ROTHAMSTED RESEARCH

Report for 1976 - Part 1

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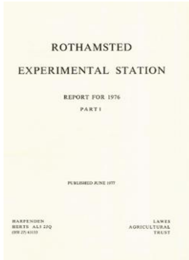
ROTHAMSTED

EXPERIMENTAL STATION

REPORT FOR 1976

PART 1

Broom's Barn Experimental Station

R. Hull

R. Hull (1977) *Broom's Barn Experimental Station ;* Report For 1976 - Part 1, pp 51 - 79 **- DOI: https://doi.org/10.23637/ERADOC-1-133**

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Introduction

The weather in the spring allowed us to sow the sugar-beet crop earlier than ever before and that gave the prospect of a large yield, but persistent drought throughout the summer defoliated many crops and severely restricted growth. This limiting factor affected the yield results from field experiments. For instance, fluid drilling that increased plant size early gave no increase in final yield. In contrast, irrigation maintained the leaf area, more than doubled sugar yield and gave increased sugar percentage in the roots. After several years when soil moisture had restricted yield, many growers are contemplating whether to

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install irrigation systems for sugar beet. However, experiments in the 1950s and 1960s showed that irrigation improved sugar yield relatively little. Winter rainfall stored in the soil profile plus summer rainfall usually provide nearly all the water needed to give maximum yield from the deep rooted sugar-beet crop. The recent sequence of dry winters and hot dry summers have, however, made irrigation more profitable.

The dry spring and hot dry summer also favoured some pests and diseases. More *Myzus persicae* were caught on sticky traps in southern England during May and June than ever before, but virus yellows did not spread as extensively as had been feared. Yellows incidence may have been underestimated, however, because of the difficulty of recognising symptoms of the disease when sugar-beet plants were suffering from drought. Several experiments gave clear evidence that some insecticides applied at the recommended rate failed to control these heavy and persistent aphid infestations and gave no decrease in yellows incidence or yield increase. Superficial damage on the roots by cutworms was universal.

Powdery mildew was again prevalent and fungicidal sprays that controlled it gave appreciable yield increases. Maybe with new varieties that seem to be more susceptible to mildews than the old ones, we are entering an era when routine fungicide sprays will be needed, as has occurred with cereals.

Arthropod pests of seedlings

Early sowing of the crop led to above average damage by the soil-inhabiting seedling pests — wireworms, millipedes, springtails and symphylids. That this damage was not much greater must have been a result of the greatly increased use of pesticides in the seedbed; carbamate granules (mainly aldicarb) in the seed furrow were used on 31% of the total crop area and an additional 8% had gamma-HCH worked into the seedbed.

In July and later, cutworms were more prevalent than ever before, damaging roots extensively but superficially; their effect on yield is unknown.

Pygmy beetle dispersal. The 913 beetles caught in the Broom's Barn 12·2 m suction trap was the largest total for five years. The recently installed 1·2 m trap caught fewer (793) and caught them, on average, later; by 15 June the former had caught 90% of its total catch, the latter only 66%. Pygmy beetles were also numerous on sticky traps at Broom's Barn, Holbeach and Rothamsted. These results give further evidence that there is a large spring dispersal after a dry previous autumn (*Rothamsted Report for 1974*, Part 2, 182); crop damage, however, was a little below the long-term average, almost certainly because the crop was sown very early. (Thornhill and Dunning)

Collembola (*Onychiurus*). An International Organization for Biological Control collaborative trial tests factors affecting *Onychiurus* damage to seedling sugar beet in seven countries. On an *Onychiurus*-infested site near March, Cambridge, plots were treated with gamma-HCH (1 kg a.i. ha^{-1} worked into the seedbed), aldicarb (1 kg a.i. in the seed furrow at drilling), or no insecticide, each being split for no herbicide or pyrazone applied pre-emergence at the commercial rate for the soil type. The trial was repeated at Broom's Barn, where there were few *Onychiurus*. The pest caused little damage due to drought, which also affected seedling establishment at March. At March, millipedes, symphylids and *Atomaria* caused some damage and the seedling establishment of 48% was improved by gamma-HCH to 59% and by aldicarb to 61%. At Broom's Barn seedling establishment of 82% was not affected by gamma-HCH or aldicarb.

Sugar yields at Broom's Barn were: control 6·7, gamma-HCH 7·0, aldicarb 7·0 t ha^{-1}; respective figures at March were 6·0, 6·9 and 7·0 t ha^{-1}. Herbicide treatments had no effect at either site. (Dunning and Thornhill, with Edwards, Entomology Department)

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Insecticides

Seed treatment. Twenty-nine trials in 16 factory areas measured the seedling establishment achieved from Filcoat pelleted Nomo seed carrying the standard 0·2% of dieldrin, or 0·05, 0·1, 0·2, 0·4 or 0·8% of methiocarb or bendiocarb, or 0·2, 0·8 or 3·2% of carbofuran, all incorporated during pelleting. All trials were sown mid-March to mid-April. Laboratory germination of the pelleted seed without insecticide was 96% but field establishment ranged from 28 to 89%, mean 61%.

At only two of the 29 sites was there a positive response to insecticide treatments; decreased seedling numbers, especially from the largest amounts of bendiocarb and carbofuran, occurred at several sites, probably due to absence of pest damage and phytotoxic effects in dry seedbeds.

Averaging all trials, 0·05% methiocarb and bendiocarb increased seedling numbers most, by 3·6%, but 0·2% methiocarb, 0·4 and 0·8% bendiocarb, 0·2, 0·8 and 3·2% carbofuran decreased seedling numbers 3·3, 3·3, 10·0, 5·7, 5·4 and 12·6% respectively; other treatments had no effect. Carbofuran, especially the two higher rates, decreased seedling numbers in several trials but in one trial on a calcareous soil these were the only treatments to improve seedling establishment significantly (see p. 61).

The same seed treatments were tested at Broom's Barn and two other sites in East Anglia. At Broom's Barn, seedling establishment (79%) was increased 3, 10, 4 and 7% by 0·2% dieldrin, 0·05, 0·1 and 0·2% methiocarb but decreased by the remainder, especially 0·8% bendiocarb, 0·2 and 0·8% carbofuran. In ploughed-up grassland infested with leatherjackets, at Erwarton, Ipswich, the 64% seedling establishment on 6 May was improved by most seed treatments, especially by 0·8% bendiocarb (20%) and 0·4% methiocarb (12%); 14 days later seedling numbers had, on average, decreased 28%, demonstrating that the seed treatments were insufficiently persistent. At March, Cambridge (fen soil infested with *Onychiurus*, symphylids and millipedes) all the seed treatments increased seedling establishment (51% on the untreated plots): 0·05, 0·1, 0·2 and 0·4% methiocarb, 0·1, 0·2 and 0·4% bendiocarb and 0·2 and 0·8% carbofuran by 18–27%. In these three trials the seed treatments were also tested in combination with aldicarb granules in the seed furrow at approximately 800 g a.i. ha^{-1}. On average the seed treatments alone increased seedling establishment by 7% (range 5–11%); aldicarb alone by 15% and the two together 23%. (Winder and Dunning)

Soil treatment. Trials at Erwarton and March (see above) compared gamma-HCH, sprayed onto and worked into the seedbed, with aldicarb, thiofanox and carbofuran granules sown in the seed furrow; at Erwarton only, 'Bayer 6829' granules (2·5% carbofuran + 5% ethiofencarb) were also tested.

At Erwarton pre-singling seedling establishment on 20 May was only 42% on the untreated plots. The granule treatments, at 280, 560 and 1120 g a.i. ha^{-1}, increased seedling numbers as follows: aldicarb 42, 59, 41%; thiofanox 34, 29, 54%; carbofuran 38, 34, 36%; 'Bayer 6829' 45, 41, (dose not tested). The gamma-HCH spray at 280, 560, 1120, and 2240 g a.i. ha^{-1} altered seedling numbers by −5, −3, +8 and +44% respectively, a result probably due to application in windy conditions.

At March pre-singling seedling establishment on 27 May in the untreated plots was 36%. The granule treatments at 840, 1120 and 1680 g a.i. ha^{-1} increased seedling numbers as follows: aldicarb 69, 62, 48%; thiofanox 53, 56, 61%; carbofuran 60, 83, 51%; gamma-HCH spray at 280, 560, 1120 and 2240 g a.i. ha^{-1} increased seedling numbers 23, 16, 31 and 51% respectively. The average number of *Pegomya*-mined seedlings was more than doubled by all gamma-HCH treatments, presumably because it controlled predators of *Pegomya* eggs. All the granule treatments at 1120 and 1680 g a.i. ha^{-1} controlled *Pegomya* mining completely, and the 840 g a.i. ha^{-1} rate by at least 70%.

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In co-operation with the Ministry of Agriculture, Fisheries and Food (MAFF), Cambridge, two trials on sandy loam soils south of Cambridge compared gamma-HCH (1120 g a.i. ha^{-1}) sprayed overall and worked into the seedbed, with aldicarb and thiofanox granules (840 g a.i. ha^{-1}) sown in the seed furrow. On 4 May seedling establishment was 73% at Ickleton and 79% at Hinxton; it was unaffected by gamma-HCH but decreased by aldicarb and thiofanox, 9 and 15% at Ickleton and 9 and 8% at Hinxton, respectively. Sugar yields at Hinxton were increased from 3·25 t ha^{-1} on the untreated plots by, respectively, 5, 23 and 30%, a result that could only partially be due to the control of virus yellows, viz. 940 infected plant weeks (i.p.w.) decreased by 2, 22 and 33%.

In the three trials at Broom's Barn testing aldicarb at 850 g a.i. ha^{-1} as an aphicide, seedling establishment was unaffected. (Dunning and Winder)

Mammal and bird damage

Wood mice. Seed taking by wood mice was first noticed in 1971. Assessments by field staff of the British Sugar Corporation (BSC) indicated that the damage was more severe in 1976 than in any year but 1974. A random sample of 82 fields throughout the beet growing area were observed in detail in 1976; 40% suffered some damage from mice and 7% had 5% or more of the seed removed before germination. This gives some indication of the magnitude of the 1974 attack, when damage was reported to be several times more severe than in 1976.

Populations and damage incidence. Mouse populations on sugar-beet fields in Cambridgeshire and West Suffolk were estimated by removal trapping in spring and early summer. The pattern of population decline paralleled that observed in 1975 but occurred earlier in 1976. The random field survey referred to above showed that damage was more likely on early than late sowings, a result consistent with the observed changes in mouse populations. Sugar beet was sown much earlier in 1976 than 1975, resulting in a prolonged exposure of ungerminated seed to mice.

Ecological studies. The long-term live-trapping study on Broom's Barn Farm, begun in 1974, was continued and yielded further information on the population dynamics of field-living wood mice. Feeding habits were investigated by examining stomach contents and faeces. Wood mice take a wide range of food (*Rothamsted Report for 1975*, Part 1, 56) and often take natural foods in beet fields but not the beet seed.

Control by poisoning. The large foraging ranges of field-living wood mice suggested that poison baits at low densities might effectively control their numbers. A field experiment, in co-operation with MAFF (Cambridge), showed that both warfarin and chlorophacinone baits laid at 2·5 ha^{-1} removed wood mice from 14 ha trial areas. (Green)

Seedling grazing

Damage incidence. The assessments of BSC fieldmen and the results of a random survey of 82 fields throughout the country indicated that seedling grazing damage was relatively slight in 1976. Observations and faecal analysis show that, where damage occurred, skylarks, red-legged partridges and, to a lesser extent, pheasants were responsible. Fragments of sugar-beet cotyledons were found in stomachs of a few wood mice. (Green)

Effect of damage on yield. A trial at Broom's Barn determined the effect on sugar yield of completely defoliating with scissors to simulate severe bird and mammal grazing,

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sugar-beet seedlings sown early (4 March) or late (28 April). Single defoliation treatments were at the following stages: very early, medium, and late cotyledon; two rough leaf; four rough leaf. Additional plots of the first four treatments were subsequently kept free of green leaf by repeated defoliation until late May on the early and mid-June on the late sowing.

Although defoliation decreased the number of plants showing virus yellows early in the season it increased it later, and the overall effect on approximately 1000 i.p.w. was unaffected. In contrast, beet mosaic virus incidence was increased by all defoliation treatments, especially the repeated ones (e.g. on 14 July, on the early sown plots, from 20 to 83–96%); this disease must have contributed to the marked depression of sugar yield by defoliation, especially repeated defoliation.

Sugar yield on the early and late sown control plots was 5·93 and 3·42 t ha^{-1}. Repeated defoliation decreased yield on both sowings to about 60% of the untreated, irrespective of the stage at which started; in contrast, single defoliation was most severe (70% of control yield) at the very early cotyledon stage on the early sowing but least severe (94%) on the late sowing.

Alternative food. At Broom's Barn fodder rape was sown thickly in a 30 cm band between the 50 cm wide rows of beet on 23 March; it germinated rapidly but did not grow large because of the drought. Grazing of the plots by birds and mammals was negligible and did not differ significantly between treatments. Although the sugar beet were growing in a 20 cm band of pyrazone-treated bare soil their growth suffered from the presence of the fodder rape, seedling dry weight being more than halved on 13 May. This adverse effect was not due to shading but may have been due to moisture or nutrient extraction. The fodder rape was hoed out on 14 May but, despite irrigation, the stunting of the beet persisted into the summer, as in 1974 and 1975, suggesting that other factors may also be involved. As in 1975, the adverse effect of the fodder rape led to increased incidence of virus yellows (from 22 to 39% on 19 July and from 53 to 82% on 25 August) and decreased sugar yield (7·24–4·65 t ha^{-1}). (Dunning, Winder and Thornhill)

Yellows and aphids

With more days with frost during January to March and lower temperatures in April than in 1974 or 1975, a less severe outbreak of yellows was anticipated. However, *M. persicae* colonised the sugar-beet crop after a few hot days in early May and exceptionally large numbers flew in May and June, clearly putting the health of the crop at risk. With predators abundant the aphid population declined rapidly at the beginning of July, and there was little spread of yellows late in the season. At the end of August only 20% of sugar-beet plants showed clear symptoms of yellows, but drought and powdery mildew masked symptoms in others.

Pesticides were widely used primarily to control aphids and virus spread. Carbamate granules were sown with the seed on about 30% of the total crop area. In addition, about 179 000 ha of beet were sprayed with aphicide and about 11 000 ha were treated with granular insecticide after crop emergence; approximately 97 000 ha received a single spray or insecticide granules, approximately 86 000 ha were treated twice, 7000 ha thrice and 400 ha four times.

Overwintering aphids and viruses. More of the mangold clamps examined in April were infested with aphids (49%) than average, but fewer than last year. Mangolds were generally scarce. Only 35% of the infested clamps examined contained *M. persicae* but, on average, 73% of the *M. persicae* were resistant to organophosphorus insecticides.

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Only 29% of the samples of weeds examined in April contained aphids, a smaller proportion than average.

Many sugar-beet seed crops were treated with aphicide and leaves and shoots sampled in May and June were generally free from *M. persicae*. One crop in Gloucestershire and another in Essex carried large overwintering populations, and these proved to be resistant to organophosphorus insecticides. No *Aphis fabae* were found on the samples received but an occasional plant in the field became infested. A light attack had been anticipated since few eggs of *A. fabae* had been found during the winter on spindle bushes though more than in the winter of 1974/75. Field beans at Broom's Barn were not damaged by *A. fabae*.

Near Bury St. Edmunds an average of 83 sugar-beet 'groundkeepers' per hectare were found in April growing in cereal crops that followed beet, only about one fifth the number that survived in the wet winter of 1975, and it decreased to an average of 49 ha^{-1} after the cereals had been harvested. Crops of oilseed rape and 'escape' plants growing at roadsides were checked for overwintering *M. persicae*; few were found in April and early May but the numbers increased rapidly in late May.

Winged aphids trapped. More *M. persicae* were caught on a sticky trap at Broom's Barn during May and June than in any year since trapping started there in 1960, and by far the largest catch of *M. persicae* on any one sticky trap operated from Broom's Barn or Rothamsted in sugar beet or potato crops was from Rochford, Essex, in the third week of June. In complete contrast, exceptionally few *A. fabae* were trapped. (Heathcote)

Insecticides

Foliage applied materials. Five field trials, in the Brigg, Felsted, Kidderminster, Newark and Wissington sugar factory areas, compared the efficiency of green aphid and virus yellows control by recommended rates of all the MAFF 'Approved' aphicides, viz.: demephion, demeton-S-methyl, dimethoate, formothion, menazon, oxydemeton-methyl, phosphamidon, pirimicarb and thiometon as sprays; disulfoton and phorate as granules. Aphicides were applied between 3 and 14 June and, except at Brigg, again between 21 June and 25 July. Aphid numbers at Brigg, Kidderminster and Wissington were sufficient to merit post-treatment counts three or four days after the first application; on average, wingless green aphids were decreased most by pirimicarb (96%), demeton-S-methyl (88%) and demephion (82%). At the second application date green aphids were numerous at Wissington (19 apterae per untreated plant) and counts three days after treatment again indicated that pirimicarb, demephion and demeton-S-methyl were best, decreasing aphid numbers by 98–100%

Aphids from the Kidderminster and Wissington trials only were tested at Rothamsted; they showed resistance to certain organophosphorus insecticides. Yellows was difficult to assess due to the drought and, in general, it was little controlled, whilst at Felsted all treatments increased yellows. Averaging the results of the five trials, pirimicarb, demephion, demeton-S-methyl and oxydemeton-methyl decreased yellows (i.p.w.) by only 14, 13, 9 and 7% respectively; other treatments had no beneficial effect and phosphamidon, phorate, disulfoton and formothion tended to increase yellows.

Sugar yields were determined only at Kidderminster, Newark and Wissington; on average, the best increases were given by demephion (+ 9%), pirimicarb (+ 5%) and demeton-S-methyl (+ 5%), whereas disulfoton decreased yield by 3% and phosphamidon by 8%. All these results, except with disulfoton and phorate, parallel previous years' results; of the 11 materials approved by MAFF for aphid and yellows control in sugar beet only demephion, demeton-S-methyl and pirimicarb can continue to be recommended.

Experimental sprays were tested in comparison with demeton-S-methyl and pirimicarb

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in two further trials. At Swaffham Prior, Cambridge, beet sown with aldicarb in the seed furrow (approximately 840 g a.i. ha^{-1}) and sprayed by the grower with demeton-S-methyl on 2 June, was infested with 19 wingless green aphids per plant on 16 June. Spray treatments were applied then and again on 30 June. On 23 June all treatments significantly ($P = 0{\cdot}05$) decreased wingless green aphid numbers (59 per plant): 91–93% by pirimicarb (140 g a.i. ha^{-1}), acephate (455 g), 'DPX 3853' (560 g), and ethiofencarb (500 g); 71–90% by permethrin (140 g), demeton-S-methyl (244 g), 'AC 85258' (500 g), methamidophos (200 g), permethrin (280 g); 78% by profenofos (400 g) and 52% by methidathion (245 g). All treatments decreased subsequent yellows incidence, ethiofencarb, 'DPX 3853', methamidophos, acephate, significantly by 20–30%. Sugar yield was increased by all treatments except methidathion and profenofos, especially by ethiofencarb (+ 24%), methamidophos (+ 27%) and, unexpectedly, 280 g of permethrin (+ 31%). Near Hadleigh, Ipswich, beet not previously treated with insecticide was infested with 10 wingless green aphids per plant on 8 June; some of the above spray treatments, at the same rates, were applied then and again on 25 June. On 15 June treatments significantly decreased numbers (50 per plant): 94% by ethiofencarb, 81–90% by pirimicarb and acephate, 71–80% by demeton-S-methyl, 'AC 85258', and methamidophos, 34% by permethrin (280 g). After the second spray pirimicarb, ethiofencarb, acephate and methamidophos decreased aphid numbers 96–100%, 'AC 85258' 81%, demeton-S-methyl 90% but permethrin (280 g) only 3%. All treatments except permethrin (280 g) controlled black wingless aphids (18/plant) by at least 95%. Yellows incidence (1103 i.p.w.) was decreased by all treatments except demeton-S-methyl, especially by pirimicarb (26%) and ethiofencarb (19%). Sugar yield was increased by all treatments except permethrin, the least by demeton-S-methyl (6%) and the most by pirimicarb (30%) and ethiofencarb (24%).

All the *M. persicae* in a sample from Swaffham Prior and 85% from Hadleigh showed resistance to certain organophosphorus insecticides (see p. 166). In this situation, pirimicarb was more effective at both sites than the only other commercial material tested, demeton-S-methyl; of the experimental materials, ethiofencarb was the most effective, followed by acephate and methamidophos. As in previous years, permethrin was variable in effect. (Winder and Dunning)

Time of spraying. A trial at Broom's Barn, similar to that in 1975, compared six different times of spraying, each with and without aldicarb (785 g a.i. ha^{-1}) in the seed furrow at sowing on 31 March. On 14, 18, 28 May, 10, 21, 28 June and 2 July there were 0·2, 0·9, 1·3, 8·5, 68·2, 8·7 and 0 wingless green aphids per untreated plant. Sprays of demeton-S-methyl + pirimicarb were applied on 18, 28 May, 10, 23 June, 5 or 20 July; these controlled the aphids well but their persistence was not determined; the aldicarb controlled them completely at the end of May, by 77% on 19 June, by 68% on 21 June but only by 36% on 28 June.

Yellows incidence (876 i.p.w. on untreated plots) was increased (7–14%) by the last two sprays, decreased (13%) only by the 10 June spray, and unaffected by the others. Sprays applied on both 28 May and 17 June within a day of receipt of the two 'Spray Warnings' from the local sugar factory decreased yellows incidence by 32%, an effect presumably due to the 17 June spray only. However, all six sprays decreased incidence by 46%; this programme did not include the 17 June spray, and the result implies that multiple spraying has some interactive effect. Aldicarb alone decreased yellows by 13%; with the six different times of spraying decreases were, respectively, 12, 15, 34, 25, 18 and 7%, with all six sprays 57%, and with the two 'warning' sprays 41%.

Sugar yield of 5·6 t ha^{-1} was unaffected by the single spray treatments; it was increased 5% by aldicarb alone but, despite the best control of yellows being given by aldicarb plus

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sprays, the largest yield increases were 24% by all six sprays, and 29% by spraying twice at the time of the sugar factory's two spray warnings.

The trial was repeated, but without aldicarb, at Terrington Experimental Husbandry Farm, King's Lynn, and near Oundle, Peterborough. At both sites the pattern of aphid infestation was similar to Broom's Barn but peak populations were only 2·5 and 11 wingless green aphids per plant respectively, on about 20 June.

At Terrington yellows incidence was low (277 i.p.w.); it was increased 25% by 2 June spray and 31% by the last spray on 4 August, but unaffected by the others. In contrast, yellows was decreased by 10% on plots sprayed at the time of both 'warnings' (2 and 22 June); all six sprays decreased yellows by 25%. Sugar yield of 10·0 t ha^{-1} was decreased 11% by the 2 June spray alone but unaffected by all other single sprays or combinations of sprays.

At Oundle, yellows incidence (879 i.p.w.) was decreased 15% by the 31 May spray, but less or not at all by the other single sprays. The two 'warning' sprays individually decreased yellows by 9 and 11%, and together by 19%. Similarly, all six sprays were additive and decreased yellows by 32%. Sugar yield of 3·9 t ha^{-1} was increased by up to 19% (all six sprays).

Aphid populations at all three sites were at about the critical level for spraying at the time of issue of the local area spray warning. However, in terms of yellows control and yield increase the optimum single spray date was 10–20 days later. On average, sprays applied at the time of the two 'warnings' for each site controlled yellows by 20%, mainly the effect of the second spray; the resultant 13% yield increase was much more than expected from the 20% control of yellows.

Soil-applied materials. On organic soil at Erwarton, Ipswich, gamma-HCH sprayed and worked into the seedbed at 280, 560, 1120 and 2240 g a.i. ha^{-1} was compared with several insecticide granules applied in the seed furrow at the three lower rates. The low yellows incidence (277 i.p.w.) was affected as follows: gamma-HCH spray +77, +23, +40%, +13%; aldicarb +22, +4, −14%; thiofanox +19, +3, −33%; carbofuran −25, −15, −25%; 'Bayer 6829' +4, −10% (dose not tested).

In two of the trials at Broom's Barn aldicarb granules at 780 g a.i. ha^{-1} decreased yellows incidence (879 and 583 i.p.w.) by 13 and 11% and increased sugar yields of 5·55 and 6·97 t ha^{-1} by 5 and 9% respectively.

Aldicarb and thiofanox were compared in observation plots at Broom's Barn; the sugar yield of 5·13 t ha^{-1} was increased 11 and 19% respectively by 840 g a.i. ha^{-1} and 12 and 12% by 1120 g a.i. ha^{-1}. The larger amounts of aldicarb and, especially, thiofanox controlled aphids well 51 days after sowing on 28 April, but poorly 11 days later.

At Hinxton, aldicarb and thiofanox at 840 g a.i. ha^{-1}, followed by a pirimicarb spray on 20 June, decreased the yellows incidence (941 i.p.w.) by 22 and 33% respectively and increased the sugar yield of 3·25 t ha^{-1} by 23 and 30%. The same treatments in a similar but unharvested trial at Ickleton decreased yellows incidence (904 i.p.w.) by 11 and 17% respectively; gamma-HCH (1120 g a.i. ha^{-1}) had little effect in these two trials.

The two trials by the International Organization for the Biological Control of Noxious Pests and Diseases (IOBC) (p. 52) compared aldicarb granules in the seed furrow with gamma-HCH sprayed overall and worked into the seedbed, both at 1000 g a.i. ha^{-1}. At Broom's Barn the relatively low yellows incidence (272 i.p.w.) was decreased 29% by aldicarb but increased 26% by gamma-HCH; however, the sugar yield of 6·65 t ha^{-1} was increased 6 and 5% respectively. At March the low yellows incidence (202 i.p.w.) was decreased 27% by aldicarb and 3·5% by gamma-HCH, and the sugar yield of 6·00 t ha^{-1} was increased 16 and 15% respectively. In most of these trials the yield increases obtained cannot be attributed solely to yellows control; at March soil-pest damage was

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also controlled but the factors involved at other sites are unknown. (Dunning, Winder and Thornhill)

Insecticide resistance. Plots of the var. Bush Mono G were sprayed on 8 and 22 June with the recommended rate of demeton-S-methyl (0·4 litre ha^{-1} in 600 litres of water) or at one third or three times the recommended rate or left unsprayed. The population of *M. persicae* reached a peak of 4·7 per untreated plant in mid-June and the highest rate of demeton-S-methyl only decreased it to 0·6 per plant. All plots were practically free from aphids by the end of June. Yellows incidence and crop yield of untreated plots and those sprayed at the recommended rate did not differ; yellows incidence was less in the plots sprayed at three times and more in plots sprayed at one third times, increasing or decreasing the yield respectively. (Heathcote)

Winged aphids were collected during May from untreated sugar beet and from potato 'trap plants' planted amongst them, caged on test plants to check for virus and then tested for resistance to organophosphorus insecticides. The sample was small (43 from potato and 17 from beet) but most of the *M. persicae* were of the organophosphorus resistant type. None of the test plants developed symptoms of yellows. (Heathcote and Sawicki)

Effect of yellowing viruses on yield. Plots of var. Vytomo and of Nomo were infested with aphids carrying yellowing viruses at the beginning of June to infect widely different percentages of plants. In the third week of July the naturally-infected plots sown on 22 March had about 14% of plants showing symptoms but those sown on 28 April had about 39%. On average of all treatments, the early-sown plots had 40% of plants showing symptoms and the late-sown plots 56%, the Vytomo plots 46% and the Nomo 50%. Half the plots were harvested on 5 October and half on 3 December.

The plots with most plants infected yielded on average 20% less sugar (1·27 t ha^{-1}) than the naturally-infected plots. Although on average the heavily-infected Vytomo plots yielded slightly more sugar than those of Nomo, the differences in sugar yield between the two varieties were not significant. The sugar content of the Vytomo was significantly greater than that of Nomo, but Nomo produced a slightly greater weight of clean roots.

Early sowing increased the sugar yield by an average of 2·45 t ha^{-1} and late harvesting by an average of 0·49 t ha^{-1}. Although plant emergence was slow from seeds sown on 28 April the number of harvestable roots produced was greater than from seeds sown on 22 March. However, the late-sown plots yielded 14·30 t ha^{-1} less clean roots than the early-sown. (Heathcote)

Leaf diseases

Powdery mildew. The hot dry weather in July and August favoured powdery mildew. Sugar factory field staffs recorded the development of the disease at weekly intervals in 88 fields distributed in all beet growing areas. The disease was already present in some fields in East Anglia when the survey began in late July. In many fields in East Anglia and South Lincolnshire infection increased to a peak in late August or early September, and subsequently declined, but in only few fields were more than half the plants infected. In the North and West the disease developed slower and was less severe. Only 12 fields were reported free from the disease throughout the season, and only one of these was in East Anglia. Cleistothecia were found in 83% of infected crops.

The control given by sulphur at 7·9 kg ha^{-1}, benomyl at 0·6 kg ha^{-1}, ethirimol at 0·3 kg ha^{-1} was assessed in trials at Fakenham, Norfolk; Stetchworth, Cambridge; Boxford, Suffolk and Terling, Essex. Sprays were applied at the first appearance of powdery

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mildew and/or 2–3 weeks later. The incidence of powdery mildew in early September and the yields of tops and sugar in October are shown in Table 1.

TABLE 1

Effect of fungicides on powdery mildew incidence and sugar yield; means of four trials

Mildew scored on scale: 0 = no infection, 5 = all plants infected with at least 2/3rds heavily infected

	Unsprayed	Sulphur			Benomyl			Ethirimol		
	—	early	late	twice	early	late	twice	early	late	twice
Mildew score	2·4	0·3	0·5	0·1	0·4	0·9	0·2	1·7	1·3	0·9
Sugar t ha^{-1}	5·6	6·3	6·0	6·5	5·7	6·1	6·4	6·1	5·8	6·2
Tops t ha^{-1}	28	31	31	32	31	34	34	32	31	31

Fungicide sprays slightly increased the sugar content of roots, but most of the sugar yield increase was due to increased root yield.

In a trial at Broom's Barn, a single or two sprays with fentin hydroxide at 0·5 kg ha^{-1}, or with benomyl at 0·6 kg ha^{-1} or with ethirimol at 0·3 kg ha^{-1}, or two sulphur sprays at 7·9 kg ha^{-1} increased sugar yield by 7, 22; 8, 13; 4, 5; and 13% and yield of tops by 11, 32; 7, 17; 1, 2; and 10% respectively. At Tuddenham, Suffolk, in a crop heavily infected with powdery mildew, sulphur at 7·9 kg ha^{-1} sprayed either at the first appearance of the disease or two weeks later, or at first appearance and four weeks later, and ethirimol at 0·3 kg ha^{-1} sprayed twice, increased sugar yield by 10, 17, 6 and 7% and yield of tops by 8, 5, 8 and 6% respectively.

At Barrow, Suffolk, where powdery mildew was scarce but all plants had yellows in July, two sprays in August and September with fentin hydroxide at 0·5 kg ha^{-1}, benomyl at 0·6 kg ha^{-1} or ethirimol at 0·3 kg ha^{-1} increased sugar yield by 3, 9 and 9% and yield of tops by 18, 15 and 11% respectively.

Plants with powdery mildew were counted and scored for severity in a variety trial at Broom's Barn in late September. The recommended varieties with least infection were Sharpe's Klein Monobeet and Sharpe's Klein Polybeet, while those with most were Nomo and Vytomo. The difference in incidence on the best and worst varieties was significant at $P < 0{\cdot}001$, but only Sharpe's Klein Monobeet differed significantly from the mean of all recommended varieties. (Byford)

Effect of leaf diseases on photosynthesis. The diffusive resistance and rate of $^{14}CO_2$ uptake at 25°C and 210 μE m^{-2} s^{-1} light intensity were measured on mature leaves infected with powdery mildew, BMYV and BYV. Leaves with powdery mildew and BMYV were tested in August; leaves with BYV in October. The virus infected leaves used had symptoms only on the distal half and diffusive resistance and $^{14}CO_2$ uptake were measured separately at the affected tip and the symptom-free base of each leaf. A disease-free leaf of similar size and age was tested in comparison with each virus or mildew infected leaf.

The diffusive resistance of powdery mildew infected leaves was similar to that of healthy leaves, but $^{14}CO_2$ uptake was 30% less. The diffusive resistance of the infected tips of leaves with BMYV was 18 times that of healthy leaves and $^{14}CO_2$ uptake was 90% less; the symptom-free leaf bases had a diffusive resistance 76% higher than healthy leaves and $^{14}CO_2$ uptake 46% lower. The diffusive resistance of the tips of BYV infected leaves was 127% higher and $^{14}CO_2$ uptake 70% lower than at the tips of healthy leaves while at the symptom-free leaf base diffusive resistance was 12% higher and $^{14}CO_2$ fixation 26% lower than at the base of healthy leaves. (Byford and Bentley)

Phyllosphere microflora. The fungi present on the surface of sugar-beet leaves, including *Erysiphe betae*, were studied in relation to the age and physiological condition of the leaf.

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Unexpanded leaves were marked on plants in the field in early July and again in late August. Leaves were sampled at marking and at weekly intervals until most were senescent. Leaf area, chlorophyll content and the rate of $^{14}CO_2$ uptake at 25°C and light intensity 210 μE m^{-2} s^{-1}, were measured and the fungi present were determined by plating leaf washings on agar and by microscopic examination of cellulose acetate films taken from the leaf surface.

Leaves marked in early July expanded to 283 cm^2, on average, after three weeks and survived for a further six to seven weeks. The uptake of $^{14}CO_2$ reached a maximum of 15 mg CO_2 dm^{-2} h^{-1}, after three weeks, declining over the next five weeks to 4 mg CO_2 dm^{-2} h^{-1}. Leaves marked in late August expanded very slowly reaching only 60 cm^2 after five weeks. The uptake of $^{14}CO_2$ by these leaves averaged about 8 mg CO_2 dm^{-2} h^{-1} over five weeks. The amount of chlorophyll per unit area of leaf was similar for the two series of leaves so the amount of chlorophyll per unit of $^{14}CO_2$ fixed was 50% higher for the second series of leaves than for those marked in July.

The first spores of *E. betae* were seen in early August on leaves marked in July. Both spores and mycelium increased rapidly on these older leaves and at the end of August mildew was already present on young unexpanded leaves when they were marked, suggesting that weather is more important to the spread of powdery mildew than age of the leaf. The other most common fungi on the leaf surface were yeasts. On the first series of leaves the increase in yeast numbers paralleled the increase in *E. betae*, but on leaves marked at the end of August the number of yeasts present increased very rapidly in late September while amounts of *E. betae* spores and mycelium were decreasing.

The increase in powdery mildew and yeasts occurred after the photosynthetic capacity of leaves marked in July had declined, but changes in fungal populations did not relate to the photosynthetic capacity of leaves marked in late August. On 31 September $^{14}CO_2$ uptake was 21% higher on leaves marked in late August sprayed with 0·6 kg ha^{-1} benomyl on 19 September to control powdery mildew than on unsprayed leaves. Some, but not all, differences in photosynthesis between the two series of leaves may therefore have been due to powdery mildew attack. (Bentley and Byford)

Nematode pests

Docking disorder was reported on only 500 ha in June, a result partly of the very dry spring and summer but also of the widespread use of pesticides. Soil fumigants are no longer used but virtually all fields prone to the disorder are now treated with granular carbamate pesticides; nationally, 31% of the beet area was so treated for the control of Docking disorder, seedling pests and, especially, aphids and yellows (aldicarb 27%, oxamyl 1%, thiofanox 3%).

Spiral nematodes. Sugar beet on calcareous soils often grows only slowly in spring and early summer. At Swaffham Prior, Cambridge, particularly severe and irregular stunting of growth occurred in a field on the Wantage series (silty clay loam, pH 7·9); available nutrients were normal and other causes were sought for the stunted beet, which had abnormally branched laterals.

Soil samples to 20 cm depth on 18 June contained spiral nematodes (3480 l^{-1} by the Seinhorst two flask method), later identified by D. Hooper as *Helicotylenchus vulgaris*, Yuen; very few other nematodes were found.

The field contained trial plots organised by the British Sugar Corporation including an insecticide seed treatment trial (see p. 53). Carbofuran, a systemic insecticide and nematicide incorporated in the seed pellet at 0·8 and 3·2% by weight of seed, significantly increased both seedling establishment and sugar yield (2·3 to 3·6 t ha^{-1}) but did not affect root shape.

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Injection of solutions of menazon, methomyl, oxamyl, terbufos (previously referred to as 'AC 92100') and 'Bayer 56129' (8 and 80 mg per plant) into the root zone of stunted plants on 7 July, under very dry conditions, failed to improve growth and decreased subsequent sugar yield.

An area of stunted crop was cleared on 22 July and plots of bare soil treated with dazomet (570 kg ha^{-1} rotovated in) or 'D-D' mixture (injected at 447 kg ha^{-1}), and then rolled and watered. On 19 August, 3·4 kg a.i. aldicarb and 5·5 kg a.i. 'AC 64475' ha^{-1} were broadcast on further plots, and the whole trial area rotovated, rolled and sown with sugar beet. Seedling establishment was improved by treatment with 'D-D' mixture but almost completely suppressed by dazomet. Soil samples in mid-October showed 70% decrease of *Helicotylenchus* numbers by 'D-D' and 90% by dazomet.

Omitting the dazomet treatment at harvest on 2 November, mean top dry weights of seedlings were unaffected; however, the numbers of stubby laterals on the tap roots at 2–7 cm depth were decreased up to 50% by the three treatments, the best being 'AC 64475', an organophosphorus pesticide. Further trials will be made in the same field, and in other fields, in 1977. (Dunning and Chwarszczynska)

Beet cyst eelworm. Three trials tested three rates of aldicarb and oxamyl (2·8, 5·6, 11·2 kg a.i. ha^{-1}) broadcast and rotovated into peat soils infested with *Heterodera schachtii* where commercial beet crops were grown under licence. Beet sickness was not apparent in any trial and the mean sugar yield was 8·2 t ha^{-1}; for the above three rates yield increases were, respectively, aldicarb 4·9, 2·4 and 1·8%, oxamyl 0·6, 7·9 and 8·4%. These results contrast with those of the two previous years, when the control yield was 5·1 t ha^{-1} and when increasing aldicarb applications led to increasing yields but oxamyl was ineffective. (Cooke and Chwarszczynska)

Seed production

Diseases in seed crops. In June, 51 sugar-beet seed crops in Bedfordshire, Cambridgeshire, Lincolnshire and Essex averaged 2·1% of plants with virus yellows and 0·04% of plants with downy mildew. Virus yellows was more prevalent than usual in crops raised under cereal cover crops which had up to 29% of plants infected.

In October, 147 sugar-beet steckling beds averaged 0·08% plants with yellows. No crop had 1% or more plants with yellows and no plants with downy mildew were seen. (Byford)

Factors affecting seed yield

Root and shoot removal. Tap roots were chopped off with spades to leave stecklings 75–100 mm long, or shoots were mown off, or both or neither treatments were made either on 26 November 1975 or 10 March 1976 to plants growing from seed sown in July 1975 at Spelsbury, Oxon. Plants from each treatment were harvested on 2, 12 and 19 August to test if treatments delayed the optimum harvest date. Shoot removal gave shorter seed plants but did not affect seed yield which was, however, greatly reduced by cutting off the roots either in the autumn or spring. There were no interactions between pruning treatments, the time when they were done, or the dates of harvest.

Herbicides. The effects of herbicides applied in the autumn were investigated in co-operation with ADAS colleagues who sprayed plots at four sites in October and November 1975 and scored for crop vigour and weed control in March 1976. One trial at Charlbury, Oxon., was abandoned due to poor crop establishment. Plants were harvested from all other plots at Sleaford, Leverington and Wisbech St. Mary, Lincolnshire, on 3,

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4 and 5 August respectively, and seed yield, germination and monogermity and size distribution were assessed. All chemicals reduced weed populations compared to the control plots but, on average, some reduction in crop vigour occurred except for carbetamide applied in November and propyzamide at reduced rate in October. With the exception of dalapon plus carbetamide applied in October, all treated plots gave, on average, more seed than the controls, the best yields coming from plots treated with propyzamide at normal or reduced rate in October or November. Germination and monogermity were slightly affected by some treatments at some sites. Considered overall, propyzamide at 1·1 kg a.i. ha^{-1} applied in November and dimefuron + carbetamide at 0·8 + 2·1 kg a.i. ha^{-1} applied in November gave better results than the controls, and dalapon at 1·9 kg a.i. ha^{-1} applied in October and methabenzthiazuron at 3·2 kg a.i. ha^{-1} applied in October gave worse results.

Factors affecting seed performance

Seed crop cultural practices. The effects of cultural practices applied to seed crops harvested in 1975 on seed quality were evaluated in field sowings in 1976.

Although nitrogen fertiliser effects were not quite significant, the best seedling emergence came from seed bearers given a single application of nitrogen in February and the poorest emergence was from seed taken from plants given a split application of nitrogen in March and April. Mean seedling shoot dry weight was not affected by nitrogen treatments.

Removal of the roots of the seed bearers gave seed with reduced emergence, particularly when this was carried out in the spring after vernalisation. Removal of shoots and other treatment interactions were not significant. When the roots were cut off and the shoots were also removed in the spring, there was a significant reduction in seedling vigour as measured by shoot weight.

Although autumn herbicide effects were not quite significant, propyzamide and TCA plus propham tended to reduce seedling emergence but none of the herbicides affected plant vigour, as shown by seedling shoot dry weights.

Seed treatment. In co-operation with National Vegetable Research Station (NVRS) staff untreated, pelleted and advanced seed was sown dry and advanced, water steeped and chitted seed was sown in fluid at Wellesbourne (27 February and 30 April), Woburn (2 March), Arthur Rickwood (4 March), Sutton Bonington (23 March) and Broom's Barn (30 March). The trial at Woburn was severely grazed and was abandoned. Advanced seed reduced the time to 50% seedling emergence from about 28 to 24 days and chitted seed sown in fluid was even quicker, emerging in about 18 days. However, the final emerged population was significantly lessened by fluid drilling except at Sutton Bonington and Arthur Rickwood. It could be that under adverse conditions after sowing the quicker emergence provided by chitted seed sown in fluid is a disadvantage and that fluid drilling may be of more use with late rather than early sowings. Plant numbers were adjusted by hoeing to a target 80 000 ha^{-1} except in treatments where there were insufficient seedlings to do this and plants were grown on for growth analysis samples and yield determination. Young plants were larger from advanced seed, particularly at Arthur Rickwood where effects were still detectable in July. By final harvest in November the yield of sugar was increased on average by about 4% from 4·8 to 5·0 t ha^{-1} when advanced seed was used, but was unaffected by chitting and fluid drilling where there were full plant populations (Arthur Rickwood and Sutton Bonington) or reduced where plant populations were low (Broom's Barn and Wellesbourne). (Longden)

The effect of soaking seed before pelleting on seedling emergence and yield of the varieties Amono, Bush Mono G, Nomo and Sharpe's Klein Monobeet was tested on

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Dunholme field in a trial sown on 22 March. Pre-soaking increased the rate of emergence of all varieties, and yield of dry matter (roots + tops) in mid-June by up to 40%. The crop suffered severely from the drought in late June/early July. Three inches of irrigation were applied in mid-July and a further two inches in August. On average of the four varieties pre-soaking the seed increased sugar yield by about 7%. (Webb)

Na and seed advancement. This was the fourth year of a study to determine whether pretreating seed decreases the detrimental effects of soluble fertilisers on seedling emergence. An experiment on Dunholme field tested all combinations of three seed treatments (rubbed and graded seed, pre-soaked and air-dried seed and chitted seed with radicles just visible), four amounts of sodium fertiliser (0, 150, 250 and 350 kg Na ha^{-1}) and two sowing dates (22 March, 21 April). Seeds were hand sown 10 cm apart into an unusually dry seedbed on both occasions. A few seedlings from chitted seed emerged first but few seedlings established (Table 2). Seedlings from pre-soaked seed emerged about five days earlier than from untreated seed but both treatments gave similar seedling stands at thinning. Increasing amounts of sodium fertiliser progressively slowed seedling emergence and, on the earlier sown crop, decreased the number of seedlings established. However, the decrease was much less with advanced or chitted seed than with untreated seed. On the later sown crop, sodium fertiliser did not affect the number of seedlings established and there was no interaction with seed treatment. At harvest, sugar yield from the earlier sown crop was not increased by pre-soaking the seed but this treatment yielded 8·5% more when sowing was delayed (Table 2). This is the third year that advancing the seed has increased yield. (Durrant and Payne)

TABLE 2

Effect of seed treatment on seedling establishment and sugar yield. (*Mean of sodium treatments*)

	Early sown crop	Late sown crop
	Seedling establishment (% seeds sown)	
Untreated seed	71	70
Pre-soaked seed	70	75
Chitted seed	38	15
	Sugar yield (t ha^{-1})	
Untreated seed	6·25	3·78
Pre-soaked seed	6·27	4·10
Chitted seed	4·46	1·93

Seed placement in the soil. Seven modifications of Stanhay drill units made by National Institute of Agricultural Engineering (NIAE) were compared with the standard unit using pelleted monogerm seed (cv. Nomo). There were three blocks of three sowing occasions, split for three depths of sowing, split for eight different drill settings. Sowings were made on 2 and 30 March and 29 April. The floating rear soil coverer with 5 kg weight on the rear press wheel was better at the second sowing at the deepest setting of 50 mm and gave 60 seedlings per 100 seeds sown (± 5·0), compared to the standard Stanhay unit which gave 45. This treatment had also been successful in 1974 and 1975. The time to half the final emergence of these two treatments was similar at 32 and 31 days respectively.

Soil temperature. Three soil pyramids 1 m high with 38° slopes facing north, south, east and west in the field showed that on average between sowing on 1 March and seedling harvest on 5 May the 16·00 h temperature 25 cm deep was 2·9°C warmer on the south facing slope than on the north facing slope. On the warmest sunny day during this

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period, 17 April, the differential was 6·0°C. During the night and for long periods on dull days, there were no detectable differences in temperature between the four faces. Seedlings emerged quicker the warmer the slope and on the warmest (south) slope became 110% heavier than those on the coolest (north) face. The final number of seedlings was not affected by aspect.

Weed beet. In a laboratory experiment weed beet seed was killed after equilibration to 50% water content by weight and storage for 63 days in alternating weekly regimes at +2, −10 and −25°C. Other treatments with drier seed and shorter storage times were less effective in killing seeds. The results suggest that a cold winter could help greatly in reducing viable weed-beet seed populations in the soil.

In the glasshouse and in a cereal crop at Orford, Suffolk, MCPA, dicamba/benazolin/dichlorprop, and ioxynil/mecoprop mixtures at normal and half rates of application satisfactorily killed beet seedlings. Chlortoluron and 2,4-D did not give satisfactory control at less than normal rates of application.

British Sugar Corporation staff were helped to collect and collate data in a large cultivation trial aimed at controlling weed beet. Seed counts up to 7·4 million ha^{-1} were recorded. Deep ploughing about halved the weed beet seedling population but may have only put off, rather than solved the problem, by burying the surface population of seeds to a depth at which they have become dormant. If ploughed up again, a large proportion may germinate. Delaying drilling into a seedbed until the first flush of germinating weed beet seedlings had been killed by a paraquat spray reduced the weed beet seedling population by about a third.

Variety: environment interaction. For the second year, 16 seed lots from European sources were grown by members of the IIRB Genetics and Breeding Study Group at more than 20 sites within an area bounded by Sweden, Ireland, Spain, Greece and Poland, in order to test for interactions between variety and the environment in which it is grown. At Broom's Barn differences were noted between seed lots in seedling establishment, the time at which virus yellows appeared but not the final proportion of infected plants, the severity of powdery mildew infection, and the height of crowns above the soil surface, and all the yield attributes. (Longden)

Sugar-beet manuring

The field experiments described here testing nitrogen and time of harvesting, sodium, and long-term effects of liming were done in co-operation with staff of the British Sugar Corporation in 1975.

Nitrogen and time of harvesting. Four experiments were made on shallow calcareous soils in Lincolnshire to test whether time of harvesting affects the amount of nitrogen needed for maximum sugar yield. On fields adequately fertilised with phosphorus, potassium and sodium, crops were given eight equal increments of nitrogen ranging from 0 to 290 kg N ha^{-1} as ammonium nitrate. Three blocks of eight plots were harvested at the end of September and three at the beginning of December.

On average of the four experiments the maximum sugar yield (5·04 t ha^{-1}) from early harvesting was with 83 kg N ha^{-1} and from late harvesting the maximum (5·60 t ha^{-1}) was with 124 kg N ha^{-1}. In two of the experiments yield increased greatly between early and late harvest but in the other two experiments yields were similar at both harvest dates. In both experiments where yield increased between September and December there was a small positive interaction between nitrogen and harvest date. In each of these

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experiments, however, maximum sugar yield was from plots given 83 kg N ha^{-1}. No evidence has yet been found for the suggestion that more than 125 kg N ha^{-1} is needed by sugar beet on these soils when the crop is harvested late in the season.

Sodium. A new investigation was started to determine the nature of the response curve by sugar beet to sodium and to compare autumn and spring applications. Sodium at 0, 38, 75, 150 and 300 kg ha^{-1} as the chloride was given in autumn before ploughing or in spring just before seedbed cultivations. There were three blocks of the five sodium treatments and these were given no potassium, 125 or 250 kg K_2O ha^{-1} in the autumn. Nine experiments were made on growers' fields on soils typical of the major sugar beet growing areas.

On average sodium greatly increased sugar yield but there was little difference between autumn and spring application. In individual experiments there was some evidence that spring application was preferable but in others the autumn application was best. All the amounts of sodium tested significantly increased yield on average, but the largest yield resulted from the largest dressing of sodium. The latter result was not anticipated as the dressing was about double that used in practice. Measurements of soil sodium on some experiments indicated that plants in spring on plots following autumn dressings of sodium were growing in soil containing little sodium. This was due either to winter leaching of the element or inversion of soil containing the fertiliser during ploughing. This work is continuing with more detailed soil and plant analyses as the results have important practical implications.

Long-term effects of liming. The final experiment of those begun in 1968 (*Rothamsted Report for 1969*, Part 1, 327) was cropped with sugar beet for the third time. Half the plots had received one dressing of lime for the 1968 crop and the other half two applications, one for 1968 and a further equal amount for the 1971 crop. None was given for the 1975 crop since the pH of all plots was considered adequate for sugar beet. Yields from the 1975 crop confirmed this as there was little difference between plots given one or two applications. Ground limestone and factory waste lime gave similar yields when given in similar quantities. Each year since 1968 the pH of all the plots has been monitored and the decline in pH has been much slower than expected, probably due to little leaching in several dry winters. This would also account for the small response to lime and the little difference between forms. (Draycott)

Plant nutrients

Sodium. The growth analysis described before (*Rothamsted Report for 1975*, Part 1, 67) was repeated on sugar beet in an experiment on Dunholme field. In the very dry spring sodium fertiliser slowed seedling emergence on plots given the largest spring application (300 kg Na ha^{-1}). Smaller dressings, however, had little effect on emergence and stimulated growth of the seedlings; dry matter yield and leaf area in May were 50% greater with sodium than without sodium fertiliser. Seedlings from plots given sodium fertiliser in autumn were of similar size to those from plots given none, suggesting the autumn fertiliser was not effective at this early stage. Soil analysis showed that most of the autumn applied sodium was at a depth of 25–50 cm. As rainfall from October to December was only 60% of average, and as only 2·5 mm fell between fertiliser application and ploughing, it seems unlikely that leaching was the cause.

The early advantages from spring application were not, however, reflected in final sugar yield. The greater leaf area of plants given sodium may have hastened soil water depletion during the very dry summer and slowed growth mid-season resulting in a

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reduction of the yield differences later in the season. Application of 130 mm of irrigation during July and August may have also reduced response as sodium gave considerable yield increases on an adjacent unirrigated rotation experiment.

Conflicting effects of sodium on water stress reported last year were investigated in a controlled environment in conjunction with the Botany Department. Results are described on page 43. (Cormack)

Time and method of applying nitrogen. The experiment was repeated comparing the effects of applying ammonium nitrate between the rows at the time of drilling and broadcasting by hand on 3 March, three weeks before drilling. Neither method of application nor fertiliser dressing affected final plant emergence this year.

Topsoils (0–22 cm) and subsoils (22–61 cm) were sampled in late May and analysed for mineral nitrogen concentrations. Table 3 shows that the greatest amount of mineral nitrogen in top soils was in plots where the nitrogen fertiliser had been applied at the time of drilling. On average, only 76% of the applied N fertiliser was found in the plots where fertiliser had been broadcast compared with 99% in plots which had received their fertiliser N application at the time of drilling.

Method of application had no effect on either root or sugar yields on average, although maximum sugar yield of 7·86 t ha^{-1} was again obtained by broadcasting only 62 kg N ha^{-1}. Sugar percentage in the roots was depressed 1·3, on average, by applying 188 kg N ha^{-1}, but the heavy dressing had less detrimental effect on sugar concentration when applied at the time of drilling. The method of applying N fertiliser had no effect on yield of tops or on number of roots harvested. Major impurities in the beet were also unaffected by the time of application of fertiliser N, but all were increased in the roots by each increment of nitrogen fertiliser, particularly the sodium and α-amino N concentrations. (Last and Webb)

TABLE 3

Amounts of mineral nitrogen in soil profile on 28 May

kg N ha^{-1}

Fertiliser N applied	Broadcast before drilling		Machine applied at drilling	
	0–22 cm	22–61 cm	0–22 cm	22–61 cm
0	27	22	30	22
62	67	34	71	28
125	97	50	111	56
188	121	62	164	78

Manganese. Experiments testing the effects of manganese incorporated in the coating of pelleted seed and foliar-sprayed manganese were continued on soils which contained little available manganese.

Manganese deficiency symptoms on the plants were not as severe as in previous years and the proportion of untreated plants with symptoms on the two Ely experiments was 40% and 20% respectively. None of the plants on either of the Wissington experiments had deficiency symptoms. At Peterborough, where the soil contained 0·85 mg exchangeable manganese (Ex Mn) kg^{-1}, 11 mg easily reducible Mn (E/R Mn) kg^{-1}, C:N 25 and pH 6·5, 21% of the plants not given manganese showed manganese deficiency symptoms. All seed-pellet treatments increased the concentration of manganese in the plants during spring and alleviated deficiency symptoms. Marginal increases in plant dry weight resulted from manganous oxide, frit and chelate in the seed pellet but manganese sulphate tended to be slightly phytotoxic during the spring. Foliar-sprayed manganese completely cured symptoms of manganese deficiency and manganous oxide in the seed pellet slightly improved the plant population.

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An experiment comparing chelated manganese (MnEDTA) with manganese sulphate as a foliar spray was conducted on West Row Fen where the soil contained 0·68 mg Ex Mn kg^{-1}, 20 mg E/R Mn kg^{-1} and pH 6·8. Seventy-five per cent of plants not given manganese were deficient but the symptoms were not as severe as in previous years. Chelated manganese and manganese sulphate were equally effective in curing the symptoms. Spraying once decreased the symptoms and spraying twice completely cured them. Marginal increases in yield resulted from the sprays and sugar beet given chelated manganese slightly out-yielded those given manganese sulphate.

An experiment on an organic fen soil containing little available manganese determined the response to foliar sprayed manganese by four genotypes supplied by the Plant Breeding Institute. The incidence of manganese deficiency was not severe and there was little visual difference between genotypes in their response to manganese during the growing season. At harvest manganese increased the yield of sugar significantly by increasing the yield of roots. One genotype appeared to yield fully, however, without manganese treatment. Sugar percentage of all four genotypes was not affected by manganese. The experiment showed that some sugar-beet lines may be more tolerant of manganese deficiency than others. Thus the variation in the susceptibility of sugar beet to manganese deficiency often observed in the field may be attributable in part to differences in genetic origin of plants constituting commercial varieties. (Farley)

Magnesium. Work is continuing on the value of calcined magnesite as a magnesium fertiliser for sugar beet. Following the laboratory investigation described in Paper No. 25 which demonstrated that it was possible to calcine magnesite and produce a fertiliser containing more exchangeable magnesium than that commonly used at present, the manufacturers varied production conditions on their kiln in order to obtain five different forms for testing in laboratory and field experiments. As is shown in Table 4, all the alternative forms contained more magnesium (acid soluble and total exchangeable) than the form now commonly used in farming practice. Magnesium was extracted most rapidly by ammonium nitrate solution from the samples of magnesite which was calcined at 750°C for 1·5 h. Sugar-beet tops sampled in August also contained most magnesium when this form was used. The results indicate that calcining at high temperatures and for long periods decreased the availability of magnesium to the crop.

TABLE 4

Analyses of various forms of calcined magnesite and the amounts of magnesium in sugar-beet tops in August

Production conditions	Acid soluble Mg %	NH^+_4 exchangeable Mg: % Total Mg	NH^+_4 exchangeable Mg: Time to 50% exchange (h)	Mg in dried sugar-beet tops in August*
Commercial product	41·0	74	9·3	0·30
750°C for 1·5 h	45·0	79	2·8	0·33
800°C for 0·75 h	44·0	93	9·5	0·32
800°C for 1·5 h	44·0	97	13·5	0·29
900°C for 0·5 h	49·5	99	7·0	0·29
900°C for 1·0 h	48·0	91	11·0	0·26

* the plants given no magnesium contained 0·21% Mg

An attempt will now be made to relate laboratory and field results and to establish a meaningful laboratory analysis for the availability of magnesium from calcined magnesite. (Hutchison)

https://doi.org/10.23637/ERADOC-1-133

Irrigation

Irrigation and nitrogen. A further experiment tested six dressings up to 207 kg N ha^{-1}, on the sandy loam of Dunholme field. On three of the six blocks, the crop was irrigated to limit the soil moisture deficit to 40 mm, and a record total of 286 mm of water was applied in June, July and August. The crop was sown early into a good seedbed and a large sugar yield was expected. Unlike the previous year, aldicarb was not applied which, in retrospect, would have been advantageous. The crop became infected with virus yellows in June and after July most plants showed symptoms despite routine insecticidal sprays.

At harvest in December the average sugar yield increased with irrigation from 4·95 to 8·77 t ha^{-1} or 77%, by far the largest increase recorded at Broom's Barn. Response to nitrogen was relatively small, a result consistent with other experiments this year. The winter was much drier than average and little nitrogen was lost from the soil by leaching, which probably explains the poor response to applied fertiliser. Sugar yield was not increased by nitrogen when the plots were not irrigated; on average, there was a small decrease where nitrogen was applied. In contrast, on irrigated plots, nitrogen slightly increased yield, maximum sugar yield of 9·50 t ha^{-1} being with 80 kg N ha^{-1}. More than 80 kg N ha^{-1} decreased yield even with irrigation.

Weekly soil moisture measurements with the neutron probe showed that root growth was extremely rapid compared with previous years. Roots had penetrated to 100 cm by 30 June, 140 cm by 31 July, 160 cm by 31 August and 180 cm by 30 September. The vigorous root growth was probably reflected in storage roots of excellent shape at harvest. Rainfall in June to August inclusive was only 62 mm, 100 mm less than average and 20 mm less than last year. Potential transpiration was also 25% more than average.

The results of this experiment will prove useful to the study of soil/water relationships in the sugar-beet crop as the season was far drier than experienced before. In particular they provide further evidence in favour of our theory that large increases in sugar yield follow *early* irrigation. In addition early irrigation encourages both rapid penetration of roots to depth in the soil and good storage root shape. (Draycott, Last and Messem)

Time, rate and method of irrigation. An experiment on Dunholme Field tested the same treatments as in 1975 (*Rothamsted Report for 1975*, Part 1, 70). Frequent irrigation increased root dry matter yield by 75% in August and 96% in October (Table 5). Application of 50 mm of water to the soil and the seven week period of mist over the leaves in June/July both increased yield by 30%. Although 180 mm of water as mist was applied, the soil moisture deficit in mid-July reached 115 mm, only 10 mm less than on unirrigated plots. The 75 mm of irrigation in August, given when the deficit was 145 mm, increased final sugar yield by 55%. The application of mist during the late summer period increased it by 23%.

Even with frequent irrigation, sugar yield was only 6·5 t ha^{-1}, considerably less than with comparable treatments on the nearby irrigation and nitrogen experiment described above. This latter experiment was sown earlier and emerged more rapidly. Neutron moderation measurements of soil water removal on unirrigated plots indicated that, by the end of August, of the 210 mm of total deficit, 50 mm water has been used from below 100 cm, whereas in this experiment less than 10 mm out of 180 mm had been removed from below this depth. This shallower root penetration probably contributed to the relatively small yields.

An experiment was also made on soil of the Worlington Series at East Harling in Norfolk, where rainfall was even less than at Broom's Barn. Single applications of 75 mm of water, using flexible lay-flat tubing, were given in each of the months June, July,

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TABLE 5

Effect of irrigation and mist treatments on root dry matter and final sugar yield

Yields, t ha^{-1}

	Root dry matter yield		Sugar yield
	August	October	October
No irrigation	3·2	4·7	3·1
50 mm in June	4·1(50)	6·4(50)	4·3
Mist June-July	4·1(180)	6·5(180)	4·5
75 mm in August	—	7·1(75)	4·8
Mist August–September	—	5·9(111)	3·8
Frequent irrigation	5·6(225)	9·2(325)	6·5

( ) Total quantity of water applied (mm)

August and September. These treatments increased sugar yield by 1·86, 2·41, 2·14 and 0·78 t ha^{-1}. Six applications from June to August totalling 330 mm increased root yield from 33 to 63 t ha^{-1}, improved sugar percentage by 2·3% and gave 5·43 t ha^{-1} or 123% more sugar. (Messem, Durrant and Milford)

Plant spacing

Time of sowing. This experiment on Dunholme field tested the effect of time of sowing and the removal of bolters on yield of sugar of two varieties, Nomo and Bush Mono G. Favourable weather at the end of February allowed the early sowing on 27 February, about a fortnight earlier than usual. This was followed by sowings on 22 March and 13 April. Both varieties established well but Bush Mono G had better seedling vigour and early plant growth, an advantage it maintained until mid-June. Virus yellows and drought then caused loss of leaf of both varieties, particularly on the early sowing.

Bolters appeared only in the early sowing, 2·7% in Nomo and 12·7% in the Bush Mono G. Bolters were either left standing, topped or pulled in early July and again in August.

Nomo gave the largest yield of sugar (Table 6) from the early sowing with the bolters removed (8·1 t ha^{-1}). Yields from both varieties were similar at the March and April sowing dates (7·2 and 6·4 t ha^{-1}). Bush Mono G sown early with the bolters removed did not yield any more than the normal sowing. (Webb)

TABLE 6

Effect of time of sowing and removal of bolters on sugar yields

Sugar yields (t ha^{-1})

	Sown 27 Feb.	Sown 22 Mar.	Sown 13 Apr.	Mean
		Nomo		
Bolters left	6·97	6·68	6·36	6·67
Bolters topped	7·71	7·47	6·08	7·09
Bolters pulled	8·09	7·42	6·36	7·29
Mean	7·59	7·19	6·27	
		Bush Mono G		
Bolters left	6·84	7·38	6·61	6·95
Bolters topped	6·62	7·49	6·80	6·97
Bolters pulled	7·20	6·84	6·15	6·73
Mean	6·89	7·24	6·52	

Cereal and rotation experiments

Fertilisers on rotation crops. This was the twelfth year of the experiment testing fertilisers applied to a rotation of sugar beet, winter wheat and barley. The fertiliser dressings are given in Table 7A.

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As in 1975, prolonged drought again greatly decreased crop yield. Table 7B shows the mean yield of grain was only about 2·5 t ha^{-1}, 1 t ha^{-1} less than in 1975 and the smallest yields recorded since the experiment started in 1965. Similarly the sugar yield of 4·04 t ha^{-1} was barely profitable. As usual, wheat and barley responded greatly to nitrogen fertiliser. N1 (75 kg N ha^{-1}) was adequate for wheat but barley may have responded to more than the 100 kg N ha^{-1} tested. Giving nitrogen to the sugar beet greatly reduced sugar yield, presumably by producing leaves at the expense of sugar in the autumn. For the first time barley responded to phosphorus and potassium and, as before, sugar yield was greatly increased by potassium and sodium fertilisers. A report, summarising yields, nutrient uptake and changes in soil analysis between 1965 and 1976, will be given in *Rothamsted Report for 1977*, Part 2. (Durrant)

TABLE 7A

Amounts of fertiliser used on the rotation crops

	N1	N2	P1	P2	K1	K2	Na	FYM
	(kg N ha^{-1})		(kg P_2O_5 ha^{-1})		(kg K_2O ha^{-1})		(kg NaCl ha^{-1})	(t ha^{-1})
Beet	100	200	50	100	100	200	377	30·6
Wheat	75	150	50	100	50	100		
Barley	50	100	50	100	50	100		

TABLE 7B

Yield response of crops to fertiliser in the twelfth year of the rotation experiment

	Wheat grain	Barley grain	Sugar
	(t ha^{-1} at 85% DM)		(t ha^{-1})
Mean yield	2·78	2·43	4·04
Response to:			
N1	+0·93	+0·65	−0·81
N2−N1	−0·10	+0·72	−0·17
P1	+0·18	+0·12	−0·08
P2−P1	+0·07	+0·57	+0·42
K1	−0·11	+0·09	+1·00
K2−K1	−0·38	+0·41	+0·51
Na	+0·03	+0·13	+0·63
FYM	−0·11	+0·35	+0·69
Compound 1	+1·03	+0·95	+0·49
Compound 2−Compound 1	+0·31	+0·64	+0·03

Nitrogen and fumigation. The experiment on Brome Pin (*Rothamsted Report for 1975*, Part 1, 74) testing residual effects of fumigation with 'D-D' and forms of nitrogen fertiliser on nematodes and crop yields was cropped with sugar beet in 1976. Appropriate plots were fumigated on 19 September 1975.

Plots were sampled to 20 cm depth on 21 January 1976 for determination of nematode numbers. All plant parasitic genera were fewer in plots which were fumigated every year, their numbers always being less than 10% of those in fumigated plots. Some genera (e.g. *Paratylenchus*, *Tylenchorhynchus*) were relatively poorly controlled where plots were fumigated only before sugar beet (Table 8).

Seedling emergence was depressed 16% in plots where 125 kg N ha^{-1} had been applied as ammonium sulphate, but the fumigation treatments had little effect on emergence.

Plant samples taken in June at the 10 leaf stage showed that both forms of nitrogen fertiliser and fumigation increased plant weight when applied in the absence of each other. Fumigation and nitrogen fertiliser together increased top and root yields particularly where plots had been fumigated every year. Nitrate nitrogen increased yields on fumigated plots more than did ammonium nitrogen. Soil samples (0–61 cm) taken at the same date

https://doi.org/10.23637/ERADOC-1-133

TABLE 8

Control of nematodes by fumigation in the nitrogen-fumigation experiment

Nematode	Unfumigated	Fumigated every year	Fumigated before sugar beet only
	Nematode numbers per litre of soil		
Tylenchus	1313	75	125
Tylenchorhynchus	1950	125	462
Heterodera larvae	300	0	25
Pratylenchus	1575	100	275
Paratylenchus	725	63	288
Rhabditida	4513	2888	1888
Trichodorus	75	0	0
Mononchidae	388	0	0
Other Dorylaimida	1400	88	113

showed little effect of fumigation on either mineralisation or nitrification and also that there was little leaching of applied nitrogen fertiliser during the spring.

At final harvest sugar yields were increased by similar amounts by both fumigation treatments. However, both forms of fertiliser N depressed sugar yield in both fumigated and unfumigated plots and decreased sugar percentage. When applied as nitrate 125 kg N ha^{-1} depressed sugar percentage by 3·1% compared with beet from control plots.

The large increases in both top yield and α-amino N concentrations in roots caused by both forms of nitrogen fertiliser indicate late uptake of mineral nitrogen by the beet crop. Fumigation had no effect on these two factors. (Cooke and Last)

Magnesium and boron. This was the sixth year of the experiment (*Rothamsted Report for 1970*, Part 1, 271) which was sown with sugar beet, variety Vytomo, on 24 March. Soil was sampled from each plot during the spring and none of the boron fertiliser applied to the soil in 1970 could be found, suggesting it had either leached or been removed in crops. The soil contained on average 0·75 mg kg^{-1} hot water soluble boron (ADAS index 1). Soil given no magnesium contained 18 mg Mg kg^{-1} (ADAS index 0), given kieserite in 1970, 35 mg Mg kg^{-1}, calcined magnesite 33 mg Mg kg^{-1} and magnesium limestone 29 mg Mg kg^{-1}. At harvest none of the treatments affected the root yield which averaged 28·7 t ha^{-1} at 15·1% sugar. The crop showed neither boron nor magnesium deficiency symptoms which was surprising, as both boron and magnesium deficiency are usually accentuated by drought.

Boron applied to the soil in 1970 had no effect on the concentration of boron in the plants which averaged 23·5 μg B g^{-1} in tops and 9·5 μg B g^{-1} in roots. Kieserite applied to the soil in 1970 was again the most effective of the magnesium treatments to supply the plants with magnesium. The concentration of magnesium in sugar-beet tops from the plots was: no magnesium 0·177%; kieserite 0.229%; calcined magnesite 0·190%; magnesium limestone 0·184%. The concentration of magnesium in roots was: no magnesium 0·065%; kieserite 0·075%; calcined magnesite 0·069%; magnesium limestone 0·062%.

Phosphorus and potassium. This experiment (*Rothamsted Report for 1973*, Part 1, 279) was sown with sugar beet, variety Vytomo. Rotational dressings of 60·5 kg P ha^{-1} and 187 kg K ha^{-1} and annual dressings of 75 kg P ha^{-1} and 125 kg K ha^{-1} were applied as it was the beginning of the second rotation. Phosphorus was given either as triple superphosphate or Gafsa phosphate, and potassium only as the chloride. As in the first sugar-beet crop, there was no response in sugar yield to either of the two forms of phosphorus but a very large response to potassium (1·19 t ha^{-1}). The overall sugar yield from the experiment was 4·30 t ha^{-1}. There was no difference in sugar yield between annual and

https://doi.org/10.23637/ERADOC-1-133

rotational dressings of any of the fertilisers. Sugar beet given rotational dressing of potassium had more portassium in tops and roots than did plants given it annually. There was little difference between the concentrations of phosphorus in tops and roots of plants given the two rates of fertiliser but plants given triple superphosphate contained more phosphorus than those given Gafsa. (Farley)

Fertilising and cultivating the subsoil

The plough layer of soil on Broom's Barn Farm is reasonably fertile and usually well structured, but the subsoil is indurated, of poor structure and relatively infertile. Subsoiling has been a routine practice on the farm in recent years, and two experiments are testing the effects of fertilising and cultivating the subsoil.

On Little Lane liquid fertiliser was again injected into the subsoil in the autumn of 1975 (see *Rothamsted Report for 1974*, Part 1, 68 for details) and the area cropped with spring barley. Neither subsoiling nor fertiliser injection affected the grain yield which averaged 4·0 t ha^{-1} at 85% dry matter (DM). Further fertiliser injections were made in the autumn of 1976.

On Windbreak field, which has not previously been subsoiled, the effects of the Wye double-digger plough (a single furrow plough working 23 cm deep with a rotovator working a further 23 cm deep in the furrow bottom) were tested. P K fertiliser (0—20—20) at 628 kg ha^{-1} was applied in the furrow bottom while subsoiling on 16 December 1975 or broadcast on the seedbed on 4 March. The equipment appeared to loosen the subsoil and stir in the fertiliser very effectively. Sugar beet was sown on the area on 22 March either with or without aldicarb granules. Germination and early growth was rather erratic in a dry seedbed so the area was given 15 mm irrigation on 30 April. The crop was defoliated by drought during the summer but was given no more irrigation. Cultivation treatments had only small, erratic effects on yield, largely accounted for by aldicarb increasing the plant stand, particularly on the double-dug plots. The autumn fertiliser application consistently under-yielded the spring application, but the fertiliser given both in autumn and spring gave the largest yields.

Large differences in subsoil bulk density were found immediately after ploughing with either a conventional plough to a depth of 23 cm, or with the Wye College plough/rotary cultivator combination to 46 cm. The mean soil bulk density for the horizon 23–46 cm for the ploughed treatment was 1·45 g ml^{-1} and 1·34 g ml^{-1} for the deeper cultivation treatment. However, when sampled again in May and October there were no significant bulk density differences between the two treatments, although the deep cultivation treatment often had a larger water content. The fact that the soil recompacted so quickly probably explains why no beneficial effects on sugar yield were found.

Observation strips of the plough treatments on the lighter sandy loam soil of Dunholme field showed that double digging increased root yield by 1·0 t ha^{-1}, but decreased sugar percentage and gave little increase in the mean sugar yield of 6·9 t ha^{-1}. (Jaggard and Webb)

Minimum cultivations. An experiment on sandy soil at Higham, near Bury St. Edmunds, assessed yield of sugar beet given minimum cultivation. The cultivation treatments, split for three rates of nitrogen fertiliser, were (1) no cultivations; (2) two passes of a rigid-tined cultivator during November followed by one pass of a dutch harrow in March before drilling; (3) mould-board plough during December followed by one pass of a dutch harrow in March. Treatment (1) was sprayed with 4 litres paraquat in 560 litres water ha^{-1} on 19 March. The cultivation plots were split for N applications of 63, 125 and 188 kg ha^{-1} as 'Nitro-Chalk' in early March before drilling on 22 March at 15 cm spacing.

https://doi.org/10.23637/ERADOC-1-133

All treatments were overall sprayed with the recommended rate of pyrazone immediately after sowing, and with phenmedipham on 10 May. Seedlings were counted during late May and early June, when significantly less had emerged on the direct drilled than on the cultivated or ploughed treatments. Despite the herbicide treatments significantly larger numbers of *Chenopodium album*, *Atriplex patula* and *Polygonum aviculare* were produced on cultivation treatments (2) and (3) than on the direct drilled plots. Conversely, more *Tripleurospermum maritimum* spp. *inodorum* were found on the direct drilled than on the other cultivation treatments. At harvest in early December the ploughed plots consistently produced more sugar than the rigid-tined cultivated, which yielded more than the direct drilled; the mean yields were 5·38, 5·14 and 4·57 t ha^{-1} sugar respectively. More than 63 kg ha^{-1} N depressed sugar yield on all cultivation treatments, largely as a result of deleterious effects on sugar concentration and plant density. (Jaggard)

Soil structure

Effects of sodium. There is much experimental evidence that on most soils sodium fertiliser increases sugar-beet yield but only half the growers use it, presumably because they fear deterioration of soil structure which may delay spring cultivations or make harvesting more difficult. Many growers on Fen soils also think their soils contain sufficient sodium already, but our present evidence suggests this is not always true.

A study started to investigate in more detail the effects of sodium fertiliser on silt, clay and organic soils. As much of the sugar beet which is not given sodium fertiliser is grown in the Fenland area it was also decided that a survey of the sodium concentration in Fen soils would be useful. This has been started in conjunction with Jealott's Hill Research Station but no results are yet available.

Samples of soil were taken for structure determinations and sodium measurements from field experiments testing sodium fertiliser on the three types of soil. Sodium did not affect soil density in the top 25 cm of the seedbed nor did it affect soil moisture content significantly. (Allen)

Damage to soil during beet harvesting. In the fourth experiment of this series, treatments simulating damage to soil structure caused by sugar-beet harvesting in wet or moist soils were made on 17 November, the site was ploughed on 11 January, and sown with winter wheat var. Flinor on 24 February. Soil conditions did not significantly affect seedling populations, but simulated harvesting in wet soil significantly decreased grain and straw yields by an average of 0·25 and 0·85 t ha^{-1} to 3·15 and 3·76 t ha^{-1} respectively. Removing the sugar-beet tops tended to increase the yield of plots harvested in good conditions and decrease the yield of the remainder, despite the addition of inorganic nutrients to balance that removed with the tops. This result was unexpected since it was thought that the tops would decay anaerobically where soil structure had been damaged and create a hostile environment for root growth. The yield reduction caused by removing the sugar-beet tops prior to ploughing was not the result of removing a source of nitrogen nutrients, since additional inorganic nitrogen (125 instead of 75 kg ha^{-1}) decreased grain yield in the absence of tops. (Jaggard)

Topping

The initial study of different levels of topping of sugar beet on the amounts of sugar left in the field was completed. Results are described in full in Paper No. 27. After removing all green material, the weight of completely untopped beet was 16% greater than normally-topped beet, but the sugar concentration was considerably less than the main storage

https://doi.org/10.23637/ERADOC-1-133

root. Overall, the amount of sugar per root increased from 140 g per root for normally topped beet to 155 g per root for scalped beet, and to 160 g per root for whole beet. All the impurities which decrease sugar extraction were, however, also increased by inclusion of these upper portions, normally discarded. The concentrations of impurities and of invert sugar suggest that the scalped beet would be acceptable for processing, but the completely untopped beet would not. (Last, Draycott and Hull)

Insecticides and fungicides on cereals

Observation plots in Maris Fundin winter wheat grown as a second wheat crop on Bullrush field were sprayed with carbendazim at growth stage 7 when up to 50% of the tillers were infected with eyespot. A single application increased yield from 4·9 to 5·3 t ha^{-1} at 85% dry matter (DM); demeton-S-methyl applied at growth stage 10·5 gave 5·3 t ha^{-1} alone and 5·7 t ha^{-1} with carbendazim.

Fungicides on barley. Fungicides were tested at the recommended rates on three varieties of spring barley; Julia, Maris Mink and Proctor. Ethirimol seed dressing gave good control of mildew on Julia and Proctor until the end of May when the drought made any remaining ethirimol unavailable. Seedling number was reduced by 25% by the use of ethirimol seed dressing on Proctor. Tridemorph gave some control of mildew when applied to the untreated crop and good control when it followed the seed dressing. Table 9 gives the yields.

TABLE 9

Effects of fungicides on three varieties of spring barley

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

	No fungicide	Tridemorph	Ethirimol	Ethirimol + tridemorph
Julia	4·0	4·2	4·2	4·5
Maris Mink	4·5	4·6	4·7	4·7
Proctor	4·0	4·2	3·7	3·8

Frequency of beet and barley

This was the 12th year of the experiment testing yields in five contrasting crop rotations (*Rothamsted Report for 1966*, 248). As in the eleventh year virus yellows and the drought severely limited sugar yields to only 4·0 t ha^{-1} (11 year mean 6·3 t ha^{-1}).

Beet after two barleys gave the largest sugar yield (4·3 t ha^{-1}). Sugar yields were similar (4·0 t ha^{-1}) from the continuous beet, after potatoes and the two year grass ley, and least (3·6 t ha^{-1}) after five barleys. No nitrogen was required for maximum sugar yield in all rotations except the continuous beet and beet after two barleys, which required 63 kg N ha^{-1}.

Barley grain yields (2·2 t ha^{-1} at 85% DM) were similar following beet or one barley, and least after four barley crops (1·7 t ha^{-1}).

The other crops all suffered badly from the drought and, as in 1975, yielded little. (Webb)

Broom's Barn Farm

Ploughing was completed by mid-January and after a dryer than average winter, the spring work started early with easily made seedbeds. The winter wheats and the grass ley on Brome Pin overwintered well and looked very promising in the spring, but due to extremely hot and dry conditions during the summer, large yields did not materialise either from these or the spring sown crops. Cereal harvest was much earlier than usual.

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Brome Pin and Bullrush fields were subsoiled both ways at 55 cm deep and 90 cm between tines. Brome Pin and parts of Bullrush and Flint Ridge were limed and Brome Pin was dressed with FYM. A roof was erected over the passage between the corn store and the cattle shed, a new silage pit put in the cattle shed and an oil fired ducted air heating system installed in the workshops. Doors were added to the cottage yards.

Cereals. The winter wheats were given only 50 kg P and 50 kg K ha^{-1} in the autumn except the second wheat crop on Bullrush, which had 23 kg N ha^{-1} in the seedbed as well. All were given a total of 108 kg N ha^{-1} in two applications, as a top dressing in the spring. Some wheats were sprayed with carbendazim to control disease and some with chlormequat ('Cycocel') to prevent lodging, and all were sprayed on 21 June with pirimicarb to control aphids.

All the spring cereals were sown in late February, wheat on White Patch and barley on The Holt and Little Lane. The spring wheat was irrigated during mid-May and also sprayed with pirimicarb to control aphids. All the cereals were sprayed with an appropriate herbicide.

Harvest started on 14 July but was held up for several days by rain. It re-started on 22 July and all but the spring wheat was finished by the end of the month. This was completed by 9 August. Grain moistures ranged from 11·5–16%.

Beans. Maris Bead Tic beans were sown on 24 February and sprayed immediately with simazine to control weeds. Bees worked the crop and no aphid control was necessary. They were harvested on 15 July at 16% moisture.

TABLE 10

Yields of cereals and beans on Broom's Barn Farm

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

	ha		Yield
Flint Ridge	8·82	Maris Huntsman wheat	4·65
Marl Pit	5·16	Maris Huntsman wheat (seed)	5·24
Bullrush	4·61	Maris Fundin wheat	4·95
White Patch	9·17	Flinor wheat (spring sown)	3·17
Little Lane	8·78	Proctor barley (undersown)	3·62
The Holt	4·49	Maris Mink barley	4·15
Hackthorn	3·93	Maris Bead beans	1·25
Windbreak	0·81	Barley	3·75

Fodder crops. The rye-grass lay on Brome Pin was given a compound fertiliser in the spring and irrigated with 50 mm water to be cut for silage during the first week of June. It was immediately top dressed with N, given a further 25 mm water and cut for hay on 1 July.

The undersown ley on Little Lane established unevenly under the barley because of the dry spring and summer and required filling in after harvest. There is now a good cover over the whole field.

Sugar beet. The fertiliser ploughed down in autumn 1975 on both Dunholme and New Piece fields supplied P_2O_5, 62; K_2O, 150; Na, 157; Mg, 62 kg ha^{-1}. The N fertiliser at 125 kg ha^{-1} was broadcast between the rows at drilling. The first sowings were made on 27 February and all but late drilling trials were finished by the end of March. All the crop was sown with pelleted monogerm seed, 80% at 15·5 cm spacing and 20% at 7 cm spacing. Most of the crop was band sprayed with pyrazone at drilling or overall sprayed on non-standard row widths. All subsequent weed control was by hoeing; *C. album* was

https://doi.org/10.23637/ERADOC-1-133

prevalent in parts of the crop. At drilling a fifth of the crop was treated with aldicarb and later sprayed once with insecticide to control aphids. Most of the remainder was sprayed three times with insecticide. The spray programme started in mid-May and continued until the end of June with a reasonable control of yellows. Dunholme field had 125 mm of irrigation and New Piece 50 mm. More would have been applied if we had not used our licenced water allowance for the year.

Harvesting started on 30 September with the soil already very wet and continued slowly in difficult conditions until early December when frost firmed the soil and enabled the remaining crop to be harvested in good conditions. All beet was lifted by 20 December. Deliveries to the factory continued into the new year. Yields averaged 35·07 t ha^{-1} of clean roots at an average sugar content of 14·5% ranging from 13·1–16·2%. Mean dirt and top tares were 14 and 4%. The country's average yield this year was 31·5 t ha^{-1} of roots at 13·85% sugar.

Livestock. In October 1975, 82 cross bred heifers were bought and fattened in the yards on *ad lib* silage, barley straw and restricted concentrate rations of 50% rolled barley and 50% beet pulp nuts. They were sold between early February and early May.

The yards were restocked with 80 cross bred heifers in October. (Golding)

Staff and visiting workers

We have welcomed numerous visitors and groups from many countries during the year. About 350 people attended the Open Day on 29 June. A few days previously the Station was host to 135 members of the Royal Agricultural Society of England for a discussion meeting and demonstration on the theme 'Drilling to a stand: Maximise your yield'. The meeting was attended by the Earl of Stradbroke, Lord Lieutenant of the County of Suffolk, by two past Chairmen of the Sugar Beet Research and Education Committee, Col. Sir Edmund Bacon (Lord Lieutenant of the County of Norfolk) and Sir Peter Greenwell as well as the present Chairman, Mr. J. N. Holmes.

We ran short courses for the sugar factory field staff and for the technical staff of fertiliser and pesticide manufacturers.

Several members of the staff contributed to the activities of the International Institute for Sugar Beet Research. R. Hull, A. P. Draycott and R. A. Dunning contributed to the Winter Congress in Brussels. P. C. Longden attended the Genetics and Breeding Study Group meeting in Bologna, Italy. R. A. Dunning, W. J. Byford and G. D. Heathcote attended the Pests and Diseases Study Group meeting in Göttingen, Germany. G. D. Heathcote also contributed to the Entomological Conference in Giessen, Germany. R. Hull and P. C. Longden participated in an O.E.C.D. Course at the Mediterranean Institute for Advanced Agronomic Studies at Zaragoza, Spain.

Dr. M. Tornebrandt, Landskrona, worked with us during March. Sandwich course students, J. Godson (Bath), D. M. Hesketh (Bath) and Pearl Parrish (Trent) each worked with us for six months.

In June 1976 D. A. Cooke left to spend a year working on beet cyst nematodes at the University of California, Riverside, USA.

Publications

Theses

1 Bentley, K. E. (1975) Physiology of seedling development in *Sinapis alba*. Ph.D. Thesis, University of Wales.

https://doi.org/10.23637/ERADOC-1-133

2 Cooke, D. A. (1976) Studies on the pathogenicity, bionomics and control of *Trichodorus* spp. and *Longidorus* spp. on sugar beet. Ph.D. Thesis, University of London.

GENERAL PAPERS

3 Draycott, A. P. (1975) Reducing fertiliser costs. *Proceedings 23rd Agricultural Staff Conference of the British Sugar Corporation Ltd.*, pp. 15–18.

4 Draycott, A. P. (1976) Growers must avoid wasteful use of fertiliser. *Roots '76. A.C.P. Annual* pp. 28–29.

5 Draycott, A. P. & Durrant, M. J. (1976) Profitable use of phosphate. *British Sugar Beet Review* **44,** 31–32.

6 Draycott, A. P., Farley, R. F. & (Turner, N. V.) (1976) Effect of method of plot harvesting on response by sugar beet to nitrogen. *British Sugar Beet Review* **44,** 30–31.

7 Dunning, R. A. (1976) Cutworms—a hazard to late-established crops. *British Sugar Beet Review* **44,** 42.

8 Dunning, R. A. (1976) Virus yellows. *Roots '76*, 32–33.

9 Dunning, R. A. (1976) Virus yellows: chemical control. *Proceedings 39th Winter Congress, International Institute for Sugar Beet Research*, pp. 13–25.

10 Dunning, R. A. (1976) Virus yellows in 1976—effectiveness of sprays and granules. *British Sugar Beet Review* **44,** 26.

11 Dunning, R. A. (1976) A wonderful summer—for aphids, virus yellows and cutworms. *Eastern Daily Press, Sugar-beet Supplement*, 27 October, p. 1.

12 Dunning, R. A. (1977) Sugar beet pests and diseases. *Farm Contractor* No. 30, 15–16.

13 Dunning, R. A. & Hull, R. (1977) Pests and diseases of sugar beet, fodder beet and mangolds. In: *Insecticide and fungicide handbook*, 4th edition, Ed. H. Martin. Oxford: Blackwell's Scientific Publications, Ch. 7.

14 Dunning, R. A. & Winder, G. H. (1976) Problems in the chemical control of aphids and yellows. *British Sugar Beet Review* **44,** 21, 30.

15 Heathcote, G. D. (1976) Insects as vectors of plant viruses. *Zeitschrift für Angewandte Entomologie* **82,** 72–80.

PAPER IN ROTHAMSTED REPORT, PART 2

16 Draycott, A. P., Durrant, M. J., Hull, R. & Messem, A. B. (1977) Changes in Broom's Barn Farm soils, 1960–75. *Rothamsted Experimental Station. Report for 1976*, Part 2, 33–52.

RESEARCH PAPERS

17 Byford, W. J. & Bentley, K. E. (1976) Cleistothecia of *Erysiphe betae* in England. *Transactions of the British Mycological Society* **67,** 54–55.

18 Byford, W. J. & Prince, J. (1976) The influence of soil-applied fungicides and previous cropping on the development of violet root rot of sugar beet. *Annals of Applied Biology* **83,** 61–67.

19 Byford, W. J. & Prince, J. (1976) Experiments with fungicides to control *Aphanomyces cochlioides* in sugar beet. *Annals of Applied Biology* **83,** 69–77.

20 Cooke, D. A. (1976) Economics of control of Docking disorder of sugar beet. *Annals of Applied Biology* **85,** 451–455.

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21 Draycott, A. P. (1976) Interactions between irrigation and other agronomic practices. *Proceedings of 39th Winter Congress of Institut International de Recherches Betteravières*, Brussels, pp. 135–147.

22 Draycott, A. P. & Durrant, M. J. (1976) Response by sugar beet to potassium and sodium fertilisers, particularly in relation to soils containing little exchangeable potassium. *Journal of Agricultural Science, Cambridge* **87,** 105–112.

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29 Longden, P. C. (1976) Seed treatments to lengthen the sugar-beet growing period. *Annals of Applied Biology* **83,** 87–92.

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