Pitfall and water traps were used to investigate the species present; data was collected on the aphids' development on the beet, their colony distributions and changes, and predator incidence was observed.

Differences in the condition of the plants and the predator complexes are thought to have been important in the contrasting success of the aphid populations on the two sites. A broad range of predators including mites and coccinellids present on mature plants on The Holt probably led to the low aphid populations compared with Flint Ridge where there were few predators, and the condition of the plants favoured aphid development. A serological analysis of predators' gut contents is being made, using anti serum prepared by Govier (Plant Pathology Department), and the aphid/host relationship is being studied in controlled conditions at the Applied Biology Department, Cambridge. (Jepson)

Leaf-surface fungi including *Erysiphe betae*. The development and growth of fungus populations on the surface of sugar-beet leaves was followed throughout the growing season of 1976, by culturing leaf washings and by microscopic examination of cellulose acetate films. The predominant fungi observed were the saprophytic *Cladosporium* spp. and yeasts, and the parasitic *Erysiphe betae*.

E. betae was first observed in late July. Rapid mycelial growth and spore production took place during August when similar growth occurred simultaneously on leaves of

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different ages. However, the growth of the mildew on leaves produced and expanding during September was much less. These results confirm those obtained in 1975, suggesting that environmental conditions are more important in determining the development of *E. betae* than is the physiological state of the leaf (assessed by the fixation of $^{14}CO_2$ and chlorophyll levels).

Yeast and *Cladosporium* populations correlate closely with the growth of *E. betae*. This inter-relationship between the mildew and the saprophytic fungi may be indirect in that the micro-environment of the leaf is made more favourable for the growth of saprophytes or because the fungi are in direct contact with the mycelium of the mildew.

In 1977 the weather was unfavourable for *E. betae* and in most of the 91 fields surveyed by BSC fieldmen the disease was slight or absent. Only three of these crops had all or most plants infected by the end of September. *E. betae* spread in some varieties at Broom's Barn in early September. Despite the intervention of 100 mm of rain between spraying and the obvious spread of disease, a single application of 11 kg wettable sulphur ha^{-1} to cv. 'Nomo' on 12 August gave almost complete control of *E. betae* and increased sugar yield by 8%. (Bentley and Byford)

Nematode pests

Docking disorder. Granular pesticides (e.g. aldicarb, oxamyl) are used on most light, sandy soils where ectoparasitic nematodes causing Docking disorder (*Trichodorus* spp., *Paratrichodorus* spp. and *Longidorus* spp.) are often numerous and can, especially in years with heavy May rainfall, cause considerable yield loss. Although damage in 1977 occurred in some treated fields, probably where the pesticide was leached below the seedling root zone, the total affected area was much smaller than in previous years; in June 103 ha were reported affected (35 from Nottingham and 33 from Selby factory areas) and in July a further 228 ha were reported (220 from the York factory area). This probably reflects the extensive use of nematicides. (Cooke)

Spiral nematodes. Trials and observations in conjunction with the Nematology Department (see p. 187) were continued on *Helicotylenchus*-infested chalk soils. At three sites south of Cambridge where beet was grown in rotation, the pre-drilling populations were low, ranging from 180 to 860 litres^{-1}. Carbofuran incorporated in the seed pellet at 0·2, 0·8 and 3·2% by weight of seed was tested in comparison with seed furrow applications of carbofuran granules (600 g a.i. ha^{-1}) at two sites and oxamyl (800 g a.i. ha^{-1}) at one. The low populations of *Helicotylenchus* produced no crop damage and treatments had no significant effect on seedling establishment. Virus yellows infection was low and unaffected by treatment. Sugar yield ranged from 5·8 to 8·1 t ha^{-1} but was not affected by treatment.

At two of these sites a range of granular pesticides was tested; 'AC 64475', aldicarb, bendiocarb, carbofuran, oxamyl, phorate and thiofanox, each at 250 and 1000 g a.i. ha^{-1}, in the seed furrow. In the absence of severe pest damage beneficial effects of treatment were slight; oxamyl gave the best sugar yield increase, 8% with the high rate, followed by carbofuran and aldicarb which were best at the low rate. The other chemicals had no effect, or decreased yield, 'AC 64475' at the high rate by 50% at each site.

Beet was grown again in 1977 on part of the field where the *Helicotylenchus* population was very high (*c.* 4000 litres^{-1}) and damage was expected. Severe bird and mammal grazing on the slow growing plants decreased the value of observations made on the eight different pesticide treatments, but carbofuran was consistently beneficial to growth. *Helicotylenchus* population studies were made by Nematology (see p. 187). (Dunning, Winder, Thornhill and Chwarsczcynska)

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Fungicides on barley. In an attempt to improve the yield of spring barley crops at Broom's Barn a series of experiments from 1975–77 tested the effect of the fungicides ethirimol, as a seed dressing and tridemorph, as a spray, on three varieties of spring barley. Infection with powdery mildew was moderate in 1975, severe in 1976 and light in 1977. Ethirimol was applied as a slurry to the seed just before sowing, and the tridemorph spray was applied when infection was increasing rapidly (growth stage 6 in 1975, 5 in 1976 and 8 in 1977). A single application either of seed dressing or spray controlled mildew and increased yield of Julia and Maris Mink, but Proctor needed both treatments. Grain size was increased more by the seed treatment than by the spray. (Webb)

Broom's Barn Farm and long-term experiments

Farm. Ploughing was completed by the end of January. After a wetter than average winter the spring work did not start until early March. The winter wheats and the grass ley overwintered badly after the very dry summer and the poor autumn drilling conditions, but recovered well in the spring to produce reasonable crops. In contrast to last year's extremely early cereal harvest, this year's was delayed by rain and was later than average. Little Lane was subsoiled both ways at 55 cm deep and 90 cm between tines, and dressed with FYM. Two new soakaways were installed, one to relieve the flooding at the northern end of the roadside ditch and the other to accommodate the run-off from the concrete farm road. Tree planting has continued.

Cereals. Of 17·3 ha of winter wheat only the second year crops had nitrogen in the seedbed. One field which looked very poor in the spring received a top dressing split between late March and late April, but the remainder had a single dressing in early April.

The spring barleys were sown during the first week of March but sowing the spring wheat was delayed until early April because of the state of the ground after sugar beet lifting and heavy rain. Proctor and Ark Royal barley seed was treated with ethirimol ('Milstem'), the only fungicide used this year. The windy conditions during late April restricted herbicide application and some plots and part of Bullrush field were left unsprayed to avoid damage to neighbouring beet crops. No aphicide was necessary.

Cereal harvest did not start until 26 August when the first of the spring barley was cut. It continued as weather permitted and finished on 9 September except for the spring wheat which was late to ripen and was cut on 19 September. Grain moistures ranged from 14–20%.

TABLE 1

Yields of cereals on Broom's Barn Farm

Grain yield (t ha^{-1} at 85% DM)

	ha.		Yield
Brome Pin	10·0	Huntsman winter wheat	5·68
Hackthorn	3·9	Hobbit winter wheat (seed)	6·95
Marl Pit	3·4	Hobbit winter wheat	5·88
New Piece	5·2	Sappo spring wheat (seed)	3·51
Dunholme	9·0	Mink barley	3·79
White Patch	9·2	Proctor barley (undersown)	4·73
Bullrush	4·6	Ark Royal barley	5·65
Windbreak	2·2	Mink barley	4·86

Fodder crops. The ryegrass ley on Little Lane was given a compound fertiliser in two applications in the spring and was cut for silage during the last week of May. It was immediately top dressed with N and irrigated. Hay was made during the first week of July. The undersown ley on White Patch established well during the wet summer and a good stand of grass was achieved.

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Sugar beet. All the fertiliser except nitrogen, which was broadcast between the rows at drilling, was ploughed down in autumn 1976. Seedbeds were prepared easily and the first sowing made at the beginning of March. Rain delayed further drilling until the end of March, when all but late sowings were completed. The early drillings had emerged by the end of March. All the crop, except the variety trials, was sown with pelleted monogerm seed; 85% was spaced at 16 cm or more. Most of the crop was band sprayed with pyrazone at drilling or overall sprayed when on non-standard row widths. Subsequent weed control was partly by hoeing and partly by post-emergence sprays. Seventy-five percent was drilled with a granular insecticide and only half required spraying once with aphicide in mid-July. Half the crop (on the lighter soil) had 75 mm of irrigation in July and a further 50 mm in August.

Harvesting started on 27 September in very hard, dry conditions which gradually eased to allow the bulk of the crop to be lifted in good order. All beet was lifted by 14 December and deliveries to the factory were completed by the end of the year. Yields averaged 35·5 t clean roots ha^{-1} at an average sugar content of 18·0% ranging from 15·9 to 19·2%. Mean dirt and top tares were 8 and 4%.

Livestock. In October 1976, 80 cross-bred heifers were bought and fattened in the yards on *ad lib* silage and a restricted concentrate ration of 50% rolled barley and 50% beet pulp nuts. They were sold between late March and early July. The yards were restocked with 85 cross-bred heifers in October. (Golding)

Frequency of beet and barley. This was the 13th year of the experiment testing yields in five contrasting crop rotations (*Rothamsted Report for 1966*, p. 298). Yields for the last 6 years are given in Part 2 of this year's Report.

After the 12th year the experiment was modified; tic beans, potatoes and grass were all replaced by spring barley. Sugar-beet plots, previously split for nitrogen rates ranging from 0–187·5 kg N ha^{-1}, were uniformly dressed with 125 kg N ha^{-1}. It was intended that this modified experiment would go through at least one more 6-year cycle. However, when harvested in October, three of the nine plots growing sugar beet for the 13th successive year were found to be infested with the beet cyst-nematode (*Heterodera schachtii*). White females or cysts were found on 100% of roots in one plot, 89% and 46% in the others. *Helicobasidium purpureum*, which has frequently been found infecting a few roots on continuous beet plots, was found in three plots in 1977, in one of which 87% of roots were attacked. The experiment in its old form will now be abandoned and the area used for new experiments testing aspects of the relationship between *H. schachtii* and sugar-beet yield and the effect of different rotations on *H. schachtii* populations. (Webb, Cooke and Byford)

Staff and visitors

R. Hull retired on 31 March after a career spanning 42 years devoted to sugar-beet research. Starting in 1935 with the Midland Agricultural College, Sutton Bonington, based at Hackthorn, Lincs, administration was transferred to Rothamsted in 1947 and the work moved to temporary buildings at Dunholme, Lincs., in 1949. The subsequent establishment of Broom's Barn as the main centre for sugar-beet research in England was due very largely to his efforts. A farewell reception at Broom's Barn on 1 April was attended by some 160 past and present members of the staff of Broom's Barn and Rothamsted, the Sugar Beet Research and Education Committee and representatives of the sugar-beet and allied industries. A presentation was made by Sir Peter Greenwell and the toast to R. Hull was proposed by Sir Edmund Bacon, both former Chairmen of the

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Committee. R. Hull was succeeded by R. K. Scott, Reader in Agronomy at the University of Nottingham School of Agriculture.

G. L. Maughan, formerly on the staff of the NIAE, and seconded to the British Sugar Corporation, was transferred to Broom's Barn staff on 1 April to co-ordinate Broom's Barn's work with the BSC. In June R. A. Dunning was awarded the Queen's Silver Jubilee Medal.

The summer meeting of the International Institute for Sugar Beet Research (IIRB) was held in England with G. L. Maughan acting as one of the organisers; on 31 May delegates to the meeting visited Broom's Barn. The February IIRB Winter Meeting in Brussels was attended by A. P. Draycott, R. A. Dunning (Chairman of the Pests and Diseases Study Group), R. Hull and G. L. Maughan (Chairman of the Spring Mechanisation Study Sub-Group). In September W. J. Byford and G. D. Heathcote attended the IIRB Virus Yellows Study Group meeting in Zurich. R. A. Dunning also attended this meeting together with a meeting of the OILB in Zurich and a meeting of the IIRB Pests and Diseases Group in Novi Sad, Yugoslavia. P. C. Longden visited Sweden and Austria to study seed work and attended the autumn meeting of the IIRB Genetics and Breeding Study Group. A. P. Draycott visited Leipzig University in the German Democratic Republic in October to study beet growing and the distribution and use of fertilisers and agrochemicals. In October A. P. Draycott, M. J. Durrant and B. J. Hutchison attended a meeting in Madrid on the availability of magnesium from calcined magnesite. Durrant and Hutchison also visited the factory of Magnesitas de Rubian near Santiago to advise on improvements in the production process. D. A. Cooke returned from a 1-year secondment to the University of California, Riverside, where he worked on beet cyst-nematode. He gave lectures to University Departments and various groups of chemical manufacturers, Agricultural Extension workers and sugar-beet growers. He attended the 15th Meeting of the Society of Nematologists at Daytona Beach, Florida, and the Annual Meeting of Californian Nematologists at Stockton, California.

SRC/CASE post-graduate students P. Jepson and R. Brown were appointed during the year in association with Cambridge and Newcastle Universities respectively. Sandwich course students A. I. Dixon, K. Pyke, F. Sica and L. Waine each worked for us for six months and J. Fröhling of Ciba Geigy worked with us in May. Five scientific meetings were held at Broom's Barn during the year including a 1-day conference in March on 'Recent Developments in Sugar-Beet Research' attended by all the sugar factory field staffs. A 2-day instruction course for sugar factory fieldmen was held in September.

W. J. Byford helped in compiling and editing this report.

Publications

General Papers

1 Byford, W. J. (1977) Sugar beet powdery mildew. *British Sugar Beet Review* **45,** 43–44.

2 Draycott, A. P. & Durrant, M. J. (1977) Sodium nutrition of sugar beet – a review of research in Great Britain. Part 1. Effect on yield and root quality. *Chile Nitrate Information* No. 137, 1–17.

3 Dunning, R. A. (1977) Pest attack forecasts: are they of dubious value? *Proceedings of the 1977 British Crop Protection Conference – Pests and Diseases*, 241–246.

4 Dunning, R. A. (1977) Sugar beet pests and diseases. *International Pest Control* **6,** 19–20.

5 Dunning, R. A. & (Dyke T. P. J.) (1977) The Beet Cyst Nematode Order, 1977. *British Sugar Beet Review* **45,** 4, 13–14.

https://doi.org/10.23637/ERADOC-1-134

6 HEATHCOTE, G. D. (1978) Should we use aphicides? *Proceedings of the 1977 British Crop Protection Conference – Pests and Diseases*, **3,** 895–901.

7 WINDER, G. H., DUNNING, R. A. & THORNHILL, W. A. (1977) Which soil pesticide treatment for pest damage control? *British Sugar Beet Review*, **45,** 4, 5, 6, 8, 36.

PAPERS IN ROTHAMSTED REPORT, PART 2

8 DRAYCOTT, A. P., DURRANT, M. J. & WEBB, D. J. (1978) Long-term effects of fertilisers at Broom's Barn, 1971–76. *Rothamsted Experimental Station. Report for 1977*, Part 2, 15–30.

9 DRAYCOTT, A. P., DURRANT, M. J., HULL, R. & WEBB, D. J. (1978) Yields of sugar beet and barley in contrasting crop rotations at Broom's Barn, 1971–76. *Rothamsted Experimental Station. Report for 1977*, Part 2, 5–13.

RESEARCH PAPERS

10 BYFORD, W. J. (1977) Effect of non-mercurial fungicide seed treatments on the emergence of sugar-beet seedlings. *Plant Pathology* **26,** 39–43.

11 BYFORD, W. J. (1977) Experiments with fungicide sprays in late summer and early autumn on sugar-beet root crops. *Annals of Applied Biology* **86,** 47–57.

12 DRAYCOTT, A. P. (1977) Sugar beet yield in relation to soil type. *Proceedings of 40th Winter Congress of Institut International de Recherches Betteravieres, Brussels*, pp. 217–232.

13 DRAYCOTT, A. P. & MESSEM, A. B. (1977) Response by sugar beet to irrigation, 1965–75. *Journal of Agricultural Science, Cambridge* **89,** 481–493.

14 DUNNING, R. A. & BAKER, A. N. (1977) Some sugar beet cultural practices in relation to incidence and damage by soil-inhabiting pests. *Annals of Applied Biology* **87,** 513–535.

15 DUNNING, R. A., MATHIAS, P. L. & CHWARSCZCYNSKA, D. M. (1977) Spiral nematodes associated with the problem of establishing sugar beet on calcareous soils. *Proceedings 40th Winter Congress, International Institute for Sugar Beet Research*, pp. 323–332.

16 DURRANT, M. J., DRAYCOTT, A. P. & MILFORD, G. F. J. (1978) Effect of sodium fertiliser on water status and yield of sugar beet. *Annals of Applied Biology* **88,** 321–328.

17 FARLEY, R. F. & DRAYCOTT, A. P. (1978) Manganese deficiency in sugar beet and the incorporation of manganese in the coating of pelleted seed. *Plant and Soil* **49,** 71–83.

18 HEATHCOTE, G. D. (1977) Effect of virus yellows on yield of some monogerm cultivars of sugar beet. *Annals of Applied Biology* **88,** 145–151.

19 JAGGARD, K. W. (1977) Effects of soil density on yield and fertiliser requirement of sugar beet. *Annals of Applied Biology* **86,** 301–312.

20 LAST, P. J. & DRAYCOTT, A. P. (1977) Relationships between clarified juice purity in sugar beet and easily-measured impurities. *International Sugar Journal* **79,** 183–185.

21 LAST, P. J. & DRAYCOTT, A. P. (1977) Methods of fertiliser application for sugar beet. *Experimental Husbandry* **32,** 56–64.

22 LONGDEN, P. C. & JOHNSON, M. G. (1977) Effects of single or split application of nitrogen fertiliser to *in situ* sugar-beet seed plants in the spring of their second year's growth. *Journal of Agricultural Science, Cambridge* **89,** 609–620.

23 (MILFORD, G. F. J.), CORMACK, W. F. & DURRANT, M. J. (1978) The effects of sodium chloride on water status and growth of sugar beet. *Journal of Experimental Botany* **28,** 1380–1388.

https://doi.org/10.23637/ERADOC-1-134 pp 21

24 Webster, R., Hodge, C. A. H., Draycott, A. P. & Durrant, M. J. (1977) The effect of soil type and related factors on sugar-beet yield. *Journal of Agricultural Science, Cambridge* **88,** 455–469.

25 (Wood, D. W.), Longden, P. C. & Scott, R. K. (1977) Seed size variation: its extent, source and significance in field crops. *Seed Science and Technology* **5,** 337–352.

https://doi.org/10.23637/ERADOC-1-134