ROTHAMSTED RESEARCH

Report for 1974 - Part 1

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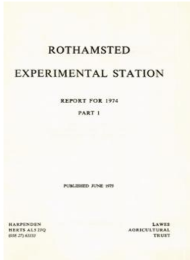
ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1974
PART 1

Broom's Barn Experimental Station

R. Hull

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Introduction

The circumstances of the field experiments on sugar beet this year have been very different from previously at Broom's Barn and our experiences with the crop have been similar to those of most growers in the east of England. Wet soil in March and lack of frost mould delayed sowing but all the experiments were sown before mid-April, though sometimes on indifferent seedbeds, after dry weather towards the end of March. The soil dried rapidly and, with no rain, germination was erratic on the rougher seedbeds or where the seed was sown shallow. Wood-mice dug out and destroyed the spaced seeds on an unprecendented scale and there were difficult decisions whether or not to resow. We have started an intensive investigation of vertebrate pests of sugar beet seed and seedlings because they have caused so much damage in recent years.

The drought persisted during the spring and early summer, resulting in a calculated

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moisture deficit under grass of 196 mm by early August. Sugar beet grew slowly and then, during May, aphids began to infest the backward and irregular crop. They were difficult to control with insecticide sprays because the chemicals had little systemic and persistent effect when sprayed on these small plants under water-stress, and reinfestation by winged aphids continued. In a few instances the aphids proved unduly resistant to some insecticides; the extent of resistance of aphids on sugar beet to insecticide will need careful scrutiny in future.

During July, plants with virus yellows were obvious in most crops and very rapidly the disease affected all plants so that crops took on a uniform yellow appearance, which intensified during the summer and persisted throughout the autumn. Plants sampled in July had storage roots only half the size of those sampled at the equivalent time in the previous year. Rain in August saturated the soil and field drains began to run at the end of September, but the plants made little fresh leaf growth throughout the summer and autumn. Sugar factory fieldmen's first estimate of a poor crop of only 5½ million tons proved over-optimistic to the extent of nearly a million tons. This was a consequence not only of poor growth but also of extensive losses of roots during attempts to harvest from soil which was wet to start with and in many fields developed into an absorptive quagmire.

Some of the experiment results described below indicate reasons for the small yield this year. Our mid-March sowings yielded well but few crops were sown then, whilst the late sowings yielded little. There was a large response in yield to increasingly dense stands up to 125 000 plants/ha, an unusual result in our experiments at Broom's Barn, but the average plant stand of the country's crop was sparse and erratic. Yellows was undoubtedly a main cause of poor growth. A granular formulation of the pesticide aldicarb sown with the seed delayed the incidence of yellows and greatly increased yield. In previous experiments, aldicarb used in this way has controlled seedling pests, leaf-feeding pests and nematodes, as well as aphids. At first its commercial use was unacceptable because of its extreme mammalian toxicity but now a dust-free formulation less attractive to birds has gained official acceptance for sowing with sugar-beet seed with adequate user precautions. Use of a wide spectrum pesticide in this way has proved so effective that the practice seems likely to be extensively used by growers. The hazards of a single treatment may well be less than using numerous separate treatments of less toxic pesticides. The practice needs careful monitoring and the principle needs further investigation.

Drought-affected crops infected early with yellows usually develop fresh leaves and look greener when the soil moistens, but they did not do so this year. The reason is not clear. Yellows infection restricts root growth and this was demonstrated by roots extracting soil moisture less deeply in the subsoil than normal; their soil moisture usage was only 35% of the calculated evapotranspiration compared with the five-year average of 80%. To what extent the poor root system was a consequence of the small and yellow leaf system and *vice versa* remains to be explained. Was the virus complex more virulent than usual or did soil conditions in some way restrict root recovery? To what extent did the cold weather from May to September determine growth? The dismal sugar beet crop of 1974 leaves us with numerous problems to solve. The mild weather of this winter so far suggests that we may well experience them again in the coming year. On the brighter side, the season that gave us such a poor sugar-beet crop allowed us to reach the objective of 3 tons/acre of wheat on two fields!

Arthropod pests of seedlings

Reported damage by both the root-eating and foliage-eating seedling pests was less than for many years, probably as a result of the drought.

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Pygmy beetle dispersal. More pygmy beetles were caught on a sticky trap at Broom's Barn (767) than in 1972 (181) or 1973 (316), but the Rothamsted and Shardlow sticky traps again caught few beetles. The suction-trap catch (895) was also greater than in 1972 (566) or 1973 (643). However, pygmy beetle damage to sugar beet reported by fieldmen was less than a quarter of that in any of the previous four years; this was because of very late or irregular germination of many crops as a result of drought.

Pitfall traps, used to study local dispersal, were operated from early March to mid-August, and some of them until mid-October. On Brome Pin (wheat after beet) the number caught was small but consistent from March to July and then declined. In contrast, on Marl Pit (beet after barley) none were caught in March and April, some in May, many in June and July, and then fewer. Traps on the small plots of the long-term rotation trial gave results similar to those in 1973. Over all traps, most pygmy beetles were caught in mid-May to late July, earlier than in 1973. (Thornhill and Dunning)

Pest aggregation. Continuing work on pest aggregation, a field experiment in 1974 showed that damage by Collembola, *Onychiurus armatus*, to roots of seedlings from raw seed was not significantly more than from pelleted seed, and that numbers in their root-zones were similar.

The numbers of *O. armatus* and millipedes (*Blaniulus guttulatus*) aggregating around both raw and pelleted germinating seed were compared in the laboratory. Eight successive sowings at 7°C of pre-germinated seed were made over a period of three months; damage to the roots was assessed for each sowing. Seedlings growing from pelleted seed attracted significantly more millipedes than Collembola but this did not increase damage. The two animals aggregated approximately equally around seedlings growing from raw seed, but Collembola caused significantly more damage than millipedes ($P < 0{\cdot}1\%$).

Seed-spacing experiments were repeated on pest-infested sites using increased replication on single row plots. At Bottisham (Cambs.) in a field where millipedes (*Boreoiulus tenuis* and *Blaniulus guttulatus*) had damaged sugar beet in 1970, there were 3·2 m/ha millipedes and 2·0 m/ha Collembola (*Onychiurus*) in the seedbed on 8 April; the millipedes were almost entirely second stadium *B. tenuis*, as in previous years at this time. Soil sampled on 4 May, centred on and including a seedling, at 4, 12 and 24 cm spacing, contained respectively 0·5, 0·6 and 0·9 millipedes/core (differences not significant). However, root damage increased significantly with wider spacing, viz: scores, on a 0–5 scale, of 1·2, 1·5 and 1·8 for the three spacings. Seedling samples on 20 May also had significantly increased damage with increased spacing (scores of 1·4, 1·9 and 2·0 per seedling respectively) and dry weight/seedling at 4 cm spacing was greater than at 24 cm.

Laboratory experiments, at temperatures similar to those of the soil in spring, confirmed that Collembola (*Onychiurus armatus*) aggregates around freshly germinated sugar-beet seedlings and produces lesions that retard growth and can kill seedlings.

At Stalham (Norfolk) there were 19·8 million *O. armatus*/ha in the top 20 cm of soil on 20 March and 13·3 million in the top 10 cm of the seedbed at sowing on 11 April. As in previous years, numbers/seedling root zone did not vary significantly with seedling spacing. On 6 May root damage did not vary significantly with seedling spacing but on 21 May seedlings at 24 cm spacing were significantly more damaged than those at 12 cm and 4 cm spacing; as at Bottisham, the most heavily damaged seedlings weighed least.

The relationship between seedling spacing, pest distribution and damage has been studied for four years. Both millipedes and pygmy beetle aggregate in the root zone of sugar-beet seedlings and at some time in the season the relative number/root is inversely related to seedling spacing. Collembola, represented mainly by *O. armatus*, aggregates less markedly in the rows than the other two pests and numbers per root zone have not

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varied significantly with seedling spacing in any samples. At the closest spacing, individual seedlings suffer less damage and grow larger and heavier but it is thought that this is not entirely due to fewer pests/seedling since it sometimes occurs at other sites where pest damage is only slight. It is recommended that, in the absence of an effective pesticide, wide seed spacing should be avoided where pest damage by a recurrent pest such as millipedes is expected. (Baker and Dunning)

Control by insecticides

Seed treatment. Trials in 16 sugar factory areas measured the seedling establishment from pelleted Monotri seed treated with 0·2% of dieldrin; 0·1, 0·2, 0·4 and 0·8% methiocarb; 0·05, 0·1, 0·2 and 0·8% bendiocarb; and 0·05, 0·1, 0·2, 0·8 and 3·2% 'PP 505' each incorporated during pelleting. The 29 trials gave irregular results due to adverse seedbeds, and seedling establishment from untreated seed was only 48%; no treatment increased seedling establishment significantly but 0·8% bendiocarb and 3·2% 'PP 505' decreased it.

The same treatments were tested on five trials at four East Anglian sites where pest attack was expected, but occurred at only one. On average, all treatments were beneficial; 39% of seeds produced seedlings on the untreated control and on the treatments as listed above: 46; 45, 42, 43, 45; 43, 45, 44, 45; 45, 43, 47, 45, 41% respectively. At Cottenham, Cambs., where wireworms decreased seedling establishment from untreated seed to 28%, big increases in establishment were obtained with 0·8% methiocarb, 0·8% bendiocarb and 0·2 and 0·8% 'PP 505' (47, 62, 45 and 48% establishment respectively compared with 42% from 0·2% dieldrin). At Stalham (Norfolk), Collembola were extracted from soil samples and seedlings scored for root damage. There was no significant difference between numbers of either living or dead *O. armatus* as a result of 0·2% dieldrin or 0·8% methiocarb but seedlings had less damage than the control, 0·8% methiocarb the least. (Winder, Dunning and Baker)

Soil treatment. Trials in 1974 on pest-infested sites at Cottenham, Stalham, Bottisham and Gedney tested several insecticides as possible alternatives to γ-BHC spray treatment currently being used by some growers. Sprays of γ-BHC, chlorpyrifos and, at Cottenham, fonofos ('Dyfonate') and 'PP 505' (630 litre/ha lightly harrowed into the seedbed) were compared with aldicarb, oxamyl and carbofuran as granules applied in the seed furrow.

At Cottenham only 23% of the seed on the untreated plots produced seedlings, mainly because of wireworm attack. Seedling establishment after treatment was: γ-BHC spray (280, 560, 1120 and 2240 g a.i./ha) 41, 51, 72 and 68% respectively; aldicarb granules (280 and 1120 g) 49 and 70%; whilst chlorpyrifos, fonofos and 'PP 505' sprays at 1120 g and oxamyl granules at 280 and 1120 g had no significant effect.

At Stalham, where *Onychiurus* were numerous, seedling establishment was 58% on the untreated plots. Significant improvement resulted from treatment with aldicarb (280 g) 69%, oxamyl (1120 g) 71% and carbofuran (280, 1120 g) 71 and 67% respectively; slight improvement was obtained with γ-BHC (280, 560 and 1120 g), oxamyl (280 g), aldicarb (1120 g) and chlorpyrifos (420 g) but not with chlorpyrifos (280 g). In soil which received a γ-BHC seedbed spray numbers of live *Onychiurus armatus* were nearly halved; but there was also a highly significant increase in numbers of dead *O. armatus* and of the large predatory soil mite *Pergamasus longicornis*, and further studies in the laboratory showed that this mite will readily feed upon *O. armatus*. The outcome was that γ-BHC neither decreased root damage nor increased seedling establishment.

At Bottisham, where millipede damage was expected, seedling establishment on the untreated plots was 74%. Gamma-BHC (1120 g) significantly improved seedling estab-

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lishment to 79% but smaller improvements were given by γ-BHC (560 g), chlorpyrifos (1120 g), aldicarb (280, 1120 g), oxamyl (280, 1120 g) and carbofuran (280 g) and none by γ-BHC (280 g), chlorpyrifos (280 g) and carbofuran (1120 g).

Averaging the treatments common to these three trials the mean seedling establishment was: untreated 51%, γ-BHC (280, 560, 1120 g) 59, 62, 72%; aldicarb (280, 1120 g) 65, 70%; oxamyl (280, 1120 g) 54, 58%, and chlorpyrifos (1120 g) 11%.

Gamma-BHC (560, 1120 g) and chlorpyrifos (1120 g) sprays on the seedbed and aldicarb, oxamyl and carbofuran granules in the seed furrow, each at 560 g, were tested in the trial at Gedney where millipedes (*Blaniulus guttulatus*) were numerous; no treatment significantly increased seedling numbers, probably due to the dry conditions; their reappearance in the surface layers in early June coincided with rain wetting the seedbed. Seedling samples taken at singling on 13 June from the untreated and the γ-BHC (1120 g a.i./ha) and oxamyl (560 g) treated plots, showed that oxamyl, and especially γ-BHC, killed many millipedes and decreased their damage to roots.

To test pesticides for control of millipede damage, trials at Bottisham and Terrington included methiocarb, bendiocarb, γ-BHC, 'PP 505' and fonofos as solutions at 370 litre/ha, and 'DS 15647', bendiocarb, 'AC 92100', 'SD 8832', 'PP 505', oxamyl, γ-BHC, aldicarb, carbofuran and isofenphos as granules at 280 and/or 1120 g a.i./ha, all applied in the seed furrow. At Broom's Barn, where pest damage was not expected, the same treatments were tested for phytotoxicity.

At Bottisham seedling establishment without local treatment was 70%; aldicarb (280 g) and carbofuran granules (280, 1120 g) significantly improved this to 79, 77 and 78% respectively. Bendiocarb solution (1120 g), 'AC 92100' granules (1120 g), γ-BHC solution (tested at 280 g only in this trial) and especially 'SD 8832' granules (1120 g) were phytotoxic, with seedling establishments of 46, 58, 54 and 14% respectively.

At Terrington in a very dry seedbed, seedling establishment was only 42%. None of the treatments significantly increased seedling numbers but solutions of bendiocarb (1120 g) and γ-BHC (280 g) greatly decreased them, to 23 and 22% seedling establishment respectively.

At Broom's Barn the seedling establishment of 51% on the untreated plots was improved by all pesticides at 280 g and by some at 1120 g a.i./ha, a result presumed due to control of damage by *Onychiurus* that were subsequently found in the soil. Aldicarb granules (280, 1120 g) were the best treatments, increasing seedling establishment to 76 and 78% respectively. Granules of carbofuran (280 g), 'PP 505' (280 and 1120 g), bendiocarb (280 g) and 'DS 15647' (280, 1120 g) gave seedling establishments of 74, 73, 73, 70, 71 and 74% respectively, while methiocarb (280 g), bendiocarb (280 g), 'PP 505' (280, 1120 g) and fonofos (280 g) solutions, and granules of 'AC 92100' (280 g), oxamyl (280 g), carbofuran (1120 g) and isofenphos (280 g), all significantly increased seedling establishment to more than 64%. Gamma-BHC solution, tested only at 1120 g a.i./ha at this site, and 'SD 8832' granules (1120 g) decreased seedling establishment to 29 and 2% respectively.

Sugar yield at Broom's Barn from the untreated seed was 5·03 t/ha; significant increases were given by 'DS 15647' (1120 g), aldicarb (280, 1120 g) and carbofuran (1120 g) with yields of 6·59, 6·00, 6·27 and 6·05 t/ha respectively. Fonofos (280 g) solution, and granules of 'DS 15647' (280 g), bendiocarb (280 g), oxamyl (1120 g) and carbofuran (280 g) gave yields of 5·70–6·00 t/ha. Methiocarb (280, 1120 g), bendiocarb (280 g) and 'PP 505' (280, 1120 g) solutions and granules of 'AC 92100' (280 g), 'PP 505' (280, 1120 g), oxamyl (280 g), γ-BHC (280 g) and isofenphos (280 g) gave 5·30–5·69 t/ha. Solutions of fonofos (1120 g), bendiocarb (1120 g) and especially γ-BHC (280, 1120 g) and granules of 'SD 8832' (1120 g) decreased yields to 4·57, 4·52, 3·34, 1·85 and 0·45 t/ha respectively. (Dunning, Winder and Baker)

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Bird and mammal damage

Wood mice caused far more damage than recorded before, digging out the newly-sown seed pellets and consuming the embryos. Damage was not confined to field margins; nationally 1200 ha of crop had to be resown and 30 000 ha were thinned. Shallow sowing and delayed germination due to drought exacerbated the damage. Damage caused by birds and mammals grazing the seedlings was slightly above the five-year average.

Control of wood mouse damage. The efficiency of various seed and other treatments in decreasing 'digging-out' of seed, and consequently increasing seedling establishment, was compared at Broom's Barn on plots sown on 9 May at 2·5 cm depth and 11·5 cm spacing. Pelleted Monotri seed, with 0·2% dieldrin, was treated superficially with various possible repellents. On the control plots 10% of the seeds were dug out by wood mice, and seedling establishment was only 43%. Adverse effects (i.e. more seeds removed and consequent decrease in establishment) followed seed treatment with thiram (1% a.i. by wt. of pellets), ziram (1%) and coumatetralyl (0·5%); 'Curb' (aluminium ammonium phosphate + additives at 2%) had no effect. Beneficial effects followed treatment with paraffin oil (1·25 v/w), sowing the seed 4·5 cm deep or sowing it without pellet coating.

Artificial defoliation. Field trials were continued to assess the effects on yield of early defoliation similar to bird and mammal grazing. Plots of sugar-beet seedlings, sown on 10 May, were completely defoliated with scissors at the very early cotyledon, middle cotyledon, late cotyledon (first true leaves appearing), 2-rough leaf or 4-rough leaf stages. On other plots the initial defoliation treatment, except that at the 4-rough leaf stage, was followed by further repeated defoliations as often as necessary to keep them free of green leaf area until mid-June. Sugar yield on the control (undefoliated) plots was 4·93 t/ha. The treatment yields were, on the once defoliated, respectively: 3·75, 3·92, 3·93, 3·86, 3·49, and on the repeatedly defoliated: 2·00, 2·06, 1·99 and 2·21. The sodium content of the harvested roots was increased by the repeated defoliations; fewer of the plants repeatedly defoliated had virus yellows.

Alternative foods. The extent of grazing was compared on five crops grown in single-row plots from pelleted seed in an isolated half-acre, mainly of sugar beet. Cauliflower was the most severely grazed followed, in decreasing order, by radish, lettuce, red beet and sugar beet.

Fodder rape sown between rows of sugar beet at Broom's Barn was grazed by birds and mammals; this treatment tended to increase the very minor damage to the beet seedlings. The fodder rape markedly decreased virus incidence in the sugar beet (67% to <10% on 17 July), an effect that declined slowly with time; the inter-row crop competed severely with the sugar beet before it was removed, decreasing its yield by 37%.

'Repellents' v. exclusion. The effects were compared on seedling grazing of sprays of methiocarb (1120 g a.i./ha) every 10 days from emergence on 16 April until 28 May, aldicarb (1120 g a.i./ha) applied in the seed-furrow, an electric fence barrier, and caging with 25 mm mesh netting to keep out both birds and large mammals. Caging almost eliminated grazing and increased seedling establishment. The electric fence similarly increased seed establishment but decreased damage less; the other treatments had no effect. Seedling dry weight was increased only by caging.

Exclusion caging. Lengths of sugar-beet row in 15 drilled-to-a-stand crops were caged until June, and crop growth compared with that in uncaged rows. Damage was, on average, much less than in similar experiments in 1973; harvested root numbers were

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increased very slightly by caging (73 300–76 000/ha) but sugar yield was not affected. (Dunning, Winder and Thornhill)

Ecology of bird and mammal pests. A study of the ecology of vertebrate pests of sugar beet was started in October. Small rodents have been live-trapped and other mammals and birds counted and their diet studied on three farms. In November and December food sources for skylarks became more localised than in October; they began to form flocks and there was a marked reduction in aggressive behaviour and singing. Harvested beet fields, autumn sown wheat and stubbles attracted many skylarks but by January most birds were on clover leys. Wood mice were common and widespread on farmland in October and remained so in December. They fed on weed seeds, grain from stubbles and autumn sowings and to a small extent, insects. Excavation of nests suggests that food stored in the autumn may be important for wood mice during winter. The mice survived ploughing and remained numerous on ploughed land. (Green)

Seedling diseases

Experiments at Broom's Barn testing control of *Phoma betae* by fungicidal seed treatments gave erratic results because of damage by wood mice. Elsewhere 16 field trials tested fungicides applied as slurries in water on to Monotri seed before pelleting. On average, ethyl mercuric phosphate (EMP) steep increased seedling establishment by 21% compared with increases of 13, 13 and 17% respectively from 'TCMTB' at 0·1%, captafol at 0·64% and maneb at 1·7%.

Aphanomyces cochlioides was scarce on sugar-beet seedlings in this dry spring. Eight trials tested fenaminosulf ('Dexon') applied in the seed pellet at 2·5, 5·0 and 7·5 g a.i./kg seed. No seedlings were found infected with *A. cochlioides* in any of the trials and treatments did not, on average, increase either seedling emergence, final plant stand or yield. Glasshouse tests of soil samples showed that the fungus was present at four of the sites but was abundant at only one site. (Byford and Bentley)

Yellows and aphids

Yellows was more intense and spread more widely in 1974 than in any year since accurate annual surveys were started in the 1940s. At the end of July, a survey of about 100 crops showed that 42% of the plants already had symptoms and with a more extensive survey fieldmen assessed that, on average, 66% showed symptoms at the end of August. The disease was most prevalent in the south of East Anglia but eventually developed in all areas, although notably later in north-east Norfolk and in north Lincolnshire than in nearby areas. As the winter of 1974 had been mild, a more severe than average attack of yellows was anticipated. The prediction based on weather at Rothamsted, where there were 43 ground frosts in January, February and March, and April warmer than average, was for 15% of plants to show symptoms at the end of August. This was obviously a gross under-estimate, possibly because the prediction does not take cognizance of the prevalence of aphids in the previous autumn; the weather in the autumn of 1973 had been very favourable for them.

The sugar factories issued spray warnings at the end of May and during June, and eventually 83% of the crop acreage was treated with insecticides, but this year, with such an intense activity of winged aphids, sprays were very ineffective at preventing spread of yellows.

Effect of yellowing viruses on yield. Plots of var. Vytomo and of Monotri were infested with aphids carrying yellowing viruses in late June (as in an experiment in 1973) but some

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plants were already beginning to show symptoms of yellows and most plants must already have been infected since the yields of naturally-infected and artificially-infected plots did not differ, averaging only 29·3 t/ha of clean roots. Although in mid-July twice as many plants of Monotri showed symptoms as of Vytomo, and the sugar content of Vytomo was significantly greater than that of Monotri (16·4 : 15·7%), the two varieties gave similar sugar yields. Plots sown on 27 March yielded an average 0·47 t/ha more sugar than plots sown on 2 May.

Winged aphids and Coccinellids on sticky traps. More than three times as many *Myzus persicae* were caught at Broom's Barn in May and June as in the equivalent period in 1973 and more than 10 times as many as in most years in the 1960s. However, the total catch of the season was not exceptionally large, e.g. more *M. persicae* were caught in July and early August in 1965 than in 1974.

A similar number of coccinellid beetles was trapped in 1974 as in 1973, and although ladybirds (mainly *Coccinella 7-punctata*) were common on sugar-beet plants in late July and early August when the aphid population had declined, they had been relatively few when aphids were numerous earlier in the season.

Groundkeepers. After a winter with few frosts many small roots of sugar beet survived in heaps of soil on cleaner-loader sites and sprouted in spring. In East Anglia many of these plants had mosaic as well as yellowing viruses. Many also survived in fields. A survey around Bury St. Edmunds showed an average of 24 plants/ha growing in March and April in the crops that followed sugar beet. Unexpectedly, herbicides used to control weeds in cereal and bean crops had little effect on beet groundkeepers and their number increased as buried root fragments grew. As many as 800 beet plants/ha still survived when cereal crops following sugar beet were harvested.

***Aphis fabae* survey.** Although eggs of *Aphis fabae* were numerous on spindle bushes at Broom's Barn they were generally few on bushes in the area and economic damage was predicted as 'unlikely' or 'possible' in East Anglia. Field beans at Broom's Barn became infested and were treated with insecticide granules on 11 July, and many *A. fabae* were caught in a suction trap in September, but in most parts of East Anglia sugar-beet crops were attacked only as heavily as in 1973.

Aphids on seed crops. *M. persicae* overwintered on some seed crops in Huntingdonshire, Bedfordshire and in Essex, and probably elsewhere. More crops were infested with *M. persicae* than usual, and winged nymphs were produced early. Many crops were sprayed with insecticide to prevent migration of winged aphids. The attack of *A. fabae* was negligible in 1974. (Heathcote)

Control by insecticides. Trials at Broom's Barn and Leaden Roding, Essex, tested aldicarb granules (1120 g a.i./ha) applied in the furrow with the seed, and spray applications of demeton-S-methyl (245 g a.i./ha) and pirimicarb (140 g a.i./ha) at the Spray Warning or some weeks later, alone or in combination with the aldicarb.

At Broom's Barn the aldicarb granules controlled the relatively small green aphid (*M. persicae*) population on the plants well until mid-June. On 30 May there were 0·8 wingless *M. persicae* per untreated plant and none on the aldicarb-treated beet. Sprays on 29 May, following the Spray Warning, decreased wingless *M. persicae* by 90%, but this effect persisted for only about a week. Demeton-S-methyl and pirimicarb sprayed on 2 July decreased the 0·71 wingless *M. persicae*/plant by 70 and 89%. Black aphids (*A. fabae*) were few until early July; on 18 June there were only 0·21 and 0·08 wingless

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A. fabae/plant on the untreated and aldicarb treated beet but the 29 May sprays now had no effect. On 5 July there were 34 wingless *A. fabae* per plant on the untreated plots; on the aldicarb treated beet there were 22% fewer; on the plots sprayed on 2 July with demeton-S-methyl and pirimicarb 80 and 75% fewer respectively.

Yellows incidence (infected-plant-weeks) was decreased only 9% by aldicarb and 0–3% by the spray treatments alone. The 28 May pirimicarb spray was not tested in combination with aldicarb but the other sprays when combined with aldicarb had an additive effect (demeton-S-methyl 29 May) or more than additive effect (both materials 2 July); the greatest decrease of yellows incidence was given by demeton-S-methyl sprayed on 2 July in combination with the aldicarb granules (Table 1). Sugar yield was increased 21% by aldicarb granules. The 29 May sprays of both materials and the 2 July pirimicarb spray gave little or no increase in yield but the 2 July demeton-S-methyl spray increased yield 9%. The sprays used in combination with the granules again tended to have an additive effect; aldicarb followed by demeton-S-methyl spray on 2 July increased yield by 31% (Table 1).

At Leaden Roding aldicarb also gave good control of *M. persicae*. At the time of the Spray Warning, 5 June, there were 6 and 0·3 wingless *M. persicae*/plant on the untreated and aldicarb-treated beet respectively. Sixteen days later, on 21 June, there were 13/plant on the untreated plots; aldicarb decreased numbers 93%. Demeton-S-methyl and pirimicarb on 5 June without aldicarb decreased numbers 84 and 87% respectively. *A. fabae* had started to colonise the plants by this time; on 21 June aldicarb decreased the numbers of wingless *A. fabae* by 98% and this effect was reflected in the later counts. The demeton-S-methyl and pirimicarb sprays on 5 June decreased numbers 92 and 96% respectively, although *A. fabae* were rare at the time of spraying; unlike the aldicarb effect, this was lost within the next 20 days. The 8 July sprays which were to plots treated with aldicarb, improved on the control given by aldicarb and the effect persisted to 18 July; thereafter *A. fabae* populations declined (Table 2).

Yellows incidence (infected-plant-weeks) was decreased 9% by aldicarb and 13% when aldicarb was followed by the 8 July sprays. The 5 June sprays decreased yellows 5%. Sugar yield was improved 15% by aldicarb and a further 11 and 7% respectively when

TABLE 1

Effect of aldicarb granules and spray treatments on virus yellows incidence and yield at Broom's Barn and Leaden Roding (Essex)

aldicarb granules (1120 g a.i./ha in seed furrow)	Spray treatment	Broom's Barn: Spray date	Broom's Barn: Virus yellows incidence (IPW)	Broom's Barn: Sugar* yield (% increase)	Leaden Roding: Spray date	Leaden Roding: Virus yellows incidence (IPW)	Leaden Roding: Sugar* yield (% increase)
−	—	—	1055	0	—	1267	0
+	—	—	963	21	—	1149	15
−	demeton-S-methyl (early)	29 May	1031	0	5 June	1209	4
+	demeton-S-methyl (late)	2 July	886	31	8 July	1107	26
−	pirimicarb (early)	29 May	1033	2	5 June	1205	6
+	pirimicarb (late)	2 July	931	23	8 July	1106	22
SED ±	—	—	22·3	5·3	—	41·0	5·1

* Sugar yields on untreated 5·48 and 4·07 t/ha

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aldicarb was followed by demeton-S-methyl and pirimicarb sprays on 8 July. The 5 June sprays of demeton-S-methyl and pirimicarb improved sugar yield 4 and 6% (Table 1). (Dunning and Winder)

TABLE 2

Effect of insecticides on aphid populations at Leaden Roding

aldicarb in seed furrow	Spray treatment	Wingless aphids/plant			
		Green	Black		
		21 June	21 June	11 July	18 July
—	—	13·1	21·2	257·5	86·9
+	—	1·0	0·4	42·4	13·5
—	demeton-S-methyl (5 June)	2·2	1·8	254·7	213·5
+	demeton-S-methyl (8 July)	1·0	0·4	14·3	8·4
—	pirimicarb (5 June)	1·7	0·8	211·3	92·9
+	pirimicarb (8 July)	1·0	0·4	9·2	9·5

A trial at Broom's Barn drilled on 19 July with rubbed and graded Sharpe's Klein E seed compared aldicarb and 'DS 15647' granules, applied in the furrow with the seed, with demeton-S-methyl spray and with menazon seed dressing (4% a.i. by wt. of seed) as used commercially on sugar-beet stecklings. The seedlings emerged within a few days of sowing. *M. persicae* was rare but *A. fabae* infested the seedlings as they emerged. Aldicarb (2242 g a.i./ha) was the most effective treatment with almost complete control of *A. fabae* for at least 54 days; it was the only treatment to significantly decrease yellows but was also the only treatment to decrease seedling numbers (24%). Aldicarb (560 g) and 'DS 15647' (560 g) decreased *A. fabae* numbers by at least 94% for the first 14 days after sowing. Thereafter the effects were more variable but the numbers were still 90 and 85% below those on the untreated plots at 54 days. Aldicarb (140 g) and 'DS 15647' (140 g) were less effective, less persistent and more variable in effect than the higher rates. Initially menazon seed-dressing was intermediate in effect between the 140 and 560 g a.i./ha granule rates; it gave good control of *A. fabae* up to 14 days after sowing, but 22 days after sowing numbers were 65% of those on the untreated beet. Demeton-S-methyl applied 14 days after sowing decreased aphid numbers by 94% but was of short persistence; there were the same numbers of *A. fabae* as on untreated plots within eight days of spraying. (Winder)

Several trials tested pesticides on soils containing large populations of nematodes. Since the soil remained relatively dry throughout the spring nematodes were inactive and the treatments had more effect on aphids and yellows than on nematodes.

At Horsford, Norwich, aldicarb, oxamyl and carbofuran at 280 and 1120 g a.i./ha were sown in the seed furrow on a sandy loam where Docking disorder was expected. On the untreated plots 79% of the seeds sown produced seedlings; aldicarb, oxamyl and carbofuran increased seedling numbers 3, 0; 8, 11; 18 and 11% respectively at the two rates of application. The trial was sprayed with demeton-S-methyl on 3 June. On 4 June there were 4·7 living wingless *M. persicae*/plant on the untreated plots and 1·6, 0·8; 1·2, 1·7; 4·7 and 4·0 respectively on the treated plots. Aldicarb decreased yellows (infected-plant-weeks) by 12 and 22%, oxamyl by 4 and 6% but carbofuran not at all.

Other granular pesticides sown in the seed furrow were also compared at the same site at 280 and, in some cases, 1120 g a.i./ha. The percentage increases (+) or decreases (−) in seedling numbers due to treatment were: aldicarb +11, +16; 'SD 8832' +8, −60; 'AC 92100' (280 g only) −14; 'AC 64475' −16, −65; isofenphos (280 g only) +16, and 'DS 15647' +13, −14. Neither trial was harvested. (Winder and Dunning)

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Three trials, on peat near Ely, loam near Ipswich, silt near Spalding, where the previous crop had suffered from damage by stem eelworm (*Ditylenchus dipsaci*) tested three rates (0·28, 0·56, 1·12 kg a.i./ha) of aldicarb and oxamyl applied in the seed furrow. No symptoms of stem eelworm damage developed but aldicarb controlled early aphid attack and delayed infection with yellows, and increased root yield and sugar content (Table 3).

Three trials tested the same materials but at three different rates (2·8, 5·6, 11·2 kg a.i./ha) broadcast and rotovated into peat (two near Ely and Wissington) where beet sick patches had previously occurred. Spread of yellows was delayed at all sites and the yield and sugar percentage increases (Table 3) were probably largely due to this rather than controlling cyst eelworm because at the Wissington trial no cysts were found on beet roots from any plot, but aldicarb increased yield to a similar extent as on the other two trials. (Cooke)

TABLE 3

Effect of aldicarb and oxamyl on sugar yield

	Stem eelworm sites (mean of three)		Cyst eelworm sites (mean of three)	
Materials	Rate (kg a.i./ha)	Sugar yield (t/ha)	Rate (kg a.i./ha)	Sugar yield (t/ha)
None	0	6·20	0	5·05
oxamyl	0·28	6·20	2·8	5·12
oxamyl	0·56	6·56	5·6	4·98
oxamyl	1·12	6·45	11·2	5·17
aldicarb	0·28	6·82	2·8	5·21
aldicarb	0·56	7·02	5·6	5·43
aldicarb	1·12	7·05	11·2	5·59

Resistance to aphicides. Field reports of apparent inefficiency of aphicides in 1973 led to surveys and trials in 1974, and to submission of samples of *M. persicae* from fields both before and after treatment with aphicides to the Insecticides Department.

Infestation of *M. persicae* on sugar beet was earlier and more severe than for many years and aphicides were used extensively, often under adverse conditions. Fieldmen reported that most cases of apparent failure of control or of very short persistence of effect were in East Anglia; all commonly-used materials were implicated, demeton-S-methyl, pirimicarb, phosphamidon, dimethoate and formothion.

In a field at Mepal, Cambs., three sprayings of formothion by the farmer at the recommended 416 g a.i./ha failed to control *M. persicae*; these aphids were subsequently shown to have resistance to some organo-phosphorus compounds (see p. 145). A trial there compared recommended field doses of demeton-S-methyl, pirimicarb, formothion, permethrin and omethoate sprayed at 438 litre/ha on 26 June when there were 470 wingless *M. persicae* and 56 *A. fabae*/plant. Seven days later there were 522 *M. persicae* and 43 *A. fabae* on the untreated plots; treatments decreased the numbers of the two aphids as follows: permethrin (560 g a.i./ha) 96%, 91%; pirimicarb (140) 93%, 86%; demeton-S-methyl (245) 92%, 95%; omethoate (405) 79%, 93%; formothion (415) 28%, 65% respectively. Counts two days after spraying were similar except that they showed omethoate to be slower acting than the other materials tested.

A further trial tested some aphicides currently used on sugar beet and some possible alternatives sprayed at 438 litre/ha on to sugar-beet stecklings at both one-tenth and the full recommended field dose for the root crop. *M. persicae* did not invade the crop but *A. fabae* were numerous. The kill on day two from a full dose of demeton-S-methyl (245 g a.i./ha), pirimicarb (140) and permethrin (490) was over 90%, with dimethoate

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(350), methomyl (245) and propoxur (560) 50–75%, but with formothion (420) only 20%. *A. fabae* numbers rose above the control levels between days six and 11 after spraying with the full dose of demeton-S-methyl and between days two and six with the full doses of the other materials. None exceeded 200% of the control except permethrin which reached a peak of 560% between days two and six; this effect was probably due to killing coccinellids which were numerous, but is a surprising effect on small plots (2·5 × 5·5 m).

At one-tenth full dose demeton-S-methyl, pirimicarb and permethrin decreased aphid numbers 75, 40 and 35% respectively on day two; the effect was lost by day six with pirimicarb and permethrin and day 12 with demeton-S-methyl. The remaining treatments at one-tenth dose had more aphids than the control on day two and thereafter. Yellows incidence at the end of August and the beginning of October did not differ significantly from the control. (Dunning and Winder)

Aphid predators. In a year of heavy infestation of sugar beet with aphids the comparatively small population of *M. persicae* (never exceeding 0·75 apterae/plant on unsprayed plots between 30 May and 5 July) on Little Lane field suggested a possible abundance of predators. The soil surface within a 10 cm radius of plants was searched on 5 July to obtain a comparative estimate of numbers of diurnal aphid predators in the crop; there were no coccinellids but the carabid *Trechus quadristriatus* averaged 0·63/plant zone and was sometimes found on the leaf bases. On the same date and a few days later at Leaden Roding (Essex), the red velvet mite, *Allothrombium fuliginosum* (Prostigmata), was active on the foliage of sugar-beet plants, averaging respectively 4·4 and 2·6/plant with no insecticide treatment and observed to be feeding on *M. persicae*. At the two sites, aldicarb (1·1 kg a.i./ha) in the seed furrow, both with and without demeton-S-methyl spray (0·2 kg a.i./ha applied on 2 July at Broom's Barn and on 5 June at Leaden Roding), significantly decreased numbers of mites on the foliage ($P < 0·001$) but pirimicarb spray (0·1 kg a.i./ha) applied on the same dates had no effect. Only at Broom's Barn did demeton-S-methyl alone significantly decrease numbers of mites. These effects may have been direct or indirect. (Baker and Dunning)

Consumption of both *M. persicae* and *A. fabae* by different predators was compared in a laboratory experiment. The adult aphids were offered on small sections of sugar-beet leaf on which they were feeding and numbers of aphids consumed recorded for between six and 34 consecutive 24-h periods. The consumption of *M. persicae*/24 h/beetle was: *Bembidion lampros* 5·8; *T. quadristriatus* 6·2; *Notiophilus biguttatus* 6·2. When *M. persicae* was no longer available from the field, *A. fabae* was offered to the same beetles. Fewer were eaten by all the carabid predators, viz: 1·6, 0·6, 1·6/beetle/24 h for each species respectively, but *Coccinella septempunctata*, now available from the field, ate a mean of 18·1/24 h. In comparison, the mite *A. fuliginosum* consumed only 1·5 *M. persicae* or 0·3 *A. fabae* in the same period; although this is only about one-quarter the consumption rate of carabid beetles their larger numbers on the foliage of sugar-beet plants may make them of significant value as aphid predators in the crop. (Dunning and Partington)

Leaf diseases

Late summer fungicide sprays. To continue the study of the effects of fungicide sprays on leaf survival and senescence, fentin hydroxide at 0·5 kg a.i./ha was sprayed once, twice or thrice between 23 August and 26 September on beet var. Amono, and benomyl at 0·42 and 'Bayer 6660' at 0·25 kg a.i./ha were sprayed once or thrice. All plants were infected with yellowing viruses before spraying began, and powdery mildew developed rapidly in late August and early September. However, the very wet weather in September

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and October made powdery mildew scarce by harvest on 6 November when, on average, it covered 6% of the leaf surface of unsprayed plants compared with 1–2% on plants sprayed with fentin hydroxide or benomyl, and 0·01% on plants given one spray with 'Bayer 6660' on 23 August. All sprays decreased *Sporobolomyces* sp. activity on the leaf surface, benomyl having most effect. *Sporobolomyces* sp. activity on stecklings in October was increased by powdery mildew infection but not by yellows. Sprays had little effect on top yield, but one, two or three fentin hydroxide sprays, and one or three sprays with benomyl or 'Bayer 6660' increased sugar yield by 8, 8, 7, 3, 9, 2 and 0% respectively compared with unsprayed plants. (Byford and Bentley)

Docking disorder

The exceptionally dry weather in April and May greatly restricted the activity of the ectoparasitic nematodes *Trichodorus* and *Longidorus* in the free draining sands in which they are widespread and may cause Docking disorder. Consequently few nematodes attacked seedling roots during the period when their feeding is most damaging to the crop. This, together with the continuing increase in the use of nematicides (especially the non-volatile systemic compounds aldicarb and oxamyl which are largely replacing the fumigants 'Telone' and 'D-D' for Docking disorder control), resulted in the smallest reported incidence of Docking disorder since records began in 1963. The 41 ha reported in June were mostly (21 ha) in Yorkshire; slightly more was reported in May (103 ha) and July (92 ha), again mostly in Yorkshire.

Several nematicide trials have yielded little information about the effects of the chemicals on nematodes, but they have given interesting effects against aphids and yellows, so are recorded under the heading 'Control by Insecticides' on p. p54–55.

Population dynamics. Numbers of *Trichodorus* (*T. anemones* and *T. primitivus*) and *Longidorus* (*L. leptocephalus* and *L. elongatus*) were assessed at regular intervals for a third year at two sampling points in three differently cropped fields at Wilberfoss, Yorks., and Gleadthorpe, Notts. *Trichodorus* were consistently more numerous in the samples with least silt + clay fractions and consequently smallest water holding capacity, and changes in numbers were closely related to the moisture content of the soil. For example, in the sandiest sampling point in the field cropped with sugar beet, numbers of *T. anemones* extracted from the surface 20 cm of soil fell steadily from 2900/litre in March to nil in July but rose again to 2050/litre in November when soil moistures were respectively 14·5%, 3·3% and 13·2%. Similar changes occurred under barley and potatoes but, as in previous years, populations remained smaller after potatoes than after sugar beet or barley. *Longidorus* were relatively few at all sampling points. The most were 45/litre in the sugar-beet field and 40/litre under grass ley in March; during the summer *Longidorus* were too few to detect but they increased slightly to 38/litre in September under ryegrass.

Crop growth in relation to nematode population. Five trials investigated the relationship between *Trichodorus* numbers after drilling and at harvest, soil texture and root yield and shape. In each trial widely separated plots in commercial sugar-beet fields were sampled after drilling and at harvest. The trial (Yorkshire II) on the lightest soil (average silt + clay 11·2%) and with the greatest *Trichodorus* population (over 1069 *T. anemones*/litre soil) was damaged by wind and was ploughed in. The dry soil in May prevented any serious nematode damage on the other trials; no Docking disorder symptoms were apparent during summer and there was no significant relationship between nematode

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numbers and root yield or shape. The two Yorkshire trials were on light sands (silt + clay ranged between 8 and 15%) and numbers of *Trichodorus* (mostly *T. anemones*) were not related to soil texture. In the trial on the heaviest soil (Lincolnshire: silt + clay between 20 and 37%) *T. primitivus* were few and occurred only in plots with less than 24% silt + clay. At King's Lynn II, silt + clay was between 10 and 20% and numbers of *T. pachydermus* were not related to soil texture; at King's Lynn I, silt + clay was 20–29%, *T. viruliferus* were few but more numerous in the lightest soil. (Cooke)

Seed production

Diseases in seed crops. In June, 74 sugar-beet seed crops distributed throughout the seed growing areas averaged 7·1% of plants with virus yellows and 0·01% of plants with downy mildew. Virus yellows was most prevalent in open *in situ* crops which, in Befordshire had up to 52% (average 26%) plants infected, and in Oxfordshire up to 21% (average 17%). Some of the heavily infected crops had shown symptoms in October, while others had not. Some seed crops raised under cereal cover crops in Holland, Cambridge and Essex had up to 9% (average 3%) yellows, but those in Kesteven were almost free.

In October, 147 sugar-beet steckling beds averaged 0·8% plants with yellows. Open *in situ* beds in Oxfordshire and Gloucestershire had less than in 1973, but of 111 beds raised under cereal cover crops in the eastern counties 26 had between 1 and 6% plants with yellows. A few plants had downy mildew. Six mangold and red-beet steckling beds in Essex averaged 5% yellows. (Byford)

Factors affecting seed yield

Nitrogen fertiliser. In two field experiments, one on shallow oolitic limestone soil at Stonesfield, Oxon., the other on deep fertile silt at Thorney, Isle of Ely, nitrochalk at 250 kg N/ha was top-dressed on to sugar-beet seed plants in February, March, April or May or in split applications totalling 250 kg N/ha in February and March, March and April, April and May or February and May. Petiole nitrate concentrations increased greatly in the month following N-application and then steadily declined. Values for plants grown at Thorney always exceeded those for plants grown at Stonesfield, where plants which received N in February had less than 100 ppm nitrate N in petioles in June. Even so, it was not possible to relate petiole nitrate values to seed yield. At Thorney most seed came from plants given N as a single dose in April or a split application in March and April, but these effects were not significant. At Stonesfield most seed came from plants given N as a single dose in February or March or split applications in February or May or April or May, although against effects were not significant. There was also a tendency at Stonesfield for February application of N to give maximum yield several weeks earlier than split application in February and May although the latter gave more seed.

Roots or shoot removal. Tap roots were chopped off with spades to leave stecklings about 75–100 mm long, or shoots were mown off, or both or neither treatment were made either in November 1973 or March 1974 to plants growing *in situ* at Spelsbury, Oxon. Considerable differences in crop growth resulted. Shoot removal, particularly in combination with tap-root removal, gave much dwarfed plants which were noticeably greener. At harvest each plot was split for three times of cutting at weekly intervals. Removing shoots did not affect seed yield but cutting off the roots reduced it greatly, more so when done in the spring. Optimum harvest date was delayed a little by shoot

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removal and much by root cutting. The greatest yield of seed came from untreated plants harvested early.

Factors affecting seed performance. Field experiments evaluated the effects of seed crop agronomy, seed pelleting, soil temperature and seed placement in the soil on the numbers and weights of seedlings which emerged.

Seed crop cultural practices. The number and average weight of seedlings were unaffected by irrigating the mother seed crop. Heavier seedlings occurred when nitrogen had been applied in March to the seed crop grown at Charlbury, but the crop grown at Long Buckby gave seed which produced more seedlings when the nitrogen was applied in February. More seedlings emerged when roots had been chopped off seed-bearing plants. Ethephon and chlorflurecolmethyl, applied to try to dwarf seed crops, reduced seedling numbers but not weights.

Pelleting. Pelleted seed coated with 2·5% agar gave some extra seedlings at Broom's Barn and significantly more at the Plant Breeding Institute, Cambridge. Sodium perborate in the pellets reduced seedling numbers at both sites. Progressive increase in pellet diameter gave progressive increase in seedling numbers both at Broom's Barn and at the Plant Breeding Institute. However, it was found that larger pellets contained the larger seed and it is thought that seed size, rather than pellet size, produced the different seedling numbers (*Rothamsted Report for 1969*, Part 1, 325).

Soil temperature. Pyramids 1 m high with 38° slopes facing north, south, east and west were made in the field to study temperature effects on seedling emergence and growth. On average during March, April and May the soil on the south facing slope was 4°C warmer at 25 mm depth than on the north slope at 16.00 h GMT. The east and west slopes had intermediate temperatures. At most, on the bright sunny 8 May, the south slope was 8·5°C warmer than the north. During the night and for large parts of dull days temperatures were similar on all faces. Seedlings appeared first on the south slope and, although final emergence percentages after 80 days were similar on all slopes, seedlings on the south slope were 52% heavier than those on the north.

Seed placement in the soil. Two Stanhay drill units were modified at the National Institute of Agricultural Engineering so as to be able to vary the opening made in the soil, the covering and pressing of soil around the seed. Sugar-beet seed was sown in the field on two occasions and cauliflower and lettuce seed provided by the National Vegetable Research Station on one date. Most treatments tested gave fewer or similar numbers of seedlings to those from an unmodified drill unit, but angled rear press wheels, the coulter which left a sheared soil surface, pressing the seed into the soil before covering and extra weight on the press wheel, often gave more seedlings. (Longden)

Sugar-beet manuring

The field experiments described here testing phosphorus, potassium, sodium and soil structure, and magnesium were done in co-operation with staff of the British Sugar Corporation in 1973.

Phosphorus. Five experiments measured response to 0, 14, 28, 56 and 112 kg P/ha on fields adequately fertilised with nitrogen, potassium and sodium. The fields were chosen by soil analysis so that the sodium bicarbonate-extractable soil P values were in the range 0–9 or 10–15 ppm (ADAS indices 0 and 1). Phosphorus greatly increased yield in each of the five experiments, again indicating that this method of analysis is a reliable

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guide to responsive fields. It was difficult, however, to decide the optimum dressing for sugar-beet crops grown on these fields and more experiments are in progress. So far, the experiments suggest that about 50 kg P/ha would be adequate for maximum yield, but as the cost of phosphate rock has quadrupled during the past 18 months, it is important to determine as precisely as possible the minimum requirement.

Potassium. Five experiments measured response to 0, 42, 84, 168 and 336 kg K/ha, with or without 377 kg/ha of agricultural salt (0 or 150 kg Na/ha) on fields adequately fertilised with nitrogen and phosphorus. The soils were in the range 0–60 or 61–120 ppm ammonium nitrate-exchangeable K (ADAS indices 0 and 1). As usual both elements greatly increased root yield and sugar percentage. Sugar-beet crops on soils in these groups need at least 100 kg K/ha plus 150 kg Na/ha; a large and profitable response is nearly always assured.

Sodium, potassium and soil structure. The background and objects of these experiments have been described in *Rothamsted Report for 1973*, Part 1, 268–269. Four more were done on similar soils on the same or neighbouring farms as previously. Sodium and potassium chloride were applied in factorial combination at 0, 83 and 333 kg K/ha and 0, 150 and 300 kg Na/ha; half the plots were dressed in autumn before ploughing and half in spring, two to three weeks before sowing.

None of the fertiliser dressings affected the number of seedlings which established. This was unusual since large seedbed dressings of fertiliser usually depress establishment by decreasing water uptake by the seed. Presumably the moist conditions after drilling prevented this osmotic effect even with double dressings of fertiliser. Staff of ADAS examined the soils in the field and found no visible effect of any of the fertiliser applications on the soil structure in spring.

Sodium increased yield considerably at Ipswich and Cantley but only slightly at Felsted and Spalding. Response to potassium was small on all four fields. Response was consistently greater to autumn application of fertiliser. Despite its mobility in soil, sodium is clearly very effective when given before ploughing, although in the winter preceding these experiments there was little excess of rainfall over evaporation and transpiration. The experiments are being continued to discover whether loss of sodium due to winter leaching is serious in wet winters. On present evidence there seems little doubt that autumn application of sodium (150 kg/ha) and potassium (83 kg/ha) is quite acceptable on these soils. A review of recent co-operative experiments with British Sugar Corporation was published this year (see Paper No. 19) which gives an account of the sodium and potassium requirements of sugar beet in relation to soil texture, soil analysis, weather and various agronomic practices.

Long-term magnesium. Five new experiments were begun designed to compare response to different forms of magnesium and different times of application over a four- or five-year period. Fields were chosen where the soil contained a small concentration of exchangeable magnesium (10–29 ppm Mg); they were all sandy loams or loamy sands so magnesium deficiency was likely. The soil pH values were in the range 6·4–8·0.

Sugar beet was the first crop to be grown in all the experiments and an adequate dressing of N, P, K and Na fertiliser given. The magnesium fertiliser treatments are shown in Table 4.

Sugar yields in the autumn of 1973 showed that crops on three of the five fields responded to magnesium fertiliser. Autumn and spring applications of kieserite were equally effective on average, but calcined magnesite was most effective when given in the previous autumn. In future years these experiments will give much-needed information on the residual value of the different forms of magnesium. A report is in the press

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TABLE 4

Fertilisers tested in the long-term magnesium experiments

	Autumn 1972	Spring 1973 (sugar beet)	Autumn 1975	Spring 1976 (sugar beet)
A	Nil	Nil	Nil	Nil
B	Nil	Nil	Nil	625 kg/ha kieserite
C	625 kg/ha kieserite	Nil	Nil	Nil
D	625 kg/ha kieserite	Nil	312 kg/ha kieserite	Nil
E	625 kg/ha kieserite	Nil	625 kg/ha kieserite	Nil
F	188 kg/ha calcined magnesite	Nil	Nil	Nil
G	188 kg/ha calcined magnesite	Nil	188 kg/ha calcined magnesite	Nil
H	375 kg/ha calcined magnesite	Nil	Nil	Nil
I	3·77 t/ha coarse Mg limestone	Nil	Nil	Nil
J	3·77 t/ha fine Mg limestone	Nil	Nil	Nil
K	Nil	625 kg/ha kieserite	Nil	Nil
L	Nil	625 kg/ha kieserite	Nil	312 kg/ha kieserite
M	Nil	625 kg/ha kieserite	Nil	625 kg/ha kieserite
N	Nil	188 kg/ha calcined magnesite	Nil	Nil

describing other experimental work on the availability to arable crops of magnesium from kieserite and two forms of calcined magnesite.

Plant nutrients

Time and method of application of fertilisers

Nitrogen. A similar experiment on Little Lane field to those made previously (*Rothamsted Report for 1973*, Part 1, 270) compared 75, 150 and 225 kg N/ha applied before ploughing during October with the same amounts applied in the spring, and with 150 kg/ha applied before ploughing plus 36 kg/ha applied in spring. Nitrogen did not increase sugar yield in this experiment which is unusual at Broom's Barn, but probably a consequence of the two previous autumns, winters and springs being relatively dry. The nitrogen did however depress sugar percentage as usual, the spring application more than the autumn application. The yields were in accord with periodic petiole nitrogen tests made throughout the growing season; these showed that plants on control plots given no nitrogen contained over 500 ppm nitrate-nitrogen in June which appears to be sufficient to ensure maximum sugar yield. All the fertiliser dressings increased petiole nitrate greatly during July, August and September but there was no commensurate increase in sugar yield. (Draycott)

K and Na. Examination of results of experiments made between 1957 and 1969 (see paper No. 19) indicated that the response to K and Na fertilisers depends on time of fertiliser application, sowing date and spring rainfall. To investigate this further a new experiment testing 0, 50, 150 and 250 kg K or Na/ha, given one or 28 days before two sowing dates (22 March and 2 May) was made on Marl Pit field.

Eighty per cent of seeds sown on 22 March were eaten by mice and were resown. Sowing in May decreased sugar yield by 0·55 t/ha. K fertiliser had little effect on yield and 50 kg Na/ha was sufficient for maximum sugar yield. Response (sugar t/ha) to 50 kg Na/ha was:

	Sowing date	
	22 March	2 May
Na applied 28 days before sowing	+ 0·50	+0·35
Na applied one day before sowing	+0·32	+0·08

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suggesting that response was greatest when the fertiliser was applied well before sowing. (Durrant)

K, Na and seed advancement. Previous laboratory and field experiments (*Rothamsted Report for 1973*, Part 1, 271) have shown that Na and K fertilisers, when concentrated near sugar-beet seed, depress germination. An experiment on Marl Pit field tested all combinations of 0 and 250 kg K or Na/ha and two seed treatments on emergence, growth and plant water status. The seed was either rubbed and graded in the usual way or rubbed, graded and 'advanced' by soaking in water for 48 h at 15°C and then air-drying. Due to the cold and dry spring, seedlings emerged slowly and erratically, taking 45 days to establish only 34–40% of seeds sown. Seed advancement slightly increased both the rate of emergence and the number of seedlings, whereas giving K and Na had the reverse effect. The increase in yield from seed advancement ranged from 50% at the seedling stage to 12% from beet at final harvest on 4 October.

Giving Na increased yield more than giving K. It did so by increasing the leaf area early in the season, increasing leaf efficiency at times of water stress, proportioning more of the total dry matter to the roots and giving more sugar in fresh and dry root matter. The measurements confirmed the relatively small leaf water potentials of sugar beet; for example, on 3 July when the soil was near field capacity and measurements were made between showers, leaf water potentials were about −8 bar. (Durrant and Milford)

Manganese. Experiments with manganese applied to sugar beet as foliar sprays of $MnSO_4$ or MnO or Mn frit incorporated in the seed pellet were continued. At Wissington the soil contained 2·2 ppm exchangeable Mn (Ex Mn) and 40·7 ppm easily-reducible Mn (E/R Mn). No plants showed manganese deficiency symptoms probably because the soil was acid (pH 5·7); no treatment affected the yield.

At Ely the soil contained 2·0 ppm Ex Mn, 68·0 ppm E/R Mn and the pH was 7·2. Forty per cent of plants not given manganese had deficiency symptoms in June but not as severely as in previous years. Two sprays and MnO in the seed pellet decreased the symptoms, three sprays completely cured them but the frit had no effect. In May, both seed pellet treatments significantly increased the seedling dry weight and the concentration of Mn in dry matter. Manganese deficiency symptoms declined at the end of July and at harvest the treatments had no significant effect on sugar yield.

Adjacent to the experiment at Ely, foliar sprays of 1120 litre/ha of 0·1% aqueous $MnSO_4$ or Mn EDTA were tested. There was no significant difference between the chelate and $MnSO_4$ in their effect on manganese deficiency symptoms or crop growth. Manganese sprayed once increased the plant dry weight in July but the second spray had no effect, probably because it was applied late in July when manganese deficiency symptoms were already declining. It increased the concentration of manganese significantly more than manganese sprayed once but at harvest did not significantly affect the yield.

Two experiments, one on organic Fen at Isleham, near Ely, and the other on Breckland at Attleborough, tested applications of solid $MnSO_4$ or MnO given in sufficient quantity to increase the E/R Mn fraction of the soil to 85 ppm, and Mn chelate to increase the Ex Mn to 1·32 ppm. These were critical concentrations above which sugar beet did not show signs of manganese deficiency in previous experiments.

Before fertiliser was applied the soil at Ely contained 1·13 ppm Ex Mn, 28·0 ppm E/R Mn and the pH was 7·2. At Attleborough the soil was pH 7·9, Ex Mn 0·59 ppm and E/R Mn 18·7 ppm. The soil treatments were compared with three foliar sprays of $MnSO_4$, each of 5 kg Mn in 550 litre/ha given ten days apart, the conventional practice for curing manganese-deficient sugar beet.

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Manganese was always more concentrated in mature than in young leaves. The concentration of manganese in the crowns was large but small in petioles and roots. The spray increased the manganese concentration in all plant organs in June but had no effect from July onwards, and manganese deficiency symptoms reappeared on a few plants. Soil application of $MnSO_4$ and MnO completely prevented manganese deficiency and always more than doubled the concentration of manganese in all parts of the plant. The chelate had no effect on the concentration of manganese in any plant organ or in soil.

The Ex Mn in both soils given each of the manganese treatments and the E/R Mn in the organic soil given MnO or $MnSO_4$ decreased rapidly but this fraction in the mineral soil remained fairly constant. The E/R Mn in the other three treatments of the organic soil increased from May to June and then gradually decreased to its former value. MnO and $MnSO_4$ increased all fractions of soil manganese. At both sites $MnSO_4$ and MnO in the seedbed increased yield slightly more than did the foliar sprays but the chelate had no effect.

Copper. Seedbed dressings of 12 kg/ha Cu as $CuSO_45H_2O$, 0·25 and 0·50 kg/ha Cu as Cu-EDTA were tested again this year with spring barley, variety Julia, at Broom's Barn on Flint Ridge field. The soil contained 1·98 ppm 'available' copper extracted with 0·05M EDTA-Na_2. None of the treatments affected the yield of grain or straw, or 1000 grain weight. Copper sulphate significantly increased the concentration and uptake of copper by grain but the chelate had no effect. It is concluded from this and earlier experiments in 1972 and 1973 that soils on Broom's Barn are adequately supplied with copper as a trace element for cereals.

Magnesium and boron. Soil from the long-term experiment on Brome Pin field (*Rothamsted Report 1970*, Part 1, 271) was sampled and analysed for exchangeable magnesium and water-soluble boron in March 1974. Soil given kieserite contained 33 ppm Mg, calcined magnesite 31 ppm Mg, magnesium limestone 27 ppm Mg and no magnesium 19 ppm Mg. Again the very dry autumn and winter resulted in little leaching and, as a result, the water-soluble boron had not changed since 1972. The experiment was sown with spring wheat, variety Maris Dove, and none of the treatments affected the yield of grain or straw. (Farley)

Irrigation

Irrigation and nitrogen. A further experiment tested six dressing up to 207 kg N/ha, this time on the shallow calcareous loam of Marl Pit field. On three blocks the crop was irrigated to limit the soil moisture deficit to 40 mm, and a total of 90 mm was applied; the other three blocks had none. The object of this study is to test whether the amount of nitrogen fertiliser needed for maximum sugar yield is decided by environmental factors early in the growing season.

During May and June there was no clear optimum dressing because yields were erratic due to irregular emergence and poor plant stand. In July 80 kg N/ha was sufficient for maximum storage root production as it was throughout the autumn. The crop was severely stunted by virus yellows from July and did not recover. For maximum final sugar yield 80 kg N/ha was the optimum dressing both with and without irrigation.This is the same result as last year when the average yield was twice that of 1974.

Periodic soil moisture measurements with the neutron probe showed that root growth was slower than in several previous seasons. In April water was extracted to 20 cm by bare soil evaporation but the total deficit was only 9 mm, due to small leaf cover. At the end of June, the measured deficit under the sugar beet was still only 25 mm, whereas the calculated potential deficit was 145 mm. The maximum soil moisture deficit was on

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5 August reaching 80 mm on plots given 207 kg N/ha and no irrigation. In mid-August the maximum depth to which roots extracted water was 105 cm compared with 140 cm in 1973, probably a consequence of the severe attack of virus yellows. (Last)

Time and amount of irrigation. The fourth year of this experiment on a clay loam on Windbreak field was similar to previous years (*Rothamsted Report for 1971*, Part 1, 287) but as the August and September rainfall was greater than average, only the June and July applications of 25 mm each were given. Rainfall during March, April and May was less than half the average and the single watering in June and that in July gave sugar yield responses of 0·18 and 0·25 t/ha respectively. Applications on both occasions increased sugar yield by 0·50 t/ha. All three irrigation treatments not only increased root yield but, unlike previous years, also increased sugar percentage by 0·5%. Previously irrigation has generally depressed sugar percentage but in 1974 sugar beet was short of water early in the season. This year irrigation benefited the crop by increasing the rate of establishment of leaf cover, not by increasing growth later in the season. This probably explains the increase in sugar percentage from irrigation rather than the more usual decrease. (Messem)

Plant spacing

Time of sowing and seed spacing. An experiment on Marl Pit field tested the effect of time of sowing on seedling establishment and yield of the varieties Bush Mono G and Sharpe's Klein Megapoly when drilled-to-a-stand. Sowing dates were (S1) 20 March, (S2) 8 April or (S3) 1 May with seed spacing at 12·5, 15·5 or 18·5 cm. Mean seedling establishment was S1, 61% of seeds sown, S2, 71% and S3, 70%. Early sowing gave the largest sugar yield of both varieties, average 5·03 t/ha, and yield increased with plant density. (Webb)

Row width. A factorial experiment compared three row widths, 38, 51 and 64 cm, at three densities, 45 000, 80 000 and 110 000 plants/ha, established either by drilling-to-a-stand or hand thinning to produce the same plant density more uniformly spaced. At harvest, plots drilled-to-a-stand had approximately 15% more plants than the hand thinned as a result of seeds germinating late. Averaged over other treatments, progressively increasing row widths produced 5·55, 5·36 and 4·94 (SED ± 0·114) t/ha of sugar respectively. Increasing plant density gave increasing sugar yields of 4·86 to 5·48 and 5·51 t/ha (SED ± 0·158). Drilled-to-a-stand plots produced a mean of 5·41 t/ha sugar compared with 5·15 t/ha from the hand thinned. These significant differences in sugar yield resulted from differences in both root yield and sugar concentration. (Jaggard)

Time of sowing and harvesting. An experiment testing three times of sowing and two times of harvesting at four plant densities produced the sugar yields shown in Table 5.

TABLE 5

Sugar yield (t/ha) from different sowing and harvesting dates at four plant densities

	Harvest date									
	25 September Plants ('000/ha)					5 December Plants ('000/ha)				
Sowing date	50	75	100	125	Mean	50	75	100	125	Mean
20 March	5·50	5·98	6·55	6·70	6·18	6·31	6·86	7·55	8·18	7·23
8 April	4·95	5·40	5·95	6·13	5·61	5·27	6·10	6·81	7·00	6·30
1 May	4·01	4·68	5·00	5·54	4·81	4·71	5·58	6·16	6·21	5·67
Mean	4·82	5·35	5·83	6·12	5·53	5·43	6·18	6·84	7·13	6·40

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The stands of 50 000 and 75 000 plants/ha were grown in rows 50 cm apart, and those of 100 000 and 125 000 plants/ha in beds of five rows, 25 cm apart.

Early sowing gave the largest sugar yield. Sugar yield increased with plant density throughout the range tested for all sowings and at both harvests. On average, sugar yield increased only 0·87 t/ha in the two months between harvests. Plants from the first and third sowings at all densities of stand were sampled and analysed for growth five times between 17 June and 16 September. The early sown crop produced the larger leaf area index(LAI) until mid-July, and maintained a larger growth rate to this date than the late sown crop. The densest stands also had large LAI's and growth rates early in the year, and these early differences in root weight persisted to final yield. (Jaggard and Webb)

Beet on ridges. An experiment on Little Lane field tested different methods and depths of seedbed preparation both on the ploughed land and on ridges set up in the autumn. Emergence from seeds sown at 7·5 cm or 15 cm spacing on 26 March was slow and erratic and more than half the seed was damaged by mice. Final plant populations ranged up to 54 000/ha. Sugar yields averaged 4·85 t/ha with differences largely attributable to plant density which was related to the extent of mouse damage rather than the treatments applied. (Webb)

Green manuring

The object of this investigation and the treatments tested are described in *Rothamsted Report for 1973*, Part 1, 274. An experiment on Marl Pit field was cropped with barley in 1973, when undersowing with ryegrass or trefoil marginally depressed grain yields. In 1974, sugar beet was grown and the top soil and subsoil sampled in March. Ammonium N concentrations were unchanged by the green manures or fertilisers of the previous year but nitrate N was increased greatly by trefoil and to a less extent by fertiliser given in the previous autumn, both in top soil and subsoil. The sugar yields (6·15 kg/ha) were only about two-thirds of those of 1973. Both the green manures and fresh nitrogen fertiliser increased yield little on average. No more than 50 kg/ha was needed for maximum yield where no fertiliser had been given in the previous autumn and no green manure grown. Any fertiliser in the previous autumn or any green manure decreased the optimum dressing of fresh nitrogen to zero. (Last)

Soil structure

Damage to the soil during beet harvesting. The experiment described in *Rothamsted Report for 1973*, Part 1, 275, was repeated. Soil compaction treatments simulating compaction during beet harvesting were applied on 16 January; the site was ploughed on 18 January and sown with spring wheat var. Maris Dove on 27 February. In collaboration with the ARC Letcombe Laboratory, soil atmosphere sampling probes were inserted on 24 January into plots with much and little soil compaction, both with and without beet tops ploughed down. No significant concentration of ethylene and nitrous oxide were found in samples taken at weekly intervals between 7 February and 18 April. The compaction treatments did not affect grain yield at harvest on 28 August, but increased straw yield by 0·3 t/ha. Ploughing down tops increased both grain and straw yield by 0·13 and 0·12 t/ha respectively despite the P and K off-take being balanced by mineral fertiliser where the tops were removed. A top-dressing of 75 or 125 kg N/ha as 'Nitro-Chalk' on 10 April had no effect on grain or straw yield on plots either with or without tops. However, the trial produced on average a poor crop of only 3·4 t/ha of grain. (Jaggard)

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Soil compaction and nematodes. An experiment at Cavenham, Suffolk, examined the effects of soil compaction and the systemic nematicide aldicarb (0·56 kg/ha in the furrow with the seed) on sugar beet growing in a soil infested with the ectoparasitic nematodes *Trichodorus* and *Longidorus* (760/litre and 75/litre soil respectively in a general sample taken in February). The experiment was drilled on 18 March, and when emergence was complete on 25 April the bulk density of dry soil to 16 cm depth was 1·58 g/ml on the compacted treatment and 1·27 g/ml on the uncompacted. Nematodes were few after the dry spring and had not multiplied when soil samples were taken at random in the sugar beet rows in July. Plots without aldicarb had 18 *Trichodorus* and 35 *Longidorus*/litre soil, plots with aldicarb had 20 *Trichodorus* and 10 *Longidorus*/litre. Compaction decreased sugar yield by 0·74 t/ha and aldicarb increased sugar yield by 0·69 t/ha. No evidence of Docking disorder was seen, and the yield increases from aldicarb must at least in part be due to control of virus yellows since on 24 July 52·5% of plants treated with aldicarb had yellows compared with 93·5% of non-treated plants. (Jaggard and Cooke)

Growth control chemicals

Chemical growth regulators 'AC 99577', 'AC 99850' and 'AC 202146' were sprayed on to sugar beet at 0·55 and 2·2 kg a.i./ha in 550 litre/ha of water on 22 August. 'AC 99850' applied at 2·2 kg a.i./ha increased sugar yield on 1 October by 0·45 t/ha and sugar concentration by 0·4%. Sodium, potassium and α-amino nitrogen were all decreased by the treatment. (Jaggard)

Sugar beet were sprayed once only, at monthly intervals mid-May to mid-September, with 1120 g a.i./ha of 'AC 99524', or in mid-June or mid-August with the same dose of 'AC 92803'; both compounds are substituted phthalamides. Sugar yield at harvest on 31 October was 7·15 t/ha on the untreated plots; the greatest yield increases of 0·9, 1·0 and 0·6 t/ha followed application of 'AC 99524' in mid-June and July, and 'AC 92803' in mid-August respectively. The potassium and, especially, the sodium content of the harvested roots was increased by the mid-July application of 'AC 99524'. No treatment caused elongation of the internodes in the crowns as in 1973 but the mid-June and, especially, the mid-July applications of 'AC 99524' increased the fibrosity of the roots. Top weights at harvest were greatest following the mid-August and September applications.

'AC 99524' was also tested at Broom's Barn as an aqueous solution in the seed furrow at sowing on 26 April at 1120 and 112 g a.i./ha. The internodes of the crown were elongated, especially by the 1120 g rate, and this was still apparent at harvest and it decreased sugar yield by 18%; the small amount did not affect yield. (Winder and Dunning)

Herbicides and weed control

Mr. W. E. Bray of Norfolk Agricultural Station tested various rates of the pre-emergence herbicide pyrazone as single or split applications at drilling or two weeks afterwards. As in 1973 the single application at drilling at the recommended rate (2·80 kg/ha) gave reasonable weed control and the largest yield of sugar, 6·19 t/ha. Unsprayed plots with no weeding until 30 May yielded 5·66 t/ha of sugar.

Stubble cultivations. An experiment started in 1972 included three stubble treatments: (1) not cultivated; (2) cultivated twice; (3) sprayed with paraquat and herbicide treatments on two cereal crops before sugar beet in the third year. Herbicide applied to Lofa Abed barley in 1972 had no effect on grain or straw yield but in 1973 'Banlene Plus' (MCPA/dicamba/mecoprop) decreased grain yield from 4·3 to 2·3 t/ha and increased straw yields from 3·9 to 5·2 t/ha; an effect doubtless due to late application because of

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inclement weather. Weed cover was very sparse on all treatments just before ploughing in 1972, but herbicide on the barley in 1973 decreased weed cover from 12 to 6% on the non-cultivation plots before ploughing. In the beet crop in 1974 herbicide on previous cereal crops and/or stubble cultivation decreased the number of weeds from approximately 150 000 to 100 000/ha. The pre-emergence herbicide pyrazone ('Pyramin') decreased weed numbers by only approximately 40%, whereas the post-emergence herbicide phenmedipham ('Betanal') controlled 70% of the weeds. Stubble cultivation and herbicides applied to the cereal crops did not affect sugar yield, but phenmedipham applied to the sugar beet significantly decreased sugar yield by 0·23 to 5·78 t/ha when compared with pyrazone, despite providing much better weed control. (Jaggard)

Cereal and rotation experiments

Fertilisers on rotation crops. This was the tenth year of the experiment testing fertilisers applied to a rotation of sugar beet, winter wheat and barley. (For the fertiliser dressings see *Rothamsted Report for 1965*, 279, Table 7).

TABLE 6

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

	Wheat grain (t/ha at 85% DM)	Barley grain (t/ha at 85% DM)	Sugar (t/ha)
Mean yield	4·29	3·87	4·07
Response to:			
N_1	+1·71	+0·94	+0·40
N_2–N_1	0	+0·32	−0·51
P_1	−0·26	+0·10	+0·04
P_2–P_1	0	+0·01	+0·61
K_1	−0·12	−0·10	+0·59
K_2–K_1	−0·39	−0·40	+0·93
Na	+0·17	−0·07	+0·92
FYM	+0·06	+0·10	+0·86
Compound 1	+1·64	+0·95	+0·97
Compound 2–Compound 1	0	+0·46	−0·23

The mean wheat and barley grain yields were similar to those in 1973 but the sugar yield was 2 t/ha less. The wheat again needed N_1 (75 kg N/ha); the barley N_2 (100 kg N/ha) but the sugar beet very little nitrogen for maximum yield. There was no response to the other nutrients by the cereals but the cation fertilisers and farmyard manure increased sugar yield by almost 1 t/ha. (Durrant)

Frequency of beet and barley. This was the tenth year of the experiment testing yields in five contrasting crop rotations (for details see *Rothamsted Report for 1966*, 248). In 1974 because of damage to seeds by mice, poor plant establishment and early infection with virus yellows, sugar yield at 3·50 t/ha was little more than half the nine-year mean of the trial (6·8 t/ha).

The largest sugar yields were from the continuous beet or following potatoes and beans (mean 3·7 t/ha). Sugar yields were similar in the other three rotations averaging 3·4 t/ha. Barley grain yields (2·56 t/ha at 85% DM) were similar following beet or one cereal crop, and slightly less after two or more cereals. The first and second year leys respectively produced 3·50 and 10·21 t/ha of dry matter. Beans yielded 1·33 t/ha grain at 85% DM and potato tubers 5·25 t/ha DM.

Nitrogen and fumigation. The experiment on Brome Pin (*Rothamsted Report for 1973*, Part 1, 278) testing the residual effects of soil fumigation with 'D-D' and form of nitrogen fertiliser on pathogens and crop yields was cropped with spring wheat in 1974. Fumiga-

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tion treatments were applied on 26 October 1973 and soil samples taken for nematode determination on 18 January 1974.

All genera of plant parasitic nematodes were less numerous in untreated plots than in January 1973; all continued to be well controlled by fumigation every year but populations had recovered somewhat in plots fumigated only before sugar beet (Table 7).

TABLE 7

Control of nematodes by soil fumigation in the nitrogen and fumigation experiment

	Nematode numbers/litre of soil		
Nematode	Unfumigated	Fumigated every year	Fumigated before sugar beet only
Tylenchus	475	25	113
Tylenchorhynchus	288	13	13
Heterodera larvae	38	0	0
Pratylenchus	1475	88	400
Paratylenchus	488	113	288
Rhabditida	10 725	10 363	7363
Trichodorus	25	0	0
Mononchidae	275	0	25
Other Dorylaimida	575	13	138

Table 8 shows the grain and straw yields; these were small due to the very dry and cold spring when the crop established slowly and each plant produced few fertile tillers. Nitrogen depressed yield significantly where the soil had been fumigated. Fumigation increased yield significantly only where no nitrogen had been given, and the negative interaction between fumigation and nitrogen was significant. Thus, although presumably fumigation increased available soil nitrogen as usual, the increase in yield may not result from this extra available nitrogen. (Cooke and Last)

TABLE 8

Grain and straw yields in the nitrogen and fumigation experiment

		Fumigation treatment		
	N dressing (kg/ha)	None	Every year	Before sugar beet only
Yield of grain (85% DM), t/ha	0	2·85	3·18	3·20
	125 (NH_4^+)	2·84	2·73	2·96
	125 (NO_3^-)	2·71	2·54	2·51
Yield of straw (85% DM), t/ha	0	2·32	4·44	4·18
	125 (NH_4^+)	3·86	4·03	4·03
	125 (NO_3^-)	3·79	3·34	3·62

Fertilising the subsoil. There is much evidence from long-term and rotation experiments at Broom's Barn that yields of sugar beet and cereals cannot be increased by incorporating more fertiliser into the plough layer than is normal practice here. Analysis of soil from below the plough layer shows, however, that it contains little phosphorus and potasium. Measurements with the neutron probe of water-uptake on many of the fields demonstrate that all the crops take much water from the subsoil, usually down to 2 m. During dry periods the crops rely on subsoil moisture for evapotranspiration, which may mean that they are short of nutrients because the supply from the plough layer is temporarily decreased.

A new experiment was begun on Little Lane field to determine whether fertilising the subsoil would increase yield. The fertiliser was placed in liquid form into the subsoil at

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55 cm deep and at 85 cm intervals with a subsoiling machine. The four treatments were: A—no subsoiling; B—subsoiling only; C—subsoiling with injection of 100 kg N/ha, 110 kg P/ha and 210 kg K/ha, and D—subsoiling with 50 kg N/ha, 55 kg P/ha and 105 kg K/ha. The experiment was cropped with sugar beet which yielded on average 33·8 t/ha roots at 15% sugar but none of the treatments affected yield or sugar percentage significantly. Further dressings of fertilisers will be given to the subsoil and yields recorded for several years.

Fungicides on barley. Fungicides were tested at the recommended rate on three spring barley varieties for the control of mildew which was very severe on Berac, severe on Julia and moderately severe on Mazurka. Ethirimol as a seed dressing and tridemorph as a spray both controlled mildew well and along with benomyl and benodanil increased the height of the crop and 1000-grain weight.

Ethirimol and tridemorph increased the yield of all varieties: Berac from 3·72 t/ha untreated to 4·48 t/ha with ethirimol and 3·95 t/ha with tridemorph; Julia from 3·29 to 4·50 and 4·29 t/ha and Mazurka from 3·81 to 4·74 and 4·28 t/ha respectively. (Webb)

Broom's Barn Farm

Changes in soil analysis, 1960–74. The object is to test if the fertiliser and cropping policy used on the farm has improved the nutrient status of the soils and made the fields more uniform for experiments. Brome Pin, Bull Rush, Flint Ridge and Hackthorn fields were sampled and analysed; the methods and results for the three fields sampled in 1973 are in *Rothamsted Report for 1973*, Part 1, 280. Changes in the topsoil analysis for 1974 are given in Table 9. During the 14 years, selective liming has increased soil pH overall and there is now much less variation in pH within each field. Except for Brome Pin, where there was a recent ley, organic matter content of all the soils decreased slightly. The fertiliser policy has been to give more phosphorus than is removed in the crops and this has increased the $NaHCO_3$-soluble P, especially on Flint Ridge. Even though the amount of potassium applied also exceeded that removed, the exchangeable soil K increased only on Brome Pin and Bull Rush. The decrease on Hackthorn was due to a marked and unexplained decrease in soil K in one corner of the field. As before, giving little or no magnesium fertiliser has resulted in a decrease in exchangeable soil Mg, especially in the sandy soil on Brome Pin. The increase in soil Mg on Bull Rush was probably due to a dressing of 63 kg/ha Mg as the oxide in 1973. (Durrant)

TABLE 9

Changes in soil analysis between 1960 and 1974 at Broom's Barn

Field	pH (in water)		Organic matter (%)		$NaHCO_3$-soluble P (ppm)		NH_4^+-exchangeable K (ppm)		NH_4^+-exchangeable Mg (ppm)	
	1960	1974	1960	1974	1960	1974	1960	1974	1960	1974
Brome Pin	7·2	8·0	1·49	1·57	20	29	92	119	43	31
Bull Rush	7·3	8·0	1·71	1·67	16	24	126	156	47	50
Flint Ridge	7·7	7·9	1·61	1·58	36	54	142	137	30	28
Hackthorn	7·6	7·5	1·71	1·67	22	23	160	135	47	43
Mean	7·5	7·9	1·63	1·62	24	33	130	137	42	38

Cropping. With some land remaining unploughed until the end of January, and a winter with negligible frost, spring work started later than usual and seedbeds were difficult to prepare. Soon after sowing the weather turned dry and all spring sown crops established poorly. The winter wheat and grass were well forward after a mild winter. Dunholme and New Piece were subsoiled this year working both ways, and Bull Rush

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one way only, all at 50 cm deep and 90 cm between tines. Dunholme, Hackthorn and part of New Piece were limed and Dunholme was dressed with FYM.

The new farm building was completed during the first half of the year and the old workshop/machinery store converted to workshops, offices and laboratories.

Cereals. The wheat crops were given only 50 kg P and K/ha in the autumn except the second wheat crop on New Piece which had 25 kg N/ha in the seedbed as well. All were top dressed with between 87 and 100 kg N/ha in the spring. The Holt and half of White Patch were sprayed with 'Cycocel' (chlormequat chloride). An aphid infestation on the wheats was controlled by rain when spraying with insecticide was contemplated. Some strips of the Atou wheat were sprayed with a mixture of 'Calixin' (tridemorph), maneb and 'Bavistin' (carbendazim) to control disease and this increased both grain yield and quality.

Barley and spring wheat were sown during late February and early March. The Proctor seed was treated with 'Milstem' (ethirimol) but also needed spraying with 'Calixin' (tridemorph) to keep it reasonably free from mildew. The Julia was also sprayed with 'Calixin'. All the wheat was sprayed with 'Banlene Plus' (MCPA/dicamba/mecoprop), the barley on Hackthorn with 'Phenoxylene Super' (MCPA/dicamba) and the undersown barley with 'Legumex Extra' (MCPA/2,4-DB/benazolin).

Harvest started briefly on 7 August, restarted a week later after rain, and was finished by 28 August. Grain moistures ranged from 14 to 18%.

Maize. Dekalb 202 maize was sown on 8 May on 0·8 ha of Windbreak and fertilised and sprayed as last year. On 9 December it yielded 2·5 t/ha of grain at 85% DM.

Beans. Maris Bead tic beans were sown into a cloddy seedbed on 21 March, immediately rolled and sprayed with simazine which controlled weeds well. Disulfoton granules were sprayed from the air on 11 July to control aphids. Five hives of bees worked the crop. The beans were harvested on 9 September at 18% moisture.

TABLE 10

Cereal and bean yields at 85% DM

	ha		t/ha
Flint Ridge	8·82	Julia barley	3·80
Hackthorn	3·93	Proctor barley	4·86
White Patch	9·17	Maris Huntsman wheat	7·53
New Piece	5·22	Atou wheat	6·14
The Holt	4·49	Maris Huntsman wheat	7·44
Brome Pin	9·77	Maris Dove wheat	3·26
Bull Rush	4·61	Maris Bead beans	3·01

Fodder crops. The Italian ryegrass and clover ley on Dunholme was given 35 mm of irrigation in late April and cut for silage at the end of May. It was immediately top dressed with 75 kg N/ha, given 50 mm of irrigation and cut again for hay on 8 July. The undersown ley on Flint Ridge was patchy in the barley stubble at harvest but has since established satisfactorily.

Sugar beet. The fertiliser ploughed down in autumn 1973 on both Little Lane and Marl Pit fields gave P_2O_5 55; K_2O 150; Na 137; Mg 62 kg/ha. The N fertiliser at 118 kg/ha was broadcast between the rows at drilling. Sowing started on 20 March and continued quickly until the end of the month; the drilling date trials had the second sowings in the middle of April, leaving only small areas for late drilling in early May. Of the crop area 88% was sown with pelleted monogerm, 8% with pelleted polyploid and 4% with

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rubbed and graded seed; 4·4 ha were sown at 7·5 cm seed spacing or less, 0·2 ha at 12·5 cm and 9·8 ha at 15–19 cm.

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. Although the crop was sprayed twice with insecticide very early in the season to control aphids, it became heavily infected with virus yellows.

Harvesting started on 20 October in wet conditions, and continued during persistent wet weather, sometimes in almost impossible conditions, to finish on 20 December. Deliveries to the factory finished by the end of the year. Yields averaged 28·5 t/ha of clean roots at an average sugar content of 15·7% ranging from 14·3 to 16·9%. Mean dirt and top tares were 163 and 52 kg/t. The country's average yield this year was 25·16 t/ha of roots at 15·50% sugar.

Livestock. In October 1973, 82 cross-bred heifers were bought and fattened in the yards on *ad lib* silage, hay, barley straw and a restricted concentrate ration of 50% rolled barley : 50% beet pulp. A small amount or concentrate was fed most of the time and only increased to finish fattening the animals for sale during April and May.

The yards were re-stocked with 91 cross-bred heifers in October. (Golding)

Staff and visiting workers

W. J. Byford, A. P. Draycott, R. A. Dunning, M. J. Durrant, R. Hull and P. C. Longden contributed to the 37th Winter Congress of the International Institute of Sugar Beet Research (IIRB) in Brussels. P. C. Longden attended the Genetics and Breeding Study Group meeting at Tienen, Belgium. R. A. Dunning was appointed Chairman of the Pests and Diseases Study Group and along with R. Hull attended an emergency meeting in October at Bergen-op-Zoom, Holland, to discuss the virus yellows epidemic in Western Europe. R. A. Dunning attended the Summer Itinerant Congress in Eire. W. F. Cormack and P. C. Longden contributed to the 12th British Weed Control Conference.

R. Hull gave the University of London Special Lecture at Wye College in January. He visited France and Spain several times to advise on the organisation of an Advanced Course on Sugar Beet to start in February 1975 at the Mediterranean Institute for Advanced Agronomic Studies at Zaragoza, Spain, sponsored by the Organisation for European Co-operation and Development in conjunction with IIRB.

Fieldmen of the British Sugar Corporation visited us in June for a two-day course of instruction. Amongst numerous visitors were the Director General of ADAS and groups from Bury Round Table, Farmers' Clubs, Dutch farmers, agricultural merchants and farm managers from Strutt and Parker, Lord Rayleigh and Lord de Ramsey farms.

Sandwich course students K. Partington and S. Loseby from Bath University worked with us for six months and M. Skidmore from Sheffield Polytechnic for nine months.

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