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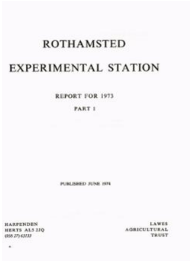
ROTHAMSTED RESEARCH

Report for 1973 - Part1


ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1973
PART 1

Broom's Barn Experimental Station

R. Hull

R. Hull (1974) *Broom's Barn Experimental Station ;* Report For 1973 - Part1, pp 256 - 282 **- DOI: https://doi.org/10.23637/ERADOC-1-130**

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BROOM'S BARN EXPERIMENTAL STATION

R. HULL

The intensive work during recent years on controlling seedling pests of sugar beet with seed treatments has resulted in methiocarb being found a suitable replacement for dieldrin and 5% of the seed supplied to growers will have this treatment in 1974. Other chemicals under test show promise that they will give equal protection and it seems likely that dieldrin will soon be completely superseded as the insecticide treatment for sugar-beet seed. Seed treatment gives adequate routine protection but severe infestations of pests need more effective treatments, usually with insecticides applied to the soil. In order to get knowledge on which to base forecasts of damage to seedlings, research on the biology, population dynamics and aggregation of seedling pests has been intensified.

The favourable weather in March allowed growers to sow almost all the crop before early April. Roots sampled in late summer indicated that large sugar yields might be expected. This proved true, but the crop did not grow well in the autumn so yields were less than expected. Our experiments and observations suggest three reasons for this; first, virus yellows was more prevalent than for many years and this, with drought, led to severe yellowing and defoliation during early autumn and consequent loss of yield; secondly, many early sown plants bolted, which is the probable reason why the yield of early sown crops failed to increase during the autumn as much as that of later sown crops without bolters; and thirdly, since land drains did not run in the dry winter and spring, soil nitrogen accumulated in the subsoil, the sugar beet absorbed it throughout the summer and this depressed sugar percentage and consequently sugar yield.

The early infestation of aphids was anticipated and sugar factories sent spray warnings to growers in good time, but in some areas growers were late to spray. This contrasts with previous experience when they have immediately heeded the warning and seems to be a consequence of the crop having been relatively free from yellows for over a decade. Growers have forgotten how damaging the disease can be. Also many were lax in cleaning up infected plants that had survived the winter, from which the disease spreads to young crops. Since the winter of 1973–74 has been mild, yellows may well be a serious threat to the 1974 crop and growers will have to take meticulous precautions to control it. Some of the insecticide treatments used in our experiments promise to give better control than the currently recommended sprays.

Seedling pests

The soil-inhabiting pests, especially millepedes, wireworms and Symphylids, caused much more damage in 1973 than in recent years; in contrast, damage by foliage-feeding pests was only average, despite the unusually early sowing of the crop.

Pygmy beetle dispersal. The dispersal and distribution of pygmy beetle (*Atomaria linearis*) was again followed by examining catches from 40 ft-high suction traps and sticky traps at four sites. The sticky trap catch (316) at Broom's Barn was greater than in 1972 (181). As in 1972, the Holbeach sticky trap caught the most (428 compared with 667 in 1972) and those at Rothamsted and Shardlow a few only. The Broom's Barn suction trap caught 643 beetles to the end of October (566 in 1972) and High Mowthorpe 31 (4); catches from other sites have still to be examined. Pygmy beetle damage reported by fieldmen was 18% more in 1973 than in 1972.

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Pitfall traps were used to study local dispersal at Broom's Barn. Many pygmy beetles were caught in the traps from late May to early August, corresponding with the pattern of the catches of the nearby sticky and suction traps. Five traps on Brome Pin field (beet after barley) and five on Flint Ridge (barley after beet) caught similar numbers per week until late June, after when most were caught on Brome Pin. Also, two traps were placed in each of nine rotation-trial plots (size 0·015 ha), three of which were in continuous beet, three beet after barley and three barley after beet. More pygmy beetles were caught on the plots with continuous beet than on those with either of the other rotations. (Thornhill and Dunning)

Millepedes: biology and control. In the laboratory, the addition of straw to the soil significantly decreased damage to the roots of sugar-beet seedlings by adult *Brachydesmus superus* and *Blaniulus guttulatus*. Other experiments tested the effect of chemical seed treatments, incorporated into the pellet, on damage to sugar-beet seedlings. Seedlings were grown at spring seedbed temperatures for one month after germination in pots of loamy soil containing millepedes, and the roots then scored for damage; no effects could be measured of seed treatment with 0·2–0·8% of methiocarb or mecarphon, 0·2% dieldrin or 0·8% 'PP 505'. A further experiment, repeated five times, confined the millepedes for five days with germinating seeds on soil in Petri dishes kept in darkness. The mean root damage score (0 = no damage to 5 = severe damage) for each seed treatment was: untreated (control) 1·16; 0·2% dieldrin 0·70; 0·2% and 0·8% methiocarb 0·47 and 0·37 respectively; 0·2% and 0·8% mecarphon 0·14 and 0·11; 0·8% 'PP 505' 0·06. The number of millepedes that had aggregated around the seedlings after 24 hours corresponded with the damage to the seedlings. Mortality of millepedes in the dishes during the experiment, and for a period afterwards with the pellet coat only (seedlings removed) was 100% with 0·8% mecarphon, only 3% for the untreated and intermediate for other treatments.

Further evidence was obtained that blaniulids breed in spring; as in previous years, the second stadium millepedes outnumbered others in the top 10 cm of soil as the beet emerged. At Marham, Norfolk, 43% of *B. tenuis* were in this stage in cores taken on 12 April but 28% on 6 June. At Kettering, Northants, 41% of *B. guttulatus* were second stadium on 25 April but only 3% on 30 May.

Pest aggregation. The effect of different seed spacings on the distribution of soil-inhabiting pests was again studied at sites chosen for specific pests, with emphasis this year on monitoring the movement of the pests towards the seedlings. The number of soil-inhabiting pests around seedlings were measured from emergence of the seedlings until singling stage.

At Marham, Norfolk, where millepedes (*B. tenuis*) had damaged the beet in 1972, soil cores (2·5 cm diameter) to a depth of 10 cm estimated 33·6 million/ha in the seedbed on 12 April when the seeds were sown. Soil samples taken on 8 May either between the rows or centred on a seedling showed that 82% of the millepedes were in the rows; the mean number/soil core centred on seedlings spaced at 24, 12 or 4 cm was 1·4, 2·9 and 0·9 respectively. Samples taken on 17 May indicated an increase in aggregation in the rows to 88% of the total, and the respective mean number/seedling core was 5·4, 5·3 and 2·3 for the three seed spacings. Only soil cores centred on seedlings were taken on 6 June, within 24 hours of singling; millepedes were then feeding only on the roots deeper than 5 cm and there were respectively 4·0, 5·1 and 3·0/core. On each of the three sampling dates 8 May, 17 May and 6 June the mean number of pygmy beetles/soil core centred on a seedling was only 0·3, 0·5 and 1·0 respectively. Numbers did not vary with seed spacing although there was marked aggregation in the row.

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On a similar experiment at Kettering, Northants, there were an estimated 0·7 million blaniulids (*B. guttulatus* plus *B. tenuis*) and 56·8 million/ha onychiurid Collembola (mainly *Onychiurus armatus*) in the seedbed sampled to a depth of 10 cm on 17 March. Soil cores centred on seedlings showed mean numbers of blaniulids/soil core at seed spacings of 24, 12 and 4 cm to be 0·8, 0·6, 0·6 on 25 April; 5·3, 3·9, 1·1 on 14 May; and 3·8, 2·0, 0·3 on 30 May. The aggregation of the blaniulids in the row increased from 73% on 25 April to 97% on 14 May. *Onychiurus* spp. also showed a marked (72%) aggregation in the row on 25 April but mean numbers/seedling at each seed spacing were similar. Although there were a few pygmy beetles (0·3 million/ha) in the soil at sowing, none was found in soil samples on 14 May and only 0·8/seedling on 30 May.

Neither *Scutigerella immaculata* nor *Onychiurus* spp. showed any significant variation in number with seed spacing in soil samples taken in April–early May at Littleport, Cambs, although most were aggregated in the rows. When the beet were at the four-leaf stage on 24 May there were 7·6, 4·3 and 2·7 pygmy beetles/soil core centred on a seedling from seed spacings at 24, 12 and 4 cm.

At Black Bank, Cambs, no pygmy beetles were present on 11 April at the time of sowing but soil cores taken on 4 June around seedlings at the six-leaf stage spaced 12, 8 and 4 cm apart were equally infested (about 6/seedling). These results confirm those obtained in 1971 and 1972. Root-feeding pests aggregate in the seedling rows; wide seed spacing increases the number of millepedes/seedling root zone, but rarely pygmy beetles. (Baker)

Control by insecticides

Seed treatment. Trials in 16 sugar factory areas measured the seedling establishment achieved from pelleted seed treated with 0·2% of dieldrin, 0·1, 0·2, 0·4 and 0·8% of either methiocarb or of mecarphon on Amono seed, all incorporated during pelleting. The sites were chosen at random. On average, treatments had no effect, the proportion of seed which produced seelings being between 50 and 54% for the control and different insecticide treatments, giving plant establishments between 3·4 and 3·7/m.

The same treatments, and also 'PP 505' (an oxime carbamate compound) at 0·8% a.i., on Monotri seed were tested and compared with gamma-BHC applied either as a spray worked into the seedbed or in the furrow with the seed, at five sites where pest damage occurred: Kettering, Northants (millepedes); Stokesby, Norfolk (wireworms and millepedes); Terrington Marsh, Norfolk (pygmy beetle); Marham, Norfolk (millepedes and pygmy beetle); and Littleport, Cambs (symphylids) (Table 1). At Broom's Barn and Black Bank, where no pest attack was observed, seedling establishment from untreated seed was respectively 65 and 93% and was unaffected by any of the above seed or soil treatments. Only the Kettering and Marham trials were harvested. Sugar yields (t/ha) were, at Kettering: 5·53 (untreated); 5·90 (0·2% dieldrin); 5·81, 6·38, 5·87, 6·26 (0·1, 0·2, 0·4, 0·8% methiocarb); 6·30, 5·86, 4·98, 5·84 (0·1, 0·2, 0·4, 0·8% mecarphon); 6·40 (0·8% 'PP 505'); 7·00, 6·90 and 7·16 (280, 560 and 1120 g a.i./ha gamma-BHC sprayed on the seedbed) and, at Marham, respectively: 7·44; 8·09; 8·24, 7·54, 8·45, 7·54; 7·81, 8·44, 7·94, 8·22, 7·36; 7·63, 6·06 and 4·64 (the larger amounts of gamma-BHC were phytotoxic because they were sprayed in the seed furrow). (Dunning and Winder)

Soil treatment. Trials in 1973 at Marham, Terrington Marsh and Broom's Barn tested insecticides as solutions at 370 litre/ha or as granules drilled in the furrow with the seed. At Terrington Marsh only 9% of the untreated seed produced seedlings because pygmy beetle (*Atomaria linearis*) caused severe damage. Seedling establishment, after treatment with solutions at 280 and 1120 g a.i./ha was: 'NC 6897' (for which the name

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TABLE 1

Effects of seed and soil treatments on the percentage of seeds producing seedlings in six trials

	Kettering	Stokesby	Terrington Marsh I	Terrington Marsh II	Marham	Littleport	Mean
Control	36	37	2	41	68	67	42
Seed treatment							
0·2% dieldrin	41	33	4	35	72	58	41
0·1% methiocarb	42	35	5	45	81	67	46
0·2% methiocarb	51	46	14	51	87	66	53
0·4% methiocarb	41	42	18	55	85	64	51
0·8% methiocarb	46	39	19	48	85	58	49
0·1% mecarphon	42	33	2	41	74	53	41
0·2% mecarphon	44	29	2	47	81	64	45
0·4% mecarphon	40	42	10	43	80	60	46
0·8% mecarphon	39	38	11	48	85	63	47
0·8% 'PP 505'	43	47	17	59	83	72	54
gamma-BHC sprays incorporated in seedbed (S) or solution trickled in furrow with the seed (F)							
	S	S	S	F	F	F	
280 g a.i./ha	70	44	4	61	84	77	57
560 g a.i./ha	68	52	5	—	78	80	—
1120 g a.i./ha	72	53	26	—	78	75	—

I—22 March drilled
II—18 May drilled

bendiocarb is being adopted) 29% and 30%; gamma-BHC 25%, 15%; diazinon 6%, 9%; mecarphon 13%, 25%; methiocarb 17%, 22%; 'Du Pont 1410' 17%, 27%; 'CGA 12223' 23%, 20% and 'PP 505' 26% and 35%. With the same amounts of granules: aldicarb 18% and 30%; mecarphon 23%, 28%; 'Du Pont 1410' 21%, 27%; 'AC 92100' 31%, 25%; 'CGA 12223' 26%, 19% and carbofuran (1120 g rate only) 34%. Sugar yield on the untreated plots was 4·94 t/ha: when treated with solutions at 280 and 1120 g a.i./ha the sugar yields were: bendiocarb 7·12, 7·71; gamma-BHC 6·64, 2·72; diazinon 3·32, 2·98; mecarphon 4·50, 9·13; methiocarb 6·66, 8·52; 'Du Pont 1410' 6·24, 8·38; 'CGA 12223' 8·09, 5·78 and 'PP 505' 6·17 and 8·93 t/ha. With the same amounts of granules: aldicarb 6·23, 7·14; mecarphon 7·39, 8·75; 'Du Pont 1410' 7·34, 7·89; 'AC 92100' 9·92, 7·93; 'CGA 12223' 7·41, 7·89 and carbofuran (1120 g rate only) 8·30.

At Marham, millepedes and pygmy beetle caused moderate damage and seedling establishment was 50% on untreated plots. After treatment with solutions at 280 and 1120 g a.i./ha, seedling establishment was: bendiocarb 80% and 72%; gamma-BHC 76%, 77%; diazinon 72%, 61%; mecarphon 59%, 75%; methiocarb 71%, 83%; 'Du Pont 1410' 79%, 81%; 'CGA 12223' 74%, 60% and 'PP 505' 82% and 76%. With granules at the same rates: aldicarb 82%, 82%; gamma-BHC 71%, 78%; carbofuran 76%, 78%; mecarphon 75%, 76%; 'Du Pont 1410' 80%, 77%; 'AC 92100' 74%, 72% and 'CGA 12223' 72% and 37%. Sugar yield on the untreated plots was 7·80 t/ha; when treated with solutions at 280 and 1120 g a.i./ha the sugar yields were: bendiocarb 8·34, 8·15; gamma-BHC 6·10, 3·27; diazinon 7·60, 6·92; mecarphon 7·82, 7·88; methiocarb 8·22, 8·41; 'Du Pont 1410' 7·96, 8·70; 'CGA 12223' 7·87, 6·39; 'PP 505' 8·54 and 8·13 t/ha. With granules at the same rates: aldicarb 8·74, 8·42; carbofuran 8·54, 8·60; mecarphon 7·00, 7·48; 'Du Pont 1410' 8·23, 8·49; 'AC 92100' 7·73, 8·65 and with gamma-BHC and 'CGA 12223' granules at 1120 g a.i./ha 5·88 and 6·58 t/ha respectively.

At Broom's Barn, where no pest damage was observed, seedling establishment was 76%. Seed-furrow treatment with 280 g a.i./ha of the above materials as solutions did not affect seedling establishment, but it was increased by most compounds when used as

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granules. Some materials were phytotoxic when applied at 1120 g a.i./ha; seedling establishment was decreased most by gamma-BHC, diazinon and 'CGA 12223' solutions and by 'CGA 12223' granules. Sugar yield paralleled the seedling establishments. (Winder and Dunning)

Seedling foliage pests

Birds and mammals often graze sugar-beet seedlings and the damage appears to be serious, especially on thin stands of seedlings. Grazing has been extensive in recent years, but was less in 1973 than in the previous two years. Sometimes seedlings are eaten off below the growing point and then they die, but more often the cotyledons and young leaves only are grazed. This delays the development of the crop but the effect on yield is not known. Experiments have assessed the effects of early defoliation on yield and possible methods of controlling damage.

Artificial defoliation. One cotyledon, half of each cotyledon or both cotyledons were cut from sugar-beet seedlings growing with their roots in a mist of nutrient solutions in the glasshouse. The treatments, especially the complete defoliation, decreased root and leaf growth; after 28 days the dry weights of the completely defoliated seedlings were only one-tenth of the untreated. (Dunning and Iwanicki)

Plots of sugar beet sown on 22 March at Broom's Barn were completely defoliated on 18 April (early cotyledon stage), 2 May (late cotyledon stage), 16 May (two rough-leaf stage), or 30 May (four rough-leaf stage), or weekly from 18 April to 30 May, from 2 to 20 May or from 16 to 30 May; care was taken not to cut out the growing points. For unknown reasons, repeated defoliation increased the percentage of plants with virus yellows on 27 July. Yield of sugar at harvest on 13 December of the untreated plants was 8·45 t/ha and on the above listed treatments, respectively, 7·64, 8·05, 7·92, 7·63, 6·26, 6·55 and 6·72.

Caging sugar beet against bird and mammal damage. Plots of Sharpe's Klein Monobeet near the farm buildings sown on 15 March and 10 May were left uncaged or were caged against bird and mammal grazing. On 31 May the uncaged plots of both sowing dates had lost half their leaf area, mainly due to grazing by the house sparrow (*Passer domesticus*). Cages were removed in late June and the plots harvested on 15 October. Sugar yields on the uncaged plots were 5·6 and 4·2 t/ha, but on the caged 5·8 and 4·7 respectively (SED $\pm$0·33).

At 12 sites throughout the country and at Broom's Barn, lengths of sugar-beet row in drilled-to-a-stand crops were caged until June, and the growth of the crop compared with that in uncaged lengths. Seedling grazing ranged from slight to severe at nine of the 13 sites; at four there was none. Only at one site was there significant damage within the cage, possibly due to fieldmice or to insects. Harvested root numbers were increased slightly by caging (67 800 to 75 100/ha) and sugar yield increased from 7·0 to 7·6 t/ha; the increase in yield resulted not only from prevention of grazing but probably also from protection against wind damage.

Grazing of seedlings: effect of seed spacing. Grazing of seedlings by any vertebrate pest was assessed in nine sugar factory areas on plots with different seed spacings. Grazing ranged from nil to 32% at the different sites but was similar, with a mean of about 8%, on the seed spacing of 7·5, 12·7 and 20·4 cm. This result contrasted with an experiment in 1972 in which grazing was more severe on wide spaced seedlings (*Rothamsted Report for 1972*, Part 1, 269).

However, at four sites where insect pests attacked the seedlings, on average 6·3,

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10·0 and 11·0% of the seedlings were grazed where seeds were spaced at 4, 12 and 24 cm respectively. Grazing was slightly heavier on plots receiving no herbicide than on those treated with pyrazone at the two sites where herbicide was tested.

Bird 'repellents'. Seedling cotyledons damaged by grazing were counted in trials at Broom's Barn and at six other centres that tested organophosphorus, carbamate or other types of insecticides and nematicides applied as seed or soil treatments for control of soil-inhabiting pests. In the untreated plots of the several trials, 7–19% of the seedlings were grazed; none of the pesticides tested influenced the amount of damage although most are systemic.

At Broom's Barn plots of sugar beet near the farm buildings were sown on 27 March with pelleted seed containing methiocarb or 'U-12171' (0·8% seed weight), or were sprayed to run-off at emergence on 27 April and again on 7, 14 and 21 May with methiocarb (0·88% a.i.) or aluminium ammonium phosphate plus additives (8·8% product—'Crop Guard'), or were caged. All treatments, except 'U-12171', increased seedling establishment. Grazing by vertebrate pests, especially by the house sparrow, was severe but very irregularly distributed. Caging prevented this grazing and nearly doubled seedling dry weight; the effects of the other treatments were inconsistent but methiocarb spray seems worth re-testing. (Dunning, Winder and Thornhill)

Seedling diseases

About 14 000 acres of sugar beet sown in March had to be redrilled, mostly after wind damage, and in these crops blackleg, caused by *Aphanomyces cochlioides*, became prevalent and caused a few to fail. The disease was favoured by the warm, moist soil in May.

Ten trials, four of them in redrilled crops, tested 'Dexon' incorporated in the seed pellet. Soil tests showed that the fungus was present at seven of the sites, but the 'Dexon' treatment did not, on average, increase either seedling emergence or final plant stand. Seedlings attacked by *A. cochlioides* were found only in two of the redrilled crops, and here 'Dexon' increased emergence from 7·9 to 8·5 seedlings/m but did not affect final plant population. In these two trials, on average, 17% of seedlings from untreated seed were attacked, compared with 9, 6 and 4% respectively from seed treated with 0·25, 0·5 and 0·75% a.i. of 'Dexon'. 'Dexon' had no significant effect on sugar yield, neither on average nor in the two trials where *A. cochlioides* caused blackleg.

In autumn 1972, soil was sampled from 25 fields in both the Allscott and the Ely sugar factory areas where *A. cochlioides* was found in many of the soil samples taken in 1971. When beet seedlings were grown in the soils while moist and warm in the glasshouse, *A. cochlioides* developed on those in 16 of the Allscott and 12 of the Ely samples. *A. cochlioides* was present at 21 of the 29 sites which were acid soils, compared with seven of the 21 which were neutral or alkaline.

Materials for controlling *Phoma betae* were tested in the field using Monotri seed. Compared with untreated seed, 0·12% a.i. TCMTB slurry (2-(thiocyanomethylthio) benzothiazole) increased seedling emergence by 20%; captafol slurry at 1·28% by 6%, TCMTB slurry at 0·08% by 14%, 'BASF 3302' dust at 0·6% by 11% and 'BASF 3501' dust at 0·3% by 18%. Maneb slurry at 1·07% a.i. did not increase emergence, and triphenyltin hydroxide slurry at 0·2% a.i. decreased emergence by 30%.

In 17 field trials with fungicides applied to Amono seed during pelleting, captafol at 0·64%, maneb at 1·07% and TCMTB at 0·08 and 0·12% increased seedling emergence by 11, 13, 12 and 9%, and final plant population by 5, 7, 7 and 5% respectively compared with untreated seed, while ethylmercuric phosphate steep increased seedling emergence by 25% and final population by 18%.

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Three seed samples were tested for seed-borne *P. betae* by four methods; on water agar, on potato dextrose agar (PDA) under continuous near u.v. (NUV) on PDA +50 ppm streptomycin with alternating 12 hours NUV, and on blotters, all with or without surface disinfection of the seed with sodium hypochlorite. Counts of seed with *P. betae* ranged from 47% on water agar to 34% on PDA with alternating NUV. The three samples averaged 23, 61 and 33% *P. betae*, and only the last showed less *P. betae*, 12%, after surface disinfection. All samples were grown in the field with and without EMP steep, which increased seedling emergence by 40, 58 and 6% respectively. It was concluded that the method used to test seed for *P. betae* was not important, but that pre-treatment with sodium hypochlorite gave results that related better to field performance than tests with untreated seed. (Byford)

Yellows and aphids

Yellows spread more widely in 1973 than in any year since 1961 and at the end of August the fieldmen assessed that, on average of all areas, 13·9% of sugar-beet plants showed symptoms. The incidence of yellows is well known to be related to the weather during the previous winter. For several years it has been accurately forecast from the number of days with frost in January, February and March at Rothamsted, but not this year. The number of days with frost was 56, forecasting yellows incidence at 3·5% but most frosts were not severe. Another forecast is based on the deviation of the mean air temperature from the long-term average. The deviations at Broom's Barn were +0·2°, +1·1° and −0·6°C for February, March and April respectively, giving an anticipated yellows incidence of 13–14%, which was that actually recorded. By August, some crops in East Anglia were predominantly yellow from virus infection, and yellowing and necrosis then increased because plants wilted during drought. Many plants also developed symptoms of magnesium deficiency which made diagnosis of the cause of yellowing difficult. The incidence of yellows decreased from south to north, ranging from 40% in Essex to only 1% in Yorkshire at the end of August.

Most growers were advised to treat their crops with an aphicide and about 136 000 ha (72% of the crop area) were treated at least once, but some growers were late to spray. Many failed to clear soil heaps at loading sites of the previous crop and the sugar beet that grew on them was a source of virus that spread to nearby sugar-beet crops. Black aphids were more numerous on sugar beet than during the previous two years, especially in the King's Lynn and Cantley sugar factory areas.

Combined treatment against speckled and virus yellows. Growers in the Fens spray their crops with manganese sulphate in May or June to prevent 'speckled yellows', and commonly include half the normally recommended amount of demeton-S-methyl to control early aphids. In two trials near Ely, aphids were killed and yellows incidence decreased from 41 to 24% at the end of August by insecticide included in the manganese spray applied 10 days before a spray warning was issued by the sugar factory. About five days after the spray warning was issued all the plots were sprayed with the normal amount of demeton-S-methyl.

Effect of yellowing viruses on yield. Plots of var. Sharpe's Klein E and of Vytomo were infected with both BYV and BMYV in mid-June. The aim was to infect all the plants in some plots, one in five or one in ten in others, and leave some plots uninfected. Virus spread during the summer and the incidence of yellows was recorded monthly, but drought, magnesium deficiency and powdery mildew made assessment difficult. By late September the plots of Sharpe's Klein E that were not infected initially had 68% of

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plants showing yellows and those of Vytomo had 44%. The yield of roots and the percentage of sugar was greater from Vytomo than from Sharpe's Klein E. The sugar yield of Vytomo ranged from 8·17 to 6·28 t/ha, depending on the level of infection, and Sharpe's Klein E from 7·98 to 5·03. Sharpe's Klein E is estimated to have lost 3·1% of its potential yield for every week the plants showed symptoms, but Vytomo only 2·2%.

***Aphis fabae* survey.** An average of 5·1 eggs of *A. fabae*/bud was found on spindle bushes near Bury St. Edmunds and they hatched in mid-March to give large populations, more than 50 aphids/new twig at several sites, in late May. Similar results were obtained from surveys made by other entomologists, co-ordinated by Professor M. J. Way of Imperial College, and a severe attack on both beans and sugar beet was expected, except in the extreme south-west of England. Most area forecasts were correct but infestations on sugar beet in Suffolk and on field beans in the east of the Weald were not severe.

Aphids on seed crops. Many *Myzus persicae* overwintered on some beet-seed crops in Essex, Bedfordshire and Gloucestershire; growers controlled these with sprays in early June. Few *M. persicae* were found on any of the other 115 samples of leaves and shoots from seed crops checked during May and June, and *A. fabae* were generally few except in parts of Oxfordshire and Gloucestershire.

Winged aphids on traps. On average, each of nine sticky traps caught 23 *M. persicae* (eight more than in 1972) of which one was caught in May and eight in June. This catch early in the season had not been exceeded since 1961 when yellows was prevalent, 27% at the end of August compared with a maximum of 9% in intervening years. More *A. fabae* were also caught than in 1972, an average of 625, but not exceptionally many (e.g. 1562 were caught/trap in 1963); the numbers of *A. fabae* trapped are not correlated with the incidence of yellows.

Trace elements. The effect of trace elements (copper, cobalt, boron, aluminium and iodine) on the spread of yellowing viruses in Sharpe's Klein Polybeet and Anglo-Maribo Poly was tested in cooperation with G. E. Russell of the Plant Breeding Institute. Yellows spread to at least half of the plants in plots not treated with aphicide, but plants wilted and were severely attacked by powdery mildew so diagnosis was difficult. No significant difference between treatments was found. (Heathcote)

Control with insecticides. At Broom's Barn aldicarb granules (1120 g a.i./ha) drilled in the furrow with seed on 11 April controlled aphids well and on 3 August had decreased virus yellows by 72% (Table 2). After this, symptoms of yellows were masked or confused by the effects of drought. Demeton-S-methyl (245 g a.i./ha) and pirimicarb (140) sprays in 340 l/ha applied on 14 June following the spray warning, also controlled aphids well but were less effective than aldicarb granules in decreasing yellows (decreases of 58 and 55% respectively). Treatment with aldicarb granules followed by demeton-S-methyl spray decreased both aphid numbers and virus yellows more than each treatment alone. Black aphids increased on all treatments in the last week of June and the counts suggest that pirimicarb was less persistent than the aldicarb or demeton-S-methyl treatments.

Three other chemicals, drilled in the furrow with the seed, were also tested. 'AC 92100' and, especially, 'CGA 12223' were phytotoxic, decreasing seedling numbers by 24 and 65% respectively, but carbofuran granules were not. 'CGA 12223' had little effect on aphid numbers on 12 June and it had no effect on yellows incidence. 'AC 92100' and carbofuran partially controlled aphids but were less persistent than aldicarb; they decreased yellows by 40 and 25% respectively. The greatest sugar yield resulted from treatment with aldicarb plus demeton-S-methyl. (Dunning and Winder)

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TABLE 2

Aphid numbers, virus yellows incidence and yield at Broom's Barn, 1973

Treatment (g a.i./ha)	Wingless green aphids per plant (Wingless black aphids per plant)					% of plants with Virus yellows		Sugar yield
	12 June	22 June	26 June	4 July	13 July	16 July	3 Aug.	(t/ha)
Untreated	5·3* (2·7*)	5·8 (11·9)	7·8 (20·5)	3·2 (126·0)	0·4 (274·6)	21·0	73·0	7·65
aldicarb granules (1120)	0·5 (0·8)	1·0 (1·3)	0·8 (4·5)	1·3 (54·9)	0·7 (24·5)	3·2	20·0	8·56
aldicarb granules (1120) + demeton-S-methyl spray (245)	— —	0·2 (0·5)	0·3 (7·3)	0·8 (62·0)	0·6 (40·0)	1·3	15·0	8·67
demeton-S-methyl spray (245)	— —	0·8 (0·9)	1·3 (4·8)	1·9 (54·6)	0·6 (62·0)	7·6	31·0	8·27
pirimicarb spray (140)	— —	0·3 (0·8)	0·2 (5·9)	0·7 (79·9)	0·5 (104·0)	8·1	33·0	7·97
SED ±	1·0 (2·8)	0·8 (4·9)	0·7 (2·1)	0·7 (24·6)	0·3 (104·2)	2·6	6·2	0·506

* 0·9 wingless black and 1·0 wingless green aphids/plant on untreated plots on 8 June

Aphid predators. The effect of three different levels of carabid beetle population on aphid infestation and virus incidence was tested in a 3 × 3 Latin square trial at Broom's Barn. A small population of beetles was achieved by spraying parathion at 9·0 kg a.i./ha on the seedbed on 10 April to kill any beetles present; strips of stiff bituminised felt were laid around a rectangular area so as to allow exit but prevent entry within each plot. A large population of beetles was encouraged in other plots by a similar barrier which allowed entry into the plot but prevented exit. No barriers were placed on control plots. Two pairs of pitfall traps of the standard design (*Rothamsted Report for 1969*, Part 1, 312) were placed in each plot. Beetles were trapped for 48-hour periods, counted and identified in the laboratory, then returned to the plots; when not in use the traps were closed. Carabid beetles were trapped in increasing numbers from 10 May until 2 August; fewest were caught on insecticide treated plots and most on plots with the 'entry only' barrier, with intermediate numbers on the control plots. In seven of the twelve trapping periods the decrease was significant, but significantly increased numbers of beetles were recorded only once.

Apterous *A. fabae* and *M. persicae* on the sugar beet were counted at intervals from 11 June to 20 July. Most were observed on plots where there were fewest beetles but differences between treatments were usually not significant. Average yellows incidence increased from 6% on 17 July to 26% on 14 August; although it was least in plots with most beetles differences between treatments were not significant. The trial failed to demonstrate any positive relationship between density of carabid beetle population and infestation by aphids but suggested that carabids may play a part in their control. (Windley and Dunning)

Leaf diseases

Powdery mildew was widespread in many beet crops in the south-east in August and September. In a trial at Tuddenham, Suffolk, 0·67 kg a.i./ha fentin hydroxide applied once or twice in August, and 0·53 kg a.i./ha chloraniformethan applied once showed little effect on powdery mildew at harvest in October, but increased sugar yield by 7, 7 and 6% respectively. In a trial at Broom's Barn where powdery mildew was less severe,

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the same spray did not influence yield of tops or sugar. In another trial at Broom's Barn three sprays of fentin hydroxide at 0·34 and 0·67 kg a.i./ha in August and September or one or three sprays of chloraniformethan at 0·56 kg a.i./ha increased top yield by 7, 5, 0 and 5% and sugar yield by 4, 2, 2 and 3% respectively.

Violet root rot

At Burwell, Cambs, where a carrot crop was heavily infected in 1972, beet grown in 1973 after fallow or after barley in 1972, had 31% plants infected by violet root rot in December, compared with 21, 28, 43 or 66% respectively grown after carrots lifted in July, rotovated in July, lifted in December or rotovated in December 1972. Other experiments were carried out where carrots had been rotovated in December 1972.

Beet sown on 20 March had 26% roots infected on 6 September, 44% on 4 October, 73% on 7 November and 74% on 12 December, when 85% of beet sown on 17 April were infected. The severity of infection scored on a 0–4 scale, based on the percentage of root surface covered by lesions, increased from 1·2 in September to 2·2 in November and 2·6 in December. There were no significant differences between the percentage of roots infected (average 56%) in 11 sugar-beet varieties.

All roots from four 15·6 m^2 plots were sorted into uninfected, infected on less than 50% of the root surface, and with over 50% affected. These were weighed and analysed separately for sugar content. The lightly infected roots were on average heavier than healthy roots, and had only a slightly lower sugar content. The heavily infected roots contained only 10·8% sugar compared with 12·5% in healthy roots, and yielded 27% less sugar/root than healthy or slightly infected roots. (Byford)

Docking disorder

Despite the wet weather in May a relatively small area of sugar beet had Docking disorder in 1973. In June, 949 ha were reported to be affected, mostly in the Yorkshire and King's Lynn factory areas (479 and 405 ha respectively); in July a further 820 ha were reported affected, mostly in the same areas (508 and 243 ha respectively). The amount of sandy soil treated with nematicides to control the disorder continues to increase.

Soil fumigants were used on about 1300 ha in East Anglia and systemic nematicides (aldicarb and 'Du Pont 1410') on about 300 ha in East Anglia and Yorkshire.

Crop growth in relation to nematode population. Trials at Holt, Norfolk, and Thornton, Yorks, investigated the relationship between *Trichodorus* population in spring and autumn with soil texture and root yield and shape. At Holt, in the heaviest soil, with silt plus clay ranging from 15 to 23%, *T. cylindricus* were fewest in the plots with the most silt and clay; in the sandier soil at Thornton where silt plus clay ranged from 10 to 17%, numbers of *Trichodorus* (mostly *T. anemones*) were not correlated with soil texture. *Trichodorus* numbers in spring were closely correlated with those in the autumn at Holt and Thornton. At both these sites increasing numbers of *Trichodorus* were associated with small yields and increased root fanginess. (Cooke)

Nematicide trials. At Harpley, Norfolk, and Gleadthorpe, Notts, aldicarb (coal-based formulation), 'Du Pont 1410', 'AC 92100', mecarphon and 'CGA 12223' at 280 and 1120 g a.i./ha, and carbofuran granules at 1120 g/ha were drilled in the furrow with the seed. Docking disorder was expected in both crops, because of the field's previous history and nematode populations, but symptoms were only mild at Harpley and were absent at Gleadthorpe.

At Harpley 74% of the seeds on the untreated plots produced seedlings; aldicarb

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(280 and 1120 g a.i./ha), 'Du Pont 1410' (280 and 1120 g) and 'CGA 12223' (280 g) increased seedling numbers 13, 5, 11, 7 and 5%, improved the vigour of the foliage, and increased sugar yield 12, 5, 23, 19 and 19% respectively. Carbofuran and 'AC 92100' (1120 g,) mecarphon (280 and 1120 g), and especially 'CGA 12223' (1120 g), were phytotoxic.

At Gleadthorpe 68% of the seeds produced seedlings on the untreated plots; all treatments, especially the larger amount, decreased seedling numbers and vigour. 'CGA 12223' (1120 g), mercarphon (1120 g) and 'AC 92100' (1120 g) decreased seedling numbers 72, 50 and 29% respectively, others less, and aldicarb (280 g) and 'Du Pont 1410' (280 g) only 3 and 5%. Sugar yields were unaffected by most treatments but decreased by the large amount of 'AC 92100', mecarphon and 'CGA 12223'. (Winder and Dunning)

Population dynamics. Numbers of *Trichodorus* (mostly *T. anemones*, some *T. primitivus*) and *Longidorus* (*L. leptocephalus* and *L. elongatus*) were assessed at regular intervals throughout the year at two sampling points in three differently cropped fields at Wilberfoss, Yorks, and Gleadthorpe, Notts, respectively. *Trichodorus* populations of 1000–2000/litre of soil in the sandiest parts of potato, barley and sugar-beet fields in March and April decreased as the soil dried during the summer. The re-establishment of high population levels following barley and sugar beet (6000/litre and 2000/litre) in October and November was associated with an increase in soil moisture, although, as in 1972, after potatoes *Trichodorus* remained few. At Gleadthorpe, Notts, in fields cropped with either sugar beet or barley, numbers of *Longidorus* declined from an initial level of over 100/litre to below 10/litre in November. Under a grass ley, two sampling points about 50 m apart had widely different populations; at one, *Longidorus* numbers varied between 150 and 400/litre throughout the year; at the other no more than 5/litre were ever found. (Cooke)

Seed production

Diseases in seed crops. In June, 89 sugar-beet seed crops distributed throughout the seed growing areas averaged 1·7% plants with virus yellows and 0·3% with downy mildew. Crops with more than 10% of plants infected by yellows were found in Beds, Oxon and Northants. In Essex some root crops growing adjacent to seed crops were heavily infected with downy mildew.

In October, 131 sugar-beet steckling beds averaged 0·6% plants with yellows, most in four open *in situ* beds in Oxfordshire and Gloucestershire which had up to 26% infected plants. Twenty-nine open *in situ* beds averaged 2·5% plants with yellows, compared with 0·03% in 100 beds raised under cereal cover crops. Eleven mangold and red beet steckling beds in Essex and Suffolk averaged 1·5% yellows. No plants with downy mildew were found.

Stecklings raised in an open bed near Grantham, Lincs, and transplanted in March to Tydd, Cambs, had 3·1% of plants with foot-rot in June. This was partly controlled by fungicidal sprays. Plants sprayed with 0·67 kg a.i./ha fentin hydroxide, fortnightly or monthly in the autumn or fortnightly from 12 April to 10 May, had 0·5, 0·8 or 1·0% with foot rot respectively. (Byford)

Factors affecting seed yield. The following field experiments determined the effects of cultural practices on the yield of seed harvested in 1973.

Irrigation. At Sharnbrook, Beds, unirrigated plots and plots restored to field capacity with 50 mm water on 4 July or 9 August gave similar yields of seed. At Broom's Barn, plots with transplated or *in situ* plants which were unirrigated or received little water

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(28 mm on 5 July) or much (100 mm on five occasions between 14 June and 1 August), developed soil moisture deficits up to 190 mm and produced different amounts of dry matter during intervals between sampling, but gave similar yields of seed. In 1972, another dry summer, irrigation also failed to increase yield of seed.

Nitrogen fertiliser. Three experiments tested the effect of top dressing with 250 kg/ha nitrogen in 'Nitro-Chalk' on *in situ* plants in February, March, April or May together with split applications totalling 250 kg/ha in February and March, or March and April, or April and May, or February and May. The experiments were on shallow oolitic limestone soil in Oxfordshire, on recently ploughed up fattening pastures in Northamptonshire and on deep silt arable soil in South Lincolnshire. At each site the treatments did not affect seed yield.

Transplanting. It has been suggested that either the transplanting of sugar-beet stecklings, or the allied procedure of chopping off the root tips at the time of planting, changes the physiology to make it a better seed producing plant. To test this, a field experiment compared yields from plants which were *in situ*, lifted and pressed back into the soil or lifted, the tap roots chopped off and then replanted. The chopped plants behaved similarly to the *in situ* ones but the lifted plants lost less seed than either at the late harvest. This retention of seed with delayed harvest could be of practical value.

Growth regulators. In the search for growth regulators to dwarf the seed crop for direct combine harvesting, plants were sprayed with chlorflurecol-methyl at 1, 10 or 100 ppm or 'Ethrel' at 10, 100 or 1000 ppm on 6 April. 'Ethrel' did not affect plant growth or seed yield. Chlorflurecol-methyl dwarfed plants, particularly at 100 ppm, and halved seed yield.

Factors affecting seed performance

Seed crop cultural practices. Samples of seed harvested in 1972 from plots testing different cultural and chemical treatments were sown in the field at Broom's Barn in early April. Seedlings were counted and their shoots weighed in late May. Irrigating the seed crop in mid-August, applying chlorflurecol-methyl, application of nitrogen fertiliser in May, and killing the plants with diquat before harvest all depressed seedling emergence. Nitrogen fertiliser applied in February, March or April, irrigation in early July and swathing before threshing gave most seedlings. Varying the plant population of the seed crop did not affect performance of the seed.

Grading. Monogerm seed (Plant Breeding Institute variety VT99) was sorted into four fractions on round hole sieves and each of these were sorted into two density grades in an air column. The eight seed lots were sown in the field at Broom's Barn and the Plant Breeding Institute. At both sites seedling emergence and seedling shoot weight increased with increase in seed diameter and density for the small but not for the large diameter seeds.

Storage. Seed lots stored since 1968, 1969 or 1970 at different controlled water contents and temperatures were again assessed. As in previous experiments most seedlings emerged from seed stored dry and cool. Monogerm sugar-beet seed has been stored without loss of viability for at least three years and probably five, provided the water content was below about 12% and the temperature below 10°C. (Longden)

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Sugar-beet manuring

The field experiments described here testing nitrogen, phosphorus, potassium and soil structure were done in co-operation with staff of the British Sugar Corporation in 1972.

Nitrogen, soil type and time of harvesting. Five further experiments determined whether soil type affects the nitrogen requirement of sugar beet and studied the relationship between the amount of nitrogen given and the 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, two on shallow calcareous soils and one on a deep, heavy clay. The experiments were harvested on two occasions to determine whether harvesting date affected the relationship between sugar yield and nitrogen dressing.

Response to nitrogen was small on most fields, probably due to the previous dry summer and little winter leaching. About 80 kg/ha N was sufficient for maximum yield on all fields and less would have given more profit on some. The experiments confirmed that sugar yield increases linearly to a maximum in response to increments of nitrogen, and larger dressings than needed for maximum yield do not further influence yield significantly. Delaying the harvest from late September to early December greatly increased yield but did not affect the amount of nitrogen fertiliser needed for maximum yield.

Phosphorus. Three experiments measured response to 0, 14, 28, 58 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). Fertiliser greatly increased yield in all the three experiments and the optimum dressing in all of them was about 50 kg/ha P. These experiments eonfirmed that this method of analysis for soil phosphorus is a good guide to responsive fields.

Potassium. Four experiments measured response to 0, 42, 84, 168 and 336 kg/ha K, with or without 377 kg/ha agricultural salt (NaCl), on fields adequately fertilised with nitrogen and phosphorus. The soils were in the range 0–60 or 61–120 ppm ammonium nitrate-exchangeable potassium (ADAS indices 0 and 1). Both sodium and potassium greatly increased sugar yield, the average increase being nearly 20%. The optimum dressing was about 100 kg/ha K plus 377 kg/ha agricultural salt.

Sodium, potassium and soil structure. Sodium is one of the most important plant nutrients for sugar beet. Experiments throughout the sugar-beet growing areas of Great Britain during the last ten years show that it ranks second only to nitrogen in terms of the increase in sugar yield produced from dressings of all the major and minor elements. Despite these findings, and the great saving which could be made in potassium fertiliser (which sodium largely replaces), it is applied on less than half the acreage. Perhaps the main reason is that growers fear that sodium may damage soil structure, which may cause greater long-term loss than the immediate gain from increased sugar yield. New experiments were therefore begun in cooperation with ADAS in four areas where few growers use sodium for sugar beet, to discover whether the element affects the physical properties of the soils.

The experiments were on a silty loam (Romney Series) in the Spalding factory area, on a fine sandy loam (Aylsham Series) in the Cantley area, on a silty clay loam (Hanslope Series) in the Felsted area and on a fine sandy clay loam (Beccles Series) in the Ipswich area. Sodium and potassium were applied in factorial combination as chlorides at 0, 83

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and 333 kg/ha K and 0, 150 and 300 kg/ha Na; half the plots were dressed in autumn before ploughing and half in spring two to three weeks before sowing.

Staff of ADAS examined the soils in the field and found no visible effect of any of the fertiliser applications on the soil structure in spring. Laboratory measurements of dispersion ratio on soil samples revealed no effect of sodium or potassium, indicating that it is unlikely that the structural stability of the soils was affected.

On average, the sugar yields were slightly greater from autumn than from spring application. Response to both sodium and potassium was smaller than average on these soils and the optimum dressing was about 150 kg/ha Na and no more than 80 kg/ha K. (Draycott)

Plant nutrients

Sodium and potassium. The effects of Na and K fertilisers on the growth of sugar beet was again studied, this year on Brome Pin field (*Rothamsted Report for 1971*, Part 1, 285, and *for 1972*, Part 1, 279). The larger rate of Na with either rate of K decreased the plant population and the leaf area index (LAI) in May. After singling, both rates of Na increased the LAI but K had little effect. Both Na and K increased the dry matter yield of tops until August and of roots at every sampling but the effect of K was smaller than that of Na. Na and K increased their respective concentrations in the plant and each suppressed that of the other. At the end of the growing season Na and K increased the sugar yield by increasing root yield and sugar percentage; Na by 0·74 and K by 0·34 t/ha sugar. As in previous years, both were needed for maximum sugar yield, the two elements together giving 1·24 t/ha extra sugar. Neither Na nor K adversely affected the juice purity.

Manganese. Experiments testing MnO and Mn 'frit' incorporated in the seed pellet and $MnSO_4$ foliar sprays were continued at Ely, Peterborough and Wissington on soils with pH greater than 7 and easily-reducible manganese concentration less than 85 ppm. The crop at Peterborough did not show Mn deficiency and there was no effect of treatments at harvest. At Wissington, 32% of untreated plants had Mn deficiency symptoms, those given 'frit' 26%, MnO 22% and none of those sprayed with $MnSO_4$. All plants in the Ely experiment had Mn deficiency symptoms. Two sprays of $MnSO_4$ cured most plants but the symptoms reappeared in July.

Although the seed pellet treatments did not eliminate the symptoms, Mn deficiency was less severe and the plants grew more vigorously than those not given Mn. All treatments increased the concentration of Mn in the leaves in June. The effect was greater than last year, probably because of the heavy rain during the spring. All treatments increased sugar yield but sprays of $MnSO_4$ were the most effective.

Two new experiments at Peterborough and Ely compared applications of MnO and Mn 'frit' in autumn, with spring applications of MnO, Mn 'frit', chelated Mn and $MnSO_4$ as a foliar spray. MnO and the 'frit' were each tested with and without extra phosphate in spring. At Ely the crop had no Mn deficiency symptoms and gave no yield response to the treatments.

At Peterborough, 40% of plants not given Mn were deficient and plants given MnO in autumn less so than those given it in spring. The additional phosphate had no effect. Plants given 'frit' in spring were less deficient than those on plots treated in autumn and extra phosphate increased the effect of the 'frit'. The plants given chelated Mn were less deficient than the control plots but not as healthy as those given MnO in autumn or 'frit' given in spring with extra phosphate. Here also foliar spray was the most effective cure for Mn deficiency.

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Copper. Again this year two experiments tested the effect of copper, the one with spring barley on Dunholme field at Broom's Barn where the soil contained 2·0 ppm 'available' Cu, the other with sugar beet at West Row fen, where the soil contained 0·9 ppm available Cu. The barley experiments compared 12 kg/ha Cu as $CuSO_4\ 5H_2O$, 0·25 and 0·5 kg/ha Cu as the chelate Cu-EDTA in the seedbed and CuOCl as a foliar spray at 0·28 kg/ha Cu. None affected yield, which averaged 4·77 t/ha grain and 4·44 t/ha straw.

Similar treatments were tested on sugar beet except that 5 kg/ha Cu as Cu 'frit' was given in place of the small dressing of Cu-EDTA. The chelate at 0·5 kg/ha Cu and $CuSO_45H_2O$ at 12 kg/ha Cu increased sugar yield from 4·13 t/ha to 4·55 and 4·51 t/ha respectively.

The effect of Mn, Fe, Cu and Zn chelates and Cu and Zn 'frits' on yield and chemical composition of sugar beet grown in an organic sandy loam and a loamy sand was studied in the glasshouse. Sufficient chelates to increase the concentration in the soil by 5 ppm Mn, 10 ppm Fe, 3 ppm Cu and 3 ppm Zn were tested separately and together. Additional Cu and Zn 'frits' were given separately and together to increase the concentration in the soil by 68 ppm of each element.

The micro-nutrients slightly increased dry weight and concentration of each element in the plants grown in the organic soil. The zinc chelate increased the Zn concentration in the plants grown in the mineral soil but none of the other elements had any effect.

Magnesium and boron. The experiment on Brome Pin field testing the residual effects of Mg and B fertilisers was sown with Bush Mono seed (*Rothamsted Report for 1970*, Part 1, 271). Soil samples were taken in March and although the soil Mg on the control plots was 22 ppm, no magnesium deficiency symptoms appeared in the crop and at harvest magnesium fertiliser did not increase the yield. Soil given kieserite in 1970 contained 38 ppm Mg, given calcined magnesite 30 ppm Mg, and given magnesium limestone 29 ppm Mg. The very dry winter resulted in little leaching of boron and the concentration of water-soluble boron had not changed from last year. Untreated soil contained 0·74 ppm B and that given boron 1·05 ppm B. No boron deficiency symptoms developed and there was no yield response to boron fertiliser. The average yield of roots was 45·2 t/ha and the sugar percentage was 17·5. (Farley)

Time and application of fertilisers

PKNaMg. A long-term experiment started in 1970 at Sutton, Suffolk, on a loamy sand (*Rothamsted Report for 1971*, Part 1, 286) was cropped with carrots. 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. Autumn and spring applications, each of 83 kg/ha K, 101 kg/ha Mg and 27 kg/ha P, were compared. The crop grew well at first but, as in previous years, growth was irregular later in the season due to drought. The crop did not respond to magnesium fertiliser but needed about 80 kg/ha K for maximum yield. Giving the PKMg fertilisers in autumn was much more effective than the seedbed application; yield from autumn application was 50·3 t/ha roots compared with 44·2 t/ha from that in the spring.

Nitrogen. A similar experiment on Bullrush field to those made previously (*Rothamsted Report for 1971*, Part 1, 286, and *for 1972*, Part 1, 281), compared 75, 150 and 225 kg/ha N applied before ploughing during November with the same amounts applied in the spring, and with 150 kg/ha applied before ploughing plus 36 kg/ha applied in spring. All the nitrogen dressings increased sugar yield. All the fertiliser dressings given in spring gave similar yields but when applied in autumn, the smallest dressing (75 kg/ha) was insufficient for maximum yield. Autumn application of 150 or 225 kg/ha gave

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similar yields to those from the same amount applied in spring; there was no advantage in splitting the dressing.

Periodical petiole analyses showed that, in June and July, plants from plots given N in spring contained more nitrate than those given N in winter. However, in August–October, plants given N in spring contained similar concentrations of nitrate to those given N in winter. Concentrations of nitrate were small in plants from all plots in August but increased after rainfall in September. This and previous experiments indicate that nitrogen fertiliser is not leached much during dry winters at Broom's Barn but that there is no advantage in giving part of the nitrogen in the previous autumn.

Aqueous ammonia. A new experiment on Brome Pin field compared aqueous ammonia with other forms of nitrogen for sugar beet. Seedbed applications of 76, 126 and 176 kg/ha N as aqueous ammonia and as ammonium nitrate were tested, as were both a sulphur-coated ammonium nitrate fertiliser and one treated with a nitrification inhibitor at 126 kg/ha N. A further treatment tested 76 kg/ha N as ammonium nitrate in the seedbed followed by 100 kg/ha N as aqueous ammonia injected along the rows in June. The nitrogen treatments increased the yield on average from 7·64 to 8·43 t/ha. The aqueous ammonia and ammonium nitrate when tested at the same rates gave the same yield of sugar. Ammonium nitrate coated with sulphur produced a crop containing the same amount of sugar as did ammonium nitrate without the sulphur; the nitrification inhibitor also had no effect on sugar yield, nor did splitting the dressing. (Draycott and Last)

Forms of magnesium fertiliser. The investigation begun last year comparing kieserite with two forms of calcined magnesite was continued. Fields were chosen for the experiments where the soil contained little exchangeable magnesium; sugar beet was grown on two fields and carrots on another. In the sugar-beet experiments autumn and spring applications were compared.

Sugar-beet plants not given magnesium fertiliser were severely deficient in both the experiments and the carrots slightly deficient. Magnesium increased sugar yields on average by 20% and the carrot dry matter yield by about 15%. This year all the forms of magnesium increased yield similarly and were equally effective given in autumn or spring. (Draycott)

Germination, emergence and seedling size. Laboratory tests showed that although dilute solutions of NaCl or KCl did not decrease the number of seeds which germinated, small differences in concentration greatly affected seedling vigour. This suggests that uneven fertiliser distribution might influence seedling growth in the field. No seeds germinated in solutions more concentrated than 0·28*M*. Soaking seed in 1·0*M* solutions killed 6% but the remainder germinated when transferred to water or dilute solutions. Differences in time taken for individual seeds to germinate also contribute to seedling variability. In the field, seedling emergence was recorded on plots receiving all combinations of 0 and 250 kg/ha K and Na (as chlorides). Emergence was decreased only when both nutrients were given. Seedlings did not emerge evenly over the whole of any plot due to differences in drilling depth, soil conductivity and clods and stones left by the drill on top of the seed. It took 17 days for any seedlings to appear and a further 23 days for maximum emergence (75% of seeds sown). (Durrant)

Irrigation

Irrigation and nitrogen. A new experiment was begun on the sandy loam soil of Brome Pin field, testing six dressings of N fertiliser between 0 and 207 kg/ha N. Three blocks

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were grown with and three without irrigation. The crop was irrigated to limit the soil moisture deficit to 40 mm, and a total of 183 mm was applied. The object of this study is to test the theory that the amount of nitrogen fertiliser needed by sugar beet for maximum sugar yield is decided by environmental factors early in the growing season. If this is so, it would explain many features of the crop's response to nitrogen, for example, the absence of response to top-dressings.

The crop was sampled at weekly intervals during May, at fortnightly intervals during June and July and at monthly intervals from August to December. Dry matter yields showed that initially root yield was depressed by all amounts of nitrogen but that 80 kg/ha N gave maximum dry matter yield of leaves and crowns. Later in May the maximum dry matter yield of roots and of tops was with 80 kg/ha N. By the middle of June, the dry matter yield of tops was greatest with the largest amount of nitrogen tested (207 kg/ha) but the maximum dry matter yield of roots was still with 80 kg/ha. This was also the case throughout the remainder of the season, both with and without irrigation. Sugar yields confirmed that the optimum nitrogen dressing was 80 kg/ha N. Irrigation increased the average sugar yield from 8·65 to 9·42 t/ha but did not affect the optimum nitrogen dressing. The results so far support the theory that the optimum nitrogen dressing is decided early in the growing season but the factors influencing the optimum need more investigation. (Last)

Time and amount of irrigation. On the heavier part of Brome Pin field a similar experiment to last year (*Rothamsted Report for 1971*, Part 1, 287) tested response of sugar beet to irrigation applied at different times and compared one with several waterings. This year there were two additional treatments; one tested the effect of a very early watering and the other tested one application of 2 in. in June.

May and June were wetter than average but from July onwards the deficit increased to a record 200 mm in mid-September. However, none of the irrigation treatments increased sugar yield, indicating that the crop was able to produce maximum sugar yield with soil water and rainfall only. This result confirms the view that on much of Broom's Barn farm sugar beet will produce maximum sugar without irrigation, even in a very dry summer with a large soil moisture deficit, provided it is not short of water early in the season. (Messem)

Plant spacing

Four different plant densities were established on plots sown early or late (13 March or 2 May) on Brome Pin field and they were harvested in early October or early December (*Rothamsted Report for 1972*, Part 1, 283). The March-sown crop yielded more roots and

TABLE 3

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

	Sowing date (meaned over two harvest dates)									
	13 March					2 May				
Density ('000/ha)	25	49	74	98	Mean	25	49	74	98	Mean
Distribution:										
Regular	6·28	7·48	7·50	7·34	7·15	3·64	5·70	6·23	6·50	5·52
Irregular	6·17	7·63	7·06	7·11	6·99	4·08	5·54	6·22	6·19	5·50
Very irregular	5·21	7·25	7·85	7·35	6·91	3·68	5·28	6·18	6·52	5·42
Mean	5·89	7·45	7·47	7·26		3·80	5·50	6·21	6·40	
October harvest	6·81					4·94				
December harvest	7·23					6·01				

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sugar than the May-sown at both harvests. The sugar yield increased little on the plots sown in March between October and December (Table 3), probably because 25% of plants had bolted; on the late sown plots none bolted and the sugar yield increased more than 1 t/ha. Stands of 25 000 and 49 000 plants/ha yielded less sugar than denser stands when sown late, but when sown in March only the 25 000 plants/ha stand yielded less. Irregular plant stands tended to decrease sugar yield, particularly in sparse stands and with short growing periods. (Jaggard)

Time of sowing and harvesting, and plant density

An experiment testing three times of sowing and two times of harvesting at four plant densities produced the sugar yields sown in Table 4. The stands of 50 000 and 75 000 plants/ha were grown in rows 50 cm apart, and the denser stands in beds of five rows, 25 cm apart. Early sowing gave the largest sugar yield. Plant density scarcely affected sugar yield. (Webb)

TABLE 4

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

	Harvest date									
	26 September Plant density ('000/ha)					10 December Plant density ('000/ha)				
Sowing date	50	75	100	125	Mean	50	75	100	125	Mean
13 March	8·71	8·34	8·10	7·74	8·22	10·05	10·22	9·94	10·03	10·06
6 April	8·06	8·02	7·89	7·48	7·86	9·89	9·87	9·98	9·77	9·88
2 May	6·43	6·78	6·65	6·59	6·61	8·62	8·66	8·66	8·54	8·62
Mean	7·73	7·71	7·55	7·27		9·52	9·58	9·53	9·45	

Plants from the first and third sowings at all densities of stand were sampled and analysed for growth five times between 18 June and 17 September. The early sown crop produced the larger leaf area index (LAI) until late July, and maintained a larger growth rate to this date than the late sown crop. During August and September growth rates from the early and late sown crops were the same and hence the difference in yield resulted from the early growth rate differences. The densest stands also had large LAI's and growth rates early in the year, but as the season progressed, interplant competition limited growth and eliminated early yield differences between plant densities. (Jaggard)

Time of sowing and seed spacing. An experiment on Brome Pin field tested the effect of time of sowing on seedling establishment and yield of two varieties when drilled-to-a-stand. Pelleted seed of varieties Bush Mono and Sharpe's Klein Megapoly was sown on 14 March (S_1), 6 April (S_2) or 2 May (S_3) spaced at 12·5 cm, 15·5 cm or 18·5 cm. Seedlings established well from all sowings and averaged 77% of seeds sown (Table 5). The densest plant stands of both varieties yielded less than sparser stands but otherwise plant density had little effect on sugar yield. The monogerm variety yielded progressively less from delayed sowing but the polyploid variety yielded similarly from the first and second sowings. This difference between varieties in response to early sowing may arise from 11% of the polyploids sown in March bolting compared with 4% of the monogerm plants. (Webb)

Beet on ridges

A trial on Bullrush field tested the effects of the following times and methods of seedbed preparation on establishment and yield of sugar beet: (1) Conventionally-prepared by

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TABLE 5

Plant densities from different sowing dates and seed spacing, and mean yield of sugar

Variety Bush Mono	Plant stations ('000/ha) from seed sown at spacings of 12·5 cm	15·5 cm	18·5 cm	Mean Plant stations ('000/ha)	Mean Sugar (t/ha)
S1	116	101	80	99	9·85
S2	118	102	87	102	9·48
S3	102	93	78	91	8·52
Mean	112	99	82	97	9·28
Variety Sharpe's Klein Megapoly					
S1	112	100	76	96	9·39
S2	124	99	91	105	9·43
S3	104	93	77	91	8·19
Mean	113	97	81	97	9·00

power and rotary harrows in the spring; (2) prepared by power harrows only in the spring; (3) wheat-type seedbed produced in the autumn by harrowing; (4) land set up in low ridges at 50 cm centres in the autumn.

Sub-plots were treated with the 'Stanhay Incorporator' working an 18 cm band at 5 cm depth immediately before drilling. Pelleted Bush Mono seed was sown at 7·5 cm or 15 cm on 21 March. The incorporator treatment increased seedling emergence by approximately 5% and consistently, but insignificantly, increased yield. (Webb)

Green manuring

Sugar-beet growers in some Continental countries plant a green manure crop in the year before sugar beet. This provides part of the nutrient requirement of the sugar beet and may also improve the physical condition of the soil. A new experiment was begun on Bullrush field to investigate these effects. The field was sown to barley in 1972 and some plots were undersown with ryegrass and some with trefoil. After the barley harvest, other plots were either sown with fodder radish, given the slow release fertilisers iso-butylidene diurea (IBDU), or glycoluril at 75 kg/ha N. The undersown crops established poorly in the dry season, particularly the trefoil, and did not affect the barley yield. The green manure crops were sampled before ploughing and the dry matter yields were 4·3 t/ha ryegrass, 0·3 t/ha trefoil and 1·6 t/ha fodder radish.

In 1973 sugar beet was grown on all plots, which were split and given 0, 50, 100 and

TABLE 6

Sugar yields (kg/ha) in the green manuring experiment, 1973

Green manure	N dressing, autumn 1972: Form	kg/ha N	N dressing, 1973 (kg/ha N): 0	50	100	150	Mean
None	None		8·27	9·03	9·78	9·94	9·25
None	Ammonium nitrate	38	9·13	9·56	10·01	9·83	9·63
None	IBDU	76	9·41	10·04	9·90	9·59	9·74
None	Glycoluril	76	9·46	9·84	9·38	9·57	9·56
Fodder radish	Ammonium nitrate	38	9·24	8·69	10·16	9·49	9·40
Fodder radish	Ammonium nitrate	76	9·80	9·62	9·29	9·56	9·57
Ryegrass	Ammonium nitrate	38	8·99	9·89	9·51	10·02	9·60
Ryegrass	Ammonium nitrate	76	9·71	9·20	9·56	9·91	9·60
Trefoil	None		8·33	9·83	8·93	9·96	9·26
Trefoil	Ammonium nitrate	38	9·18	9·26	10·03	9·73	9·55
Mean			9·15	9·50	9·65	9·76	

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150 kg/ha N. Seedling counts in May showed that the treatments in the previous year did not affect the number emerging. Similarly, dry matter weights of seedlings indicated no residual effect of the previous cropping or manuring. Sugar yields at harvest (Table 6) show that the three green manure crops had little effect on sugar yield; however, there was a large residual effect of nitrogen fertiliser given the previous autumn. The ammonium nitrate given then was as effective as the two slow-release fertilisers IBDU and glycoluril. This is probably explained by the very dry autumn and winter. The crop given no nitrogen in autumn needed 100 kg/ha N for maximum sugar yield but where nitrogen had been given in autumn, irrespective of its form, or green manure, 50 kg/ha N was usually sufficient. (Last)

Soil structure

Damage to soil during beet harvesting. In this factorial experiment started in October 1972 the soil conditions produced by harvesting sugar beet from wet, damp or dry soil were simulated, by running a loaded tractor up and down the plots to produce ruts and mud. During most of the autumn the soil was too dry for wheels to sink into it so the treatments were delayed until after heavy rain in mid-November and early December. The beet tops were removed from some plots or twice the normal amount of tops ploughed in to others. The experiment site was ploughed on 15 December, and drilled with wheat var. Maris Ranger on 20 December. Plots were split for either 75 or 125 kg/ha of nitrogen fertiliser applied on 17 April 1973. The soil injury treatments produced no significant differences in grain yield at harvest on 20 August, but simulated beet harvesting under wet conditions decreased straw yield by 0·2 t/ha. Ploughing in beet tops decreased grain yield by 0·2 t/ha, but had no significant effect on straw yield. Additional nitrogen fertiliser decreased grain and straw yields by 0·4 t/ha and 0·2 t/ha respectively, despite the crop not lodging on any plots. (Jaggard)

Soil compaction. On Bullrush field a third experiment tested the effects of soil compaction on fertiliser requirement and yield of sugar beet (*Rothamsted Report for 1971*, Part 1, 289; *for 1972*, Part 1, 285). At seedling emergence the mean bulk densities of dry soil from each cultivation treatment to a depth of 16 cm were: compacted seedbed 1·68 g/ml; normal seedbed 1·52 g/ml; loose seedbed 1·45 g/ml. The treatments gave no significant differences in seedling emergence. Soil compaction decreased sugar yield by 1·9 t/ha and top yield by 7 t/ha compared with the normal and open seedbeds. Sugar yields of beet grown on all seedbed treatments responded to 150 kg/ha of nitrogen fertiliser, and additional phosphate fertiliser had no significant effect.

An experiment of the same design as that reported in the two previous years (*Rothamsted Report for 1971*, Part 1, 289; *for 1972*, Part 1, 285) was carried out at Harpley, Norfolk, to examine the effects of soil compaction and the systemic nematicide aldicarb on sugar beet growing in a soil infested with the nematode *Trichodorus*. Compaction had no effect upon the numbers of *Trichodorus* extracted from soil samples taken at drilling (average 1337/litre soil), and very few were extracted from soil samples taken at random in the row on 15 June when the soil was dry (average 6/litre). Numbers extracted had increased by harvest on 22 October (average 1473/litre), but there was no significant difference between treatments. When seedling emergence was complete on 10 May, the bulk density of dry soil to 16 cm depth was 1·55 g/ml on the compacted treatment, and 1·31 g/ml on the uncompacted. The compact seedbed without aldicarb decreased sugar yield by 1·4 t/ha but by only 0·3 t/ha with aldicarb. A significant response to aldicarb was thus confined to compact seedbeds. Soil compaction in the absence of aldicarb increased the number of severely misshapen roots. (Cooke and Jaggard)

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Growth control chemicals

'AC 99524' was sprayed on to sugar beet plots at Broom's Barn at 560 and 1120 g a.i./ha on 14 June, at 1120 g on 3 August and at 560 g on both dates. All treatments increased the numbers of plants with elongated internodes in the crown at harvest on 24 October, especially the larger amount applied early and the smaller amount applied twice. The treatments on 3 August, especially the larger amount, increased root weight but proportionally decreased sugar percentage; the sugar yield was not affected. (Dunning and Winder)

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. The single application of the herbicide at drilling at the recommended rate (1·3 kg/ha) gave good weed control and the largest yield of sugar, 9·53 t/ha. Unsprayed plots with no weeding until 15 June yielded 8·75 t/ha of sugar.

Varieties

Commercial. An experiment done in cooperation with the National Institute of Agricultural Botany tested 11 varieties of sugar beet sown on 14 March on Brome Pin Field. The experiment is one of the NIAB series testing varieties sown as pelleted seed spaced at 16 cm and the crop grown without handwork. The plant population of the different varieties ranged from 57 000 to 107 000/ha and bolters from 4·5% to 26%. Of the four largest yielding varieties, two are polyploids and two are monogerm.

Yellows tolerant. Plots of six commercial or breeders' varieties sown on 21 March were either infected with both beet yellows and beet mild yellowing viruses or kept free from yellows by insecticide sprays. This experiment was 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 8·99 and 5·73 t/ha; roots 51·9 and 36·2 t/ha; sugar percentage 17·3 and 15·8. The varieties Bush Mono and Bush Mono A gave the largest yields when healthy, but lost 41% of their sugar yield when infected. The varieties Nomo and Vytomo yielded well when healthy and lost only 30% of their sugar yield when infected. Yields averaged over the infected and healthy plots were Vytomo 7·67, Nomo 7·53, Bush Mono 7·46, Maris Vanguard 7·43, Bush Mono A 7·19 and Sharpe's Klein E 6·89 t/ha sugar.

Bolters

This year many of the early sown plants bolted, up to 25% in some of the currently recommended varieties. To assess the effect of bolting on yield, bolters, adjacent plants in the row and other plants of var. Amono drilled on 16 March were harvested separately and yields determined (Table 7).

Total yield was 49·9 t/ha of roots and 8·15 t/ha of sugar. Bolting depressed the sugar percentage by 1·2 and the roots were lighter. The 24% of bolters contributing only 19% of the sugar yield of the sample compared with 46% of non-bolters contributing 50% of sugar yield and the 30% of plants adjacent to bolters contributing 31% of the sugar yield. (Webb)

Cereal and rotation experiments

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

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TABLE 7

Effect of bolters on yield

	Bolters	Plants adjacent to bolters	Other plants
Sugar %	15·4	16·7	16·6
Individual root weight (g)	550·0	620·0	660·0
% of root number	24·0	30·0	46·0
% of root yield	21·0	30·0	49·0
% of sugar yield	19·0	31·0	50·0

TABLE 8

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

	Wheat grain (t/ha at 85% DM)	Barley grain (t/ha at 85% DM)	Sugar (t/ha)
Mean yield	4·22	4·12	6·60
Response to:			
N_1	+1·69	+1·72	0
N_2–N_1	−1·21	+0·32	+0·24
P_1	+0·09	+0·47	−0·20
P_2–P_1	+0·06	+0·46	+0·41
K_1	−0·06	−0·02	+0·64
K_2–K_1	−0·43	+0·26	+0·65
Na	−0·12	+0·02	+1·19
FYM	+0·17	+0·20	+0·62
Compound 1	+1·41	+1·82	+0·91
Compound 2–Compound 1	−1·18	−0·24	−0·48

As shown in Table 8, N_1 (75 kg N/ha) was needed for maximum wheat grain yield; either more or less significantly decreased yield. N_2 (100 kg N/ha) was needed by barley, but as in 1971 and 1972, response to nitrogen fertiliser by sugar beet was small. Phosphorus fertiliser did not increase wheat or sugar yield but P_2 (44 kg P/ha) gave an extra 0·93 t/ha barley grain. There was no response to potassium fertilisers by wheat or barley, but as usual sugar yield was much increased by the cation fertilisers. Leaching losses have been small during recent winters so nitrogen residues have accumulated. This has had a marked effect on sugar percentage (Table 9). (Durrant)

TABLE 9

Effect of N fertiliser on sugar percentage, 1969–73

	1969	1970	1971	1972	1973
Without N	19·6	18·8	18·3	18·0	16·8
With 200 kg N/ha	18·8	17·9	16·7	16·0	14·4
Difference	0·8	0·9	1·6	2·0	2·4

Frequency of beet and barley. This was the ninth year of the experiment testing yields in five contrasting crop rotations (for details see *Rothamsted Report for 1966*, 248). In 1973, the largest sugar yield was from sugar beet grown after two cereals or following potatoes and beans (average 7·1 t/ha). Sugar yields were similar in the other three rotations, averaging 6·7 t/ha. With the exception of sugar beet grown in rotation with the two-year grass ley, which needed none, all the rotations needed 63 kg/ha N for maximum sugar yield. As before, barley grain yields (3·46 t/ha at 85% DM) were similar following two-year grass ley, which needed none, 63 kg/ha N gave maximum sugar yield in all the rotations. As before, barley grain yields (3·46 t/ha at 85% DM) were similar following sugar beet or one or two cereal crops, slightly less after three cereals and 0·5 t/ha less after four cereals. The first and second year leys produced 7·34 and 10·45 t/ha DM respectively. Beans yielded 2·99 t/ha grain at 85% DM and potato tubers 7·28 t/ha DM.

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Nitrogen and fumigation. The experiment on Brome Pin (*Rothamsted Report for 1972*, Part 1, 288) testing the residual effects of soil fumigation with 'D-D' and form of nitrogen fertiliser on pathogens and crop yields was cropped with sugar beet in 1973. Fumigation treatments were applied on 20 September 1972 and soil samples were taken for nematode determination on 11 January 1973. All genera were more numerous in unfumigated plots than on any previous sampling date and most were controlled well both in plots fumigated every year and on those fumigated only before each sugar-beet crop (Table 10).

TABLE 10

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

	Nematode numbers per litre of soil		
Nematode	Unfumigated	Fumigated every year (18.3.70, 13.11.70, 14.9.71, 20.9.72)	Fumigated before sugar beet only (18.3.70, 20.9.72)
Tylenchus	838	25	13
Tylenchorhynchus	1588	100	0
Heterodera larvae	588	13	13
Pratylenchus	2375	38	313
Paratylenchus	1125	138	225
Rhabditida	4800	1350	750
Trichodorus	50	0	0
Mononchidae	200	0	0
Other Dorylaimida	1375	50	300

Samples of seedlings taken in May showed that either fumigation and nitrogen increased plant weights by similar amounts when applied in the absence of the other. Giving both increased yield further, particularly when the nitrogen was given as nitrate. Dry matter yields in June confirmed these effects although the superiority of nitrate compared with ammonium had diminished. Sugar yields were increased slightly by fumigation or by either form of nitrogen; giving both did not increase yields further. (Cooke and Last)

Irrigation and nitrogen for cereals. Experiments made in cooperation with the Botany and Chemistry Departments 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. 49 and 94). At Broom's Barn the Cappelle wheat was on New Piece field and the Julia barley on Windbreak field. The barley seed was treated with ethirimol and both the barley and wheat sprayed with tridemorph. The fertiliser and irrigation treatments were

TABLE 11

Effects of irrigation and nitrogen on yields of wheat and barley in 1973

	N dressing (kg/ha)						
	31	63	94	125	157	188	Mean
	Grain yield, t/ha at 85% DM						
	Wheat						
Without irrigation	5·19	5·73	5·87	5·86	5·40	5·45	5·59
With irrigation	5·15	5·86	6·03	5·86	5·73	5·43	5·68
Mean	5·17	5·80	5·95	5·86	5·57	5·44	5·63
	Barley						
Without irrigation	5·89	6·01	5·24	5·20	5·43	5·39	5·52
With irrigation	5·86	6·10	5·79	5·81	5·77	5·97	5·88
Mean	5·87	6·05	5·51	5·50	5·60	5·68	5·70

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as before (*Rothamsted Report for 1971*, Part 1, 294). A total of 110 mm irrigation was given to the wheat and 112 mm to the barley.

The barley yielded very well and the wheat yield was near average for Broom's Barn, irrigation increasing yield of both crops slightly on average (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, also both with and without irrigation.

The maximum soil moisture deficit as determined by neutron moderation was 149 mm on the unirrigated wheat plots on 16 August and 110 mm on the corresponding barley plots on 9 August. Before irrigation on 4 June, the deficit was 73 mm in the wheat and 68 mm in the barley. As in 1972, the potential deficit and the measured deficits were very similar—for wheat 145 and 149 mm and for barley 125 and 110 mm respectively, both crops being able to obtain nearly all their water requirement from rainfall and soil reserves. Wheat took up water from 150 cm and barley from 120 cm, slightly deeper than last year. Irrigating decreased the measured maximum soil moisture deficit to 39 mm in wheat and to 8 mm in barley.

TABLE 12

Effects of irrigation and nitrogen on yields of wheat and barley; mean of years 1971–73

	N dressing (kg/ha)						
	31	63	94	125	157	188	Mean
	Grain yield (t/ha at 85% DM)						
	Wheat						
Without irrigation	5·09	5·78	5·96	5·94	5·94	5·89	5·77
With irrigation	5·46	6·09	6·38	6·43	6·36	5·98	6·12
Mean	5·27	5·93	6·17	6·18	6·15	5·93	5·94
	Barley						
Without irrigation	4·84	5·38	5·46	5·67	5·84	5·78	5·49
With irrigation	5·13	5·85	5·87	5·87	5·71	5·54	5·66
Mean	4·98	5·61	5·66	5·77	5·77	5·66	5·77

Table 12 shows the average grain yields in the three years of experiments as the investigation concluded with the experiments made in 1973. The two crops appeared to respond to water and nitrogen in different ways in these three drier-than-average years. Irrigating the wheat increased the yield by 0·09 t/ha on average but did not affect the amount of nitrogen needed for maximum yield; the optimum dressing was about 80 kg/ha, which is the amount used on the commercial crop at Broom's Barn. The average response to water by the barley was 0·36 t/ha but the optimum dressing of nitrogen was greatly affected by watering. Without irrigation, the barley responded almost up to the largest amount of N tested and about 160 kg/ha was needed for maximum yield. With irrigation, 60 kg/ha was sufficient and giving more than 125 kg/ha plus irrigation lodged the crop and depressed yield. (Draycott, Messem and Webb)

Phosphorus and potassium. A new experiment on Brome Pin field compared the effects of phosphorus and potassium fertilisers applied every year with the same total amount applied once in the rotation immediately before the sugar beet. The annual dressings of fertiliser tested were 27·5 kg/ha P and 125 kg/ha K for sugar beet and 16·5 kg/ha P and 31 kg/ha K for cereals, compared with rotational dressings of 60·5 kg/ha P and 187 kg/ha K. Phosphorus was applied both as triple superphosphate and as Gafsa phosphate but potassium was applied only as the chloride. The sugar yields in this first year showed a marginal response to phosphorus (0·1 t/ha) with no difference between the two forms but

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a large response to potash (0·6 t/ha) with an overall mean yield from the experiment of 7·4 t/ha. (Draycott)

Fungicides on barley. The fungicides ethirimol, tridemorph, benomyl and 'BAS 3170F' were tested on three varieties of spring barley for the control of mildew. Mildew was moderately severe on Berac and Julia but slight on Mazurka. Ethirimol as a seed dressing controlled mildew well, increased the height of all varieties, and reduced the lodging in Mazurka and Julia.

Thousand-grain weight was increased by all the fungicides. Yields of the varieties averaged for all the treatments were Berac 4·8 t/ha, Julia 5·2 t/ha and Mazurka 4·9 t/ha. Of the fungicides, ethirimol increased yield most consistently. (Webb)

Broom's Barn Farm

Changes in soil analysis 1960–73. In the spring of 1960, just after Broom's Barn Farm was acquired, soil samples (0–22 cm and 22–44 cm deep) were taken from alternate 20-m squares from each field. The samples were air-dried, ground to less than 2 mm, analysed and stored. In 1973, three fields (Dunholme, Marl Pit and The Holt) were resampled and analysed to test if the five-year rotation (sugar beet, winter wheat, barley, ley or beans, winter wheat) and fertiliser practice has, as intended, improved the nutrient status of the soils and made the fields more uniform for field experiments. Results (average for the topsoil of each field) are given in Table 13. Over the 13 years, the pH has not changed greatly. However, small acidic areas have been limed and now there is less variation within each field. On average, even though the rotation included a ley, the organic matter decreased slightly. In all years P applied was greater than P removed so residues accumulated. These gave an extra 6 ppm $NaHCO_3$-soluble P in the topsoil but no increase in the subsoil. Conversely, K residues increased the readily exchangeable K in the subsoil more than in the topsoil. Only small amounts of Mg fertiliser have been given so offtake has consistently exceeded that applied. However, exchangeable Mg has only decreased appreciably on Dunholme field (sandy loam). (Durrant)

TABLE 13

Changes in soil analysis between 1960 and 1973 at Broom's Barn

	pH (in water)		Organic matter (%) (Tinsley's method)		P (ppm) $NaHCO_3$-soluble		K (ppm) (NH_4^+-exchangeable)		Mg (ppm) (NH_4^+-exchangeable)	
Field	1960	1973	1960	1973	1960	1973	1960	1973	1960	1973
Dunhole	7·3	7·6	1·80	1·81	23	31	133	138	42	31
Marl Pit	7·8	7·9	2·06	1·90	22	27	161	162	37	35
The Holt	8·3	7·8	2·10	2·00	22	26	127	147	39	39
Mean	7·9	7·8	1·99	1·90	22	28	140	149	39	35

Soil Survey. Members of the Soil Survey of England and Wales began mapping in West Suffolk and made a detailed examination of the soils of Broom's Barn farm. Pits were opened with an excavator on Marl Pit (N), Dunholme (N), Brome Pin (N and SW) and Bull Rush (N, W and SE) fields in November. The soil horizons were described and sampled for chemical analysis. Samples were also taken for moisture-release characteristics. An up-to-date soil map of the farm will be useful in planning the layout of our field experiments, and the chemical and physical soil analyses should help in their interpretation.

https://doi.org/10.23637/ERADOC-1-130

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Cropping. Ploughing was completed by the end of 1972 and, although we had few severe frosts, good seedbeds were readily prepared and crops were sown early. The grass on White Patch was given 50 mm of irrigation in June. Sub-soiling continued this year with a three-tined machine at 50 cm deep and 90 cm apart on White Patch field which was worked both ways. Marl Pit field was worked at 90° to last year's work which was done with a single-tined machine at 1·5–2-m intervals and left the following barley crop more prolific immediately over the line of the sub-soiler. Again a wide variety of subsoil was encountered, some of which was very difficult to penetrate. White Patch was levelled after subsoiling and cultivating, and dressed with farmyard manure.

The pond on Bullrush was filled in. A new farm building to the east of the farmyard approached completion at the end of the year.

Cereals. The cereal crops were manured with P and K as in previous years but since the winter was very dry the N was decreased by 12–20 kg/ha and few patches of corn lodged. All the cereals were sprayed with herbicide except on Marl Pit where few weeds emerged above the crop.

All the barley was sown by mid-March and kept reasonably free from mildew by tridemorph spray. Barley yellow dwarf virus infected all the barley crops which resulted in early yellowing and loss of yield.

The Maris Ranger wheat sown in mid-December on Flint Ridge following sugar beet was heavily infected with mildew. Harvest lasted from 2 to 20 August with grain moistures ranging from 14–18%.

Maize. One and a half acres of maize var. Dekalb 202 was sown on May 9 on Windbreak field. It was given N 125; P_2O_5 62; K_2O 62 kg/ha immediately before drilling and sprayed with atrazine herbicide immediately after drilling; 75 kg/ha N was given as a top dressing on 15 June. A contractor harvested it on 8 November and the yield at 85% DM was 4·0 t/ha.

TABLE 14

Cereal and bean yields at 85% DM moisture

Field	Area (ha)	Variety	Yield (t/ha)
Dunholme	8·97	Julia barley (undersown)	4·14
Marl Pit	5·16	Lofa Abed barley	3·89
Little Lane	8·78	Maris Huntsman wheat	6·30
Hackthorn	3·93	Maris Nimrod wheat	5·74
New Piece	5·22	Maris Nimrod wheat (including 0·81 ha Cappelle wheat experiments)	5·90
Flint Ridge	8·82	Maris Ranger wheat	3·61
The Holt	4·49	Maris Bead beans	3·77

Beans. Maris Bead tic beans were sown in a good seedbed on 13 March and immediately rolled and sprayed with simazine which controlled weeds well and with disulfoton granules from the air on 5 July to control aphids. Five hives of bees worked the crop. Although the stalks were very green, the beans were harvested on 23 and 24 August at 41% moisture.

Fodder crops. The Italian ryegrass and clover ley on White Patch was cut for silage during the first week of June and immediately top dressed with 75 kg/ha N and then irrigated to yield a hay crop in mid-July. The undersown ley on Dunholme looked thin in the stubble at harvest but has established well with adequate rainfall during the autumn.

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Sugar beet. The fertiliser ploughed down on Bullrush in the autumn of 1972 gave P_2O_5 55; K_2O 150; Na 137 and Mg 62 kg/ha. The east of Brome Pin had the same dressing but the west is designated a low PK area and had P_2O_5 27·5; K_2O 75; Na 137 and Mg 0 kg/ha ploughed down. The N fertiliser, at 125 kg/ha, was broadcast between the rows immediately after drilling. Sowing started on 14 March and continued until 26 March when 11 ha had been sown. Most of the remainder was sown during early April leaving only small areas for experimental sowings later in the month. Of the crop area, 66% was sown with pelleted monogerm, 30% with pelleted polyploid and 3% with rubbed and graded seed. Seven and a half hectares were sown at 10 cm seed spacing or less, 5·4 ha at 11·5 to 16·5 cm and 0·4 ha at 17·5 cm or more. Most of the crop was band sprayed, or overall sprayed on non-standard row widths, with pyrazone herbicide at the time of drilling. All subsequent weed control was by hoeing. All the crop except specific experiments was sprayed twice with aphicide and fungicide and the light soil once with boron. Harvesting started on 2 October with the soil moist and easy to work, but continued later in the season in difficult soil conditions in wet and frosty weather, to finish on 20 December. Deliveries to the factory continued into 1974. Yields averaged 43·94 t/ha of clean roots at an average sugar content of 16·46% ranging from 14·1% to 17·7%. Mean dirt and top tares were 89·7 and 41·5 kg/t. The country's average yield this year was 39·37 t/ha of roots at 15·87% sugar.

Livestock. During October 1972, 58 cross-bred steers and 14 cross-bred heifers were bought at liveweights of 280 kg and 226 kg respectively. All were fed with silage *ad lib*, fresh straw, restricted concentrates and mineral licks. Hay was used when the silage finished. The concentrate ratio was supplemented with protein at first but was basically equal parts of rolled barley and sugar-beet pulp nuts fed to a maximum of 4·5 and 1·3 kg/head/day for the steers and heifers respectively. Their average liveweight gain was 0·63 kg/head/day for both steers and heifers. All were sold between 3 April and 7 June at finished liveweights of 410 kg and 354 kg respectively. The yard was restocked in October with 82 cross-bred heifers. (Golding)

Staff and visiting workers

P. C. Longden was awarded the Ph.D. degree of Nottingham University, M. J. Durrant elected a Member of the Institute of Biology as a result of his thesis and R. F. Farley elected a Licentiate of the Royal Institute of Chemistry. Sandwich Course Students, S. D. Freeman, R. A. Paton and R. F. F. Windley, of the University of Bath, were with us for six months.

D. A. Cooke, A. P. Draycott and R. A. Dunning contributed to the 36th Winter Congress of the International Institute of Sugar Beet Research in Brussels. P. C. Longden attended the Genetics and Breeding Study Group meeting at Wageningen, Holland; W. J. Byford, R. A. Dunning and R. Hull attended the Pests and Diseases Study Group meeting at Bergen op Zoom, Holland, and R. Hull attended both the Winter Congress in Brussels and the Summer Itinerant Congress in the USA.

Among numerous visitors to the Station were groups from Newcastle University, Suffolk and Yorkshire ADAS, Rothamsted Field Plots Committee, Young Farmers and Farmers Discussion Clubs, the Hellenic Sugar Industry and from Portugal. About 350 people attended an Open Day in July. Members of other research institutes attended a Symposium on 'Problems of establishing a stand of sugar-beet seedlings'.

https://doi.org/10.23637/ERADOC-1-130