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Rothamsted Experimental Station Report for 1965

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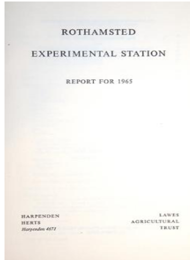

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EXPERIMENTAL STATION

REPORT FOR 1965

Broom's Barn Experimental Station

R. Hull

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BROOM'S BARN EXPERIMENTAL STATION

R. HULL

P. B. H. Tinker left and A. P. Draycott joined the staff. W. J. Byford, R. A. Dunning, R. Hull and R. K. Scott attended the winter congress of the International Institute of Sugar Beet Research in Brussels, and R. Hull attended the joint meeting of the Institute with the American Society of Sugar Beet Technologists in June in North America. W. J. Byford, R. A. Dunning, R. Hull and G. H. Winder contributed to the Insecticide and Fungicide Conference at Brighton. Mr. Gul Nawab of Pakistan, studying sugar beet in this country under the Colombo Plan, was with us for a few months.

The open day in July attracted about 300 people, and throughout the summer we had many parties of visitors. His Excellency the Minister of Agriculture of Afghanistan spent a day at the Station in July. The scientific meetings during the winter were well attended by visitors and have proved useful to us.

As usual, the agricultural staff of the British Sugar Corporation have helped us greatly with surveys and field experiments. A 2-day course of instruction at Broom's Barn on pests, diseases, fertilisers and field experimentation was attended by 30 fieldmen, and steckling inspectors and seed merchants met in July and October to discuss experimental work and arrange the steckling inspections. Work continued on pests, diseases and manuring of sugar beet, which is our special responsibility for the Sugar Beet Research and Education Committee, but this year emphasis has been on the study of factors affecting plant stands and their yield and the production of seed. Several long-term fertiliser and rotation experiments were started on the farm.

Yellows and Aphids on Sugar Beet

In eastern England mean temperature in February deviated from the average by $-1{\cdot}3°$ F and in March by $-2{\cdot}0°$ F. On average in past years, such weather has produced a mean incidence in the country's sugar-beet crop of 8% yellows at the end of August, ranging from 4 to 18% in individual years; in 1965 yellows incidence was 7·2%. Few green aphids infested sugar beet until the middle of June, when they increased rapidly and approached an average of 1 per plant in the middle of July, a pattern of infestation closely resembling that of 1964. The increasing infestation during favourable weather after the middle of June justified the sugar factories sending spray warnings to growers in some areas, and 171,000 acres of sugar beet were sprayed with systemic insecticide. This also helped to control black aphids, which were numerous on beet in the Midlands at the end of July.

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Seventeen trials, one in each of the English sugar-factory areas, compared the incidence of yellowing viruses in plots sprayed when the area spray warning was sent to growers, sprayed earlier, sprayed later or left unsprayed. On average, only 8·8% of plants in unsprayed plots had yellows at the end of September, 6·6% in plots sprayed early and 4·8% in plots sprayed at the "warning". Not all plots had the late spray because the weather at the time was unsuitable. At the time of the "warning" spray, mostly in early July, there were, on average, 0·9 green and 17·7 black aphids/plant. On seven of the experiments where yellows incidence exceeded 10% on the unsprayed plots, yellows incidence averaged 17·6, 9·4, 8·0 and 9·9% respectively on the unsprayed, early, "warning" and late-sprayed plots; spraying halved yellows incidence irrespective of its timing. At none of the sites did the yellows on the unsprayed plots seem to stunt the plants appreciably because it developed late, so yields were not measured.

At Ely, Felsted, Ipswich and Peterborough plots sown with menazon-treated seed had appreciably fewer green and black aphids, but they had a light incidence of yellows similar to untreated plots. Yellows had little effect on yield of the country's sugar-beet crop in 1965. Incidence at the end of August exceeded 20% on 14,300 acres, and it exceeded 60% on 1,600 acres.

Weeds. During the last 2 weeks of April, 14% of 42 samples of over-wintering weeds collected from sheltered sites adjacent to mangold clamps, beet seed crops or 1964 sugar-beet fields were infested with aphids, a proportion similar to 1964. A few of the weeds were infected with beet mild yellowing virus (BMYV), but beet yellow virus (BYV) was not recovered from any.

No aphids were found on wild beet (*Beta maritima*) on the Suffolk coast in the spring of 1965, but 10 of 18 plants collected from the Deben and Orwell estuaries were infected with BMYV and one with BYV. Weeds seemed not to contribute greatly to the initial infestation of beet crops with aphids and viruses this year.

Mangold clamps. As in previous years, fieldmen surveyed mangold clamps during late April. Of the 2,421 farms in beet-growing areas visited, 952 (39%) grew mangolds, fodder beet or red beet, and 478 (20%) still had clamped mangolds; 136 of these contained aphids, 22 of which had large infestations, 49 moderate and 65 small. *M. persicae* and, especially, *R. staphyleae* were by far the most numerous of the species in 65 aphid-infested clamps.

In recent years the incidence of yellows in beet crops at the end of August has paralleled the number of aphid-infested clamps/square mile in late April (see *Rothamsted Report* for 1964, p. 254, Table 1), and this happened again in 1965. The average number of aphid-infested clamps/square mile was 0·17, and the incidence of yellows at the end of August was 4·6% in the fieldmen's sample crops of beet in the same areas as surveyed for clamps. The acreage of mangolds and the number of farms growing mangolds has decreased steadily in recent years, from the 1945 peak of

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300,000 acres to 148,000 acres in 1957 and approximately 70,000 in 1965. The percentage of farms growing mangolds in the sugar-beet-growing areas declined from approximately 60% in 1957 to 37% in 1965; 85% of mangold growers in these areas also grew beet.

Fifty-six samples of aphids from clamped mangolds were tested for virus; 14 contained BMYV-carrying aphids, and one BYV-carrying aphids. Forty-two per cent of the samples that contained *M. persicae* alone had virus-infected aphids, 15% of those with *R. staphyleae* alone and 29% of those with both *M. persicae* and *R. staphyleae*.

Winged aphids. Sticky traps in nine beet crops in eastern England caught similar numbers of aphids as in 1964, but many aphids flew earlier in 1965. On average, three times as many *M. persicae* and six times as many *A. fabae* were trapped in July 1965 as in July 1964. Exceptionally many *M. persicae* were trapped at Broom's Barn during the last week of July, but their source is not known. Young sugar-beet seedlings were heavily infested with alate *M. persicae* at this time.

Seed crops. Samples of shoots and leaves submitted by the seed merchants from 34% of the country's 319 beet-seed crops were examined for aphids between mid-May and mid-June. Winged adults and nymphs of *A. fabae* were found on shoots in the third week of May, at least 2 weeks earlier than in 1964, but they multiplied slowly and few plants were infested with blackfly. *M. persicae* were found on a crop in Kent (17 aphids), where they had probably overwintered and on one in Essex (one aphid). Few seed crops were sprayed with insecticide this year. Growers destroyed most of the stecklings found in the previous autumn to have cucumber mosaic virus (CMV), and in the spring of 1965 only one seriously affected mangold crop remained, but many crops had a few infected plants. Infected plants remained very small, but the virus did not spread, and neighbouring healthy plants compensated to some extent for their failure. CMV was found in only one mangold steckling bed in August 1965.

When examined in June, 62 sugar beet and 17 mangold seed crops averaged 0·7 and 1·8% plants with yellows respectively. The stecklings for the 1966 seed crop were also relatively free from yellows; sugar-beet stecklings averaged 0·07% and mangold stecklings 0·35% of plants with yellows. Downy mildew was prevalent in both seed crops and stecklings as described in a later section.

Cultural factors, aphids and yellows. When spread of aphids and yellows is restricted by unfavourable summer weather, crop cultural factors seem to influence incidence. Experiments at Broom's Barn comparing sowing dates, plant stands and fertilizers showed some effects, but most were small (see also *Rothamsted Report* for 1964, pp. 268–269).

On plots comparing Sharpe's E sown on 17 March, 6 April or 6 May, each divided to give average plant populations of 35·7, 24·6 and 19·1 thousands/acre, the numbers of apterous green and black aphids/plant on 28 July were inversely proportional to plant population and were

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greater on the later sowings. There were 0·9 green apterae and 138 black apterae/plant on the 17 March sowings with 35,700 plants/acre, but 7·6 and 608 on the 6 May sowing with 19,100 plants/acre. On the March, April and May sowings respectively, 8, 12 and 10% of plants had yellows on 15 September. Percentages of plants with yellows on the three plant densities in descending order were 6·5, 9·6 and 13·3, giving 2,306, 2,371 and 2,535 infected plants/acre respectively.

In Triplex M variety sown on 3 April, yellows incidence on 15 September with different plant populations/acre was: 0·4% with 58,000, 3·5% with 35,000, 6·6% with 22,000, and 17·3% with 13,000; the plant stand greatly influenced the number of plants/acre with yellows, which were 212, 1,207, 1,433 and 2,201 respectively.

In an experiment sown on 24 April the percentage of plants with BMYV increased with decreasing plant density. Plots with 18,400 plants/acre (20-in. rows, 20 in. between plants) had 8·2%, plots with 34,100 plants/acre (20-in. rows, 10 in. between plants) 6·3% and plots with 54,000 plants/acre (beds of 10-in. rows, 10 in. between plants) 4·1%. There was no difference between the number of infected plants/acre in the more densely planted plots (approx. 2,200), but there were fewer in the thinnest-planted plots (1,518). Two inches of irrigation water did not affect yellows incidence.

Plots with 0·6 cwt/acre of N had 5% of plants with BMYV and plots with 1·8 cwt/acre had 7·5%. On another experiment neither 1·4 cwt/acre of N, 4·0 cwt/acre of K_2O nor 7·5 cwt/acre of salt appreciably affected yellows incidence, which averaged 9%.

Effect of yellowing viruses on yield. Plots of Sharpe's E and of the yellows-tolerant variety TN 59/5 were infected with yellows viruses on 2 June or on 14 July, and others were sprayed regularly with insecticide to keep them as free as possible from yellows. Many plants of both varieties, particularly of TN 59/5, were killed by the weedkiller "Pyramin"; Sharpe's E averaged 30,000 plants/acre and TN 59/5 averaged 23,000 plants/acre. As in 1964, TN 59/5 again proved more susceptible to downy mildew, and 14·4% of plants were infected in early September, compared with only 5·5% of Sharpe's E. The mean yield from Sharpe's E was 39·2 cwt/acre of sugar and from TN 59/5 29·4 cwt/acre. The earliest infection with BYV decreased the sugar yield of Sharpe's E by 36%, from 46 to 29½ cwt/acre, and of TN 59/5 by 25%, from 32 to 24 cwt/acre. The earliest infection with BMYV decreased the yields of the two varieties by 24% and 9% respectively.

Yellows-tolerant varieties. The yield of four varieties bred by the Plant Breeding Institute and one by Bush-Johnson were compared with Sharpe's E on plots treated in three different ways: (1) plants inoculated with BYV + BMYV; (2) inoculated with BMYV alone; (3) uninoculated and kept as free as possible from yellows by spraying. On 13 October the plots had 99, 94 and 50% of plants with yellows respectively. On average of all varieties, the yield of roots given by the three infection treatments were 11·05, 13·87 and 15·08 tons/acre respectively and sugar contents were 15·2, 15·5 and 16·1%. The best yielding variety, PBI's

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VT39, gave 50·5 cwt/acre of sugar when uninoculated and 37·6 cwt/acre when inoculated with both viruses. Corresponding yields for Bush VT were 50·4 and 34·9 and for Sharpe's E 46·4 and 28·5 cwt/acre. The corresponding means of the four PBI varieties was 48·7 and 34·5 cwt/acre. Yields of all varieties inoculated with BMYV were intermediate between those of uninoculated and those inoculated with the two viruses. Sharpe's E had the thinnest plant stand (24,000/acre), because it suffered most from "Pyramin" damage; the other varieties had plant populations ranging from 25,000 to 30,000/acre.

Screen and cover crops. Sugar beet were sown in rows 20 in. apart on 11 May, some without cover, some with two rows of barley or mustard and others with strips of aluminium foil 2½ in. wide, between the rows of beet. Aphids were few on the sugar beet throughout the season, and in mid-July there were 1·3 green and 3·9 black aphids/plant in the open beds. Only 7·1% of the plants in the open beds had yellows at the end of September. Although the barley was damaged by birds and provided a poor barrier, yellows incidence in these plots was only 1·0%; it was 0·1% on the plots with a thick cover of mustard, and 2·3% on the plots with aluminium foil.

Aphid parasites. Aphids infected by *Entomophthora* spp. were found in samples from eight mangold clamps, one in Hereford, the others in the eastern counties, received at Broom's Barn in April and May. *E. aphidis* Hoff. was in five samples, *E. thaxteriana* Petch in two and *E. planchoniana* Cornu in one. The aphid species infected were *R. staphylae*, *Macrosiphum euphorbiae* and *Myzus persicae*. Of 17 samples of diseased aphids collected in July and August, *E. aphidis* was found in 12, *E. planchoniana* in 6, *E. thaxteriana* in 3 and *E. fresenii* Nowak in 1. (Byford, Dunning, Heathcote and Hull)

Aphicides

Pelleted Bush monogerm seed was sown at Broom's Barn on 16 April at 3-in. spacing and, on half the plots, the seed carried 4% by weight of menazon, applied before pelleting. Menazon-treated seed gave a few more seedlings than untreated seed. Demeton-S-methyl at the standard rate was sprayed on five occasions on both menazon-treated and untreated plots. Few green or black aphids infested the plants until July, and yellows incidence, which averaged 8% of plants on 21 September, was not affected by menazon or demeton-S-methyl.

Sharpe's E natural or rubbed and graded seed was sown at Broom's Barn on 16 July at 1½ in. and 2 in. spacing respectively, with and without menazon seed treatment at 4% by weight of active ingredient (8·2 oz. and 4·6 oz a.i./acre with the natural and rubbed seed respectively). The seedling populations achieved, 35·6 and 29·1 per yard of row respectively on 10 August, did not differ as much as intended. Aphids, which infested the untreated seedlings immediately they emerged, reached a peak population of about four wingless green aphids/plant on 10 August and 85 wingless black aphids/plant on 16 August, and then declined to fewer than 0·1 and

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1 per plant on 27 August and 7 September respectively. The plants always carried a few living wingless aphids, progeny of fresh invasions of winged aphids, but these never exceeded 0·4 green or 5 black/plant; they were fewer per plant with the larger plant population.

Yellows incidence on 18 October was: natural seed, untreated 4·0%; menazon-treated 1·1%; rubbed seed, untreated 5·1%; menazon-treated 1·1%. A demeton-S-methyl spray applied on 17 August decreased yellows incidence with untreated seed from 4·5 to 2·9%, and with menazon-treated seed from 1·1 to 0·8%.

Carrots drilled for Marion A. Watson on 23 April in 10-in. row beds were slightly infested with *Cavariella aegopodii* at the end of May. Five sprays of menazon (8 oz. a.i./acre) applied between 26 May and 17 July increased yield of washed, ungraded carrots on 18 November by 24% from 27 to 33·5 tons/acre. Menazon granules (32 oz a.i./acre) applied at drilling in the soil covering the seed (not under the seed as in 1964), increased yield by 12·6% and, with the five sprays in addition, by 24%. More detailed results are in the Plant Pathology report, p 116. (Dunning and Winder)

Plant Losses in the Field

The relative importance of seedling losses increases as less seed is sown to decrease the hand work required to establish a stand of singled plants. Other plants are lost between singling and harvest. We need to determine not only the effect on yield of different plant stands and plant distributions but the chances of achieving them from different seeding patterns.

At Broom's Barn pelleted Triplex M seed was sown on 3 April at four different spacings, and seedlings were counted on marked lengths of row on seven occasions between 20 April and 21 May (Table 1). In this experiment the greatest cause of lost seedlings was the herbicide pyrazon, which killed approximately 40%. The pyrazon was applied at the recommended commercial rate on the soil surface over the drills at the time of sowing, and the unexpected toxicity was ascribed to abnormally hot weather when the plants were in the two rough-leaf stage (see Herbicide section below). Only 2% of the plants were lost during the 3 weeks after singling and few later, although the loss of beet considered to be too small to harvest (passing through an aperture 4 × 1·75 in.) ranged from 21 to 2% on the plots with the largest and smallest plant populations respectively.

TABLE 1

Seedling and plant populations achieved from different seed spacings of pelleted Triplex M seed at Broom's Barn, 1965

Seed spacing (in.)	Seed positions	Maximum no. of seedlings (6 May)	Seedlings immediately pre-singling (21 May)	Singled plants (28 May)	Roots harvested (6 Dec.)	Sugar yield (cwt/acre)
	(Thousands/acre)					
1½	200	186	120	58	43	58·4
3	100	94	64	35	31	59·3
6	50	46	28	22	20	49·0
10	30	27	17	13	12	40·8

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British Sugar Corporation fieldmen counted plants at intervals from emergence to 1 month after singling in fields sown with seeds spaced either not more than 2 in. apart or 3 in. and more apart. On average, in 9 fields with a mean sowing date 11 April and seed spacing of 1·75 in., 143,200 seedlings emerged per acre and 10,000 (7%) were lost; in 10 fields with a mean sowing date 8 April and seed spacing of 3·4 in., 63,000 seedlings emerged per acre and only 3,200 (5%) were lost. Despite the wide differences in mean seedling populations in the two groups of fields, the final plant population was 29,000 and 28,000/acre respectively. (Dunning)

Fungicide seed treatment. In 10 replicated field trials a 1·2% solution of ethyl mercuric phosphate (EMP) applied to seed at 1% vol/wt in the "Mist-o-matic" machine gave 34% more seedlings and 6% more plants in the final stand than untreated seed, compared with increases of 28%, 32% and 32% of seedlings, and 5%, 7% and 5% of established plants given respectively by commercial EMP steep, Murphy organo-mercury dust and "Agrosol" applied in the "Plantector" machine. Seed steeped in EMP solution at Broom's Barn gave 5% more seedlings and 2·5% more established plants than commercially steeped seed, but as drills sowed slightly more of our treated seed, the number of seedlings/oz of seed sown was only 2% greater than from commercially steeped seed.

Fifty tons of seed were treated with EMP in a "Mist-o-matic" machine, but a few weeks after treatment the germination tested in the laboratory was less than the accepted minimum for commercial seed. This was investigated in co-operation with the Murphy Chemical Co. Ltd. and the Central Laboratory of the British Sugar Corporation. Seed sprayed with 1% v/w of 1·2% EMP solution, stored in polythene bags for 10 weeks and then germinated on blotting-paper showed up to 35% more abnormal seedlings than when germinated in sand, giving corresponding falls in the germination percentage. Thus, the change made in 1965 from sand to blotting-paper in the official method for testing seed germination to some extent accounted for the EMP-sprayed seed being unacceptable. Some of the EMP-sprayed seeds were heavily stained and had much more mercury than the remainder; their germination after storage was also more affected. As this effect on germination was sometimes enough to influence seedling emergence in the field, the efficiency of the "Mist-o-matic" machine must be improved.

In small-scale field trials the Murphy organo-mercury dust gave 16%, 12% and 7% more seedlings than three other standard organo-mercury dusts, but 4% fewer than the "Mist-o-matic" EMP treatment. Methyl arsenic sulphide dust was relatively ineffective this year, in contrast to 1964. (Byford)

Wireworm control. Various insecticides were tested in three fields where the wireworm (>5 mm) infestations were determined by sampling in the trial area immediately before treatment. A "Stanhay Master Land Wheel Drive" drill was used at all sites to sow Triplex M seed, some of it pelleted. Treatment effects were determined by counting seedlings and plants.

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At Upware, near Ely, the peat fen was ploughed from permanent pasture in late 1963 and had 180,000 wireworms/acre on 1 April. Sprays were applied on 31 March and worked in thoroughly during seedbed preparation, and the trial was drilled on 1–2 April at $1\frac{1}{2}$ in. spacing. Seedling and post-singling plant populations were counted at intervals from 21 April to 21 June. Wireworms damaged the braird on the untreated plots, but left enough seedlings to give an adequate stand of plants.

Some of the treatments applied, followed by figures giving (1) the rates of active ingredient in oz/acre (theoretical with seed dressings), (2) the pre-singling seedling populations per yard and (3) the plant populations per chain of row on 21 June, were: Control, nil, 13·0, 66·1; dieldrin seed dressing (Murphy), 0·2, 16·5, 75·6; dieldrin seed dressing (Shell), 0·3, 15·0, 73·2; γ-BHC seed dressing, 0·2, 14·0, 67·5; Bayer 5195a seed dressing, 0·2, 14·5, 71·1; γ-BHC spray on seedbed, 9·1, 20·0, 75·3; aldrin spray on seedbed, 41·0, 20·8, 75·6; Bayer 5019 spray on seedbed, 13·6, 13·9, 68·9; Bayer 5299 granules in furrow with seed, 3·3, 16·7, 73·7; Bayer 5299, in a band in the soil above the seed, 3·3, 15·0, 69·7; phorate granules in a band in the soil above the seed, 8·2, 15·4, 73·9.

Gamma-BHC and aldrin sprays gave the greatest seedling and plant populations. Dieldrin seed dressing, especially Murphy's, effectively protected seedlings from damage despite the small amount of active ingredient used per acre. As in 1964, the γ-BHC seed dressing was ineffective, and this is discussed in more detail below. The Bayer 5195a seed dressing was intermediate. The phorate granules and the Bayer 38156 (*O*-ethyl *S*-*p*-tolylethyl phosphonodithioate) spray and granule formulations were all less effective than the best dieldrin dressing, although some were used at larger amounts of active ingredient per acre.

At Hardwick, near Bury St. Edmunds, there were 70,000 wireworms/acre on 30 March in the trial area on an arable field of gravelly loam. The sprays were applied on 29 March and worked in during seed-bed preparation; the trial was drilled on 30 March at $1\frac{1}{2}$ in. spacing. Some of the treatments followed by figures give (1) the ounces of active ingredient per acre, (2) the number of seedlings per yard on 15 May immediately before singling, and (3) the numbers of plants per chain on 21 July were: Control, nil, 14·7, 95·2; dieldrin seed dressing (Murphy), 0·2, 16·2, 99·0; dieldrin seed dressing (Shell), 0·3, 15·9, 94·1; γ-BHC seed dressing, 0·2, 15·6, 94·7; γ-BHC spray, 8, 18·0, 99·9; Bayer 5299 granules in a band in soil over the seed, 4·6, 14·8, 101·9. As at Upware, γ-BHC spray on the soil gave the greatest seedling population. Murphy's dieldrin seed dressing also largely prevented seedling and plant loss from the small population of wireworms. Plant populations did not parallel seedling populations with the other treatments.

At Ringshall, near Stowmarket, the clay loam contained 87,500 wireworms/acre on 5 April, when sprays were worked in during seedbed preparation. All the seed was pelleted (Germain's) and the trial was drilled on 6 April at 3-in. spacing. Some of the treatments, followed by figures giving (1) the rates of active ingredient in oz/acre (theoretical in the case of seed dressings), (2) the seedlings per yard at the final pre-singling count on 21 May and (3) plants per chain on 11 June, were: Control, nil,

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8·4, 65·7; dieldrin seed dressing, 0·1, 9·1, 74·8; γ-BHC spray, 6·7, 10·7, 75·9; Bayer 5019 spray, 8, 9·7, 71·5; Bayer 5299 granules in furrow with seed, 7·5, 9·8, 72·5; Bayers 5299 granules in band in soil above seed, 7·5, 9·3, 75·3; N 2790 granules in furrow with seed, 8, 9·5, 70·4; phorate granules in furrow with seed, 9, 9·9, 72·2; dieldrin granules in furrow with seed, 8·0, 8·6, 69·0. Wireworm damage was slight, but all treatments improved seedling and plant populations. Dieldrin granules at 8 oz a.i./ acre was the least effective, whereas dieldrin seed dressing, before pelleting, at 0·1 oz a.i./acre was nearly the most effective.

P. Needham (Insecticides Department) analysed the insecticide on treated seed by gas–liquid chromatography. Small batches of rubbed and graded $\frac{8}{64}$–$\frac{10}{64}$-in. seed were treated for 6 mintues with the appropriate amount of seed dressing in a cylinder rotating round an axis 30° from horizontal. Samples of seed were transferred by forceps from the churn to boiling tubes, in which the insecticide was extracted. Pelleted seed samples were taken from the batches used in the field trials. Mean results for the different treatments are expressed as a percentage of the amount applied to the seed, which was 0·5–0·67% by weight according to the concentration of the dressing: Murphy No. 2, 40% dieldrin, 94; Shell 50% dieldrin dust concentrate, 33; Plant Protection "Abol-S-gamma", 30% γ-BHC, 11; Murphy No. 2, 40% dieldrin (pelleted seed), 100. The relative efficiencies of the different insecticide dressings in protecting seedlings from wireworm damage in the field trials approximately paralleled the percentage of active ingredient adhering to the seed. Particle size of the active ingredient probably influences its adhesion, which may be modified by oil additives. The commercial γ-BHC seed dressing was compared with an experimental formulation: the percentage by weight of active ingredient retained on a 100 B.S. mesh (152-μ aperture) sieve and the percentage of applied dressing adhering to the seed was: "Abol-S-gamma" 56 and 11, JF 346 experimental formulation 0·5 and 61. JF 346 damages sugar-beet seedlings, but whether this happens from some intrinsic function of the small particles, or because more chemical as small particles sticks to the seed than as larger particles, is not known. Neither of the two dieldrin dressings used are retained on a 100 B.S. mesh sieve, and the specifications state that at least 87·5% of the Shell dieldrin dust concentrate and 95% of the Murphy No. 2 dieldrin dressing must pass through a 200 B.S. mesh (76-μ aperture) sieve; the dieldrin particles in Murphy No. 2 are very small, between 10 and 15 μ. (Dunning, Needham and Winder)

Docking disorder. Of 110 samples of stunted beets submitted by fieldmen, soil acidity or poor drainage accounted for 8, herbicide injury for 18 and 84 were classified as Docking disorder; most were of the type associated with root ectoparasitic nematodes. About 900 acres of sugar beet had Docking disorder, compared with 1,200 acres in 1964 and 500 in 1963. Most affected crops were in Norfolk and Suffolk and several on a light sand east of York. Tobacco rattle virus (vector, *Trichodorus* spp.) was isolated from plants from 10 of the 84 fields, and tomato blackring virus (vector, *Longidorus* spp.) from 4. The proposed common names for the diseases caused by these two viruses in sugar-beet are respectively yellow-

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blotch and ring-spot. In crops at Cockley Cley and at Harling, where the beet was uniformly stunted, plants made relatively good growth in lines across the rows where implement wheels had run before drilling. This effect has been seen previously and attributed to soil compaction. In eight fields in East Anglia where the fieldman's experience suggested that Docking disorder was likely to occur, but in fact it did not, different methods of seedbed preparation, time of drilling, pre-emergence herbicide and compaction of the seedbed before drilling did not appreciably affect the appearance of the crop. The good effect of nitrogen fertiliser on crops with Docking disorder suggests that the plants along wheelmarks may be bigger because they get more fertiliser, which tends to fall in the wheel track made by the fertiliser distributor in the loose seedbeds on these light sands.

Analyses of plants with Docking disorder showed them to contain very small amounts of nitrate in leaf and petiole. Affected plants from Herringswell, transplanted into pots of the field soil in which they were growing, made normal growth when given nitrogenous fertiliser. In a field at Barnham, Suffolk, large dressings of a 16:9:9 compound fertiliser with boron gave a vigorous-looking crop in July, whereas the normal dressing gave a crop with stunted growth, small, cupped leaves and plants of various sizes typical of Docking disorder. Despite this great difference in top growth, the yields at harvest for nil, 10 and 20 cwt/acre of fertiliser were respectively: 53·6, 58·8 and 60·4 cwt/acre of sugar.

Nematicides and organo-phosphorus materials were tested in two fields. As soon as the beet was seen to be stunted, the granules were cut into the soil on both sides of the rows of plants as close and as deep as possible without damaging the roots; a "Horstine Farmery Microband Applicator" metered the granules into knife-edged coulters mounted on a steerage hoe frame. At Gayton Thorpe, Norfolk, *Longidorus attenuatus* were numerous in the soil around stunted plants at the time of treatment, but decreased afterwards. On 31 May the following chemicals were placed $4\frac{1}{4}$ in. deep and 4 in. to either side of the plants at lb/acre of active ingredient: "Nemafos," 5·1; "Nemagon," 6·6; phorate, 4·3; CR 6014, 4·9; menazon, 3·0. The treatments did not affect growth, final numbers of plants or yield, which averaged 13·9 tons/acre at 15·1% sugar content. The very light, sandy loam had liberal organic and inorganic manure.

At Herringswell, West Suffolk, most plants in the lighter half of a field were severely stunted before singling, and few grew normally throughout the year. *L. attenuatus* were numerous in the soil near affected beet in June and July, but then became fewer. Sample plots had 20,000 plants/acre in mid-October, yielding 5 tons/acre of washed beet at 15% sugar content. In the other half of the field the soil was heavier; the plants grew vigorously throughout the season, and no *L. attenuatus* were found near them. In mid-October there were 25,000 plants/acre, yielding 24 tons/acre of washed beet at 17·2% sugar content.

On 15–16 June nematicide and fertiliser granules were placed 2·5 in. deep and 2·0 in. to either side of the plants in the affected area of the field, and then the soil was compacted with a heavy rubber tyre. The nematicide and lb/acre of active ingredient used were: "Nemafos," 4·6; "Nemagon,"

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6·3; phorate, 4·2; CR 6014, 4·8. The fertiliser treatments, expressed as units/acre of N, P_2O_5 and K_2O were: 18:10:10 + boron, 15:8:8, 21:0:0 and 0:42:0. At the time of treatment there were 33 *L. attenuatus* per 200 ml of soil close to the roots of the plants on the control plot, but fewer afterwards. Plant growth in July was improved slightly by all the fertilisers. In early August only phorate had decreased numbers of *Longidorus* in the root zone. On 19 October the mean yield for the trial was 7·7 tons of washed beet with 15·7% sugar. Passage of the knife coulter close to the plants depressed sugar yield by 14%. No nematicide increased sugar yield, and "Nemagon" depressed it, but the three fertilisers that contained nitrogen increased yield by 22% on average.

Cucumber seedlings were grown as "bait plants" in samples of soil collected in early March 1965, from the Docking disorder trial site at Hopton, Norfolk. A few plants developed TRV when growing in soil from near the surface and to a depth of 22 in. (Dunning, Heathcote, Winder and Tinker)

Other reports of investigation on Docking disorder are in the Nematology (p. 141) and Plant Pathology reports (p. 121).

Sugar-beet Seed Crops

Experiments at Broom's Barn, at Gleadthorpe Experimental Husbandry Farm, at Preston Capes near Daventry, Northants, and at Chipping Norton, Oxon., tested various cultural practices. Seed ripened very much slower than in 1964, and harvest was a month later at all centres; yields are known only at Broom's Barn and Chipping Norton.

Time of drilling. At Gleadthorpe more of the plants sown on 29 July survived the winter than of those sown on 21 August. At Chipping Norton the plants sown on 21 July suffered more from boron deficiency during the autumn and more died during the winter than of those sown on 6 or 21 August. The crop was sprayed with borax in November and again in May. At both centres plants sown early started to bolt and flower earlier than those sown late. At Gleadthorpe all sowings ripened simultaneously and all plots were cut and placed on tripods at the beginning of October. At Chipping Norton, Ramularia leaf spot defoliated the plants during July, particularly where the stand was dense. The third sowing ripened 10 days later than the earlier sowings. Yield of clean seed averaged 18·7 cwt/acre and was less from the third than from the first and second sowings; seed from all plots was unusually small. Last year seed that ripened earliest germinated most vigorously.

Time of harvesting. The crops at Broom's Barn and Chipping Norton were harvested during August and September. Yields increased as the crop ripened, and then declined as shedding and bird damage increased; there was an optimum cutting date for recovering most seed from each treatment. At Chipping Norton when harvest of the earlier sowing was delayed 10 days after ripening, it gave a similar yield to the later sowing when harvested ripe. Harvesting in August when the seed was immature greatly depressed yield and germination.

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Row width and plant spacing. The experiments at Gleadthorpe and at Chipping Norton compared crops sown in rows 10 in. and 20 in. apart. At Gleadthorpe plots with rows spaced at 20 in. lodged and secondary growth developed which made harvest difficult. The Chipping Norton crop did not lodge.

At Chipping Norton rows were either 20 in. apart or in beds of 5 rows 10 in. apart with 20 in. between beds for the tractor wheels. Yields of three inner and two outer rows were determined separately. The 10-in. rows yielded slightly more than the 20-in. rows, but the whole beds gave similar yields to 20-in. rows. At Gleadthorpe in 1964, 10-in. rows produced 15% more seed, but smaller seed than 20-in. rows.

At Chipping Norton yield from inter-plant spacings of 2 in., 6 in. and 12 in. differed on wide and narrow rows (Table 2). With 20-in. rows the 2-in. spacing produced the most seed, but with 10-in. rows in beds 2-in. spacing gave the least seed. A stand of 100,000 plants/acre, obtained by 6-in. spacing in beds of 10-in. rows, yielded most seed.

TABLE 2

The effect of spacing on yield of clean seed at Chipping Norton, 1965

Row width	Plant spacing 2 in. cwt/acre	6 in. (±0·70)	12 in.	Mean (±0·41)
20 in.	19.1	18·2	17·4	18·2
10 in.	15·9	21·4	20·2	19·2
Mean ± (0·51)	17·5	19·8	18·8	

Nitrogen. At Chipping Norton five rates of ammonium sulphate (0, 0·5, 1·0, 1·5, 2·0 cwt/acre of N) in the spring of the second year were tested. During May and June plants with no and 0·5 cwt/acre N were obviously undernourished, and weeds infested these plots. During July Ramularia leaf spot damaged the leaves in all plots, and by the middle of August plants were completely defoliated. Nitrogen did not affect the time of ripening.

Plots with rows 10 in. and 20 in. apart were harvested on four occasions, but gave no interaction between nitrogen and row width or between nitrogen and harvest date on seed yield. Despite nitrogen giving considerable differences in plant size, it had only a small effect on seed yields. The mean yield of seed for the five nitrogen dressings were respectively 22·3, 24·0, 24·5, 23·8 and 22·5 cwt/acre (±0·43).

Irrigation. Half of the seed crop at Broom's Barn received 1 in. of water on 28 June, immediately before flowering, and yielded 10% more seed than the unwatered half.

Method of harvest. At the sample harvests the seed bearers were cut, placed in sugar-beet pulp sacks and cold air was blown through them before thrashing. Mean yields of seed from plots harvested in this way were almost identical with those obtained by swathing whole plots on the same day and combine-threshing from the swathe.

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Weed control. On light soil at Great Tew, Oxon, 1·5, 3·0 and 6·0 lb/acre of "pyrazon", or 1·0, 2·0 and 4·0 lb/acre "Dupont 634" were applied either before drilling on 16 July, at the four-leaf stage on 27 August or on both dates. The pre-drilling spray was incorporated in the seedbed by harrowing. The site proved to be relatively free from weeds, but the chemicals stunted the sugar beet. The 4 lb of "Dupont 634" applied before drilling killed many plants and 2 lb of "Dupont 634" and 6 lb of "pyrazon" also damaged the plants, though less severely. Stunted plants recovered except on plots given 4 lb of "Dupont 634". Spraying after the seedlings emerged had little effect, except pyrazon at 6 lb/acre scorched the leaves of plants on plots also sprayed with pyrazon before drilling.

Pollen liberation. The effect of weather on the liberation of sugar-beet pollen was studied in a half acre of seed crop transplanted at Broom's Barn. A "Hirst" trap, situated 5 ft above the ground in the centre of the crop, was operated from 11 June to 19 August, and first caught pollen on 27 June. Daily catches increased until 5 July; most pollen was trapped between 5 and 25 July and only small amounts after 31 July.

The weather during pollen production was cool and cloudy, with average rainfall and only few fine, sunny days. Wind force and direction varied greatly. Rain and increase in surface wetness prevented pollen release, and lack of sunshine delayed it. Most pollen was released when relative humidity suddenly became less, usually because temperature increased. Most pollen was caught on days when relative humidity fell after an extended period of dull, damp weather.

A second "Hirst" trap situated 5 ft above the ground 250 yd east of the crop collected little pollen unless there was a strong westerly wind. Even then the pollen catch was not related to that within the crop. (Scott)

Downy Mildew

On average, 2·8% of plants in sugar-beet seed crops had downy mildew in June. Crops in the Eastern Counties raised under a cereal cover crop and grown-on *in situ* averaged 4·8% infected plants, compared with 1% in transplanted crops from stecklings grown under cereals. This incidence of downy mildew in seed crops was not unusual, and compared with 3·0 and 2·1% in 1961 and 1962 respectively. In contrast to these years, when the disease did not become prevalent in root crops, the weather favoured its spread in 1965, and it became unusually widespread and severe. At the end of July more than half the country's sugar-beet acreage contained plants with mildew, and 6,400 acres had more than 10%. The greatest incidence in root crops was in the main seed-growing area of south Lincolnshire and west Norfolk.

Regular assessments of varietal susceptibility to downy mildew are difficult to make because the disease is sporadic. In conjunction with the National Institute of Agricultural Botany, a variety trial was sown at their regional centre at Trawscoed, Cardiganshire, and downy mildew was introduced on stecklings planted in a regular pattern in the experimental field. This centre is isolated enough for the disease not to spread to other

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farmers' sugar-beet and mangold crops. The disease spread from the stecklings to the 16 commercial and 16 new sugar-beet varieties tested, which differed in the proportion of plants getting mildew. The commercial varieties with the fewest infections were: Anglo Maribo Poly, Zwaanpoly, Sharpe's Klein Polybeet and Triplex M; those with most were: Bush-Johnson's N, Hilleshog N, Hilleshog Polyploid and Zwaanesse III. Stecklings were sown in the field in the autumn, and it is hoped to maintain the disease there for further trials of varieties and breeding material in future.

At Broom's Barn downy mildew incidence was inversely related to the density of plant stand in two experiments. In one, populations of 52,000, 26,000 and 20,000 plants/acre had 8·6%, 14·5% and 18·7% of plants with mildew respectively; in the other, populations of 52,000, 32,000 and 16,000 plants/acre had 3·5%, 6·0% and 12·9% respectively. Plots receiving no nitrogen fertiliser had 5·2% infected plants, whereas those given 180 units/acre of N as "Nitro-chalk" had 9·7%. Overhead irrigation had no effect on mildew incidence. (Byford)

Sugar-beet Manuring

The results reported are those of trials done in co-operation with the British Sugar Corporation in 1964, for few results of the 1965 trials are yet known.

Magnesium. Three trials on fields selected by fieldmen as likely to have magnesium-deficient sugar beet tested 0, 2·5 or 5 cwt/acre kieserite or 1 ton/acre dolomitic limestone; 0·8 or 1·2 cwt/acre N as ammonium sulphate; and 0 or 3 cwt/acre salt, in a factorial design. Extra plots received an additional dressing of 1·0 cwt/acre of K_2O or of 7 cwt/acre of kainit.

On average, magnesium increased yield of sugar by 1 cwt/acre, but response to magnesium was not significant in any experiment. Nevertheless, 2·5 cwt/acre of kieserite and 1 ton/acre of dolomitic limestone paid on average. Kainit and salt gave similar yield increases. All the magnesium dressings increased the purity of the beet juice slightly.

In July magnesium sprays were tested on crops showing magnesium deficiency. The treatments were nil; 75 lb of Epsom salts in 45 gal/acre of water; 2 cwt of Epsom salts in 120 gal/acre; 2 cwt/acre of kieserite broadcast dry. All the treatments alleviated magnesium deficiency symptoms, but did not increase yield. Spraying in July seems of little value.

NPKNa on Black Fen. There was no response to increased dressings of P and K in the first year of this series of experiments, so in 1964 the treatments were changed to test whether even a small dressing of P and K had any effect. In five trials neither 0·75 cwt/acre P_2O_5 nor 1·5 cwt/acre of K_2O affected yield on average; nor did doubling the dressing of either. Salt at 3 cwt/acre increased yield by 1·1 cwt/acre of sugar. Sulphate of ammonia (0·4 cwt/acre of N) increased sugar yield by 0·5 cwt/acre, but 0·8 cwt/acre of N decreased sugar yield. N decreased sugar percentage and juice purity. The provisional conclusion from the two years' experiments is that

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only maintenance dressings of P and K are needed on black fen for sugar beet, which is likely to respond, however, to salt.

Nitrogen requirement. In the second year of this series 10 trials tested the effect of 0, 0·45, 0·9, 1·35 and 1·8 cwt/acre of N as sulphate of ammonia in the seedbed and 0·45 cwt/acre N as sulphate of ammonia in the seedbed with top-dressings of 0·45, 0·9 or 1·35 cwt/acre of N as "Nitro-Chalk". Basal dressings of P_2O_5, K_2O and salt were respectively 0·5, 1·0 and 5 cwt/acre. The mean yield for all trials was 15·5 tons/acre of roots at 19·7% sugar, giving 60·6 cwt/acre of sugar. On average, nitrogen at 0·9 cwt/acre increased sugar yield by 9½ cwt/acre whether all applied to the seedbed or part top-dressed. More N decreased sugar yield, sugar percentage and juice purity, although it increased the yield of tops and the apparent vigour of the crop. In five of the 10 experiments giving more than 0·9 cwt N in the seedbed slightly increased yield, but in only one experiment when given partly as top dressing. Plant analysis indicated that the top-dressed N may have remained in the surface soil and was not available to the plants.

N Na Dung. More information is required about the effect of sodium and dung on the nitrogen response curve. In this first year of the series four trials tested nil, 0·6, 1·2 or 1·8 cwt/acre of N as ammonium sulphate; nil or 5 cwt/acre of salt and nil or 12 tons/acre of dung. The basal dressing was 0·5 cwt/acre P_2O_5 and 0·95 cwt/acre K_2O. Yields with the four dressings of N were, respectively, 45·2, 51·9, 50·1 and 50·6 cwt/acre of sugar. On average, dung increased sugar yield by 4·9 cwt/acre. The unusual effect of sodium in depressing yield greatly in one experiment was unexplained. The interactions between N, Na and dung were unusual, and conclusions must await the results of more experiments.

Boron deficiency developed in the beet at Kidderminster in August. All manures, including dung, increased the incidence of heart rot. Nitrogen and dung increased growth, and therefore increased the demand for boron from the soil, but sodium decreased yield of both leaves and sugar, and therefore had a specific antagonistic effect on boron uptake, as was suggested by the results of a trial at Broom's Barn in 1963.

Growth substances. Neither chlorocholine chloride, which is claimed to shorten leaves and stems, nor gibberellic acid, which might affect sugar content, altered the appearance or yield of beet given three different amounts of N fertiliser.

Alkali metals. Caesium chloride was toxic to beets grown in pots, and caused the leaves to die rapidly after unfolding. Beet given rubidium had long, soft petioles, but otherwise grew normally; those given lithium were stunted, and the leaf edges were necrotic. All the salts were supplied as chloride at 0·36 meq/100 g of soil.

An experiment done in co-operation with J. K. Coulter and O. Talibudeen on the effect of plant spacing and manuring on rooting depth of sugar beet is described in the Chemistry Department report p. 40. (Tinker)

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Broom's Barn Farm

The concrete to the north and north-east of the farm building was extended and a vehicle-washing basin built. Soakaways were extended and new ones dug in the farm-building area. The roadside ditch along Black House field was deepened 12 in., which has helped it to absorb the considerable volume of water it receives during the winter.

Favourable weather and relatively dry soil in March gave opportunity for work on the land, and much corn and a small area of sugar beet was drilled. Then the weather became unsettled, and although not heavy, rain was frequent and the soil surface seldom dried until early April. Warm weather in May led to lush growth of cereals and grass. The summer was cool, and crops had ample water except for a short period in July. Cereal harvest started late (13 August) and was interrupted by wet weather, so was not finished until 19 September. Mean yield of grain at 15% moisture from 48 acres of barley was 34·6 cwt/acre and from 47·7 acres of wheat was 41·0 cwt/acre. Ploughing, and the autumn cultivations on the rotation experiments, were often held up because the soil was wet, but were nearly completed by the end of the year.

We now grow more straw than is needed in the cattle yard, so the wheat straw on Flint Ridge and the Holt was burnt, and on Hackthorn, which will have sugar-beet experiments in 1966, it was chopped and worked into the soil. All the barley straw was baled and stacked.

Cereals. Winter wheat var. Cappelle established well, and in Hackthorn field and the Holt was sprayed with barban to control wild oats; later, these fields and Flint Ridge were sprayed with dicamba + TBA + mecoprop + MCPA to control other weeds. When harvested on 12–19 September, yields of grain at 15% moisture content from the three fields were 40·4, 41·8 and 38·5 cwt/acre respectively. Rothwell Perdix var. on 4½ acres of Flint Ridge was heavily grazed by pests during the winter and developed eye-spot, but yielded 43·5 cwt/acre of grain.

Wild oats were controlled with barban in barley var. Pallas in Little Lane; later, this field and also Marl Pit and Dunholme fields were sprayed with TBA + MCPA. All crops grew strongly, but lodged early in patches, particularly in Dunholme after sugar beet. When harvested between 13 August and 7 September the three fields yielded 33·2, 35·8 and 34·9 cwt/acre of grain respectively.

On Dunholme F. V. Widdowson measured the residual effects on barley of fertiliser applied to sugar beet in 1964. In 1964 sugar yields with nil, 0·5, 1·0 and 1·5 cwt/acre of N as "Nitro-Chalk" were 61·4, 66·1, 63·7 and 61·9 cwt/acre; the heavier N dressings gave similar root yields, but smaller sugar percentages. A granular fertiliser supplying 200 units/acre of both P and K had no effect on sugar yield. In 1965 Pallas barley measured residual effects from these N and PK fertiliser dressings in all combinations with nil, 0·33, 0·66 and 1·0 cwt/acre of freshly applied N. On plots unmanured with N in either year the barley yielded 35·4 cwt/acre of grain. The barley on the remaining plots was lodged; both N applied for the preceding beet

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and the greater dressings of N freshly applied for the barley decreased grain yields (Table 3). Plots given the most nitrogen for each crop yielded least (31·3 cwt/acre), and plots given least N for each crop yielded most (38·8 cwt/acre) grain. PK residuals had no effect on grain yield.

TABLE 3

Mean effects of "Nitro-Chalk" applied in 1964 or in 1965 on barley grain yields (cwt/acre at 15% moisture content) in 1965

	N (cwt/acre) applied in 1964				S.E.
	0·0	0·5	1·0	1·5	
Grain yield	35·9	35·2	34·5	34·6	±0·46
	N (cwt/acre) applied in 1965				S.E.
	0·0	0·33	0·66	1·0	
Grain yield	34·9	37·6	35·4	32·3	±0·46

An experiment of F. V. Widdowson on Marl Pit gave results contrasting with these on Dunholme. Barley grown after wheat on a shallower soil yielded only 14·8 cwt/acre of grain without N and 30·8, 40·1 and 40·9 cwt/acre of grain respectively with 0·4, 0·8 or 1·2 cwt/acre of N. In the same experiment salt and muriate of potash both slightly decreased, whereas superphosphate slightly increased, yields.

Sugar beet. The crop was grown on Brome Pin (9 acres) after barley, White Patch (23 acres) after wheat after grass seed, and on part of Little Lane (5 acres). Experiments occupied almost the whole crop. White Patch field has not yet been summer fallowed and levelled, and the soil is variable and stony, so the crop was less uniform than in other fields. On the chalky patches of thin soil on the hillside the sugar beet were stunted and had signs of P deficiency.

Sowing started on 17 March, but was often stopped by rain. Most was sown in early April, but some was not sown until mid-May. One acre of White Patch had 1½ in. of irrigation water, but rain then made further watering unnecessary. Harvesting started on 20 September and progressed smoothly until mid-November, but was then stopped by rain, frost and snow. The remainder of the crop was lifted in appalling weather and soil conditions. All plots were harvested by mid-December. Yields from experiments on Brome Pin were approximately 17·7 tons/acre of roots, on White Patch 15·9 tons/acre and on Little Lane 18·6. The average yield delivered to the sugar factory from the farm was 13·46 tons/acre, with sugar contents ranging from 15·0 to 17·6%, average 16·64%, and dirt and top tares averaged 13 lb/cwt. The country's average yield this year was 15·3 tons/acre of roots at 15·6% sugar.

Herbicides. Because of the success of "Pyramin" (80% pyrazon) herbicide in experiments in previous years it was used on most of the sugar beet, applied at 1 lb/acre of crop as a 7-in. band spray on the soil surface behind the seed drills (equivalent to 2·8 lb/acre). It controlled weeds excellently, but on plots drilled during the first week of April it killed many beet seedlings about 16–18 May. Earlier and later sowings were not appreciably affected; in the time-of-sowing experiment the 6 April sowing finished with 26,500 plants/acre compared with 28,600 for the 17 March and 33,700 for

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the 6 May sowing. No damage was apparent on 14 May, but 3 days later many plants had shrivelled, and those remaining were pale green with scorched leaf edges. Some plants recovered gradually, but the crop was backward and the stand thin. Some areas had to be resown. Triplex M variety sown on 3 April had 40% of seedlings killed. A crop drilled on 9 April and sprayed with "Pyramin" on 15 April was little affected. The trouble, which occurred on both the light soil on Brome Pin and the heavier soil on White Patch, was most severe on some of the experimental varieties, but commercial varieties such as Sharpe's E and Hilleshog N were also severely affected. The unusual weather is thought to have made the chemical damage the beet. Only 3 days between 6 April and 8 May were without rain, and a total of 2·96 in. fell in the 31 days. The weather then became hot, bright and dry, and between 12 and 16 May, when the seedlings were killed, the maximum air temperature ranged from 65° to 79° F and the relative humidity was very low. There was no damage on plots sown on 31 March by "Pyramin" at 3·5 lb/acre, "Murbetex" at 21 pints/acre or "Dupont 634" at 1·5 lb/acre, all applied as band sprays over the drills, but "Dipro" at 4 lb/acre gave a very thin braird; groups of seedlings/yard from 2-in.-spaced seed shortly before singling numbered respectively 16, 16, 18 and 10. "Pyramin" controlled weeds best, and "Murbetex" worst.

In an experiment by Mr. G. Cussans of Norfolk Agricultural Station, pre- and post-drilling sprays of "Pyramin" and of "Dupont 634" were tested on Sharpe's E beet drilled on 10 May in White Patch field. Pre-drilling sprays (6 May) with up to 3 lb/acre of "Pyramin" and 4 lb/acre of "Dupont 634" did not affect sugar yield, but plots sprayed on 10 May with "Pyramin" at 1·5, 3 and 6 lb/acre respectively yielded 57·9, 51·5 and 46·4 cwt/acre of sugar. Post-drilling sprays of "Dupont 634" at 2 lb/acre did not affect yield, but 4 lb/acre probably did. All except the smallest amount of "Pyramin" killed some plants, and populations were 8,000/acre fewer with 6 lb/acre applied after drilling, whereas only the greatest amount (4 lb/acre) of "Dupont 634" applied after drilling decreased the plant stand, by 8,000 plants/acre.

In another of Mr. G. Cussans' experiments sugar-beet rows sprayed with "Preeglone" and "Gramoxone" at 2 pt/acre and "Tri-P.E." at 2 gal/acre shortly before emergence gave similar sugar yields to untreated beet, but gave thinner plant stands. "Trixabon" at 7, 10·5 and 15·75 pt/acre gave 64, 58 and 54 cwt/acre of sugar, compared with 64 cwt/acre from untreated plots; plants populations were unaffected. The chemicals tended to damage the sugar beet more when sprayed 1 day than 3–4 days before emergence, but the differences were small.

Sprays of a proprietary formulation of TBA plus MCPA, applied to winter wheat in White Patch field on 24 April 1964, depressed the grain yield (1964 report, p. 267). The yield of sugar beet sown 31 March 1965 on these plots was unaffected, and the beet showed no abnormalities. The chemical seemed active in February because sugar beet grew less vigorously in the glasshouse in soil from the plots given three times the recommended dosage than from the others. Neither cultivation of the wheat stubble in autumn nor growing a catch crop of fodder radish after the wheat affected the yield of sugar beet. In Brome Pin, where barley was

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sprayed in spring 1964 with this chemical, sugar beet in patches on the headland, where spraying started before the tractor moved, developed symptoms, but not until September.

Plant spacing, nitrogen and irrigation. Methods of growing sugar beet with less labour may well result in different patterns of plant distribution from current ones, so experiments were made to see how the yields from different stands of plants are affected by manuring, water, sowing date and variety.

In White Patch field on the Streatham series, Sharpe's E variety was sown on 24 April either in rows 20 in. apart and singled at 10 in. or 20 in., or in beds of 5 rows 10 in. apart with plants singled at 10 in. and with 20 in. between beds. Plots received 0, 0·6, 1·2 or 1·8 cwt/acre of N as "Nitro-Chalk" with a basal dressing of 50 units/acre of P_2O_5 and K_2O. Some plots given 1·8 cwt/acre of N had a double dressing of P and K. The maximum irrigation need was about $2\frac{1}{2}$ in. of water, and some plots had $\frac{3}{4}$ in. in July and $1\frac{3}{4}$ in. in August of irrigation water.

Nitrogen had a big effect on the leaf cover and on yield, the four dressings giving 50·7, 59·2, 59·1 and 64·1 cwt/acre of sugar respectively. The densest plant stand gave the greatest yield (66·9 cwt/acre) with the most nitrogen, although the interaction between nitrogen and plant spacing was not significant. The different plant spacings gave populations of 19,600, 35,300 and 54,900/acre respectively. The two greater plant populations gave identical root (16·85 tons/acre) and sugar yields (58·8 cwt/acre) and sugar percentages (17·4%); the smallest plant population gave the same root yield, but 0·5% smaller sugar content and $1\frac{1}{2}$ cwt/acre less sugar. The root juice impurities, K_2O, Na_2O and α-amino N, became less as plant stands increased. Plants spaced 10 in. apart yielded more sugar (1·2 cwt/acre) when watered, but those spaced 20 in. apart did not, and neither the total effect of watering nor the interaction between watering and plant spacing was significant. Plots given most nitrogen and additional P and K yielded more sugar (1 cwt/acre) at 10 × 10 in. spacing than at 20 × 20 in. spacing. All these effects are surprisingly small, and few are significant, for such a wide range of plant stands.

Variety spacing. The three varieties Sharpe's E, Hilleshog N and Bush Monogerm were compared on 20-in. rows and in beds of 10-in. rows with 20 in. between beds. The seed of all varieties was pelleted and sown with "Stanhay" precision drills using a No. 17 belt to give 8-in. spacing between seeds on 9 April. The area was sprayed on 15 April with 2·8 lb/acre of "Pyramin" herbicide, and again on 4 June with 2 lb/acre. No hand or tractor work was done on the plots after sowing, except to remove by hand at an early stage one of the seedlings where two emerged together; this was done to simulate monogerm seed. The soil capped after the seedlings had emerged, but the plants continued to grow satisfactorily. The plots remained free from weeds. They were harvested by hand on two occasions, 23 September and 3 December. The plant population with 20-in. spacing averaged 25,000/acre and on the 10-in. row beds 40,500/acre; averaged over other treatments the stands of Sharpe's E, Hilleshog N and Bush

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Monogerm were respectively 30,000, 33,000 and 35,000/acre. At the early harvest the mean yield of sugar was 49·2 cwt/acre and at the late harvest 61·6 cwt/acre. Table 4 gives the yields of the varieties at the two spacings averaged for both harvests.

TABLE 4

Sugar yield of different varieties grown on wide and narrow rows without cultivation after sowing, Brome Pin, 1965

	Sugar yield (cwt/acre)			
	Sharpe's E	Hilleshog N	Bush Monogerm	Mean
20-in. rows	58·8	59·2	44·6	54·2
10-in. row beds	64·7	61·9	47·5	58·0
Mean	61·8	60·6	46·0	56·1

Hilleshog N yielded more than the other varieties with the wide spacing, but Sharpe's E with the narrow. Previous experiments (*Rothamsted Report* for 1964, p. 270, for 1963, p. 216) also showed the suitability of Sharpe's E for growing in dense stands. On average, the sugar content of closely spaced roots was 0·4% greater than of widely spaced, and the root juice impurities were fewer with the narrow rows.

Obviously sugar beet can be grown satisfactorily without any cultivations after sowing. Probably the plant stand with 20-in. spacing was too thin to give a full yield, and sowing closer would have increased yield. With 10-in. spacing there was a reserve of plants that could have been lost without prejudicing yield.

On observation plots Sharpe's E pelleted seed sown at 3-in., 5-in. and 7-in. spacing gave plant populations of 50,000, 32,000 and 24,000/acre when left untouched, and 37,000, 29,000 and 21,000/acre after "trimming up" by hand hoe. On 10-in. row beds seed spacings of 6 in., 8 in. and 10 in. left untouched gave plant stands of 47,000, 32,000 and 29,000/acre. When these plots were harvested by machine from very wet soil in December the 20-in. rows slightly out-yielded the 10-in. rows.

Plant population and sowing date. Plots of Sharpe's E sown on 17 March, 6 April or 6 May in 20-in. rows were singled at 6 in., 12 in. or 20 in., giving plant populations of 36,000, 25,000 and 19,000/acre. With each sowing date, yield harvested on 9 December was greatest with the largest plant population (Table 5).

TABLE 5

Sugar yield obtained from different plant stands sown on three occasions. White Patch, 1965

Plant spacing	6 in.	12 in.	20 in.	Mean
	Plants 1,000/acre			
Date sown	37	25	19	
	cwt/acre			
17 March	75·2	68·5	68·2	70·6
6 April	65·5	61·0	62·1	62·9
6 May	52·1	49·1	40·5	47·2
Mean	64·3	59·5	57·0	60·2

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Time of sowing and harvesting. The weather allowed sowing at the planned dates, and each sowing emerged well, but "Pyramin" herbicide damaged the plants of the April sowing just before singling, and about 4,000 plants/acre were lost. The early, mid and late sowing respectively gave plant populations of 28,600, 26,500 and 33,700/acre. Less than 1% of plants bolted. Table 6 gives the sugar yields, sowing and harvesting dates.

TABLE 6

Yield of sugar from beet sown and lifted on different dates on White Patch Field, 1965

Sowing date	Lifting date: 20 Sept. cpa	%	18 Oct. cpa	%	15 Nov. cpa	%	8 Dec. cpa	%	Mean cpa	%
17 March	52·3	16·3	59·3	16·3	65·5	17·2	66·2	16·8	60·8	16·7
6 April	45·0	16·3	58·2	16·7	57·5	17·3	59·3	16·7	55·0	16·7
6 May	35·5	15·8	48·2	16·2	51·5	17·0	51·9	16·8	46·8	16·5
Mean	44·3	16·1	55·2	16·4	58·1	17·2	59·1	16·8	54·2	16·6

Delaying sowing decreased sugar yield but had little effect on sugar percentage, except at the first harvest, when it was less with the May than the earlier sowings. Yield increased greatly between the September and the November harvests, but less during late November. Sugar percentage reached a maximum at the November harvest. Early sowing increased juice purity, as did delaying harvest, because the roots contained less K_2O. Later sowing increased Na_2O and α-amino N, but these impurities varied erratically with changes in harvest date.

Subsoiling and yield responses to nitrogen after various crops. A final test crop of sugar beet was sown on all the plots on 9 April. Subsoiling in 1961 has given small increases in yield of barley, wheat, lucerne and sugar beet each year (*Rothamsted Reports* for 1964, p. 271; for 1963, p. 217; for 1962, p. 226) but the response to a large dressing of compound fertiliser compared with a small one has varied with crop and year. The fertiliser-dressing plots were split in 1965 and given 0, 40, 80 or 120 units of N as ammonium sulphate; all plots had a basic dressing of 6 cwt/acre of kainit and 2 cwt/acre of superphosphate (19% P_2O). Averaging all treatments, subsoiling increased sugar yield again by 1·8 cwt/acre, but there were no significant interactions between sub-soiling and the fertiliser treatments. Yields of sugar from beet following beet, wheat, barley or lucerne were respectively 65·2, 66·1, 64·7 and 68·9 cwt/acre; the plots given large dressings of fertiliser since 1962 yielded 66·7 and those given small dressings 65·8 cwt/acre. On the heavily fertilised plots 80 units N/acre gave the most sugar after beet, wheat and barley; on the lightly fertilised plots 120 units N gave more sugar than 80 units after wheat and barley but not after beet, when 80 units N gave most. On the heavily fertilised plots after lucerne 0, 40 and 80 units of N gave similar sugar yields, and 120 units N/acre gave less; on the lightly fertilised plots 40 units was the optimum.

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Long-term experiments

Fertilisers on rotation crops. This experiment, started in 1965 on Brome Pin Field, tests dressings of "Nitro-Chalk", triple superphosphate, muriate of potash, agricultural salt and farmyard manure on sugar beet, winter wheat and barley. Table 7 gives the dressings given to each crop and Table 8 the yield responses in 1965. The previous crop on the site was barley, which probably accounts for the wheat suffering from take-all this year.

TABLE 7

Rates of fertiliser used on the rotation crops

	N1	N2	P1	P2	K1	K2	Na	Dung
	(cwt/acre N)		(cwt/acre P_2O_5)		(cwt/acre K_2O)		(cwt/acre salt)	(tons/acre)
Beet	0·8	1·6	0·4	0·8	0·8	1·6	3	12
Winter wheat	0.6	1·2	0·4	0·8	0·4	0·8		
Barley	0·4	0·8	0·4	0·8	0·4	0·8		

TABLE 8

Yield responses of rotation crops to fertiliser treatments in the first year of the long-term experiment. (Compound refers to NPK for cereals and NPK Na for sugar beet at the rates given in Table 7)

	Wheat grain (cwt/acre)	Barley grain (cwt/acre)	Sugar-beet sugar (cwt/acre)
Mean yield	25·6	30·1	58·0
Response to:			
N1	+ 8·8	+12·9	+12·4
N2–N1	−10·0	+ 6·2	− 5·5
P1	+ 1·4	+ 0·6	+ 1·4
P2–P1	+ 0·9	+ 2·8	+ 0·4
K1	− 2·1	+ 2·7	+ 1·9
K2–K1	− 6·4	− 2·6	− 4·4
Na	− 3·5	− 0·3	+ 4·1
Dung	+ 2·5	+ 0·5	+ 5·6
Compound 1	+12·2	+14·0	+14·2
Compound 2–Compound 1	−10·2	+ 6·9	+ 0·3

Experiments were also started in Brome Pin to test the effect of different frequencies of sugar beet and barley in a 6-year rotation. In Marl Pit field potatoes, barley, wheat, 1-year ley and barley undersown with trefoil were grown in 1965 to test their effect on beet yield in 1966.

Livestock. Sixty-one Hereford-cross single-suckled stores were bought in the autumn of 1964 with an average live weight of 4·9 cwt. They were fed on silage, hay, barley and protein supplement until they weighed 6 cwt, when the protein was stopped and up to 10 lb/day of barley fed until slaughter. Average weight gain was 1·7 lb/day. Also, 20 Hereford × Friesian calves were bought which had been intensively fed, and they were continued on a ration of barley, beet pulp and protein supplement up to a maximum of 15 lb + 2 lb hay/head/day. Their average weight gain was 2·4 lb/day. The cattle were sold between 29 March and 31 May. The yard was restocked with stores in the autumn of 1965.

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Weather Records

TABLE 9

Monthly means of measurements at Broom's Barn in 1965 and the differences of these from the long-term means at Mildenhall (in brackets)

	Mean temp. (° F)		Mean daily sunshine (hours)		Total rainfall (in.)	
Jan.	37·5	(−0·6)	2·60	(+0·90)	1·96	(+0·06)
Feb.	36·7	(−2·3)	1·20	(−1·31)	0·79	(−0·62)
Mar.	41·1	(−2·2)	4·39	(+0·39)	2·20	(+0·95)
April	46·4	(−1·4)	4·38	(−0·98)	2·24	(+0·53)
May	53·1	(−0·3)	5·53	(−0·97)	1·77	(+0·15)
June	57·5	(−1·5)	6·02	(−1·02)	2·56	(+1·07)
July	57·3	(−4·9)	3·94	(−2·30)	2·79	(+0·37)
Aug.	59·1	(−3·0)	5·72	(−0·24)	2·78	(+0·75)
Sept.	55·1	(−3·0)	4·35	(−0·36)	3·40	(+1·39)
Oct.	51·6	(+0·3)	4·86	(+1·40)	0·73	(−1·19)
Nov.	39·7	(−4·9)	2·88	(+1·00)	2·20	(+0·15)
Dec.	39·3	(−1·2)	1·84	(+0·42)	3·78	(+1·98)
Year	47·9	(−2·1)	3·98	(−0·26)	27·20	(+5·59)

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