ROTHAMSTED RESEARCH

Report for 1972 - Part 1

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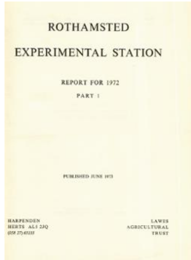
ROTHAMSTED

EXPERIMENTAL STATION

REPORT FOR 1972

PART 1

Broom's Barn Experimental Station

R. Hull

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BROOM'S BARN EXPERIMENTAL STATION

R. HULL

Introduction

Scientists concentrating their research on one crop, such as those at Broom's Barn working on sugar beet, have their ideas and programme of work considerably influenced by the different problems experienced in observing and growing the crop each year. The early sowing of the sugar-beet crop this year, when half the crop had been sown by the end of March, augured a large yield, similar to the record yield of 1971. However, the six million tons delivered to the factories was barely an average yield, largely due to the summer weather being unfavourable for growth. At Broom's Barn, every month was colder, all but August had fewer hours of sunshine and every month had less rainfall than average. Roots were small and contained little sugar at the end of August compared with the 1971 crop, and although in most parts of England yield increased at the usual rate during the autumn, it did not make up for the poor growth during summer.

The drought was most severe in the southern part of East Anglia and the crop lost leaves when it wilted during the summer. Virus yellows became widespread in the autumn and the foliage of some crops became very yellow by the end of September, a phenomenon we have not seen for several years. Past experiments have shown only small yield loss from such late infection, but this year's experience raises doubts whether infection with yellows of plants that lose much of their leaf area by drought may not affect yield appreciably. Field observations failed to determine to what extent drought or yellows were responsible for the below-average yield increase in the autumn in this area.

For much of this dry summer sugar beet depended on moisture from the subsoil extracted by deep roots. The deleterious effect of restricting root penetration was obvious not only in our soil compaction experiments but also in many fields where poor growth of sugar beet on the headlands resulted from soil compaction by machines used for cultivating during the spring. Our experiments also clearly show that nitrogen fertiliser leached deep into the soil is taken up by roots when the surface soil is too dry for the plants to absorb the nitrogen it contains. Less mobile fertiliser elements are applied to and mostly remain in the ploughed layer and are not available to the plants when the soil is dry. Would sugar beet benefit from more nutrients in the subsoil and in the water that it absorbs there? The results of some of our experiments described below are relevant to these problems but by no means solve them, so the experiences of the season will certainly influence our future programme of work.

Seedling pests

The British Sugar Corporation fieldmen reported that damage to sugar-beet seedlings by birds and mammals was nearly as extensive as in 1971, and far more than in any of the previous five years. Insect and allied pest damage approximately equalled that of the average for 1966 to 1971 inclusive. Half of the sugar-beet acreage was sown before 1 April and early sowing, followed by cold weather, is probably inimical to extensive damage by invertebrate pests, but does not decrease the activity of the vertebrates.

Pygmy beetle. The dispersal and distribution of pygmy beetle (*Atomaria linearis*) was assessed by the catches in 40-ft high suction traps at Broom's Barn, Rothamsted, Wye,

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Shardlow and High Mowthorpe, and on sticky traps at nine sites in eastern England, particularly in the Fens. The Broom's Barn trap caught 566 beetles to the end of October, Rothamsted 286, but Wye, Shardlow and High Mowthorpe each less than ten. At Broom's Barn pygmy beetles were not caught in quantity until mid-May, approximately two weeks later than in 1971, and large catches occurred on favourable days in June and July; in 1971 catches were most numerous in May and reported damage was greater than in 1972.

In 1972 the sticky traps at Rothamsted and Shardlow caught many fewer pygmy beetles than those in the Fens and East Anglia; those at Holbeach, Lincs., and Somersham, East Suffolk, caught most. (Dunning and Thornhill)

Millepedes. In the laboratory, previously germinated 'Amono' pelleted sugar-beet seed without insecticide was grown in Petri dishes containing millepedes (*Boreoiulus tenuis*) collected from the field in June, at mean temperatures of 4·5, 7·5, 12·5, 15 and 18°C. After three days most root damage was done at 7·5 and 12·5°, and least at 4·5 and 18°. Removing these damaged seedlings and repeatedly adding freshly germinated ones showed that damage declined with time, especially at 18°, the temperature that evoked the earliest onset of inactivity of the millepedes and their subsequent moulting. In another experiment with *B. tenuis*, at 9–12°, 74% more aggregated around germinating pelleted than around raw 'Amono' seed, but root damage did not differ.

The effect of rising, falling and constant temperature on the behaviour of *Blaniulus guttulatus* in both horizontal and vertical sealed chambers was studied. The millepedes responded to temperature changes and appeared to crawl downwards as temperature dropped towards 2°; increasing the temperature induced increased activity and dispersal throughout the chambers. (Baker)

Pitfall trapping. The effects of the insecticides trichlorphon ('Dipterex') and aldicarb ('Temik') at commercial rates on the numbers of beetles caught in pitfall traps (*Rothamsted Report for 1969*, Part 1, 312) were tested on the Holt field. Square plots of approximately 0·08 ha in a 3 × 3 Latin square each had three traps centrally placed 3 m apart in the beet row. Aldicarb granules at 1·12 kg a.i./ha were applied in the seed furrow at drilling on 7 April and trichlorphon was sprayed overall at 0·07 kg a.i./ha on 10 May and again on 13 June. Traps were changed at weekly intervals from 17 May until 30 August. *Feronia melanaria* was the most numerous carabid beetle with peak numbers caught in August, but, as in 1971, few were caught in May when *Bembidion* spp. were dominant. Trichlorphon decreased the catch of the most frequent genera (*Feronia*, *Bembidion*, *Trechus* and *Clivina*) by an average of 15% over the trapping period and aldicarb decreased the catch by 27%, except for *Bembidion* spp. of which 31% more were caught on the treated plots. (Baker, Dunning, Winder and Windley)

Control by insecticides. Trials in 15 sugar-factory areas tested 0·2% of dieldrin and 0·2, 0·8 and 3·2% of methiocarb on 'Amono' seed, all incorporated during pelleting, and compared their effect on seedling establishment with 0·56 kg/ha of γ-BHC sprayed and harrowed into the soil during final seed-bed preparation. The sites were chosen for convenience, not because seedling pest damage was anticipated. On average, the proportion of seeds which produced seedlings were: control (no insecticide) 62·8%; 0·2% dieldrin 62·5%; 0·2, 0·8 and 3·2% methiocarb 64·1, 62·6 and 61·5% respectively; γ-BHC spray on seed bed 65·4% (S.E.D. ± 0·86). Gamma-BHC spray significantly increased seedling numbers in three trials, 0·2% methiocarb in one; no other treatment had significant effect. The same pelleted seed treatments and also 6·4% methiocarb, 0·2, 0·8 and 3·2% mecarphon, 0·2, 0·8 and 3·2% 'Ciba C10015', 0·8% carbaryl, 0·8% propoxur and 1%

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'Curb' (sold as a bird and mammal repellent) were compared with γ-BHC sprayed on the seed bed at 0·28, 0·56 and 1·12 kg a.i./ha at Benwick, Magdalen, Shouldham and Melbourn where pest damage was expected, and at Broom's Barn where it was not.

At Benwick, sugar beet was damaged by pygmy beetle in 1971 and this year damage was very severe; most of the seedlings were killed before they emerged from the soil. The best treatments, the 3·2% rates of methiocarb, mecarphon and 'C10015', gave seedlings from only 8·5–8·9% of seeds sown. Gamma-BHC spray on the seed bed had no effect on seedling numbers. Aggregation and mortality of pygmy beetle was determined from soil cores (5·9 cm diameter × 10 cm deep) centred over seedlings. On untreated plots cores were taken centred on dying seedlings or in gaps; they contained only few beetles, mean 3·8 live and 0·1 dead. Around seedlings in the rows treated with 'Du Pont 1410' and carbofuran (at 0·70 kg a.i./ha) there were approximately equal numbers of living beetles, 12·6 and 10·8 per core; however, carbofuran, the best treatment, that gave 40% seedling establishment, had 111 dead beetles per core compared with only 15 from 'Du Pont 1410', a poor treatment giving only 12% seedling establishment. As in 1971, the numbers of dead beetles recovered increased with improved seedling establishment; seedlings were protected by the insecticides killing beetles in the root zone rather than repelling them. After rotovating, the trial was resown. Although only 1·1% of the seed on the untreated plots produced seedlings that survived, responses to insecticide treatment were greater than at the first sowing; the seed treated with the largest amounts of mecarphon, methiocarb or 'C10015' gave the best results. Gamma-BHC sprayed on the seedbed was again ineffective (Table 1).

At Magdalen the trial also followed a poor beet crop in 1971 damaged by millepedes, symphylids and pygmy beetle; these pests were present again in 1972 but caused little damage. At Shouldham the millepede *Boreoiulus tenuis*, and at Melbourn and Broom's Barn wireworms damaged the crops. At Benwick, where pest attack was severe, the beneficial effects of methiocarb, mecarphon and 'C10015' seed treatment increased with dose but at the other sites, where pest attack was less severe, the larger amounts of insec-

TABLE 1

Effects of seed and soil treatments on the percentage of seeds producing seedlings at five sites (excluding the first drilling at Benwick)

	Benwick	Magdalen	Shouldham	Melbourn	Broom's Barn
Control	1	60	61	69	49
Seed treatment					
0·2% dieldrin	4	62	58	72	56
0·2% methiocarb	16	67	62	69	61
0·8% methiocarb	31	63	58	67	59
3·2% methiocarb	38	59	57	73	58
6·4% methiocarb	50	67	52	69	57
0·2% mecarphon	27	67	66	75	55
0·8% mecarphon	60	61	63	71	59
3·2% mecarphon	73	63	60	73	57
0·2% 'C10015'	1	62	63	67	56
0·8% 'C10015'	11	63	61	72	57
3·2% 'C10015'	44	67	55	65	56
0·8% carbaryl	12	57	55	67	53
0·8% propoxur	16	63	61	64	50
1·0% 'Curb'	0	48	56	71	51
γ-BHC sprays incorporated in seed bed					
0·28 kg a.i./ha	—	65	71	74	70
0·56 kg a.i./ha	8	61	71	69	65
1·121 kg a.i./ha	—	65	69	73	71
S.E.D.±	5·66	3·83	7·25	3·67	4·25

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ticide often resulted in fewer seedlings than the smaller. Gamma-BHC spray on the seed bed was not effective at Benwick, but was among the best treatments in the other trials. (Dunning, Winder and Baker)

Further trials at Benwick, Shouldham and Magdalen tested insecticides drilled in the furrow with the seed as solutions at 370 litres/ha and concentrations to give 0·70 and 0·07 kg a.i./ha, or as granules at 0·70 kg/ha. At Broom's Barn a range of insecticides was tested as granules or solutions at 0·70 kg a.i./ha to check for adverse effects on seedling establishment in the absence of pests. As in 1971, the greatest increase in seedling numbers occurred where pest attack was most severe, e.g. at Benwick, and the adverse effects were most obvious at Broom's Barn.

At Benwick no seedlings survived from untreated seed sown on 24 March. With row treatment at 0·70 kg a.i./ha the proportions of seeds producing seedlings were: carbofuran granules 44%, γ-BHC solution 24%, 'Du Pont 1410' granules 12%, methiocarb solution and aldicarb granules 10% and 'Du Pont 1410' solution 6%; mecarphon, 'C10015' and propoxur solutions and 'Bayer 92114' granules 2–4%, 'CGA 10576', carbaryl, 'Dursban', diazinon and 'Bayer 92114' solution, less than 1%. Less than 1% of the seed produced seedlings in rows treated with the solutions at 0·07 kg a.i./ha. The trial site was rotovated and resown with a modified range of treatments on 23 May. On the untreated plots 0·8% of the seeds produced seedlings and the sugar yield from these plots in late September was only 0·07 t/ha. When treated with granules at 0·70 kg a.i./ha the percentage of seeds producing seedlings and the sugar yields (t/ha) were: 'AC 92,100' 78%, 3·97; mecarphon 74%, 3·48; 'Du Pont 1410' 57%, 3·13; carbofuran 53%, 2·17; aldicarb 52%, 3·45; 'AC 64,475' 0·8%, 0·01. Effects of the same amounts of insecticides in solution were: γ-BHC 71%, 3·25; methiocarb 48%, 3·02; 'Du Pont 1410' 40%, 2·65; 'C10015' 38%, 2·35; mecarphon 38%, 2·65; 'Dursban' 28%, 2·29; and diazinon 13%, 1·14. Gamma-BHC and 'Dursban' as solutions at 0·07 kg/ha were only partially effective, with 15 and 7% of the seeds producing seedlings respectively, and the other treatments at this rate were ineffective.

At Shouldham 40% of the untreated seeds produced seedlings. The percentage of seeds giving seedlings in rows treated with solutions, at 0·70 and 0·07 kg a.i./ha, of diazinon were, respectively, 82% and 44%; methiocarb 74%, 60%; 'Dursban' 73%, 50%; 'Bayer 92114' 71%, 61%; 'CGA 10576' 65%, 62%; 'Du Pont 1410' 63%, 45%; 'C10015' 63%, 47%; mecarphon 56%, 40%; carbaryl 52%, 46%; and propoxur 52%, 42%; but γ-BHC 28% and 72%, and tetrachlorvinphos 37 and 53%. With granules at 0·70 kg/ha the proportions were: aldicarb 78%, 'Bayer 92114' 73%, carbofuran 70% and 'Du Pont 1410' 68%, whilst for pelleted seed containing 0·2% dieldrin, 0·2 and 3·2% methiocarb 41, 59 and 37% respectively.

At Magdalen 61% of the untreated seed produced seedlings. The proportion producing seedlings when the rows were treated with solutions during sowing at 0·70 and 0·07 kg a.i./ha were: methiocarb 66% and 56%; γ-BHC 63%, 61%; propoxur 64%, 52%; 'Bayer 92114' 63%, 55%; diazinon 62%, 51%; 'Du Pont 1410' 60%, 57%; 'C10015' 60%, 59%; mecarphon 60%, 57%; carbaryl 53%, 52%; 'Dursban' 47%, 59%; 'CGA 10576' 44%, 46%. Granular formulations at 0·70 kg a.i./ha gave: aldicarb 70%, 'Bayer 92114' 69%, 'Du Pont 1410' 69%, carbofuran 68%, whilst pelleted seed containing 0·2% dieldrin, 0·2% mecarphon or 3·2% methiocarb gave 59%, 67% and 62% respectively.

At Broom's Barn 94% of the untreated seed produced seedlings that survived, an unusually large proportion, and yield was 6·77 t/ha of sugar. The proportion of seed which produced seedlings and the sugar yields (t/ha), when treated with solutions at 0·70 kg/ha in the seed furrow were: γ-BHC 32%, 2·90; carbaryl 80%, 5·64; propoxur 76%, 6·03; methiocarb 82%, 6·82; 'Dursban' 60%, 5·24; diazinon 83%, 6·44; 'C10015' 88%, 6·40; 'CGA 10576' 36%, 4·50; 'Du Pont 1410' 89%, 7·27; mecarphon 90%, 6·79;

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'CGA 13527' 82%, 7·01; 'Nemacur P' 82%, 6·87; 'Bayer 92114' 74%, 6·82; 'PP156' 91%, 7·17; and tetrachlorvinphos 74%, 6·72. When treated with granular formulations: aldicarb 96%, 7·11; 'Du Pont 1410' 93%, 7·07; 'CGA 10576' 36%, 4·75; 'Tirpate' 87%, 6·09; carbofuran 88%, 6·65; 'Nemacur P' 87%, 7·25; 'Bayer 92114' 81%, 6·99. (Dunning and Winder)

Pest aggregation. Soil samples estimated the degree of aggregation of pests in the root zone of seedlings established from seed without insecticide spaced at 4, 12 and 24 cm. At Shouldham (Norfolk), a site where previous sugar-beet crops had been damaged by millepedes, soil cores 5·9 cm diameter × 10 cm deep taken when sowing on 20 April indicated a fairly uniform distribution of millepedes, averaging 7·9/core (29 million/ha) *Boreoiulus tenuis*. After 19 days, cores either centred on a seedling or taken between the rows showed that 63% of the millepedes (9·2/core) were aggregated around the seedlings but that seed spacing had not yet affected the numbers per seedling. In samples taken 28 days later the millepedes between the rows had decreased from 37% to 4·5% of the total; the mean number around seedlings spaced at 24, 12 and 4 cm was 11·2, 9·2 and 4·6 respectively. Pygmy beetle (*Atomaria linearis*), not found in April and May, aggregated in June around seedlings, in similar numbers irrespective of seed spacing, as in 1971 (*Rothamsted Report for 1971*, Part 1, 273).

Observations were made in two fields where sugar beet was grown in consecutive years. At Benwick (Cambs.) the estimated resident population of pygmy beetle was 4·2 million/hectare and no seedlings survived without insecticide treatment. At Magdalen (Norfolk), the resident population was 445 000/ha and here 56% of the untreated seeds gave seedlings; the pygmy beetles aggregated around the seedlings and, as at Shouldham, numbers did not increase with wider seedling spacing.

Soil samples to 34 cm depth from Magdalen and Shouldham in March showed that many of the blaniulid millepedes were in the second stadium (95% of the total at Shouldham) as in 1971. Samples taken in April, May and July at Shouldham contained progressively more adults; when *B. tenuis* were damaging seedlings only the adults (55% of the total) distinctly aggregated in the rows, emphasising the comparative immobility of young stages. Blaniulids were found to have spring and autumn breeding peaks.

At Shouldham pelleted 'Amono' sugar-beet seed without insecticide was sown 3·8 cm apart and 3·8 cm deep in replicated plots on 20 April, 12 May, 1 June and 23 July, and respectively 45, 12, 19 and 23% of these seeds established seedlings. Although millepedes were numerous in the seed bed in April, damage was slight, probably because few millepedes were adult. Fewest seedlings survived from the second sowing when numbers of adults and millepede activity was greatest. The better seedling establishment and decreasing number of millepedes in the root zone of later sowings suggests that millepedes disperse and move deeper in July. (Baker)

Herbicides. Selective herbicides used on sugar beet eliminate weeds that may be alternative food for pests and tend to weaken sugar-beet seedlings. Their effect on plant establishment was observed at four sites. At Broom's Barn, Magdalen, Melbourn and Shouldham pelleted 'Amono' monogerm seed, without dieldrin, was sown at 4, 12 and 24 cm spacing in rows 51 cm apart, and half the plots of each spacing were sprayed overall immediately after drilling with herbicide at the rate recommended for the soil type; pyrazone was used at Broom's Barn, Melbourn and Shouldham, and a proprietary mixture of propham, fenuron and chlorpropham at Magdalen. With herbicide treatment, increasing the seed spacing tended to increase seedling numbers, but had no effect without herbicide. In early summer the seedling dry weight was usually greater on the plots without than with herbicide at 4 and 12 cm spacing but less at 24 cm on spacing. As expected,

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post-singling plant populations decreased with increased seed spacing, but they were greater with herbicide than without. Differences in root yield in the autumn were very small but the herbicide-treated plots tended to yield slightly better than the untreated. At Broom's Barn, where there were many weeds on the untreated plots which were not removed until 3 June, virus yellows incidence at the end of August on the herbicide-treated plots was double that on the untreated plots—33 and 17% respectively.

Bird damage control. Grazing of seedlings by birds, especially sparrows, skylarks and game birds, has increased in recent years, probably because of the greater use of herbicides and the wide spacing of monogerm seeds. For instance, at Melbourn, Cambs., plots with seeds spaced at 4, 12 and 24 cm had, respectively, 7, 15 and 18% of the seedlings grazed by birds.

At Broom's Barn two trials tested whether some pesticides protected seedlings from damage by birds. In one trial dieldrin (0·2% seed wt.), mecarphon (0·8%), methiocarb (0·8, 3·2 and 6·4%), propoxur (0·8% and 'Curb' (1·0%) incorporated during seed pelleting, and 'Curb' sprayed on the emerging cotyledons in late May, did not decrease severe grazing of foliage, mainly by sparrows, nor affect seedling establishment. In another trial 70% of the seedlings had been grazed by various birds within three weeks of sowing in mid-July. Caging with 25 mm wire mesh completely prevented this, increased seedling establishment slightly and doubled seedling dry weight; frequent spraying to run-off of the seedling foliage with 0·1% methiocarb had no effect. On other trials at Broom's Barn and elsewhere, testing various pesticide formulations, no treatments significantly affected the extent of bird damage. (Dunning and Winder)

Leaf pests

Caterpillars often damage foliage in some areas of the Fens during the summer; a field trial at Prickwillow, Cambs., showed that *Bacillus thuringiensis* and, especially, trichlorphon killed the caterpillars and decreased damage. Yield was not assessed, because the infestation was slight. The identity of the several species of caterpillars involved in this damage is uncertain; specimens were collected at this and other sites for rearing and identification. (Winder and Thornhill)

Seedling diseases

Aphanomyces cochlioides was scarce on sugar-beet seedlings this spring. Six trials tested 'Dexon' in the seed pellet for controlling *A. cochlioides* but, although the fungus was detected in the soil from three sites, no infected seedlings were found in the trials; up to 7·8 g a.i./kg seed did not affect seedling emergence or final plant stand.

Soil was sampled in August and September 1971 in 183 sugar-beet fields chosen at random. When beet seedlings were grown in these soils in warm damp conditions in the glasshouse, *A. cochlioides* developed on those in 29 samples. *A. cochlioides* was not particularly prevalent in organic soils from the Ely factory area, as it had been in 1970, but it was in sand and loam soils from the Allscott factory area. The fungus developed in 16% of sands, 14% of loams, 16% of clays or clay loams and 22% or organic soils. It was most prevalent on acid soils; 34% of acid soils were infective compared with only 8% of alkaline.

In a field trial at Broom's Barn, maneb slurry at 10·7 g a.i./kg of seed increased seedling emergence by 12% while captafol at 6·4 g a.i./kg increased it by 6% and TCMTB at 0·75 and 1·2 g a.i./kg increased emergence by 29% and 18% respectively. In a trial in boxes at alternating 6° and 12°C, EMP steep, maneb slurry, captafol and TCMTB at 1·2 g a.i./kg increased emergence by 34, 40, 36 and 30% respectively.

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In the field at Broom's Barn the increase in seedling emergence from EMP (ethyl mercury phosphate) steep corresponded better with laboratory tests for *Phoma betae* on surface sterilised than on untreated seed. In these tests the decrease in *P. betae* after surface sterilisation was much less in some samples than in others, suggesting that these samples had more deep-seated infection.

Rubbing seed decreased *P. betae* almost as much as surface sterilisation. In the field the effect of rubbing on seedling emergence ranged from a small decrease to an increase of 48%. On average, the increase in emergence obtained by rubbing was 40% of that given by EMP steep. Rubbing before steeping increased emergence on average by only 3%. (Byford)

Yellows and aphids

The early months of the year were relatively mild and in previous years these conditions have favoured aphid infestations and yellows in the sugar-beet crop. The prediction this year on the basis of mean air temperature was that an average of 12% of sugar-beet plants throughout the country would have yellows at the end of August. The prediction based on the number of days with frost and the mean air temperature in April was 9% of plants infected. These predictions over-estimated disease incidence, for the fieldmen's survey at the end of August gave 5·1% of plants with yellows. Incidence was light in the centre, west and north of England and in Norfolk, but averaged 8–15% in the Bury St. Edmunds, Ely, Felsted and Ipswich factory areas. Towards the end of September and throughout the autumn many crops in these areas became predominantly yellow. Drought and magnesium deficiency added to the yellowing and made certain diagnosis difficult, but clearly both beet yellows and beet mild yellowing viruses were more prevalent than for several years. The persistent drought led to wilting and loss of foliage; new leaves developed only slowly and root weight increased little during the autumn. Infection with yellows as late as this normally decreases yield only little but, in conjunction with drought, its effect may have been greater than experiments in more normal circumstances have indicated.

The late spread of yellows resulted from aphids flying late in July and early August when crops were no longer protected by insecticides. Aphid infestation was light in most areas during June, but built up in some areas during July. The sugar factories sent spray warnings to growers and 125 000 acres of sugar beet were treated with insecticide. Insecticide sprays did not appreciably influence the late spread of yellows. Black aphids remained few on crops during the summer but increased later in the west and, in many areas, they thrived on bolters during the autumn.

Several instances where disease, especially yellows and downy mildew, spread to root crops from the beet remaining on the loading sites of the previous beet crop were seen in East Anglia.

Aphid predators. Ladybird beetles (coccinellids) were unusually numerous in 1971 and many survived the winter, but relatively few were found on sugar-beet crops in 1972, probably because the aphid population increased slowly and the ladybirds starved. Other predators such as hoverflies (syrphids), lacewings (chrysopids) and predatory bugs (anthocorids) were not abundant on sugar-beet crops.

A field experiment in which the freshly cultivated soil was sprayed with γ-BHC, but not the sugar-beet plants, showed no significant effect from this treatment on the small infestation of *M. persicae*; there were 4·4 aphids/plant on the treated and 3·4 on the untreated plots. Later, alate aphids that did not colonise the beet plants spread BMYV and in September 26% of plants on the treated plots had yellows and 34% on the untreated. (Heathcote)

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In the laboratory, all of nine species of carabid beetle tested ate black aphids when confined with them, the most voracious being *Bembidion quadrimaculatum*, *Agonum dorsale* and *Clivina fossor*. All of six species tested (*B. quadrimaculatum*, *Trechus quadristriatus*, *A. dorsale*, *F. melanaria*, *Amara familiaris* and *Harpalas rufipes*) climbed sugar-beet plants and roamed over the leaves, as indicated by fluorescent powder tracing which defined their tracks on petioles and leaf laminae. Black aphid colonies on the leaves of plants were found and eaten by beetles which had climbed the plant; for example, three *F. melanaria* consumed 41 aphids within three days. Some carabids and staphylinids were collected from the crop foliage in the field by sweeping and suction sampling. The contribution of carabids and staphylinids to the control of aphids and other pests on the beet crop needs further study. (Windley, Baker and Dunning)

Aphids infesting clamped mangolds and weeds. Twenty-five per cent of mangold clamps were infested with aphids in late April, a smaller proportion than in 1971; only one in ten of the infested clamps contained *M. persicae*. Samples of aphids from seven of 29 clamps carried beet yellowing viruses (five BMYV and one BYV alone, and one both BMYV and BYV). All three samples tested from the Cantley sugar factory area contained infective aphids but yellows incidence remained light in that area.

Forty-four per cent of the samples of weeds collected alongside fields where sugar beet was grown in 1971 were infested with aphids, a similar proportion to the previous two years. Twenty-two samples were checked for virus; BYV was recovered from one sample of chickweed and BMV from another, together with BMYV from one sample of groundsel.

***Aphis fabae* survey.** Very few eggs were found on spindle bushes in December near Bury St. Edmunds and few aphids in spring. The attack of *A. fabae* on sugar beet was light, but infestations survived on sugar beet 'bolters' until late autumn and then many eggs were laid on spindle near Broom's Barn.

Aphids on seed crops. Samples of leaves and shoots from about half of the known sugar-beet seed crops were examined during May and June and no *A. fabae* were found. Samples from Gloucester were heavily infested with *M. persicae*, some from Bedfordshire, Huntingdonshire and Northamptonshire were moderately infested and a few green aphids were found on those from elsewhere.

Winged aphids on traps. Fewer aphids were caught on sticky traps than in 1971, but the willow-carrot aphid and the leaf-curling plum aphid were numerous. On average of all traps, more *M. persicae* were caught in July and more *A. fabae* in August than in 1971.

Influence of cultural factors. In a year when irrigation had a marked effect on the height and yield of sugar-beet plants, it had little effect on yellowing viruses in plots with plants normally or widely spaced. In both watered and unwatered plots the percentage of plants infected with yellowing viruses was greater on the sparser plant stands, but there were fewer infected plants per unit area.

Plants top-dressed with additional N fertiliser (44 kg/ha) had 26% of plants showing symptoms of BMYV in September compared with 35% in plots without additional fertiliser, but the infected plants were in groups and the difference was not consistent. Only 18% of Bush Mono plants showed symptoms of BMYV in September compared with 37% of Hilleshog Monotri and 36% of Sharpe's Klein Monobeet. (Heathcote)

Control with insecticide. Two formulations of aldicarb and one of 'Du Pont 1410' were each applied at 0·28 and 1·12 kg a.i./ha in the seed furrow during sowing at Broom's

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TABLE 2

Effect of aldicarb and 'Du Pont 1410' on aphids, virus yellows and sugar yield

Treatments	kg a.i./ha	Apterous green aphids/plant 30 June	18 July	Virus yellows infection (%) 30 August	Sugar yield (t/ha)
aldicarb					
'Temik 10GV'	0·28	1·7	2·3	17	7·44
	1·12	0·1	0·2	1	7·69
'Temik 10G-BC'	0·28	1·0	1·6	6	7·73
	1·12	0·1	0·3	3	7·72
'Du Pont 1410'	0·28	5·4	5·3	9	7·68
	1·12	2·5	3·7	16	7·63
Untreated control	—	3·0	5·2	29	7·22
S.E.D.±		1·30	1·12	5·7	0·27

Barn on 17 April. No treatment affected seedling numbers but some affected green aphid infestation, and the number of plants with yellows; effects on yield were small (Table 2).

The insecticides used in the pitfall trapping trial (p. 265) affected, directly or indirectly, the aphid infestation and yellows incidence. Green aphids were most numerous on the plants on 3 July, 1·2 apterae per plant on untreated plots, 1·6 on trichlorphon-treated and 0·03 on aldicarb-treated; the corresponding numbers of apterous black aphids, most numerous on 2 August, were 10·4, 7·6 and 5·3 per plant. There were respectively 15, 17 and 4% of plants with yellows on 1 September. (Dunning and Winder)

Leaf diseases

Downy mildew. A few plants had downy mildew in seed crops in Bedfordshire, Northants and Oxfordshire in June, more than in any year since 1969. In July, occasional infected plants occurred in root crops in East Anglia and south Lincolnshire, and some crops sited near seed crops were more heavily infected, although in June no downy mildew was reported from the 44 seed crops examined in this area. In co-operation with the National Institute of Agricultural Botany at their Regional Centre at Trawscoed, Cardiganshire, the susceptibility to downy mildew of varieties and breeders' lines was tested in a field where the disease was encouraged. Once established, the disease spread rapidly and incidence on different varieties ranged from 12 to 56%. Sharpe's Klein Polybeet, Sharpe's Klein E end Anglo Maribo Poly were the varieties with fewest infected plants and Trihil, Hilleshog Monotri and Sharpe's Klein Monobeet had most.

Late-summer fungicide sprays. Continuing the study of the effects of controlling leaf pathogens during late summer on leaf survival and senescence, benomyl or fentin hydroxide were sprayed at three-weekly intervals from 4 August to 2 October on to beet var. 'Amono' sown on 21 March at Broom's Barn. On 11 October samples of leaves were assessed for diseases, area and colour. On unsprayed plants powdery mildew covered, on average, from 10% of the surface of leaves of 50–250 sq. cm area to over 75% of larger leaves. All sprays controlled powdery mildew almost completely, and other diseases were rare. Spraying decreased yellowing, other than that due to yellows virus, in large leaves. The crop was harvested on 27 November. The sprays all increased leaf area index, on average, by 19% (Table 3), yield of tops (20%) and sugar yield (7%).

Ramularia leaf spot. The development of leaf spot on unsprayed and fungicide sprayed plants in an open direct-drilled seed crop near Chipping Norton, Oxfordshire, was

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TABLE 3

Effect of fungicide sprays in August and September on leaf area and yield

		benomyl (kg/ha of active ingredient)		fentin hydroxide		
	Unsprayed	0·28	0·56	0·34	0·67	S.E.±
Leaf area index 10 October	2·31	2·81	2·65	2·78	2·71	—
Sugar yield on 27 November, t/ha	8·91	9·57	9·21	9·60	9·82	0·172
Top yield on 27 November, t/ha	30·3	38·1	34·5	36·4	36·4	0·82

studied by estimating the percentage of leaf area covered by spots in samples of 100 mid-stem leaves per plot taken at weekly intervals from 28 June to 9 August. Samples of basal leaves were also taken on the first three occasions, but leaves in this position were dead by mid-July, whether sprayed or not, although they had only 3% and 0·04% leaf spot respectively. Three sprays were given in May at two-week intervals, with 0·67 kg a.i./ha fentin hydroxide.

On unsprayed plants leaf spot increased on mid-stem leaves from 1% on 12 July to 19% on 2 August, but then appeared to decline as dead and dying leaves made assessment difficult. Leaf spot remained less than 1% on sprayed plants until 26 July, and reached 7% on 9 August when leaves were dying rapidly. At harvest, sprayed plants yielded 8% more seed than unsprayed.

In an adjoining trial, plants given three sprays in May of benomyl at 0·28 kg a.i./ha or three, two or one fentin hydroxide sprays, had 0·2, 0·6, 0·4 and 0·8% leaf spot respectively on mid-stem leaves on 26 July compared with 8% on unsprayed plants. Those given three benomyl sprays yielded 7% more seed than unsprayed and those given two or three fentin hydroxide sprays yielded 4% more than unsprayed. One fentin hydroxide spray did not increase yield. (Byford)

Powdery mildew. Ethirimol as a seed dressing at 32, 16 and 8 g of a.i./kg seed, controlled powdery mildew (*Erysiphe polygoni*) on beet for 12 weeks from sowing in the glasshouse. Germination and final leaf area were not affected but a soil drench at sowing at 0·46 g of a.i./kg soil decreased germination by 40%. The surviving plants were stunted and had severely scorched leaves, finally yielding less tops and roots than untreated plants or those given seed treatments. Aphids fed freely on plants with all treatments and showed no preference. (Prince)

Docking disorder

Although relatively wet in most parts of England, May had less than average rainfall in East Anglia and this, as well as the extending practice of fumigating sandy soil before drilling, probably accounted for few sugar-beet crops having Docking disorder. In June 567 ha of affected crops were reported, mostly in the Selby (164 ha) and King's Lynn (101 ha) sugar factory areas. A further 397 ha were reported in July, mostly in the Selby area (360 ha).

Fumigant injection methods. Trials at Aldwark and Holt that tested fumigation with 'Telone', either injected behind tines or as a sub-surface spray, in autumn 1970 (see *Rothamsted Report for 1971*, Part 1, 279) were cropped with barley in 1972. In the spring of 1972 there were fewer *Trichodorus* in the soil from plots given the largest amounts of

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'Telone' applied in either way (Table 4). At Aldwark none of the treatments appreciably affected the yield of about 4·5 t/ha barley grain. Yields were not recorded at Holt.

In two similar trials at Wilberfoss and Gayton started in 1972, increasing the amount of 'Telone' improved control of nematodes, but methods of injection showed no difference. Large amounts of fumigant improved yield of sugar beet at Gayton, where plants on untreated plots had Docking disorder, but not at Wilberfoss where they had not. (Cooke)

TABLE 4

Effect of methods of application and different amounts of 'Telone' on nematode numbers and crop yields

Application method and amount of 'Telone' (litre/ha)	Fumigated 20.10.70	Fumigated 29.9.70	Fumigated 16.12.71	Fumigated 14.12.71			
	Trichodorus/litre soil		*Trichodorus*/litre soil		*Longidorus*/litre soil	Sugar, t/ha	
	Aldwark Yorks 20.4.72	Holt Norfolk 15.3.72	Wilberfoss Yorks 4.5.72	Gayton Norfolk 12.5.72	Gayton Norfolk 12.5.72	Wilberfoss Yorks 30.10.72	Gayton Norfolk 16.10.72
0	1063	2080	1130	26	56	7·45	5·45
Sub-soil spray							
*45	1088	1405	940	11	38	7·38	5·96
135	350	815	75	5	8	7·79	6·18
404	150	175	40	0	0	7·74	6·99
Tine injection							
45	894	1480	605	9	18	7·07	5·70
*45	1044	1695	440	9	8	7·94	6·07
135	300	545	235	4	6	7·59	6·54
404	194	125	130	0	1	7·74	6·94

* As a 50% emulsion

Row treatment with nematicide. Trials at five sites prone to Docking disorder again tested row treatment with 'D-D' (at 1·6, 3·3 and 6·6 ml/m of row) and 'Telone' (at 1·1, 2·2 and 4·4 ml/m) applied two weeks before or immediately before drilling, aldicarb (at 1·1 kg/ha) in the furrow with the seed, and top dressings with nitrogen. The trials at Gleadthorpe, Notts., and Raskelf, Yorks., were redrilled after the beet was damaged by wind; some plots of the redrilled trial at Gleadthorpe were harvested. The largest amounts of 'D-D' and 'Telone' applied immediately before drilling decreased seedling numbers by up to 65% but differences in plant numbers after singling were small between treatments, and even smaller at harvest. Docking disorder was never severe on any trial sites although plant vigour was usually improved by nematicide. The poor yields at Butley, Ipswich (6·05 t/ha sugar from untreated plots) and Freckenham, Suffolk (3·54 t/ha sugar) were due more to drought than nematode damage. The average yield in untreated plots at the three sites was 5·72 t/ha sugar and was increased by all fumigation treatments; the best rates of 'Telone' were 2·2 ml/m two weeks before drilling and 1·1 ml/m immediately before drilling, giving average yield increases of 0·93 t/ha and 0·78 t/ha respectively; the best rates of 'D-D' were 3·3 ml/m either two weeks before drilling or immediately before drilling giving average yield increases of 0·61 and 0·65 t/ha respectively. Aldicarb increased yield on average by 0·81 t/ha but nitrogen top dressing did not improve yield. (Cooke, Dunning and Winder)

Nematicide trials. At Gayton, Norfolk, and Butley, Suffolk, 10% 'Du Pont 1410' granules and two formulations of 10% aldicarb granules ('Temik 10GV' on corn cob

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granules and 'Temik 10G-BC' on coal granules) were drilled in the furrow with the seed at 0·28 and 1·12 kg a.i./ha. Docking disorder was expected but did not develop at either site. A similar trial on a non-Docking disorder soil at Broom's Barn is reported on p. 271. The summer drought resulted in uneven crops and treatments did not consistently affect seedling growth, plant establishment or yield.

At Freckenham, where Docking disorder was also expected but did not occur, a range of nematicides were drilled in the furrow with the seed, as granules or as solutions, at both 1·12 and 0·28 kg a.i./ha. All treatments decreased seedling numbers and plant populations, especially the 1·12 kg a.i./ha rates of 'CGA 13527' solution, 'CGA 10576' solution and granules, 'Nemacur P' granules and 'Tirpate' granules. Plant populations largely reflected seedling populations but some of the less phytotoxic chemicals increased seedling vigour and some increased yield, although they had decreased seedling numbers. Increases in sugar yield of 0·8–1·2 t/ha were given by 'Du Pont 1410' solution at 1·12 kg/ha and 'CGA 10576' granules at 0·28 kg/ha, and of 0·4–0·8 t/ha by aldicarb granules and 'Du Pont 1410' granules both at 1·12 and 0·28 kg/ha, 'Du Pont 1410' solution, 'CGA 13527' solution and 'Tirpate' granules at 0·28 kg/ha, and carbofuran granules at 1·12 kg/ha. 'Tirpate' granules at 1·12 kg/ha decreased yield by 0·8–1·2 t/ha; 'CGA 13527' solution and 'CGA 10576' solution at 1·12 kg/ha decreased yield by 1·2–2·0 t/ha. 'CGA 10576' granules at 1·12 kg/ha decreased yield more than 2 t/ha; 'Nemacur P' solution, 'Nemacur P' granules, PP156 solution and methiocarb solution at 1·12 and 0·28 kg/ha, 'CGA 10576' solution and carbofuran granules at 0·28 kg/ha had little effect on yield ($<\pm 0{\cdot}4$ t/ha). (Winder and Dunning)

Population dynamics of *Trichodorus* spp. and *Longidorus* spp. Numbers of *Trichodorus* and *Longidorus* spp. were assessed at approximately five-weekly intervals throughout the year in fields in Wilberfoss, Yorks., and Shifnal, Salop, respectively. Three differently cropped fields were chosen at each location and the areas of lightest and heaviest soil in each field were sampled. At Wilberfoss, *Trichodorus* were consistently much more numerous in the lighter soil and there was a close correlation between numbers of nematodes and soil moisture at the time of sampling. *Trichodorus* were most numerous (up to 3000/litre of soil) in February/April and fewest when soil was driest in August. At Shifnal there was no measurable difference in soil texture between the selected sampling areas of any field; they were generally heavier and soil moisture varied less than those from Wilberfoss. *Longidorus* numbers seemed to be less dependent on soil moisture; this nematode was most numerous in January (up to 700/litre of soil) and after ploughing a grass ley in July. (Cooke)

Herbicide trials. A trial on sandy soil near Threxton infested with ectoparasitic nematodes and tobacco rattle virus (TRV) tested the effects of different rates of the herbicide phenmedipham and of hand weeding. *Trichodorus* and *Longidorus* caused considerable damage to roots; soil samples taken in June showed no difference in numbers of nematodes between treatments (average 325 *T. pachydermus*/litre and 56 *L. attenuatus*/litre). At the time when 8% of the plants showed clear symptoms of TRV neither herbicide nor hand weeding affected the incidence of infected plants. On average, plants showing TRV symptoms in June weighed less than half their symptomless neighbours at harvest, but plant size ranged widely, the tops from 13 to 713 g and the roots from 11 to 694 g. TRV was more prevalent in a neighbouring trial where untreated plots had 18% of plants with symptoms in July, but plots treated with 'D-D' soil fumigant had 3% or less; few plants showed symptoms of TRV at harvest. (Cooke and Heathcote)

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Seed production

Diseases in seed crops. In June, 74 sugar-beet seed crops distributed throughout seed growing areas averaged 0·9% of plants with virus yellows. Most was in ten open *in situ* crops in Gloucestershire and Oxfordshire which had up to 20% plants infected, averaging 6·3%. Downy mildew, which has been almost absent for two years, was seen in five crops in central England, but not in seed crops in the eastern counties.

In October, 134 steckling beds averaged 0·2% of plants with yellows, most in 37 open *in situ* beds which had up to 15%, averaging 0·9% compared with an average of 0·02% in 104 beds raised under cereal cover crops. No plants with downy mildew were found. (Byford)

Factors affecting seed yield

Irrigation. Unirrigated plots and those restored to field capacity with 10 cm water on 11 July or 15 cm water on 15 August gave similar yields of seed. Irrigation on either occasion significantly increased the proportion of seed larger than 4·5 mm diameter by 65 g/kg, but did not affect germination.

Growth regulators. If the 2 m high sugar-beet seed crop could be dwarfed, direct combine harvesting might be possible. If seed losses by abscission could be prevented, all mature viable seed would be retained and seeds would not be returned to the soil to produce beets that are weeds in subsequent crops. Morphactin at 10 ppm or 100 ppm sprayed on plants on 12 April or 16 May significantly decreased plant height by coiling the stems. Morphactin at 100 ppm depressed the yield of seed. Naphthylacetic acid (NAA), at 100 ppm on 30 August, did not affect seed yield. Seed size distribution was not affected by growth regulator treatment. Morphactin at 100 ppm sprayed on both dates and at 10 ppm sprayed on 16 May depressed germination by up to 40%. NAA did not affect germination. Monogermity was not affected by growth regulator treatment.

Plant population. The largest yield of seed came from the densest population tested, 750 000 plants/ha spaced 5 cm apart in rows 25 cm apart. When plants were spaced more widely along the rows the proportion of large seed increased by 46 g/kg. Treatments did not affect germination.

Nitrogen fertiliser. Top dressings of 'Nitro-Chalk' on plants in the spring of the second year gave the largest yield of seed when 188 kg/ha N was applied on 22 February, the earliest date tested. Applications later than this or split applications of 94 kg/ha on two occasions between 22 February and 17 May gave a similar yield. Leaf petiole nitrate concentration was about 500 ppm before adding any nitrogen fertiliser and increased to about 900 ppm one month after top dressing and then declined to 200–300 ppm four months afterwards. These differences in leaf petiole nitrate concentrations were not related to differences in yield of seed. The nitrogen treatments did not affect seed size distribution, germination percentage or monogermity.

Harvest method. Plants killed by diquat (770 g/1350 litres/ha on 31 August or 7 September) were ready to be threshed about seven days before plants which had been cut and laid in a swath, but they yielded 398 kg/ha less seed. A delay of one or two weeks between cutting or spraying and threshing resulted in a greater loss of seed from sprayed (717 kg/ha) than from cut plants (79 kg/ha). Diquat-killed plants gave seed of similar size distribution to that of swathed plants, but its germination was 12% less.

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Factors affecting seed performance

Seed crop cultural practices. Seed harvested in 1971 was sown in the field at Broom's Barn in March and seedlings were counted and their shoots weighed at the end of May. Chlormequat chloride, aminozide, NAA and 2,4,5-T applied to the seed crop did not affect seedling emergence or weight. Nitrogen fertiliser (125 kg/ha N) applied in February and in April 1971 resulted in seed that produced 12% more but 10% lighter seedlings than did seed harvested from plants given similar amounts of N on different occasions. Plants killed with diquat on 26 August 1971 gave seed which produced 10% fewer seedlings than seed from barn dried, swathed or tripodded plants. When harvested later, on 3 or 10 September, these harvest methods did not affect emergence from the seed produced. Seed plants grown *in situ* and spaced 7·5 cm apart in rows 25 cm apart gave 15% fewer seedlings than seed from plants grown *in situ* 15 cm apart in rows 51 cm apart or from those transplanted 75 cm apart in rows 75 cm apart.

Grading. Monogerm seed sorted into eight fractions on round hole sieves gave laboratory germination of 66 to 167 seedlings/100 fruits with increase in diameter from <7/64 to >12/64 in. When sown in the field at Broom's Barn, 28 to 108 seedlings/100 fruits emerged and had seedling shoot dry weights ranging from 179 to 352 mg. Similar samples of seed sown at the Plant Breeding Institute, Cambridge, gave 24 to 111 seedlings with shoot dry weights of 354 to 492 mg. Seedling emergence from different grades at Broom's Barn was closely correlated with that at the Plant Breeding Institute ($r = 0{\cdot}98$) and emergence at both sites was closely correlated with laboratory germination ($r = 0{\cdot}95$).

Storage. Seed stored at 8 and 12% moisture content at 2°C and 8% moisture content at 10°C since 1968 gave up to 40% more seedlings than seed stored more moist or warmer. Seed stored at 5 and 10% moisture content at 10 or 15°C since 1969 gave on average 29% more and threefold heavier seedlings than seed stored at 15% moisture content at either temperature. Other seed stored at 5% moisture content since 1970, irrespective of whether it was stored at 5, 10 or 15°C, gave on average 12% more seedlings than seed stored at 10 or 15% moisture content or seed stored open to the atmosphere at 5, 10 or 15°C.

Washing. Rinsing with 21 changes of water at 25°C during 3·5 hours gave 12% more seedlings than rinsing at 18°C (11% more seedlings), than immersion in a large (7% more) or small (4% more) volume of unheated water, or in a small volume of aerated water (10% more). Thirteen seed lots out of 17 tested gave up to 15% (average 9%) more seedlings after rinsing in warmed water.

Pelleting. Clay pellets were made by rolling seeds in a rotating car tyre and adding water and clay dust alternately until the pellets built up. Sodium perborate was incorporated into some pellets and others were agar coated. Emergence tests were made in soils at controlled moisture contents in the laboratory and also in the field. Only the pellet with a 4% (by weight) agar coat gave a significantly greater number of seedlings (19%) than the unpelleted seed in the field. Pellets made with sodium perborate gave up to 31% fewer seedlings in the field. The results from laboratory tests did not correlate well with those from the field. The percentage seedling emergence from pelleted or unpelleted seed respectively in peat was 52 and 65; in limestone loam, 52 and 78; in flinty loam, 53 and 70 and in sandy loam, 58 and 74 (±4·4). (Longden)

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Sugar-beet manuring

The field experiments testing magnesium, nitrogen, phosphorus, potassium and lime were done in cooperation with staff of the British Sugar Corporation in 1971.

Magnesium. Five experiments compared kieserite and calcined magnesite and measured response to magnesium, some in areas where few experiments have been made with magnesium fertiliser. Fields were chosen so that all soils were in the range 0–50 ppm exchangeable magnesium and most were in the range 0–25 ppm. The treatments tested were 0, 188 and 378 kg/ha calcined magnesite (0, 102 and 202 kg/ha Mg); 314 and 628 kg/ha kieserite (51 and 102 kg/ha Mg). All plots received a dressing of 125 kg/ha N, 27 kg/ha P, 104 kg/ha K and 377 kg/ha agricultural salt (NaCl). Mg increased yield considerably in two experiments, on average by 0·4 t/ha of sugar, but only slightly in the other three. Kieserite was more effective than calcined magnesite in depressing deficiency symptoms, increasing yield and increasing the concentration of magnesium in the plants.

Three fields where experiments started in 1967 in the Allscott, Bury St. Edmunds and Cantley factory areas and one started in 1964 in the King's Lynn area (*Rothamsted Report for 1966*, 292) were cropped with sugar beet. These experiments gave information on the long-term effect of kieserite, kainit and magnesium and calcium limestones both on sugar-beet yield and on exchangeable soil magnesium. In the first three experiments, kieserite was effective both when given in the sugar-beet seed bed and when given to sugar beet three years before. However, soil analysis showed that much of the magnesium given three years before had leached out of the plough-layer. Magnesium limestone given four years before supplied little magnesium to sugar-beet on neutral and alkaline soils but much on slightly acid soils. The King's Lynn experiment, which gave information from three sugar-beet crops over a period of eight years, confirmed these results and gave further evidence that on very deficient sandy soils (0–25 ppm exchangeable Mg), 100 kg/ha Mg in a plant-available form is needed each time sugar beet is grown.

Nitrogen, soil type and time of harvesting. Further experiments determined whether soil type affects the nitrogen requirement of sugar beet and studied the relationship between the amount of nitrogen fertiliser dressing given and yield of sugar. Fields adequately manured with phosphorus, potassium and sodium were given eight equal increments of nitrogen ranging from 0 to 290 kg/ha N as 'Nitro-chalk'. Two were on soils with a sandy texture, four were on shallow, calcareous soils and three were on deep, heavy clay. This year the experiments were harvested on two occasions to determine whether harvesting date affected the relationship between sugar yield and nitrogen dressing.

Small increments of nitrogen fertiliser increased sugar yield linearly on all soil types but giving more than 124 kg/ha neither increased nor decreased yield significantly on any field. Delaying the harvest from late September to early December greatly increased yield, by 1·56 t/ha of sugar on average, but did not affect the amount of nitrogen fertiliser needed for maximum yield.

Phosphorus. Four experiments were made to measure response to 0, 14, 28, 56 and 112 kg/ha P 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). Most fields where sugar beet is grown contain much more extractable P, especially on farms with a good standard of husbandry. These farms are where most of our experiments have been made, so we have little knowledge of response to phosphorus fertiliser on soils poor in extractable P. Fertiliser increased yield in all the four experiments and the largest dressing tested

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(112 kg/ha P) gave most sugar in two of them. On one field the phosphorus fertiliser increased yield by 2 t/ha sugar, an unusually large increase. On average of all the experiments, 56 kg/ha P fertiliser was needed, and this increased sugar yield by 0·71 kg/ha.

Potassium. An experiment in the Nottingham factory area measured response to 0, 42, 84, 168 and 336 kg/ha K, with and without 377 kg/ha agricultural salt (NaCl) on a field adequately fertilised with nitrogen and phosphorus. The soil contained only 68 ppm ammonium nitrate–exchangeable potassium (ADAS index 1). The crop was very responsive to both potassium and sodium fertiliser, each element in the absence of the other increasing sugar yield by nearly 1 t/ha. Without sodium, yield still appeared to be increasing with 336 kg/ha K but where sodium was given, potassium increased yield little.

Long-term effects of liming. Three of the experiments begun in 1969 (*Rothamsted Report for 1969*, Part 1, 327) were cropped with sugar beet for the second time. All the plots were split and a fresh dressing of ground limestone or chalk at 6·25 and 12·5 t/ha and sugar factory waste lime at 12·5 or 25 t/ha given to half of each plot. None of the treatments affected sugar yield significantly. Periodic soil pH determinations since 1969 show that the two forms of lime give very similar increases in pH. The experiments will be continued and the plots split for further lime dressings when sugar beet is grown again. (Draycott)

Plant nutrients

Potassium and sodium. The growth of sugar beet given chemically equivalent amounts of sodium and potassium was again studied. This year the experiment was on Flint Ridge field and the treatments were 74 and 296 kg/ha Na as agricultural salt and 46 and 184 kg/ha K as muriate of potash (see *Rothamsted Report for 1971*, Part 1, 285). The fertilisers were applied about 14 days before sowing and none affected seedling numbers. Plants were sampled each month for yield and leaf area measurements, and for chemical analysis.

The maximum leaf area index (LAI) was only 2·2 on untreated plots, reached only by September this year. Plants given 74 kg/ha of sodium achieved maximum LAI (2·6) in August and those given 296 kg/ha sodium, 2·6 in July. The maximum LAI of plants given either amount of potassium was 2·6 in August. Chemically equivalent amounts of sodium and potassium had similar effects on LAI. Sodium and potassium increased their respective concentrations in the crop and each suppressed the concentration of the other. Both increased yield of tops and roots throughout the season.

On average of the last two harvests, sodium alone increased sugar yield by 0·85 t/ha, and potassium by 0·81 t/ha. This year the larger dressing of both elements was needed for maximum sugar yield, the two giving 1·54 t/ha extra sugar. (Farley)

Distribution of nutrients. Continuing measurements described in *Rothamsted Report for 1971*, Part 1, 285, ten plants adequately supplied with nutrients, were sampled at monthly intervals from June to November, and were divided into tops, crown and root and the tops further divided according to leaf size. Each part was dried and analysed for N, P, K, Na, Ca and Mg. On each occasion, the youngest leaf on each of 20 other plants was labelled with a wire tie and the leaf area noted at that date and subsequent sampling dates. As in 1971, all elements except K were more concentrated in the lamina than in the petiole, and P and N concentration decreased with increase in size of leaf. The concentration of K in dead leaf material was similar to the concentration in living material, N and P concentrations were much smaller, and Na, Ca and Mg much greater. The concen-

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tration of N, P and K in leaves of the same size decreased progressively until October but Ca and Mg dropped sharply in June and then remained constant. During much of the season, leaves took about two months to reach their maximum area and remained viable for a further six to ten weeks. (Wright)

Forms of magnesium fertiliser. Experiments in 1968–71 (see Research Paper Summary 16.15, p. 366) showed that the magnesium in the calcined magnesite was not immediately available to sugar beet, particularly in neutral and alkaline soil. As a result, the manufacturers have decreased both the temperature of calcining and the time which the magnesite rock is in the kilns. Laboratory measurements indicated that more of the magnesium in this new form of calcined magnesite would probably be available to plants. Four field experiments were therefore made to compare new and old forms of calcined magnesite with kieserite, each applied at 50 and 100 kg/ha Mg. Sugar beet was grown on three fields and carrots on the other.

On one field, sugar beet not given magnesium was severely affected by deficiency symptoms, which provided a good test of the availability of the element from the different forms of fertiliser. Both the number of plants with deficiency symptoms and yields indicated that much more magnesium was available from the new form of magnesite than from the old, a result confirmed by the other experiments. No conclusions can be drawn on the relative merits of kieserite and the new calcined magnesite until the crop samples have been analysed. (Bennett)

Nitrogen, cations and varieties. An experiment, in cooperation with Dr. G. E. Russell of the Plant Breeding Institute, investigated the nitrogen, sodium and potassium fertiliser requirements of four sugar-beet varieties. The experiment was on Flint Ridge field and the number of seedlings that emerged from each variety differed greatly, 12/m of row from Sharpe's Klein E, 11 from Maris Vanguard, eight from VT 137 and ten from Anglo Maribo Poly. However, none of the fertilisers affected the number of seedlings that emerged. On average of the fertiliser treatments, the varieties yielded similarly, Sharpe's Klein E giving 7·8 t/ha, Maris Vanguard and VT 137, 7·6 t/ha and Anglo Maribo Poly 8·0 t/ha sugar. There was no evidence that the fertiliser requirement of the four varieties differed. This agrees with results from similar experiments in 1970 and 1971. (Draycott)

Time of application of fertilisers

P K Na Mg. Of the two long-term experiments started last year in East Suffolk on loamy sand (*Rothamsted Report for 1971*, Part 1, 286), was one cropped with winter wheat and the other with spring barley. The amounts of fertiliser used were 0, 42, 83, and 167 kg/ha K; 0 and 101 kg/ha Mg and 27 kg/ha P. For comparison of autumn and spring applications, 83 kg/ha K, 101 kg/ha Mg and 27 kg/ha P were used. Both crops grew irregularly due to a shortage of water and the wheat yielded little, the average grain yields being 3·63 t/ha of barley and 2·16 t/ha of wheat. In both experiments, grain yield was the same whether the fertiliser was given before ploughing or in the seedbed. There were no significant yield responses to any of the potassium or magnesium treatments. On average, those plots which received fertiliser in 1972 yielded approximately 0·15 t/ha more grain than those fertilised only in 1971. As in 1971, the results suggest that on such fields as these, yield is not lost when P K Mg fertiliser is ploughed in, but the results are not conclusive because water, not nutrients, was the dominant factor limiting yield. (Bennett)

Nitrogen and phosphorus. Another experiment on The Holt field compared phosphorus fertiliser applied during autumn or to the seed bed, and nitrogen before or after

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sowing. Phosphorus was applied on 28 October or 9 March at 0, 14, 28, 55 and 110 kg/ha P and nitrogen on 9 or 30 March at 125 kg/ha N; the crop was sown on 9 March. Phosphorus increased yield, on average, by only 0·11 t/ha sugar and the time when it was applied did not affect yield. The crop given nitrogen at sowing yielded 8·48 t/ha sugar, whereas the crop given nitrogen three weeks later yielded 8·19 t/ha. (Draycott)

Nitrogen. A similar experiment on The Holt to that last year (*Rothamsted Report for 1971*, Part 1, 286) compared 75, 150 and 225 kg/ha N applied before ploughing during September, with the same amounts ayplied in the spring, and with 150 kg/ha applied before ploughing, plus 36 kg/ha applied in the spring. Analysis of soil in spring from plots which had N fertiliser before ploughing showed that the nitrogen had leached below 60 cm. Periodic petiole analyses showed that early in the season, plants from plots given N in spring contained more than those given N in winter. However, in July plants given N in winter contained more than those given N in spring and also appeared more vigorous in August and September. Presumably the roots were taking up N fertiliser which had leached into the subsoil; neutron probe measurements nearby showed that sugar-beet roots were taking up water during the late summer from 100–150 cm deep. Sugar beet on The Holt needed little N fertiliser for maximum yield and applying the fertiliser at different times did not affect sugar yield. (Chapman)

Nutrients in drainage. Water from field drains has been sampled periodically since January 1970 and the concentration of nitrate-N, Na, K, Mg and Ca measured by R. J. B. Williams. In the first winter, nitrate concentrations were in the range 14–17 ppm N and in 1971–72, 14–21 ppm N, in both years following wheat. After the bean crop of 1970, nitrate concentrations were much greater and reached 35 ppm N in mid-November about ten days after drainage began.

From estimates of the flow-rates and catchment on The Holt, the loss of nitrate-N was 30, 61 and 7 kg/ha in each of the winters 1969–70, 1970–71 and 1971–72 respectively. The rainfall in each of these winters after the onset of drainage was 236, 277 and 185 mm and the number of occasions when any two-day period of rain exceeded 20 mm was 3, 7 and 1. The large loss in 1970 was due partly to the increased concentration of N after the bean crop and partly to the large outfall of drainage water resulting from large rainfall in short periods.

The heavy initial rainfall of 1969–70 winter also produced a peak of Na concentration but the water generally contained about 10 ppm Na. Mg concentrations were constant in all winters at 2–4 ppm and K at 0·2–0·8 ppm. The Ca concentration in the first two winters was fairly constant at 150 ppm but in January and February 1972 the flow rate was small and Ca concentration reached 230 ppm. Estimates of the average loss of these nutrients each winter were 17 kg/ha Na, 0·3 kg/ha K, 3·7 kg/ha Mg and 210 kg/ha Ca. (Messem)

Manganese. Three experiments on fields in the Ely, Peterborough and Wissington factory areas tested 0, 4·5 and 9 kg/ha Mn as manganese sulphate in a foliar spray and 6 kg/ha Mn as manganous oxide or 2 kg/ha Mn as manganese silicate 'frit' incorporated in the seed pellet by Germain's 'Filcoat' process. The Ely soil, pH 7·5, contained 0·67 ppm exchangeable Mn and 25 ppm easily reducible Mn; the Peterborough soil, pH 7·0, contained 0·70 ppm exchangeable Mn and 24 ppm easily reducible Mn; and Wissington soil, pH 7·5, contained 0·36 ppm exchangeable Mn and 20 ppm easily reducible Mn.

The depth to which roots extracted soil moisture was measured weekly from May to August by neutron moderation and the percentage of plants with manganese deficiency symptoms on untreated plots recorded. Typically, manganese deficiency in sugar beet is

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most severe in May or June and symptoms generally disappear as the season progresses. On the Peterborough soil, symptoms disappeared early in the season, when the roots penetrated the acid, clay subsoil; although 50% of the seedlings were manganese-deficient, none of the treatments affected the yield at harvest, which averaged 6·24 t/ha. Symptoms persisted much longer on the Ely and Wissington crops, probably because the soil pH was 7·5 down to 150 cm. The average depth of peat was 40 cm over sand and gravel. On these two fields, all the treatments increased sugar yield, the spray by up to 0·88 t/ha, the 'frit' by 0·33 t/ha and the manganese oxide by 0·65 t/ha sugar.

Copper. The effect of copper on spring barley, variety Lofa Abed, was tested at Broom's Barn and on sugar beet, variety Sharpe's Klein Poly, at Herringswell. The cereal experiment was on White Patch field where the soil contained 1·4 ppm 'available' copper. Copper sulphate ($CuSO_4 5H_2O$) at 7 kg/ha Cu and copper chelate (Cu-EDTA) at 0·23 kg/ha Cu was given in the seed bed and were compared with one foliar spray of copper oxychloride (CuOCl) suspension at 0·28 kg/ha Cu on the crop at the late tillering stage. None of the treatments affected the yields of grain or straw which averaged 5·5 t/ha and 4·5 t/ha respectively. Only the foliar spray increased the concentration of copper from 2·0 to 2·5 ppm Cu in grain and from 5 to 35 ppm Cu in straw.

The same treatments were tested on sugar beet except that the copper sulphate was given at 12 kg/ha Cu. The soil in experiment I was loamy sand over sand subsoil and contained only 1·1 ppm 'available' copper. Experiment II was on loamy sand over chalk subsoil and contained 1·6 ppm 'available' copper. The crop of experiment I was irrigated and none of the treatments affected the yield of sugar, average 7·20 t/ha. Experiment II was not irrigated and the sugar yield of 5·77 t/ha was increased slightly by all the copper treatments, the foliar spray giving 5·80 t/ha, the chelate 6·40 t/ha and the copper sulphate 6·04 t/ha sugar. (Farley)

Irrigation

Fertiliser, spacing and irrigation. This experiment examined how density of plant stand, fertiliser and irrigation affect yield and water use by sugar beet. The plant populations (D_1—18·5, D_2—37·0, D_3—74·0 and D_4—130 thousand/ha), potassium (0, 140 kg/ha K), sodium (0, 245 kg/ha Na) and irrigation treatments were as before (*Rothamsted Report for 1970*, Part 1, 266, and *for 1971*, Part 1, 286).

Rainfall and radiation were below average for much of the season and yields were small from plots without irrigation. Table 5 shows the effect of irrigation and plant population on sugar yield. A total of 130 mm of irrigation increased sugar yield, on average, by 1·75 t/ha sugar—the largest response to irrigation recorded at Broom's Barn. Irrigation increased the yield of D_4 more than D_1 (+1·94 and +1·23 t/ha respectively). Without irrigation the maximum soil moisture deficit, as determined by field measurements with

TABLE 5

The effect of plant population and irrigation on sugar yield

	Plant density ('000/ha)				
	D_1 18·5	D_2 37·0	D_3 74·0	D_4 130	Mean
	Sugar (t/ha)				
Without irrigation	4·13	5·75	6·14	6·33	5·59
With irrigation	5·36	7·96	7·76	8·27	7·34
Mean	4·75	6·86	6·95	7·30	6·46

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the neutron probe, was in the first week of September when it reached 175 mm on D_4 and 162 mm on D_1. All four plant densities were using soil water from at least 150 cm deep in September.

Samples of plants from plots D_1, D_3 and D_4, given the extremes of fertiliser treatments with and without irrigation, were weighed at two-week intervals during June and then at four-week intervals until harvest. Competition began to decrease total dry matter yield per plant with D_3 and D_4 on 26 June. Fertiliser increased yield at each sampling but the interaction between plant population and fertiliser was generally small. Irrigation always increased yield of D_3 and D_4 more than D_1. (Durrant and Messem)

Time and amount of irrigation. This experiment measured the response of sugar beet to irrigation applied at different times and compared one with several waterings. The method of watering and the amounts were as before (*Rothamsted Report for 1971*, Part 1, 287). Watering in June (25 mm), July (50 mm) or August (50 mm) increased yield slightly but giving water every month (125 mm total) increased sugar yield by 1·31 t/ha. Giving 50 mm water in September only, when the soil moisture deficit was maximal, increased root yield but decreased sugar percentage by a commensurate amount and sugar yield was unchanged. (Messem)

Plant spacing

Plant density and distribution. Four different plant densities were established on plots sown early or late on Flint Ridge field (cf. *Rothamsted Report for 1971*, Part 1, 287) and they were harvested either in early October or early December. Seed of the variety 'Amono' was sown on 21 March or 2 May in rows 51 cm apart, and the braird was thinned by hand. The March-sown crop yielded more roots and sugar than the May-sown at both harvests (Table 6). Stands of 25 000 and 49 000 plants/ha yielded less roots, sugar and tops than the denser stands. Irregular spacing of the two sparsest plant stands decreased root and sugar yield but not top yield at all sowing and harvesting dates. The early sown and late harvested crops were not obviously better able to compensate for irregular spacing than those with shorter growing periods. (Jaggard)

TABLE 6

Sugar yield (t/ha) from different sowing dates, plant densities and distributions

	Sowing date (Meaned over two harvest dates)									
	21 March					2 May				
Density ('000/ha)	25	49	74	98	Mean	25	49	74	98	Mean
Distribution:										
Regular	5·15	6·50	6·44	6·54	6·16	4·68	5·94	6·14	5·78	5·64
Irregular	5·20	6·40	6·63	6·75	6·25	4·44	5·81	5·95	5·88	5·52
Very irregular	4·68	6·26	6·50	6·50	5·99	4·05	5·67	5·92	5·86	5·38
Mean	5·01	6·39	6·52	6·60	6·13	4·39	5·81	6·00	5·84	5·51
October harvest			5·57					4·87		
December harvest			6·66					6·14		

Time of sowing, harvesting and plant density

An experiment testing three times of sowing and two times of harvesting at four plant densities produced the sugar yields shown in Table 7. The 50 and 75 thousand plants/ha

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treatments were grown in rows 50 cm apart, and the denser stands in beds of 5 rows, 25 cm apart. The first and second sowings yielded similarly but more than the third sowing at both harvests. Plant density did not significantly affect sugar yield, but 75 000 plants/ha produced the smallest sugar yield at the second harvest from all sowing dates. This is an incongruous and unexplained result since 75 000 plants/ha is usually the optimum density for sugar beet. (Webb)

Plants from the first and third sowings at all four plant densities were sampled and analysed for growth five times between 19 June and 18 September. The early sown crop produced the larger leaf area index (LAI) until mid-August, and hence maintained a larger growth rate than the late-sown crop. The densest stands also had large LAI's early in the year, but inter-plant competition limited growth so that the early-sown crop reached its maximum growth rate in early July, and the late-sown by the end of July. Nevertheless, the early-sown and dense stands continued until September to yield the most total dry matter and roots. (Jaggard)

TABLE 7

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

	Harvest date									
	27 September Plant density '000/ha					29 November Plant density '000/ha				
Sowing date	50	75	100	125	Mean	50	75	100	125	Mean
17 March	5·15	5·50	5·81	5·91	5·59	7·02	6·63	7·77	7·18	7·15
6 April	5·43	5·80	5·67	5·44	5·58	7·62	6·91	7·25	7·03	7·20
2 May	4·73	4·96	5·02	4·75	4·88	7·09	6·82	6·95	6·86	6·93

Time of sowing and seed spacing. An experiment on Flint Ridge field tested the effect of time of sowing on seedling establishment and yield of two varieties when drilled to a stand. Pelleted seed vars. Bush Mono and Sharpe's Klein Megapoly was sown on 17 March, 6 April or 2 May spaced at 12·5 cm, 15·5 cm or 18·5 cm. Plant establishment ranged from 57% of seeds sown in March to 75% for the later sowings (Table 8). The densest plant stand yielded less with the polyploid variety, but otherwise plant density had little effect on sugar yield. (Webb)

TABLE 8

Plant densities from different sowing dates and seed spacings, and mean yields of sugar

	Sown at 12·5 cm spacing Plant stations '000/ha	Sown at 15·5 cm spacing Plant stations '000/ha	Sown at 18·5 cm spacing Plant stations '000/ha	Mean Sugar t/ha	Mean Plant stations '000/ha
Variety Bush Mono					
S1	88	74	62	7·36	75
S2	114	89	85	7·26	96
S3	103	90	78	6·46	90
Mean	102	84	75	7·03	87
Variety Sharpe's Klein Megapoly					
S1	84	77	57	7·62	73
S2	113	95	80	7·17	96
S3	114	93	74	6·61	94
Mean	104	88	70	7·13	88

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Plant density and regularity. A randomised block experiment on Flint Ridge examined the effects on yield of irregularity of plant stand at a range of plant densities. The irregularity and plant density treatments simulated what could occur as a result of poor seedling emergence when drilling to a stand. Viable seed mixed with varying quantities of killed seed produced seedling emergence values of 77%, 61%, 54% and 40% of seeds sown. Sowing the seed mixtures at 12 cm and 19 cm intervals gave plant densities ranging from 40 000 to 125 000 plants/ha. These stands were compared with four regularly distributed populations of 35, 50, 75 and 95 thousand plants/ha produced by hand singling. The different plant stands gave no significant differences in root yield, although fewer than 55 000 plants/ha always tended to yield least. (Jaggard)

Twin rows on ridges. An experiment on The Holt again tested narrow rows (25 cm) on ridges or on the flat in comparison with wide rows (50 cm) on the flat (cf. *Rothamsted Report for 1971*, Part 1, 288). Pelleted seed var. Bush Mono was sown at 12·5 cm or 20 cm spacing on 15 March. Pheasants severely and irregularly thinned the stand of plants during June, particularly on the ridges, where the final stand was 83 000 plants/ha compared with 111 000/ha on the flat and 87 000 in the wide rows. On average, narrow seed spacing gave 114 000/ha and wide seed spacing gave 74 000/ha. The sugar yield from the crop on the flat, whether in wide or narrow rows, was 9·14 t/ha, compared with 8·81 t/ha from the ridges. The narrower seed spacing slightly outyielded the wide spacing. These yield differences seem the consequence of differences in density and regularity of plant stand. (Hull)

Soil compaction

An experiment on The Holt tested the effects of soil compaction on fertiliser requirement and yield of sugar beet (*Rothamsted Report for 1971*, Part 1, 289). The soil conditions tested were: (1) compaction produced by rolling the land with tractor wheels; (2) a seed bed produced by shallow cultivations immediately before drilling; (3) a very loose seed bed produced by a powered harrow operating 15 cm deep immediately before drilling. At seedling emergence the mean bulk densities of soil from the surface 16 cm of each treatment were: compacted seed bed, 1·63 g/ml; normal seed bed, 1·55 g/ml; loose seed bed 1·36 g/ml. Significantly fewer seedlings emerged from the compacted than from the normal and loose seed beds. Soil compaction decreased the sugar yield by 1·9 t/ha and top yield by 10 t/ha compared with the normal and open seed beds. Sugar yield on the compacted plots increased with up to 150 kg/ha of nitrogen fertiliser, while the normal and loose seed beds responded to no more than 75 kg/ha of nitrogen. Additional phosphate fertiliser had no significant effect.

In cooperation with the ARC Letcombe Laboratory, samples of the soil atmosphere from a depth of 30 cm were analysed at weekly intervals during the period mid-April to mid-June. Very little ethylene and no nitrous oxide was found under either compact or loose seed beds, and no large differences between treatments were recorded for oxygen or carbon dioxide content. It seems that the poorer crop on the compacted plots resulted from physical impedance of root growth rather than toxic soil atmosphere.

An experiment of the same design as that reported last year (*Rothamsted Report for 1971*, Part 1, 289) was carried out at Freckenham, Suffolk, to examine the effects of soil compaction and the systemic nematicide, aldicarb, on sugar beet growing in a sandy soil infested with the ectoparasitic nematode *Longidorus*. When the seedlings emerged, the mean soil bulk density to a depth of 16 cm was 1·28 g/ml on the uncompacted plots, and 1·53 g/ml on the compacted. Compacting the seed bed decreased the yield of roots and sugar by 3 t/ha and 0·7 t/ha respectively. Treatment with 0·84 kg/ha of aldicarb did not

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affect either root or sugar yield. The effect of soil compaction on yield was not significant because the crop was very irregular in the dry summer on this light soil of variable depth over chalk. (Jaggard)

Analysis of sugar-beet crowns

Samples of plants of different sizes were again taken from the spacing and irrigation experiment described on p. 282 (see also *Rothamsted Report for 1971*, Part 1, 291). They were trimmed to remove leaf stalks and cossette samples taken with a grating machine from the growing points, crowns and storage roots. Each part was weighed and analysed for Na, K, α-amino nitrogen, invert sugar and sucrose concentration. The juice purity was calculated for whole, scalped and topped beet. On average, the untopped beets weighed 17% and the scalped beet 13% more than beet topped normally. The largest untopped beets resulted from growing the crop at 18·5 thousand plants/ha. These weighed 24% more than topped beet, but the smallest roots, grown at 130 thousand plants/ha were only 13% heavier than the corresponding normally topped beet. With the growing point removed, the corresponding scalped beets weighed 17% and 10% more.

The scalp contained 11·9% sucrose, the crown 15·1% and the normally topped beet 18·6%. Calculated juice purities were 84% in the scalp, 89% in the crown and 94% in topped beet. The juice purities for whole, scalped and topped beets were calculated to be 92·7%, 93·0% and 93·6% respectively.

The invert sugar concentration in the scalp was 1·51 g/100 g sugar, in the crown 0·66 and in the root 0·33 g/100 g. Thus the invert sugar concentrations in whole, scalped and topped beet were 0·40, 0·37 and 0·33 g/100 g respectively. (Last)

Growth control chemicals

A randomised block experiment examined the effects of three rates of the growth retardant 'MON 0845' (N,N-bis(phosphonomethyl) glycine) (supplied by the Monsanto Chemical Corp.) on the yield of sugar beet var. Sharpe's Klein Monobeet. The chemical was applied as a foliar spray in 560 l/ha of water on 19 September at 0, 0·28, 0·55 and 0·82 kg a.i./ha, and the plots were harvested on three occasions, 10 October, 25 October and 8 November. The treated plots all yielded less roots and sugar than the control at the first two harvests. At the third harvest, however, plots treated with 0·28 and 0·55 kg/ha of the chemical yielded more than the control, but not significantly. The yield of the control plots did not increase between the second and third harvests; this is unusual and may account for the apparent effect of the chemical. As in previous experiments the chemical slightly increased the sugar content of fresh roots, and significantly decreased the yield of tops. (Jaggard)

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. Treatments gave good weed control and sugar yields were up to 7·9 t/ha, whereas unsprayed plots which were not hand weeded until 7 June yielded 7·3 t/ha.

Varieties

Commercial. An experiment done in cooperation with the National Institute of Agricultural Botany tested ten varieties of sugar beet sown on 21 March on Flint Ridge. The pelleted seed was spaced at 16 cm and the crop grown without hand work. The experiment is one of the NIAB series testing varieties grown in this way. The plant population

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of the different varieties ranged from 61·3 to 92·5 thousand/ha and bolters from 4% to 20%. Sugar percentage ranged from 18·7 to 19·5, mean 19·1. The root yield and sugar yield of the varieties did not differ significantly and averaged 35·4 and 6·73 t/ha respectively.

Yellows tolerant. Plots of 14 commercial or breeder's varieties sown on 22 March were either infected with a mixture of beet yellows virus and beet mild yellowing virus or kept free from yellows by insecticide sprays. This experiment was also done in cooperation with the NIAB as one of their series testing yellows tolerant varieties. Average yields for all varieties when healthy or infected were respectively: sugar 6·63 and 4·29 t/ha; roots 37·5 and 26·3 t/ha; sugar percentage 17·63 and 16·25; juice purity 94·62 and 93·36%. As in previous years the Hilleshog variety 'Nomo V.T.' (L.34240) gave outstandingly large yields of sugar whether infected or healthy. (Webb)

Cereal and rotation experiments

Fertilisers on rotation crops. This was the eighth 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 9 shows the effect of the treatments in 1972. As in 1971, wheat and barley needed N_2 (150 and 100 kg/ha nitrogen respectively) but did not respond to phosphorus or potassium fertilisers. Response to nitrogen fertiliser was much greater with wheat than with barley grain (+2·46 and +1·08 t/ha respectively). Potassium and sodium fertilisers increased sugar yield but nitrogen fertiliser had little effect. The large increase in yield from a moderate dressing of N P K (Compound 1) for wheat and barley was mainly due to the nitrogen it contained. FYM increased sugar yield even when large amounts of inorganic fertilisers were also given.

TABLE 9

Yield responses of crops to fertiliser treatments in the eighth year of the rotation experiment

	Wheat grain (t/ha at 85% DM)	Barley grain (t/ha at 85% DM)	Sugar beet (sugar, t/ha)
Mean yield	4·13	4·41	5·16
Response to:			
N_1	+2·25	+0·84	+0·08
N_2–N_1	+0·21	+0·24	−0·60
P_1	0	−0·01	−0·08
P_2–P_1	+0·38	+0·27	−0·30
K_1	−0·16	0	+0·94
K_2–K_1	+0·24	−0·36	+0·54
Na	+0·12	+0·06	+0·35
FYM	+0·21	+0·04	+1·23
Compound 1	+1·98	+1·06	+0·93
Compound 2–Compound 1	+0·21	+0·08	−0·31

Frequency of beet and barley. This was the eighth year of the experiment testing yields in five contrasting crop rotations (*Rothamsted Report for 1966*, 298). In 1972 the largest yield (6·64 t/ha sugar) was when sugar beet was grown after the two-year grass ley. Sugar yields were similar in the continuous sugar beet and cereal rotations (average 5·60 t/ha). Sugar beet in none of the rotations needed more than 63 kg/ha N for maximum yield. Barley grain yields were similar, 4·00 t/ha at 85% dry matter (DM), following sugar beet,

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one or two cereal crops but were less following three or four barley crops (3·72 and 3·57 t/ha respectively). With little rain it was again difficult to establish the grass following sugar beet and it yielded only 2·91 t/ha DM. Grass established one year before gave 9·78 t/ha DM. Beans yielded 1·77 t/ha grain at 85% DM and potato tubers gave 7·0 t/ha DM. (Durrant)

Nitrogen and fumigation. The experiment on Brome Pin (*Rothamsted Report for 1971*, Part 1, 293) testing the residual effects of soil fumigation and form of nitrogen fertiliser on pathogens and crop yields, was cropped with spring barley in 1972. Yields of grain and straw were improved by repeated fumigation and by both forms of fertilisers (Table 10). In contrast to 1971, nitrate fertiliser increased yield as much as ammonium fertiliser. The small yield increases from fumigation in 1970 were not significant. Larger yields after annual fumigation were probably partly a result of increasing the amount of available nitrogen in the soil, since the largest increases were in plots receiving no nitrogen, and partly a result of controlling soil pathogens. (Cooke and Last)

TABLE 10

Grain and straw yields in the nitrogen and fumigation experiment

	N dressing (kg/ha)	Fumigation treatment: None	Every year (18.3.70; 13.11.70) and 14.9.71)	18.3.70 only
Yield of grain (85% DM) t/ha	0	2·02	3·66	2·03
	125 (NH_4^+)	4·06	4·85	4·34
	125 (NO_3^-)	4·32	4·76	4·42
Yield of straw (85% DM) t/ha	0	1·73	3·62	1·94
	125 (NH_4^+)	3·69	4·88	4·41
	125 (NO_3^-)	4·06	4·95	4·26

Magnesium and boron. This was the third year of the experiment testing the residual effects of magnesium and boron (*Rothamsted Report for 1970*, Part 1, 271). It was sown with barley, variety Julia, on 10 March. Neither element effected yield of grain or straw which averaged 3·98 t/ha and 3·33 t/ha respectively. The average concentration of magnesium in the grain was 0·11% and in straw 0·032%. The boron concentration in the grain was 0·46 ppm and in straw 4·3 ppm. Soil concentrations of exchangeable magnesium and hot water soluble boron had changed little since 1971. (Farley)

Irrigation and nitrogen for cereals. Experiments organised by the Botany and Chemistry Department of Rothamsted again compared the growth and yield of winter wheat and spring barley at Broom's Barn with similar crops at Harpenden (see pp. 48 and 90) At Broom's Barn, the wheat was on Hackthorn field and the barley on Windbreak field. The fertiliser and irrigation treatments were as before (*Rothamsted Report for 1971*, Part 1, 294). A total of 126 mm of water was applied to the wheat and 81 mm to the barley.

Yields of both crops were above average for Broom's Barn. Wheat yielded 5·9 t/ha grain without irrigation and 6·5 t/ha with irrigation; on average, irrigation had little effect on yield of barley grain (Table 11). The wheat needed about 90 kg/ha N for maximum yield both with and without irrigation, whereas the optimum dressing for barley was about 60 kg/ha with irrigation and 160 kg/ha without irrigation. Giving more than 60 kg/ha N and water to barley greatly decreased yield, probably as a result of the crop lodging.

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The maximum soil moisture deficit as determined by neutron moderation was 170 mm on the unirrigated wheat plots on 14 August and 133 mm on the corresponding barley plots on 17 July. Before irrigation on 2 June, the deficit was 67 mm in the wheat and 54 mm in the barley. The potential deficit, calculated as the difference between potential transpiration and the rainfall, was 168 mm on 14 August in the wheat and 145 mm on 17 July in the barley, showing close similarity to the measured maximum soil moisture deficits. This suggests that both crops were able to obtain the whole of their water requirement from soil reserves and rainfall, and that the increase in yield of wheat from irrigation resulted from either increased nutrient availability or some other cause. Irrigating decreased the measured maximum soil moisture deficit to 59 mm in wheat and to 57 mm in barley. The theoretical values (maximum soil moisture deficit *minus* irrigation) were very similar; for wheat 170 − 126 = 44 mm and for barley 133 − 81 = 52 mm. This year, wheat extracted water to 120 cm depth and barley to 100 cm. Without irrigation, wheat removed more than twice as much water as barley from below 50 cm. (Draycott, Messem and Webb)

TABLE 11

Effects of irrigation and nitrogen on yields of wheat and barley

	Grain yield, t/ha at 85% DM N dressing (kg/ha)						
	31	63	94	125	157	188	Mean
			Wheat				
Without irrigation	5·46	6·05	6·37	5·89	6·06	5·85	5·94
With irrigation	6·09	6·67	6·71	6·64	6·48	6·14	6·45
Mean	5·77	6·36	6·54	6·26	6·27	5·99	6·20
			Barley				
Without irrigation	4·55	5·13	5·76	5·96	6·19	6·19	5·63
With irrigation	4·76	6·10	5·82	5·88	5·24	5·11	5·48
Mean	4·65	5·61	5·79	5·92	5·71	5·65	5·56

Fungicides on barley. Fungicides were tested on three varieties of spring barley for the control of mildew and brown rust. Mildew was severe on Berac, moderately severe on Julia and very little was found on Mazurka. Brown rust was more severe on Berac and Mazurka than on Julia. Ethirimol ('Milstem') as a seed dressing and tridemorph ('Calixin') as a spray controlled mildew well, better than benomyl ('Benlate'), but had little effect on brown rust. All these fungicides increased 1000 grain weight and ethirimol increased the height of all the varieties by 5–10 cm. Ethirimol also slightly delayed maturity of the crop and decreased 'ear loss' on average of all varieties. Ear loss from Mazurka was particularly heavy, averaging 1 t/ha over all treatments. Yields of all varieties averaged for all treatments were 5·1 t/ha. Fungicide combinations incorporating ethirimol increased yield most consistently. (Webb)

Broom's Barn farm

Since acquiring Broom's Barn farm in 1959, we have developed a five-course rotation of sugar beet, three cereal crops and a temporary grass ley or beans. The land in grass ley is cultivated about 40 cm deep in July, planed, limed when necessary, spread with farm yard manure, ploughed and sown with winter wheat as a preparation for the sugar

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beet experiments in the following year. Tile drains have been laid where necessary and practical. This method of farming has resulted in more level fields with soil of a more uniform colour after ploughing and usually more even crops. The soil seems to be easier to work and good seed beds are more readily made now than in the earlier years.

Although the structure of the surface soil has improved, problems still remain. The light soil of the Dullingham, Moulton, Newmarket and Ashley variant Series still tend to slake and set when fallow. The damage caused to the stronger soils by using machines on them when wet was revealed this summer. For instance, when Little Lane (Ashley and Stretham Series) was deep cultivated in July, while dry after the hay crop, it worked up as a mass of intractable clods, some of a half cubic meter or so. The clods were compacted and structureless with roots confined to worm holes and the large fissures. This bad soil structure was created by harvesting the sugar-beet crop in 1969 when the land was very wet. Heavy rain in late July saturated the clods which then shattered and readily worked down to a uniform, crumbly tilth into which winter wheat was sown. Correcting this damage has taken three years and the yields of the intervening crops may have been depressed by it. Deep cultivating Hackthorn (Stretham Series) also brought up similar clods, though fewer. The damage here had been done while harvesting the sugar beet in 1970 and in preparing the land for sowing beans in the spring of 1971.

In fields stretching across the valley that runs north-east to south-west across the farm, the soil tends to dry slowly in spring where the Stretham and Ashley Series meet the lighter soil (Dullingham Series) of the valley bottom. This latter soil is easily worked into a fine tilth. It is not practical to tile drain these fields. Marl Pit, Hackthorn and part of Bull Rush were subsoiled in August, using a single tine with an angled chisel head drawn 50–55 cm deep at 1·5–2 m intervals. This penetrated well on the slopes but would not penetrate deeper than 40 cm in the valley bottom where there was an indurated layer of dry, brown sand about 25 cm thick, structureless but penetrated by occasional worm holes. Below this there was loose brown sand and flints. Although the subsoiler was induced to score this hard layer, it failed to shatter it and different tools will have to be used to break it. On the slopes and plateau the subsoiler encountered a variety of materials such as wet clay, chalk, flint beds, boulders which made it ride out of the ground, as well as the predominant chalky and sandy clay with flints.

On the Moulton Series in Flint Ridge field, strips of wilted sugar beet about 60–90 cm wide and 5–7 m apart, stretched sinuously down the slopes in August. Under the upstanding plants between, the subsoil was chalky and solid chalk came to within 50 cm of the surface; under the wilted plants the subsoil was gravel and contained water-worn erratic pebbles. These channels in the chalk are believed to have originated as cracks in periglacial conditions and to have been filled with water-borne material. The stripes are usually obvious in aerial photographs of most crops in summer but are apparent on the ground only in drought. In August the roots of the wilting plants were heavier than those of the upstanding ones. We have farmed the surface soil into a satisfactory, uniform condition but now we will have to attend to the great diversity of subsoil, which will be a more difficult task.

Ploughing was completed before the end of December 1971 and although there were few frosts, the land worked well in March and spring sowings were early. After harvest, part of Marl Pit and the whole of Brome Pin and Bullrush were limed. All the sugar beet on Flint Ridge was given 50 mm of irrigation and the northern half of the field an additional 50 mm. Again this autumn all the land was ploughed before Christmas.

Some of the old unsafe beeches and oaks around the farm buildings were felled and have been replaced with young standards. A large open pit has been dug to the north of the farm buildings to take drainage water from the roofs, concrete areas and laboratory sinks. Existing soakaways have proved inadequate.

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Cereals. The cereal crops were manured and sprayed with herbicide as in previous years. Part of the barley on Marl Pit had no herbicide and had no noticeable difference in weed infestation in the stubble after harvest from the treated area.

A few acres of the Joss Cambier wheat on Brome Pin was fertilised with an extra 25 kg/ha N and sprayed with chlormequat chloride. The crop was blighted with yellow rust and the treatments did not affect yield. The Maris Ranger sown in December after sugar beet on Dunholme was heavily infected with mildew but the Maris Nimrod on Hackthorn kept healthy.

All the barley was sown in mid-March. Ethirimol seed dressing kept the Proctor free from mildew and tridemorph spray kept Julia relatively free. Lofa Abed, a resistant variety, had mildew slightly. No cereal crop lodged and harvesting lasted from 10 to 27 August with grain moistures ranging from 14 to 22%. The yields are in Table 12.

TABLE 12

Cereal and bean yields at 85% DM

Field	Area (ha)	Variety	Yield (t/ha)
Windbreak	1·21	Julia barley	5·12
White Patch	9·18	Julia barley (undersown)	4·98
Marl Pit	4·85	Lofa Abed barley	4·75
Bullrush	4·61	Proctor barley	4·88
Brome Pin	8·50	Joss Cambier wheat	4·60
Hackthorn	3·03	Maris Nimrod wheat (seed)	6·32
	0·89	Cappelle wheat (experiments)	5·67
Dunholme	8·50	Maris Ranger wheat	4·26
New Piece	5·22	Maris Bead beans	3·12

Beans. Tick beans var. Maris Bead were sown in a good seedbed on 18 March, and immediately rolled and sprayed with simazine. This controlled weeds without damage to the beans. Five hives of bees worked the crop and no aphid control was necessary. They were harvested on 21 and 22 September although the stalks were still very green.

Fodder crops. The Italian ryegrass and clover ley on Little Lane was cut for silage during the third week of May and immediately top dressed with 130 kg/ha N to yield a hay crop in mid-July. The ley under the barley on White Patch has established well.

Sugar beet. The basic fertiliser on Flint Ridge was 750 kg/ha of kainit ploughed down in the autumn and 660 kg/ha of compound fertiliser containing 20% N, 10% P_2O_5, 10% K_2O (abbreviated to 20–10–10) in the seedbed. The Holt had 750 kg/ha kainit and 350 kg/ha of 0 : 20 : 20 compound ploughed down in the autumn, then 440 kg/ha of 34% N fertiliser at sowing. Sowing started on 15 March and continued while the weather was dry for two weeks when more than 8 ha had been sown. The remainder, except for experimental late sowings, was sown between showers in less settled weather during the next two weeks. Seventy-five per cent of the crop area was sown with pelleted monogerm, 12·5% with pelleted polyploid and 12·5% with rubbed and graded seed. About 2 ha was sown at 6 cm seed spacing or less, 5·5 ha at 5–12 cm and about 6 ha at 15 cm or more. Most of the crop was band sprayed with pyrazone herbicide during sowing. Phenmedipham was used after seedling emergence on experiments with different row widths instead of tractor hoeing. All the crop was sprayed with aphicide and that on the light soil with boron. Harvesting started on 2 October when the soil was very dry, but many roots broke in the hard ground. The area irrigated in August was harvested more efficiently. The harvester worked better after rain fell and the soil became rather wet before harvest finished on 13 December. Delivery to the factory was completed by 20

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December. Yields averaged 30·9 t/ha of clean roots at an average sugar content of 18%, ranging from 16·6% to 19·3%. Mean dirt and top tares were 73 and 46 kg/t. The country's average yield this year was 34·6 t/ha of roots at 17·0% sugar.

Livestock. Forty Hereford cross steers and 30 heifers, average liveweight 280 kg and 260 kg respectively, were bought in October 1971. All were fed with silage *ad lib*, hay when the silage was finished, fresh straw, restricted concentrates and mineral licks. The concentrate ration was supplemented with protein at first but was basically equal parts of rolled barley and sugar beet pulp nuts to a maximum of 5·4 and 1·8 kg/head/day for the steers and heifers respectively. Their average live weight gain was 0·72 and 0·68 kg/head/day respectively. All were sold between 14 March and 3 July at finished weights of 445 kg and 389 kg respectively. The yard was restocked in October with 58 steers and 18 heifers.

Staff and visiting workers

Mr. Z. T. Aytug, Turkish Sugar Corporation, worked with us for two months during his tenure of a British Council Fellowship. Sandwich course students, C. J. Irons and R. Windley of the University of Bath and C. A. Hinson of Trent University, were with us for six months.

R. A. Dunning visited research stations and Universities in the United States and Canada during April and May. A. P. Draycott gave an invited paper at the centenary celebrations of the Agricultural Department of the University of Vienna and visited the Austrian Sugar Research Station at Fuchsenbigl. A. P. Draycott and P. C. Longden contributed to the 35th Winter Congress of the International Institute of Sugar Beet Research in Brussels, which R. Hull and R. A. Dunning also attended. R. Hull and P. C. Longden also attended the IIRB Summer Congress in south Sweden and afterwards Longden visited seed research centres in Denmark and Holland. D. A. Cooke attended the 9th International Nematology Symposium at Reading.

The Breeding and Genetics group of the IIRB visited Broom's Barn in September and the Sugar Beet Research and Education Committee held their Open Summer meeting there. A two-day course was arranged for the Field Agricultural Development Officers of the British Sugar Corporation Ltd. Among numerous visitors were groups from the Austrian Sugar Industry, Leeds University, several Young Farmers' Clubs, Bury St. Edmunds Chamber of Commerce and Past and Present Society.

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