ROTHAMSTED RESEARCH

Report for 1982 - Part 1

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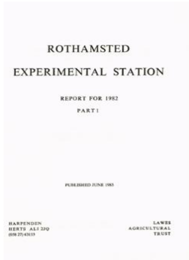
ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1982
PART 1

Broom's Barn Experimental Station

R. K. Scott

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Introduction

The year 1982 and the growth of the crop. The 1982 season was exceptional for sugar beet and the national yield of 8·1 t sugar ha^{-1} delivered to the factories was the highest ever, appreciably more than the previous best yield of 7·2 t ha^{-1} in 1960 and 1971. At Broom's Barn, yields from hand-harvested plots in experiments reached 15·4 t ha^{-1}, the highest ever recorded.

The crop was sown early, although not exceptionally so, with 88% sown between 21 March and 10 April. In general the weather following sowing was very favourable

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for seedling establishment and early growth. During April and early May the average temperature remained at about 8°C and from mid-May onwards consistently exceeded 14°C with four consecutive weeks about 4°C above the long-term average. At the same time rain fell frequently with the total of 134 mm in May and June at Broom's Barn, 37 mm above average.

As a result the crop established quickly and escaped the damaging combination of wet and cold soil that often follows immediately after early drilling. Satisfactory plant populations of around 71 000 plants ha^{-1} were commonly achieved. Because the rate of leaf expansion is directly related to temperature the foliage of the experimental crop at Broom's Barn had covered almost all of the soil surface by 21 June, and was intercepting 80% of the incident radiation compared with only 30% at the same time in 1981. The total radiation intercepted by the experimental crop from May to September 1982 was 1450 MJ m^{-2} compared with 1150 MJ m^{-2} in 1981; in the absence of adverse factors such as disease or water stress, sugar production is directly related to intercepted solar radiation.

In fact, 1982 was reasonably free from factors likely to cause loss of yield. Seedling establishment was generally good, and although some 10 000 ha had to be redrilled, mostly because of localized wind and frost damage, the remaining 95% of the crop was generally free from major problems. The number of samples received by the Broom's Barn Plant Clinic (123 up to the end of August) was about average and soil conditions, mainly acidity and compaction, and nutrient problems, accounted for most of the samples received early in the season.

Aphanomyces cochlioides caused seedling blackleg on some redrilled fields and, in a few cases, led to crops being abandoned. The fungicide hymexazol increased establishment in many test fields in the warm moist soil conditions following drilling, as it did in 1981. This material, applied to half a tonne of seed commercially in 1982 will be applied to 25 tonnes in 1983 including all the manganese treated pellets which are commonly used on soils where *A. cochlioides* can cause damage.

The relatively early sowing of the crop would have given rise to a moderate level of bolting, given average post-sowing temperatures and up to 10% bolters was forecast. However, the warm weather following sowing and emergence decreased the probability of bolting and less than 0·5% was finally forecast which was in good agreement with British Sugar field survey data.

With the crop sown and established early, the important period for determining the amount of damage to seedlings by the ectoparasitic nematodes which cause Docking disorder (*Trichodorus*, *Paratrichodorus* and *Longidorus* spp.) was the end of April/beginning of May. In the 6 weeks from 11 April–22 May, only 22 mm of rain fell (mean of records at 13 sugar factories) compared with 106 mm in the same period in 1981. The consequent dry soil conditions did not favour nematode activity and this, together with the protection given by nematicides applied in the seed furrow, meant that the area of Docking disorder reported by the end of June was very small (350 ha). However, several fields (especially in the York factory area) which had to be redrilled in early May following severe wind damage were not retreated with nematicides and seedlings grew in the moister soil conditions in late May/early June, resulting in some nematode damage; at the end of July a further 655 ha of beet were reported affected. The total estimated root yield loss due to Docking disorder was 3900 tonnes.

Numbers of aphids on sugar-beet and oilseed rape crops in May and June were very low. Although in commercial sugar-beet crops green aphids were found in a few areas in June an unusually high proportion of these were *Macrosiphum euphorbiae*, which is a poor vector of virus yellows. *Myzus persicae* were less abundant in June and July than in recent years and the national incidence of virus yellows at the end of August (2%)

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was rather less than the forecast of 5·5% made at the end of April. This may have been because the prediction formula does not take into account December weather, which was exceptionally severe in 1981. Suction trap catches at the end of July showed that many *M. persicae* were flying in South-east England and these probably accounted for a large increase in virus yellows in many crops in this area in September, too late to have a significant effect on yield.

The great increase in the area of oilseed rape in recent years provides a large potential overwintering site for *M. persicae*. Some oilseed rape crops in Bedfordshire, near sugar-beet seed crops that were infected with BMYV and BYV, were tested against antisera to the two viruses in the ELISA test. Positive results with BMYV antiserum were obtained from some plants and the virus was subsequently transmitted to beet using aphids. There are several viruses of the luteovirus group sufficiently closely related to BMYV to give a positive ELISA reaction, and further work will seek to identify the virus occurring in oilseed rape.

Powdery mildew (*Erysiphe betae*) was first seen in early August but, with August and September rainfall at or just above average, it only increased slowly. As in 1981, about half the crop in East Anglia was sprayed with sulphur against the disease. The results of a limited number of trials carried out in collaboration with British Sugar suggested that in most cases, despite the relatively mild attack of mildew, profitable yield increases were obtained. Plants infected with downy mildew, *Peronospora farinosa*, were found in many crops but the only severe attack reported was in a crop of a susceptible variety grown adjoining an overwintered spinach-beet crop.

Some crops in Essex were found defoliated by *Ramularia beticola* at the end of August; later both *R. beticola* and *Uromyces betae* became widespread. These early attacks by *R. beticola* undoubtedly caused yield losses and will justify future control experiments in the worst affected area, but most of the severe defoliation probably occurred too late to affect yield. However, both *R. beticola* and *U. betae* have become increasingly common in recent years and the possibility that they cause economically important yield losses requires investigation.

The autumn was very wet with rainfall from October to December 79 mm above average but despite difficulties, the harvest, both at Broom's Barn and nationally, progressed well. There is no doubt that this was made possible by the decrease in sugar-beet growing on the heavier soils and the increase in numbers of large multi-row harvesting machines. Rather more cases of root rots than usual were sent to the Broom's Barn Plant Clinic in the autumn. Although *Fusarium* spp. were isolated, precise diagnosis of the cause was difficult and it was surmised that fungal or bacterial rots had often developed during the wet autumn on roots previously affected by drought which had occurred in a few areas.

At Broom's Barn the June to August rainfall was 147 mm, and results from experimental evidence over the last 17 years suggest that on most of our fields irrigation should have increased yield by about 5 t roots ha^{-1}. The light soil where the experiment was being conducted on Flint Ridge enhanced this response which was 13 t ha^{-1} with no reduction in sugar percentage.

Nationally, the responses to irrigation were different because June rainfall was less than 100 mm in only three factory areas. Previous evidence from Broom's Barn suggests that under these circumstances, if rainfall for the remainder of the season is about average, which it was, then there will be little, if any, response to irrigation. Using data supplied by the Meteorological Office from the MORECS scheme, Broom's Barn produced a pilot series of Irrigation Bulletins this year. Weekly, from June to September inclusive, the potential evaporation and soil moisture deficit were calculated for each factory area and, based on these data, irrigation was recommended as appropriate. These bulletins

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which were sent to each Factory Agricultural Manager, suggested that irrigation was only required in the Bury, Ipswich and King's Lynn factory areas and then only on the lighter soils. Nationally, therefore, little response to irrigation was expected.

Comparison of winter wheat yields in 1981 and 1982. The yields of experimental crops sown on similar dates at Broom's Barn in the last two years were smaller in 1982 than in 1981 and this also occurred in other areas. Using the yields of crops from three sowing dates the differences between yields can be explained, at least in part, in terms of the temperatures experienced during specific stages in development, i.e. floret survival and grain growth.

The September-sown crop had 427 ears m^{-2} in 1982, 40 more than in 1981, but the yield of 7·81 t ha^{-1} was 0·26 t ha^{-1} smaller. The number of grains per ear was similar in both years, but in 1982 mean weight per grain was only 40·8 mg compared with 45·6 in 1981. Mean air temperatures during grain growth in the 2 years were very different, 14·7° and 16·1°C in 1981 and 1982 respectively, primarily due to a period of abnormally high temperature at the beginning of June 1982. Because the duration of grain growth is temperature-dependent, requiring about 690°C days above 0°C, the 1981 crop had about 4 days more to accumulate dry matter and the grains therefore grew larger.

The November-sown crop had the same number of ears and same mean weight per grain in both years but the yield of 7·68 t ha^{-1} in 1982 was 0·36 t ha^{-1} less than in 1981 because the number of grains per ear was 43·4 compared with 44·9. Floret number is determined before anthesis and it has been shown (Rawsom & Bagga, *Aust. Journal of Plant Physiology* (1979) **6,** 391–400) that the number of grains per ear is directly related to temperature pre-anthesis. Mean daily temperature for the week preceding anthesis in 1982 was 19·6° compared with only 12·9°C in 1981; the four preceding weeks were also about 2°C warmer in 1982. It seems probable that these high temperatures decreased floret survival resulting in smaller ears. Mean weights per grain were similar because mean temperatures during grain growth were similar and the duration of grain growth was 46 days in both years.

The crop sown in February 1982 yielded 6·68 t ha^{-1}, 0·63 t ha^{-1} less than in 1981, even though there were 483 ears m^{-2}, 70 more than 1981. However, both the number of grains per ear and mean weight per grain were smaller in 1982. As with the November-sown crop the high temperatures in early June coincided with pre-anthesis ear growth and this, together with a large number of ears, led to a decrease in the number of grains per ear from 43·3 in 1981 to 34·3 in 1982. Air temperatures during grain growth were also higher in 1982 and this decreased the duration of grain growth by 2 days.

Thus the above average temperatures in May and June which gave the exceptional sugar-beet yields of 1982 had adverse effects on the yield of winter wheat.

Plant establishment

Fungicide seed treatment trials. All sugar-beet seed used in England is steeped in an aqueous solution of ethyl mercury phosphate (EMP) to control seed-borne *Phoma betae*, the most important cause of seedling blackleg. After drying, the mercury content of the seed is low and the treatment is of little value in controlling soil-borne fungi that also cause blackleg. However, although fungi of several soil inhabiting genera are known to attack beet seedlings only *Aphanomyces cochlioides* is regularly recorded as damaging sugar-beet in England, usually in late-sown or redrilled crops.

A. cochlioides can be controlled with fenaminosulf (*Rothamsted Report for 1973*, Part 1, 261) but this material is slightly phytotoxic at the optimum dosage rates, and is not cleared for commercial use in Great Britain. In an earlier series of experiments this

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and other fungicide seed treatments, active against soil-borne seedling pathogens, did not improve seedling establishment when used on fields selected at random (*Rothamsted Report for 1969*, Part 1, 314; and *1970*, Part 1, 251).

The new fungicides metalaxyl and hymexazol, applied as seed treatments at pelleting, were tested in trials in commercial sugar-beet crops from 1980 to 1982. The results are summarized in Table 1. The fungicides, particularly hymexazol, improved establishment in late-sown (after mid-April) trials in 1980 and in both early and late-sown trials in 1981 and 1982, when wet weather favoured the soil-borne fungi, which cause blackleg, *Pythium* spp. as well as *A. cochlioides*. On average 14·7 g hymexazol kg^{-1} seed increased seedling establishment by 4·6%; 10·5 g was less effective whilst 21 g showed no adverse effects, suggesting that there is little risk of phytotoxicity at the lower dosage rates. In more than a quarter of the trials hymexazol seed treatment increased establishment by over 10%. Seedlings attacked by *A. cochlioides* were only found and counted in four of the trials. In these 14·7 g hymexazol decreased the proportion of infected seedlings by 75% but in none of the trials were many plants attacked.

TABLE 1

Field trials of fungicide treatments on sugar-beet seed. Percent seedling establishment. All seed EMP steeped + 2 g methiocarb kg^{-1} seed

No. of trials	Year	Treatment g kg^{-1} seed: None	Metalaxyl	Hymexazol		
		—	0·7	10·5	14·7	21
11	1980 early sown	62·8	61·4	60·9	—	—
5	1980 late sown	54·0	54·9	61·0	—	—
16	1981 all sowings	59·3	62·0	61·9	63·6	—
12	1982 all sowings	64·5	—	64·3	67·8	68·3

The benefits of treating sugar-beet seed with hymexazol are similar to those from insecticide treatments, with a small overall increase in seedling establishment due mainly to large increases in some fields. An increasing proportion of the sugar-beet seed used in England is likely to be treated with this fungicide, but further experiments are needed to determine how effectively it controls *A. cochlioides* under conditions of heavy infection. (Byford and Payne)

Springtails as pests of sugar beet. Springtails (Collembola) belonging to the genus *Onychiurus* can damage sugar beet. The species most frequently found in association with damaged crops is *Onychiurus armatus* (Tullberg) which feeds on the seedling roots causing damage which stresses the plant and, if severe, kills it.

To estimate the population density of *O. armatus* in an area of homogeneous soil type it was found necessary to take a minimum of 20 soil cores, 15 cm deep by 5 cm in diameter, on each sampling occasion; in practice 24 cores were normally taken. The animals were then expelled from the cores in a dynamic extractor, built to the design of the 'Rothamsted controlled temperature gradient apparatus' (Edwards & Fletcher (1971), *IPB Handbook, No. 18*). Two such extractors were built, each housing 70 aluminium baskets (12·8 cm in diameter by 7·5 cm deep), with 2 mm aperture wire mesh bottoms. Each core was split between two baskets, and a temperature and humidity gradient created by heating the top to 37°C whilst simultaneously cooling from below. *O. armatus* and other soil animals move to the cool, moist lower area and eventually fall through the mesh as the core dries out, to be collected in plastic pots containing glycerol–70% alcohol (1:9, v/v). Most of the animals had been expelled after 2 days heating and all after 4

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days. Examination of the dried remains of the cores showed the system to be approximately 70% efficient.

Analysis of the horizontal and vertical distribution of *O. armatus* in cultivated soil showed that they form aggregates in areas 25 to 30 cm in diameter, containing between 150 and 400 individuals. Such aggregates were found at densities of 1–2·5 m^{-2} of soil surface at a mean depth of 8 cm in March, but 12·5 cm in July.

Of at least 136 species reputed to belong to the genus *Onychiurus*, 49 have been recorded in the British Isles, of which 30 belong to the *O. armatus* group. The taxonomic characters that are used to separate species of the *O. armatus* group were found to be unreliable and, at one site studied in 1980, 45% of the 96 specimens of the *O. armatus* type examined were found to be intermediate forms between conventional species. Because no differences could be found in the feeding behaviour, ecology, or reproduction of these intermediate forms, they were all considered as *O. armatus* in the ecological study.

O. armatus was found to have two generations per year in English arable fields. In East Anglia they breed in May and late August, in N. Yorkshire in June and mid-winter. The difference in breeding dates between areas can be explained by the accumulated temperature above 4°C needed by *O. armatus* to complete a generation. Life table analysis of a population of *O. armatus* showed that mortality was greatest among the newly-hatched juveniles, apparently due to predation by Mesostigmatid mites.

Studies of gut contents showed that *O. armatus* feeds on fungal spores and mycelia, algae, its own shed skin and higher plant material. In the field it was found that *O. armatus* discriminated little between the species of seedling roots on which it fed, but in experiments it appeared to prefer sugar-beet seedlings to seedlings of *Chenopodium album*, *Polygonum aviculare*, *Polygonum persicaria* and *Atriplex patula*. (Brown)

Forecasting damage to sugar-beet seedlings caused by the Soil Pest Complex. Damage by the soil pest complex (*O. armatus*, millipedes and the symphylid *Scutigerella immaculata*) was found to reduce sugar-beet yields by causing low and irregular plant populations and by stunting some of the remaining plants. The vulnerability of seedlings to damage by these pests has been discussed (*Rothamsted Report for 1980*, Part 1, 69–70), and the need to develop a simple method for monitoring soil pest numbers in individual fields highlighted. Such a method is being developed for monitoring the number of *O. armatus* and millipedes in a field before the sugar-beet crop is sown.

Large bore plastic drinking straws were punched with holes (not less than 0·75 mm in diameter) and filled with a mixture of bran and dried meat. The ends of the straws were sealed with staples and the straws inserted vertically in the soil to a depth of about 10 cm in sugar-beet fields approximately 5 weeks before drilling. After 2 weeks in the field the straws were removed, returned to the laboratory, and opened in dishes of water so that any pests inside could be counted as they floated out. During the 2 weeks that the straws were in the fields, a series of soil cores were taken and extracted on the temperature gradient apparatus to assess with known accuracy the numbers of pests present in the fields. In 10 fields, using 2·5 straws per hectare, it was found that the estimates of pest numbers from the straws were closely correlated with the estimates obtained by extracting soil cores ($r = 8{\cdot}80$, $P < 0{\cdot}01$). Thus the 'baited straw' technique is a quick and simple method of estimating field populations of *O. armatus* and millipedes before drilling, possibly offering the basis for a forecasting scheme. (Brown and Cooper)

Environmental and nutritional aspects of crop growth and productivity

Yield prediction. The sugar-beet crop has to be processed within about 4 months in 13 factories. Considerable planning is needed to ensure that the crop is processed effi-

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ciently and sold competitively and it is therefore important that British Sugar have early and accurate predictions of both root and white sugar yields. In recent years the average sugar yield in England has varied from 3·9 t ha^{-1} in 1974 to 8·1 t ha^{-1} in 1982. Since 1978 we have been providing British Sugar with a yield forecast in early September. These forecasts are based on the close linear relationship between dry matter production and the amount of solar radiation which the crop intercepts; sugar yield is governed by the amount of dry matter produced and the way it is partitioned. After early August, beet partitions an approximately constant proportion of its dry matter to sugar, so yields can therefore be predicted from estimates of the amount of radiation intercepted and the rate of conversion to sugar, the latter being affected by drought and disease.

British Sugar have set up four radiation-measuring sites within the beet-growing area; these are maintained by Broom's Barn staff and, together with the data from our own meteorological station, give the amount of radiation received on the land surface. Solarimeters in a standard, non-irrigated crop at Broom's Barn each year are used to estimate the proportion of the radiation which is intercepted. Each week, for most of August and early September, the amounts of radiation intercepted are plotted against the average sugar yield of samples taken by the factory fieldmen from approximately 350 randomly selected fields throughout the beet-growing area. This gives the rate of sugar production per MJ of intercepted radiation. Because, from year to year, the radiation receipts do not vary greatly in summer and autumn, and during this period the proportion of the radiation which is intercepted changes little, the data can be used to predict crop growth and final yield. Having made this prediction the results are then adjusted by a factor which makes allowance for many sources of yield loss, including the distribution of harvest dates from September to December, losses while harvesting, poor growth on headlands (which are not sampled) and losses during storage prior to processing the roots. In recent years this factor has been relatively constant at about 0·7, suggesting that the 'losses' total approximately 30%. This procedure has given, in mid-September, national yield predictions in the years 1978 to 1981 which have all been within 0·2 t ha^{-1} of the final sugar yield of about 6 t ha^{-1}.

It would be of benefit to British Sugar in anticipating the need to divert beet between factories if accurate predictions could be made for smaller areas of the country and if the national values could be calculated earlier. The latter will require a knowledge of how the leaf canopy is expanding in different localities so that the radiation being intercepted can be estimated much earlier in the life of the crop. Eventually it might be possible to do this with a mathematical model of crop growth which relates leaf production and expansion to air temperatures. In the meantime, a more direct approach is to assess leaf cover from measurements of the light being reflected from the field surface which could be done with a spectral ratio meter mounted in an aircraft flying transects across sample fields. This could rapidly give measurements of crop growth on a large area and could measure variations in growth within fields. Such a system should reduce the size of the correction factor used in the present prediction system. This would be an advantage because, at present, we do not know the size and variability, regional or seasonal, of the factors which make up this correction. The use of spectral ratio measurements for remote sensing of crop growth to predict yield will be investigated further. (Biscoe and Jaggard)

The yield of a field. In 1980 Broom's Barn was approached by two farming companies who were concerned that their beet yields were no more than average for their district, despite their high variable costs and optimum timing of operations whenever possible. During 1981, samples taken throughout the season in their crops gave no indication that growth rates were less than expected for good crops grown at Broom's Barn and large hand-harvested plots taken from within some of the fields just before harvest indicated

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root yields of 55 t ha^{-1}. However, the growers only delivered approximately 36 t ha^{-1} of beet to the factory from these fields. Aerial photographs, taken by the ADAS Aerial Photography Unit, did not indicate that the samples were taken from abnormally good parts of the fields. However, the photographs did show that 5 to 12% of the croppable areas were without plants. If allowance is made for the croppable area being less than the Ordnance Survey field acreage and for the proportion of the former which carried no plants then the discrepancy between the two yields is 10 t ha^{-1}. This difference is still much larger than the yield differences usually produced in experiments by changing cultural practices and it is important to investigate it further.

In 1982, six fields, managed by growers whose yields normally range from below to well above average for their districts, were intensively sampled and were photographed by ADAS Aerial Photography Unit in an effort to trace the causes of these discrepancies. The indications were that there are large variations in yield within fields. This work will continue and will use remote sensing from the air by the spectral ratio meter; this seems likely to be an effective and economical way of monitoring patchy growth within a crop. (Jaggard)

Sowing date, plant population, bolters and yield. The results of the series of variety/sowing date experiments at Broom's Barn from 1976 to 1978 have been analysed in detail together with those from a similar series at Arthur Rickwood Experimental Husbandry Farm between 1974 and 1978. Sowing dates ranged from late February to late April. Sowing before mid-March often gave very gappy crops with many bolters and, in consequence, poor yields. Late-March sowings were almost free from plant establishment problems, and where the bolting-resistant variety 'Nomo' was used, bolters were few and yields were greater than from early April sowings. A study of all published yield comparisons for sowings made over the period late March–early April, showed that when there were few bolters the earlier sowing gave a significantly better yield, and not a similar yield as had previously been supposed.

In both series of experiments, variation in bolting between sites, seasons and sowing date treatments was accounted for by variations in the number of cool days (with a maximum temperature of less than 12°C) after sowing. Yield was lost at the rate of 0·7% for every 1% of bolters within the range 5 to 40%. From October to December crops at Arthur Rickwood which had more than 5% bolters and/or less than 60 000 plants ha^{-1} gained 0·45 t ha^{-1} less sugar than did those with full, bolter-free plant stands. In the absence of other constraints (e.g. soil type) poorly established crops, or those with many bolters, should always be harvested first. (Jaggard, Webb, with Mr R. Wickens, Arthur Rickwood EHF)

Diurnal and seasonal changes in the CO_2 exchange of beet carbon. Previous studies on the relationship between the environment and the productivity of sugar beet have relied on growth analysis techniques. However, it is difficult to relate different growth rates to one environmental factor because of the large fluctuations in environmental conditions during the interval between samples. Also, without adequate replication, sampling errors associated with growth analysis of sugar beet can be large because of the large size of individual plants, the variations in size and growth rate between individuals. Late in the season sampling errors become as great as many of the yield changes which need to be detected.

In response to these problems a mobile gas-exchange system was developed in conjunction with environmental physicists at Nottingham University, and used at Broom's Barn in 1979 and 1980. The objective was to measure the rate of net photosynthesis of small areas of undisturbed beet in the field over periods of several days. Typically,

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experiments were made on four replicate plots each of six sugar-beet plants grown at 70 000 plants ha^{-1}. For each plot rates of CO_2 exchange were measured ten times during the season for between 3 and 4 days, while the temperature in the chamber was either the same as the air outside or kept at a constant 20°C.

The measurements were used to produce photosynthesis-light response curves to which rectangular hyperbolae were fitted, enabling the three parameters—dark respiration (R_d), photochemical efficiency (α) and the maximum rate of net photosynthesis (P_{max})—to be derived and expressed per unit leaf area rather than per unit ground area. A characteristic of the fitted rectangular hyperbola is that P_{max} is always faster than the maximum measured rate of net photosynthesis and to introduce a degree of parity the rate of net photosynthesis at an incident irradiance of 500W m^{-2} (P_{500}) was computed. Throughout this was similar to the maximum measured rates of net photosynthesis. From June until early October the shape of the photosynthesis-light response curve varied little, the parameters having values of $R_d = 0{\cdot}4$ g CO_2 m^{-2} h^{-1}, $\alpha = 7{\cdot}0$ mg CO_2 J^{-1} and $P_{500} = 5{\cdot}5$ g CO_2 m^{-2} h^{-1}. Consequently, over the range of irradiances experienced during this period there was an essentially linear relationship with photosynthesis confirming the previous field results that dry matter growth is proportional to the amount of radiation intercepted. When the parameters were plotted against mean chamber temperature, there was a positive, linear relationship between temperature and both R_d and P_{500}, the coefficients being 0·018 and 0·13 g CO_2 m^{-2} h^{-1} per °C respectively. Throughout the season α remained almost constant except for a slight decrease just before harvest at the end of November.

Weekly carbon budgets of the crop were obtained from the gas-exchange measurements by integrating the rates of net photosynthesis and the measurement of dark respiration using the fitted hyperbolae and measurements of incident radiation. These agreed well with those from growth analysis until August, when both methods showed an average efficiency for the conversion of intercepted radiation to dry matter of 1·7 g MJ^{-1}. Later in the season growth analysis estimates of dry matter growth became very variable and the agreement was less good. Integrating the data from the gas-exchange system for the whole season the estimate of total dry matter production of 1830 g m^{-2} is close to the 1860 g m^{-2} from the growth analysis measurements.

The equipment is currently being used to investigate the effect of a plant growth regulator on crop photosynthesis in a project sponsored by Imperial Chemical Industries. (Glauert and Biscoe)

Sugar beet tolerance to herbicides. On many occasions when post-emergence herbicides have checked the early growth of sugar beet, the weather at or shortly after spraying has been considered the most important contributing factor. It has not proved possible in field experiments to examine how individual weather variables influence the effect of selective herbicides (*Rothamsted Report for 1981*, Part 1, 74). In part, this was because individual weather factors are often closely correlated, e.g. during the spring, radiation and temperature tend to increase together. Also, to ensure that the crop can be sprayed at the required stage over a wide range of an individual weather factor requires a large number of field experiments over many years. Consequently, controlled environment facilities must be used because they allow one environmental variable to be altered while the others remain constant, and environmental extremes can be easily maintained.

The effects of relative humidity (r.h.), temperature and light on the tolerance of sugar beet to metamitron and phenmedipham, the two major post-emergence herbicides, were investigated under controlled conditions in collaboration with the Weed Research Organization, Oxford. Plants to be used in comparisons of the effects of humidity and temperature were grown under standard conditions in the growth room. Where light

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intensity treatments were applied experiments were made in the glasshouse, because light intensity in the growth rooms is low compared with that out-of-doors in May. Plants were sprayed with either metamitron or phenmedipham when the second pair of true leaves were 1 cm long. Humidity treatments, 95% and 50% r.h., were imposed 3 days prior to spraying. The temperature treatments, 26°C day/16°C night and 10°C day/6°C night, and light intensity treatments, full sunlight and 50% shade provided by covers made of Tygon mesh, were imposed after spraying. Plants were kept under the test conditions after spraying, and plant growth and development were measured at 3 to 7-day intervals until the 10–12 true leaf stage.

Necrosis of leaf margins showed within 3 days of spraying metamitron at high r.h. but there was no visible damage at low r.h. At the eight true leaf stage, when the difference between treatments was largest, the total dry weight of plants treated with metamitron at high r.h. was about 30% less than the controls, but there was no difference when treated at low r.h. On the other hand, phenmedipham did not affect growth at either high or low r.h.

In contrast metamitron did not stunt growth in either of the temperature or light intensity treatments whereas with phenmedipham there was a large modifying effect of both temperature and light intensity but not of humidity. At high temperature or in bright light, characteristic symptoms of phenmedipham toxicity, areas of chlorosis or necrosis over the leaf surface, appeared within 2 h of spraying and by the eight true-leaf stage plants weighed about 65% less than the controls. At low temperature, or in dull light, visible symptoms of damage took several days to appear and the effect on dry weights was significantly less.

In field experiments at the Norfolk Agricultural Station in 1980 and 1981 the weather before, at and after the time of spraying was recorded, and the effect on the early growth of sugar beet of the post-emergence herbicides which were applied in sequence with a pre-emergence application of a PCF (propham+chlorpropham+fenuron) mixture, was measured. In 1980 when conditions were warm and bright, phenmedipham was less safe, whereas in humid, wet conditions during 1981 metamitron caused more damage. These field results are therefore consistent with those from the experiments in controlled conditions.

While field and controlled environment room experiments have identified weather factors which will cause crop damage, further work will concentrate on identifying the precise time or times, i.e. before, at, or after spraying, when these factors exert their greatest influence. The cooperation and help of the Environmental Studies Section at the Weed Research Organization, Oxford, is gratefully acknowledged. (Preston and Biscoe)

Leaf growth and development. Progress in the studies of both yield variation and prediction depends on gaining a better understanding of the factors that govern yields in particular environments. One of the purposes of our intensive studies, started in 1978, on a range of healthy, irrigated crops, was to separate the influences of the individual components of weather, e.g. temperature, radiation, rainfall, etc., on the various processes governing sugar production. This was to enable us to determine the potential for sugar yield of a particular site or season against which actual yields can be compared and the success of decisions on crop management judged.

Earlier reports demonstrated how the production of total dry matter and sugar depended on the amount of solar radiation intercepted during growth, and emphasized the importance to radiation interception of the expansion of the leaf canopy early in the season (*Rothamsted Report for 1979*, Part 1, 60). At this time, air temperature is the main climatic factor and nitrogen the main agricultural input affecting leaf growth.

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Studies of the growth of individual leaves have shown that the rates at which they appear and expand increase linearly with air temperature, over the range experienced in the field. This is a key relationship because it means that leaf area indices should also increase linearly with temperature and that their increase can be related to accumulated air temperature rather than days from sowing. This would allow the effects of specific treatments on leaf canopy growth and radiation interception to be compared quantitatively in crops grown on different sites and in different seasons.

Crops grown on our study areas between 1978 and 1982 showed large differences in the dynamics of leaf area index (L). Maximum L ranged from 1·5 to 5·3 and, in crops where it was not severely restricted, the date when L reached between 2·5 and 3·0, sufficient to intercept most of the incident radiation, varied between mid-June in the record-yielding crop of 1982, to mid-August in crops given no nitrogen fertilizer in 1979. Analysis of the leaf area growth of these crops confirmed the linear relationship with accumulated temperature but showed that it was also strongly influenced by the nitrogen status of the laminae.

In 1981, on an accumulated temperature basis, L expanded at a rate of 0·79 index units per 100°C days when the laminae dry matter contained, on average, 4·71% N. This was faster than in 1978, 1979 or 1980 when L expanded at rates of about 0·55 index units per 100°C days and the laminae contained 4·00% N in dry matter. Thermal expansion of L was even faster in 1982, 0·90 units per 100°C days, but lamina nitrogen concentrations are not yet available. In 1979 and 1982, comparisons between crops given no nitrogen fertilizer or 125 kg N ha^{-1} showed that lack of nitrogen halved the rate at which L expanded.

The need now is to understand how differences in lamina nitrogen concentrations arise and how they cause L to respond differently to temperature. There is circumstantial evidence that processes early in leaf development, e.g. the division and expansion of cells in leaf primordia, may determine how soon L starts to expand linearly with temperature and these aspects of leaf growth will be investigated. (Milford)

Diseases and pests

Oilseed rape and sugar-beet yellowing viruses. A very important unknown factor in the study of the yellowing viruses of beet is the principal over-wintering sites of both the viruses and their main aphid vector, *Myzus persicae*. The alternative hosts of beet yellows virus (BYV) are believed to be mostly members of the Chenopodiaceae, but the commoner beet mild yellowing virus (BMYV) can infect plants from several families. The area of oilseed rape crops has increased very rapidly in recent years and brassicas are known to be overwintering hosts for *M. persicae*. If this crop were also a potential overwintering site for beet yellowing viruses it would pose a very severe new threat to sugar beet.

This possibility has been checked using BYV and BMYV antisera in the enzyme-linked immunosorbent assay (ELISA) test. In cooperation with ADAS, Cambridge, leaves were collected from plants showing reddish tinges on the older leaves in nine oilseed rape crops in Bedfordshire, selected because of their proximity to sugar-beet seed crops known to be infected with BMYV and BYV. One leaf from each of five plants per site was tested against antisera to BYV and BMYV, using ELISA. With the BYV antiserum, the absorbance (A_{405}) values were very low, ranging from 0·04 to 0·06. With BMYV antiserum 21 of the 30 leaves from six sites gave A_{405} values between 0·66 and 1·49. At the remaining three sites values were all low, ranging from 0·05 to 0·10. In collaboration with R. Woods (Plant Pathology), the presence of spherical virus particles was confirmed in oilseed rape leaves giving high A_{405} values by means of the immunosorbent electron

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microscope technique. The presence of reddened leaves was not a reliable indication of infection.

Ten oilseed rape plants giving high A_{405} values with BMYV antiserum were tested against antisera to potato leafroll virus (PLRV) and barley yellow dwarf virus (BYDV), both mild and severe strains, but the virus present did not react with these antisera (Table 2).

TABLE 2

ELISA tests, with different antisera, on ten oilseed rape plants giving positive responses to BMYV antiserum

	Antisera			
	BMYV	PLRV	BYDV (severe) strain	BYDV (mild) strain
A_{405} range	0·50–1·55	0–0·03	0–0·02	0–0·02
A_{405} mean	1·05	<0·01	0·01	0·01

Antisera to BYV and BMYV supplied by D. A. Govier (Plant Pathology); antisera to PLRV and BYDV supplied by Dr S. A. Hill (ADAS, Cambridge)

Attempts were made to transmit the oilseed rape virus to sugar beet. Adult wingless *M. persicae* were fed for 5 days on oilseed rape plants which had given high A_{405} values with BMYV antiserum in ELISA tests; ten of these were then transferred to each of 54 sugar-beet seedlings, cv. Bush Mono G, where they fed for a further 72 h. Inoculated and uninoculated control sugar-beet plants were grown-on in the glasshouse in Perspex containers to prevent contamination from other virus sources. After 6 weeks each plant was tested against BMYV antiserum using ELISA. The 30 uninoculated plants gave A_{405} values which ranged from 0 to 0·17, indicating an upper limit of 0·20 for negative results. The 54 inoculated plants gave A_{405} values ranging from 0 to 0·44; ten of them had values in excess of 0·20, indicating that they were infected. This preliminary study shows that the virus in oilseed rape can be transmitted to sugar beet by *M. persicae*, but further tests are necessary before the virus can be positively identified. (Smith and Hinckes)

Effects of beet cryptic virus on sugar beet. The seed-transmitted beet cryptic virus (BCV) has been found in 90% of sugar-beet plants, although no symptoms are apparent (*Rothamsted Report for 1977*, Part 1, 210). Field, glasshouse and growth room studies were carried out to determine whether BCV decreases sugar yield or has any other detrimental effects on the plant. In 1980 and 1981 BCV-infected and healthy sugar beet were compared in field trials. Early crop growth and development were measured fortnightly by destructive analysis, while non-destructive leaf area measurements were made twice weekly. Root yield, sugar and impurities content of the roots, and top dry weights were assessed at final harvest in October.

As BCV is seed-transmitted, the seed used in the trials was produced from plants selected following electron microscope checks on sap at Rothamsted, and seedlings grown from the seed were rechecked for presence or absence of BCV before use. In the 1980 field trials the multigerm variety Sharpes Klein E was used, and in the 1981 trial, crosses from a diploid monogerm pollen fertile family from Anglo Maribo Seed Company Limited.

Some differences were found in the early growth stages, with the healthy plants generally larger in both leaf area and leaf and root weights. However, these differences were small and disappeared as the season progressed. In 1980, BCV-infected plants yielded 4·9% less sugar than healthy plants but the difference was not significant. In 1981,

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BCV-infected plants yielded 10·9% less sugar than healthy plants at final harvest, a difference significant at $P<0{\cdot}05$.

In growth rooms at Rothamsted further experiments with the monogerm seed also compared the early growth of BCV-infected and healthy plants by destructive and non-destructive assessments. Initially there was a significant difference between BCV-infected and healthy plants, with the infected plants having larger leaf areas and leaf and root dry weights, but this difference disappeared as growth continued.

Experiments in the glasshouse, and the field at Close House Field Station, Newcastle, measured leaf primordia production and early growth of plants, and studied seed production. These experiments also showed differences between BCV-infected and healthy sugar beet, which were largest in the early growth stages of the plant. However, there were indications in this series of experiments that effects could be reversed by the conditions under which the plants were grown. Generally it seemed that healthy plants grew better than BCV-infected plants when in the field or when under stress in the glasshouse (lack of water or nutrients), but BCV-infected plants grew better in the glasshouse and growth room when not under stress. (Moir)

Beet cyst-nematode. In 1977 the MAFF Beet Eelworm Order was revoked. It had restricted the frequency with which host crops of beet cyst-nematode (*Heterodera schachtii*) could be grown in the main infested (scheduled) area of the Fens and in all other fields known to be infested. The only remaining enforced rotational restriction on sugar-beet growing was then Clause 21 of the contract between the growers and British Sugar, which stipulated that beet could only be sown in fields which had not grown a host crop of the nematode in the previous 2 years. From 1983 onwards even this clause will be removed from the contract, so there will be no enforceable constraints on cropping prior to sowing sugar beet. It remains to be seen whether this will lead to a significant change towards growing beet in rotations which include a greater proportion of host crops and, if so, whether this will result in an increase in the pest status of *H. schachtii*. More research and advisory work on this pest may be needed in the future to develop alternatives to crop rotation in pest management strategies, and to ensure that they are used effectively.

Advice on pest management requires an understanding of the relationship between initial pest population and yield loss. A field experiment at Broom's Barn from 1978–81 assessed this relationship for *H. schachtii* and sugar beet in a typical East Anglian mineral soil. In each of these 4 years sugar yield and initial and final populations of *H. schachtii* were determined in 36 small plots on land which had previously grown sugar beet continuously since 1965. Initial populations (P_i) in 1978 varied between 0 and 29·3 eggs g^{-1} (mean 6·7), in 1979 between 0 and 14·5 (mean 4·9) and by 1981 between 0 and 59·5 (mean 21·9). The effect of these populations on root yield of sugar beet (Y) can be described by Seinhorst's equation:

$$Y = Y_{min} + (Y_{max} - Y_{min})Z^{P_i - T}$$

where Y_{min} is the minimum root yield at greatest nematode population densities, Y_{max} the root yield in the absence of nematodes, T the tolerance limit (i.e. the nematode population below which no damage is done) and Z a constant slightly less than 1. An iterative computer program was used to derive the best fitting values of Y_{min}, Y_{max}, Z and T for each year and over the whole period of the experiment. Annual estimates of Y_{max} varied from 37·3 to 43·0 t ha^{-1}; annual estimates of Y_{min}, T and Z were less dependable because the range of P_i was not large in the early years of the experiment. Over the 4 years of the experiment, however, the best fitting values of Y_{max}, Y_{min}, T and Z were 39·4, 7·7, 0·0 and 0·99938 respectively. Thus, a root yield loss of 5 t ha^{-1} would be caused

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by an initial *H. schachtii* population of 2·8 eggs g^{-1}, and 10 t ha^{-1} would be lost in soil containing 6·1 eggs g^{-1}. (Cooke)

Weed beet

Weed beet. In recent years sugar-beet plants which become reproductive in their first season (bolters) and produce viable seed have become a weed problem of arable land. They are a particular problem in the sugar-beet crop where they cannot be controlled by selective herbicides. They are less troublesome in crops such as potatoes and peas, and only slightly so in cereals where the dense canopy appears to inhibit germination and growth, and in which selective herbicides are generally effective. Surveys indicate that about 27% of the English sugar-beet crop is infested by weed beet.

Weed beet can develop from seed shed by bolters in a previous sugar-beet root crop grown from an early sowing which had received some vernalization; from contamination of the seed by pollen from true annual types during seed production, particularly in Southern Europe; or from groundkeepers, either unharvested roots or crowns from overtopped plants. Because *Beta* is wind pollinated and outbreeding, the characteristics of each of these three types of population have merged imperceptibly over recent years to produce what can now only be termed weed beet.

At first work sought to identify seed stocks which contained some annual types and were introducing the problem. A warm glasshouse test under long days, which allows true annuals to show, was devised and is now widely used by seed merchants. However, many sugar-beet seed stocks which give bolters contain easy bolting types rather than true annuals. These do not show up in the warm glasshouse tests, because they have a small vernalization requirement, but they can be detected in May field sowings. These are made at high plant populations in order to give enough plants to estimate low frequencies of bolting confidently while at the same time accommodating the trials (now carried out as routine by NIAB) within a reasonable area.

More recent work has concentrated on preventing further multiplication of weed beet in already infested fields. The key to this is to prevent viable seed production. A total of 15 field trials were made in 1979, 1980 and 1981, all including plots in which bolter development was studied and others in which the effects of different control measures were evaluated. The first bolters appeared in late May or early June and most produced inflorescences in June and July with flowering spread over about 6 weeks, partly because of the spread in bolting, partly because of the extended flowering period of individual plants. The first live seeds were found in early August, 28–42 days after the first flowers opened, their numbers rose to a peak of up to 2000 per bolter by mid-September and then declined due to shedding.

Cutting bolters was one method of control tested. If done too soon bolters appeared after cutting and produced viable seeds; if done too late live seeds were already present at cutting and were shed. However, as cut plants often regrew and were still capable of producing viable seeds, satisfactory control generally required two cuts at fortnightly intervals starting about 28 days after first flowering. Selective application of a non-selective herbicide (glyphosate) was found to be very effective when made twice at a fortnightly interval starting at, or 14 days after, first flowering. A series of extension type experiments is being carried out in collaboration with British Sugar to develop this method of control and to show advisers and farmers how to use it.

Further studies are in progress to find how best to exhaust viable seed reserves in the soil so that the conditions under which weed beet populations can be expected to increase or decrease can be defined. The seed of *Beta* spp. is embedded in lignified perianth remains giving a dispersal unit very resistant to rotting. Long survival, particularly when

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buried to plough layer depth in the soil, also seems to involve some form of enforced dormancy.

A long-term experiment has been set up at Broom's Barn in which there are fully phased entries into one-in-three and one-in-six year rotations of sugar beet and barley on land which will be either inverted by ploughing to 25 cm depth or cultivated to 20 cm depth only throughout the life of the experiment. Bolters which occur in the sugar-beet crop are recorded and destroyed and weed-beet seed grown elsewhere is introduced uniformly at known numbers per unit area. When a plot returns to sugar beet it is split so that half receives no further seed and half has a second seeding. Numbers of viable weed-beet seeds are determined in soil samples from 0–7·5, 7·5–15·0, 15·0–22·5 cm depth before each sugar-beet crop after the first. Weed-beet seedlings are counted in all crops. In subsidiary experiments seed, buried at known depths in nylon bags, will be recovered annually to determine loss of viability at different depths over several years.

The first sugar-beet crop was in 1979, so the first one-in-three rotation was completed in 1982. Fewer weed beet were found in barley following sugar beet on ploughed than on cultivated plots. Very few weed beet were found in the second barley crop but in the following sugar-beet crop there were almost twice as many weed beet on ploughed as on culvitated plots. It already appears that deep burial maintains viability, so that in known weed-beet infestations viable seed populations are likely to decline most quickly if seeds are left as near the soil surface as possible where they may germinate, and be killed, or where they may be eaten by birds or mammals, or die. (Longden and Johnson)

Broom's Barn Farm

The modified rotation (sugar beet—spring barley—winter oats—winter wheat—winter barley) and fertilizer policy (applying phosphate and potash only twice in the rotation), is now in its third year and some of the advantages have become obvious and the initial problems solved. All the cereals are drilled on a 12 m tramline pattern which makes subsequent fertilizer spreading and spraying much quicker and more accurate. The tramlines are also used on the stubble to apply phosphate and potash fertilizers before ploughing, and to spray glyphosate on the winter barley stubble to control couch grass and perennial weeds before ploughing for the following beet crop. Following stubble cultivations all the land is ploughed and autumn-sown wheat and barley are sprayed with a suitable herbicide to control cultivated and wild oats. This has been successful and very few volunteers appeared this year. The pH is checked regularly and very little liming was required this autumn. Subsoiling had to be abandoned due to the very wet conditions in the early autumn.

Cereals. The winter cereal land was ploughed and all were drilled by mid-October 1981. The wheat and barley were sprayed in the autumn with chlortoluron post-emergence to control cultivated and wild oats; bad weather prevented the oats from being sprayed so it was treated in the spring. One field of winter barley, sown on 23 September, was treated with insecticide in the autumn to control barley yellow dwarf virus. The first spring barley was sown on 16 February on the light soil, but it was not possible to sow the remainder until 23 March. The first application of nitrogen to all the winter crops was made during the second week of March and the second and final application together with nitrogen for the spring barley was applied in the third week of April. The total amounts of N applied (kg ha^{-1}) were: winter wheat 180; winter barley 145; winter oats 120; spring barley 95. The oats needed no fungicide spray but the winter wheat was sprayed three times; early, for eyespot and mildew; mid-season, and at ear emergence, for *Septoria*. The winter barley was sprayed for eyespot and mildew early in the season,

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and the spring barley at ear emergence for *Rhyncosporium*, net blotch and mildew. The only volunteer oats were on the heavier soil, suggesting that ploughing and the action of residual herbicide was less effective than on the lighter soils. Harvest started on 19 July with the winter barley followed very quickly by the other crops and was finished on 21 August. Yields, generally the highest ever produced at Broom's Barn, were: t ha^{-1} —winter wheat (Norman) 8·0–9·2; winter barley (Igri) 7·1–7·7; winter oats (Peniarth) 6·2–6·4; spring barley (Triumph) 5·0–6·2. The higher yields were from the heavier fields except for spring barley which gave the higher yield from the lighter field which had been drilled earlier.

Sugar beet. Seed beds were easy to prepare in the spring, even on the heavy land, due to the very penetrating winter frosts. Sowing started on 9 March (early drilling of time-of-sowing experiment) and most was drilled during the last week of March and the first week of April. All the crop was sown with pelleted monogerm seed, and 70% was spaced at 18 cm or wider. Sixty-five per cent was treated with a granular insecticide at drilling, mainly to minimize the risk of early virus infection in experiments.

Most was band-sprayed at drilling with chloridazon and in mid-May with one-third rate of phenmedipham at high pressure. The Holt was also sprayed with 3,6-dichloropicolinic acid to control thistles. Tractor and hand hoes were also used when necessary. Weed control was variable due to the fast growth in the warm, damp weather after the beet had emerged and some hand pulling of fathen was necessary. One aphicide spray was applied in early July and only a few plants had virus yellows. There were less than 1% bolters. Powdery mildew was found in the crop in mid-August and a sulphur spray was applied to control it.

Harvest started on 23 September but difficult, wet conditions with above-average rainfall began early in October and continued throughout the lifting period which did not finish until 23 December. Yields of roots were better than the good 1981 yield (although the sugar percentage was lower) and averaged 54·7 t clean roots ha^{-1} at an average sugar concentration of 16·6%, ranging from 15·7 to 17·8%. Mean dirt top tares were 9 and 4%. National yields averaged 49·8 t ha^{-1} at 16·3% sugar.

Livestock. In October and November 1981, 53 heifers, Friesian and cross-bred, and 50 steers, mainly Friesian, were bought and fattened in the yards on a ration of one-third brewers' grains and two-thirds pressed beet pulp. Some dry pulp was substituted, with the amount adjusted to maintain the same dry matter intake for pressed pulp. This was fed *ad lib* with added minerals, and fresh straw was always available. All were sold between 8 February and 19 April 1982. The yards were restocked in autumn 1982 with 67 Friesian steers and 32 cross-bred heifers. (Golding)

Staff and visitors

A. P. Draycott resigned from 31 December after 17 years working on the nutrition of the sugar-beet crop. At the end of March, G. L. Maughan retired from the post of Co-ordinating Officer between Broom's Barn and British Sugar plc. H. Klemp retired after 18 years working on the field experiments. M. J. Armstrong was appointed as crop nutritionist, initially to work on the effect of fertilizer applications on the uptake and distribution of nutrients within the sugar beet crop and their influences on the processes governing productivity. R. A. Brown, P. E. Preston and D. L. Moir left after completing their post-graduate research projects. R. A. Brown and P. C. Jepson were awarded Ph.D. degrees by Newcastle and Cambridge Universities respectively. J. Iwanicki received the Director-General's award for long service as a meteorological observer.

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BROOM'S BARN EXPERIMENTAL STATION

Members of Broom's Barn staff took an active part in the work of the International Organization for Biological Control and of the International Institute for Sugar Beet Research, where they contributed to the Winter Congress in Brussels in February and the Pest and Diseases Study Group meeting in Greece in September. R. K. Scott, R. A. Dunning, A. P. Draycott and P. C. Longden attended a reunion of students from the IIRB Zaragoza course which was held in the Netherlands in February. R. A. Dunning attended the 50th Anniversary celebrations of the Institut Belge pour l'Amélioration de la Betterave in September; in November he was a guest speaker of the Czechoslovak Academy of Sciences at a conference on Protection of Sugar Beet. P. V. Biscoe gave two seminars to staff at the Centre for Agricultural Research, Wageningen, Netherlands, in October, and gave the 6th Robinson Memorial lecture at Nottingham University. P. C. Longden led a seminar on weed beet for Monsanto plc in Brussels and discussed plant establishment on Anglia TV's 'Farming Diary'. A. P. Draycott contributed to a programme on sugar beet for BBC TV's 'Farming World'.

An ADAS Sugar-Beet Advisory Course was held at Broom's Barn in February to which many of the staff contributed, as they did to the British Sugar plc Staff Conference also in February. D. A. Cooke contributed to the 16th International Symposium of the European Society of Nematologists at St Andrews in September and also organized a 1-day training course in June for Ministry of Agriculture cyst-nematode surveyors. P. C. Longden organized a 2-day Weed Beet Workshop at Broom's Barn in June. Four trainee fieldmen from British Sugar worked in the field experiments section in early summer and again in the autumn.

Four winter Scientific Meetings were held at Broom's Barn and the Station contributed exhibits to the Spring and Autumn National Sugar Beet demonstrations at Newport, Shropshire. Members of staff gave talks on a variety of topics to many farmers' meetings organized by ADAS, British Sugar plc, agrochemical companies, agricultural clubs, etc. Groups of visitors during the year included students from the University of Newcastle, Bishop Burton Agricultural College and the Netherlands; farmers from England and France, and sugar factory managers and agriculturalists from Italy.

M. Hurej of the Agricultural University, Wroclaw, Poland, worked at Broom's Barn from April to July studying aphids on oilseed rape and sugar beet.

The work of Broom's Barn is undertaken for the Sugar Beet Research and Education Committee. W. J. Byford assisted in compiling this report.

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