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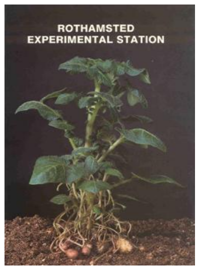

Multidisciplinary Agronomy

Rothamsted Research

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MULTIDISCIPLINARY AGRONOMY

The series of multidisciplinary experiments on winter wheat, winter barley, winter and spring beans continued on new sites. The longer-term experiment on intensive potato growing continued into its second year and multidisciplinary experimentation on leafy peas was started.

Factors limiting yield of winter wheat

The multifactorial experiment at Rothamsted, which was modified in the previous season primarily to test the effects of previous crops, continued but tested slightly increased rates of nitrogen and some changes of fungicides (Table 1).

Yield at maturity. Grain yields were larger than last year with a best 16-plot mean of 10·4 t ha^{-1}. On average wheat after oats yielded nearly 2 t ha^{-1} more than wheat after barley and when these crops were early-sown the difference was much greater (Table 1).

TABLE 1

Factors tested and their effects on grain yield (t ha^{-1}) of Avalon winter wheat grown after oats (O) or after barley (B): Means over all other factors

Level 1		Yield	Level 2		Yield
(1) Sown early (E) 15 September	O B	10·03 7·62	Sown later (L) 26 October	O B	9·61 8·26
(2) Nitrogen rate 1, 180 kg ha^{-1}	O B	9·74 7·75	Nitrogen rate 2, 250 kg ha^{-1}	O B	9·91 8·12
(3) Timing of main nitrogen application at ear initiation of early-sown (4 March)	O B	9·74 7·82	Timing of main nitrogen appplication at ear initiation of later-sown (5 April)	O B	9·91 8·06
(4) Growth regulator chlormequat. ('New 5C Cycocel' at 1·75 l ha^{-1}, E 8 March, L 14 April)	O B	9·83 7·90	None	O B	9·82 7·98
(5) Spring fungicide tridemorph. ('Calixin' at 0·7 l ha^{-1}, 13 April)	O B	9·88 8·14	None	O B	9·77 7·74
(6) Summer fungicide propiconazole ('Tilt' at 0·5 l ha^{-1}, 25 May and 22 June) +carbendazim+maneb. ('Delsene M' at 2·5 kg ha^{-1}, 22 June)	O B	10·17 8·24	None	O B	9·48 7·64
(7) Pesticide. Aldicarb ('Temik' at 50 kg ha^{-1}) to seedbed +pirimicarb ('Aphox' at 0·28 kg ha^{-1}, 23 June)	O B	9·85 7·79	None	O B	9·80 8·09
Plus extra plots not given nitrogen, growth regulator, fungicides or pesticides:					
Sown early (E) 15 September	O B	3·88 2·45	Sown later (L) 26 October	O B	3·90 2·07

Early sowing increased the yield after oats, but decreased it after barley because of increased amounts of take-all. Summer fungicide again increased yields substantially. Yield increases from early sowing and fungicides were in the form of larger grains; the yield benefit from following oats came from more ears with larger and slightly more grains. The 70 kg ha^{-1} of extra nitrogen decreased grain size but increased yields by

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increasing the number of grains per spikelet. Timing of nitrogen had no effect on yield but the earlier application increased ear number and decreased the number of grains per spikelet. (Thorne, Physiology and Environmental Physics; Dewar, Entomology; Prew, Field Experiments; Williams, Nematology; Lacey and Plumb, Plant Pathology; Penny, Soils and Plant Nutrition; Church and Todd, Statistics)

Growth and development. The experiment was sampled seven times (Table 2). The number of plants established from both sowings was 308 m^{-2}. The difference between crops sown early (E) and later (L) in growth and development was large during the winter but small from June onwards. The two crops reached comparable stages of development on the following dates: double ridges E 7 February, L 28 March; terminal spikelet E 12 April, L 28 April; 50% anthesis E 17 June, L 21 June. The early-sown crop reached zero leaf area and ripeness 2–3 days before the later-sown. Maximum shoot number of the early-sown crop was reached about mid-January and was 10% larger than the number on 24 February. With later sowing maximum shoot number occurred close to the time of double ridges and was well estimated by the numbers recorded on 21 March.

Wheat after barley grew slower than after oats in May and June: dry weight at anthesis was 7% less after barley than after oats and leaf area index 29% less. The difference in dry weight increased thereafter, especially with early sowing (Table 2). Complete leaf senescence and ripeness were 2 days earlier after barley than after oats.

Applying nitrogen early rather than later consistently increased shoot number, dry weight and leaf area. Effects were small except in March just before the main application of late N, when increases reached 40%. Using the larger amount of nitrogen gave slightly larger leaf areas in May and June and 4% more total dry weight at maturity. An extra 40 kg N at sowing, tested on eight extra plots, gave better growth during the autumn and winter but the benefit became negligible after applying the main applications of nitrogen.

TABLE 2

Avalon winter wheat. Change with time in total dry weight (g m^{-2}), leaf area index, number of shoots m^{-1} and Zadoks growth stage of winter wheat sown on 15 September (E) or 26 October (L). Means over all other treatments except on 8 August when shown separately for after oats (O) or after barley (B)

	Sowing date	6 December	24 February	21 March	3 May (E) 16 May (L)	20 June (E) 27 June (L)	25 July	8 August	
								O	B
Total dry weight	E	50	86	1149	381	1342	1786	1860	1500
	L	7	25	52	422	1245	1721	1730	1540
Leaf area index	E	0·8	1·0	2·0	5·7	8·5	0·2	0	0
	L	0·1	0·3	0·7	7·1	7·9	0·6	0	0
Number of shoots	E	1350	1385	1192	876	526	470	535	479
	L	328	838	1056	880	538	505	549	526
Growth stage	E	15/23	17/24	19/30	33	69	85	92	92
	L	11	13/22	15/23	33	69	85	92	92

The growth regulator decreased final stem length by 2 cm and had negligible other effects. (Thorne, Mullen and Wood, Physiology and Environmental Physics)

Nitrogen contents. Data are available only for the first four samplings (December–May). Percentages of N differed little with previous crop but were usually larger after oats. Mean values in December, March and May were 3·95, 4·87 and 3·35 respectively. Uptake of N was little affected by previous crop until May when wheat grown after oats contained 141 kg N ha^{-1}, that after barley, 127 kg.

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Although %N was slightly larger in the early-sown wheat than in the later-sown in December, it was much smaller in February (4·19 *vs* 4·86) and March (4·49 *vs* 5·26); by May the difference was small. From December to March the early-sown took up much more N than the later-sown (20 *vs* 3 kg ha^{-1} in December, 67 *vs* 28 in March) but by May the difference was insignificant (mean 134 kg ha^{-1}).

The first part of the early N (40 kg ha^{-1}) applied on 2 February significantly increased %N and amount of N on 24 February in the early-sown wheat, but not in the later-sown. Effects of amount and timing of N fertilizer on N content were not comparable until anthesis (June) because the last part of the N was not applied until May.

On 2 December the sap of the lower parts of the wheat stems contained 830 ppm of NO_3-N where sown early and 870 where sown later. On 28 February (a week before applying the main part of the early N dressing) early-sown wheat not given N contained 300 ppm, the later-sown contained 710 ppm; corresponding values on 24 March (12 days before applying the main part of the late N dressing) were 50 and 370 ppm. Without fertilizer N, NO_3-N values had fallen to nil in both early- and later-sown by 25 April, but with fertilizer N not until 29 June. (Penny, Widdowson, Darby and Hewitt, Soils and Plant Nutrition)

Nematodes. Numbers of plant-parasitic nematodes in soil prior to sowing are given in Table 3; no cereal cyst nematodes *(Heterodera avenae)* were found. In mid-season (June 7) *Pratylenchus* (mostly *P. neglectus*) were present in roots unaffected by the pesticide treatment but more after oats, 23 g^{-1} than after barley, 5 g^{-1}. In the soil numbers of most genera (and totals of parasitic nematodes) were decreased by pesticide in mid-season and post-harvest (11 August). *Pratylenchus* were more numerous after oats, 'spiral' nematodes, *Helicotylenchus*/*Rotylenchus* spp., and totals more numerous after early sowing. In untreated plots after harvest numbers of 'spiral' nematodes had increased substantially, all other genera, except *Tylenchorhynchus,* had decreased compared to numbers before sowing. (Williams and Beane, Nematology)

Aphids. More *Rhopalosiphum padi* and *Sitobion avenae* were present than in autumn 1981 especially in September, and were still flying in the second week of November resulting in colonization of all plots without aldicarb especially the early-sown (Table 4). Aldicarb gave good control of aphids throughout the winter. Total numbers of aphids in the untreated plots changed little from December to April. *R. padi* predominated until December, but declined markedly in January and February as

TABLE 3

Avalon winter wheat. Effects of previous crops and pesticide on plant-parasitic nematodes (numbers litre^{-1} soil). Means over all other treatments

	Pratylenchus	*Tylenchus*	*Tylenchorhynchus*	*Helicotylenchus*/ *Rotylenchus*	Totals
1 September 1982					
After oats	1275	850	1125	3875	7275
After barley	475	1050	525	2425	4775
7 June 1983					
With pesticide	147	250	472	1888	2757
Without pesticide	238	434	847	2759	4278
11 August 1983					
After oats	284	303	494	5394	6475
After barley	131	297	509	3434	4371
With pesticide	181	203	334	3972	4690
Without pesticide	234	397	669	4856	6156

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TABLE 4

The effect of aldicarb (P) and sowing date on the number of aphids (m^{-2}) surviving on Avalon winter wheat

	Date of sampling							
	2/11	16/12	11/1	13/2	18/3	13/4	18/4	20/5
Sown 15 September								
—	13	18	23	25	22	24	26	71
P	2	1	2	6	—	—	—	48
Sown 26 October								
—	—	1	1	1	2	tr	8	27
P	—	0	1	tr	—	—	—	11

tr=trace

S. avenae increased. *Metopolophium festucae* was scarce until April when numbers increased rapidly to a maximum in May before declining again in June.

Immigrant *S. avenae* and *M. festucae* were responsible for the large increase in numbers in late May (Table 4); aldicarb-treated plots still had fewer aphids in May but not by June. *S. avenae* predominated during June and July although there were a few *M. dirhodum*. The combined population of these species reached a maximum of about two per shoot in early July which, although greater than in 1981, was too small to affect yield. Pirimicarb, applied on 23 June, significantly lessened aphid numbers for three weeks but numbers were increasing by 8 July. Aphid density declined rapidly in all plots to less than one per five shoots by 15 July because of natural enemies. There were no consistent effects of the other treatments on aphid numbers. (Dewar, Entomology)

Barley yellow dwarf virus (BYDV). Our forecast for infection with BYDV based on the Infectivity Index in autumn 1982 (*Rothamsted Report for 1982,* Part 1, 195–196) was that infection would be greater than in the 1981/82 crop but less than in 1980/81. This forecast was not fulfilled. Aphids, principally *S. avenae,* collected from plots on 18 March did transmit BYDV and samples from plots of plants apparently showing symptoms of BYDV on 4 May were confirmed as infected; the virus isolates were most closely related to the 'mild' BYDV strain. However, the extent of infection was slight and insufficient to have affected yield. This result is surprising, especially as within 100 m a winter barley experiment sown on the same day was infected by BYDV which autumn pesticide prevented and increased yield (see p. 31). (Plumb and Lennon, Plant Pathology)

Fungal diseases. Foliar diseases were never present in very great amounts. Mildew and *Septoria* were present from late spring onwards; later in the summer brown rust was also present on the leaves and mildew on the ears. At the milky-ripe stage (on 13 July) the area of the flag leaf infected on plots not receiving the summer fungicide was mildew 0·4%, *Septoria* 0·2%, brown rust 0·3%, with 0·9% area of the ear with mildew.

Eyespot was present in moderate amounts, sharp eyespot and brown foot rot slight. Tridemorph was used in error, instead of benomyl, as the spring fungicide and so there was no effect on the foot rot diseases. Take-all was common in the wheat after barley, although winter infection was less than in 1981; by July the early-sown crop was severely infected but the later-sown one much less so (Table 5). (Prew, Field Experiments)

The microflora of ripening ears. Because of the hot dry summer weather, populations of both bacteria and fungi colonizing the ripening ears were smaller than in previous years. Bacterial numbers decreased during grain filling (Zadoks growth stage 70–92)

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TABLE 5

The effects of previous crops, sowing dates and amounts of nitrogen on the incidence of foot and root rots in Avalon winter wheat. Means over all other treatments

	% shoots infected on 4 July			Take-all		
				% plants infected		Rating* 4 July
	Eyespot	Sharp eyespot	*Fusarium* foot rot	6 Dec.	21 March	
After oats	34	9	11	0	2	10
After barley	53	6	22	22	33	118
Sown 15 September	48	10	21	22	31	100
Sown 26 October	39	6	12	0	4	28
180 kg N	49	8	13	—	17	66
250 kg N	39	8	20	—	18	62

*Rating=% slight+(2×% moderate)+(3×% severe) plants with take-all.

TABLE 6

Avalon winter wheat. The effect of fungicide (F) on the microflora of ripening ears, assessed by dilution plating (means of 16 plots)

Date	23 June		7 July		21 July		4 August	
Growth stage (Zadoks)	70		81		89		92	
	—	F	—	F	—	F	—	F
	(No. of colony forming units $\times 10^{-4}$ g^{-1} of ears)							
Yeasts	2·60	0·49	3·31	1·89	26·30	15·0	170·60	155·30
Yeast-like fungi	0·90	1·89	1·88	1·66	12·20	6·7	229·60	412·40
Filamentous fungi*	0·26	0·56	0·39	1·34	17·20	16·4	119·30	141·10
Bacteria	7330	8290	49130	101070	650	1230	1333	1931

**Alternaria alternata, Arthrinium, Cladosporium* spp., *Epicoccum nigrum, Fusarium* spp., *Mucor* and *Verticillium lecanii*

and were more numerous on fungicide-treated than untreated plots; total fungi increased during the same period. Populations of pink and white yeasts dominated the mycoflora at Zadoks growth stage 70 with smaller numbers of yeast-like fungi such as *Aureobasidium pullulans* and *Hyalodendron* spp. and a few filamentous fungi (Table 6). *Alternaria* and *Fusarium* were seldom detected between Zadoks growth stage 70 and 81 but then increased rapidly just before harvest from $1·6\times10^2$ and $3·4\times10^1$, respectively, to both with $4·8\times10^4$ colony forming units g^{-1} of ears. At harvest, 89% of the grain was contaminated with *Alternaria,* 7% with *Fusarium* and 4% with *Epicoccum.* The grain was also contaminated with some storage fungi, 31% with *Penicillium* spp. and 2% *Aspergillus* spp.

Fungicide application at Zadoks growth stage 70 had a significant effect on *A. pullulans* only and a marked effect on pink and white yeasts for about 4 weeks. The filamentous fungi were often more numerous on fungicide-treated than untreated plots. *Cladosporium* spp., *Alternaria* and *Fusarium* spp. were all unaffected by the late fungicide application. Treatments other than fungicide had little effect on fungal populations. (Magan and Lacey, Plant Pathology)

Growth and yield of winter wheat on contrasting soils at Woburn

Experiments were again sown to winter wheat following potatoes on Cottenham series sandy silt loam in Butt Close and on Blithe series sandy loam (over clay) in Broad Mead.

Six factors were tested on Broad Mead, but only five on Butt Close where only the first sowing was achieved before the site became waterlogged (Table 7).

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TABLE 7

The effects of six factors on grain yield (t ha^{-1}) of Avalon winter wheat at Woburn. Means over all other treatments

	Butt Close (BC) sandy soil Sown 16/9	Broad Mead (BM) sandy-clay soil Sown 16/9	Broad Mead (BM) sandy-clay soil Sown 20/10
(1) Aldicarb (5·6 kg a.i. ha^{-1}) to seedbed			
Without	9·05	8·24	8·44
With	9·18	8·35	9·07
(2) Total N kg ha^{-1} in spring			
N1 180 (BC), 100 (BM)	9·39	8·60	8·60
N2 240 (BC), 160 (BM)	8·84	7·99	8·92
(3) N time			
Main nitrogen on 2 March	9·11	8·19	8·88
Main nitrogen on 7 April	9·12	8·40	8·63
(4) Winter N kg ha^{-1} (on 2 February)			
Without	8·97	8·21	8·54
With, 60 (BC), 30 (BM)	9·26	8·38	8·97
(5) Irrigation (mm)			
None	9·36	8·65	9·17
Full, 112 (BC), 88 (BM)	8·87	7·94	8·35

Surprisingly, yields were larger on the sandy loam, whatever the treatment, despite better early growth on the sandy clay. Also, the later sowing yielded more than the early on the sandy clay. The poor yields on the sandy clay may be explained by the unusually large amounts of take-all present in this first wheat crop, details of final infection are not yet available but in spring the early-sown crop had 59% plants infected and the later-sown 22%. The benefit from winter N, which was not anticipated on this nitrogen-rich sandy clay may also be explained by its effect on take-all. The lack of response to irrigation on the sandy clay was not unexpected, but a negative response on the sand, where benefits from irrigation had previously been obtained, was unexpected.

Growth of the crops. Unless stated otherwise, this account refers to the crops sown on 16 September. The experiments were sampled on seven occasions, corresponding to those for the Rothamsted Factors Limiting Yield experiment (Table 2). Plant stands established from the September sowing were 223 m^{-2} on the sandy and 239 m^{-2} on the sandy-clay soil, and 308 m^{-2} from the October sowing on the sandy clay. Early growth was slower on the sandy than on the sandy-clay soil (878 *vs* 1482 shoots m^{-2} by 7 December; dry weight 32·2 *vs* 67·2 g m^{-2} and a leaf area index (LAI) of 0·5 *vs* 1·1). Growth and development continued more slowly on the sandy soil during the winter and the double-ridge stage of ear initiation was achieved on 8 March *vs* 26 January. However, growth rates on both soils were similar after sampling on 2 March and by the time ear initiation was complete the lag in development was much less (terminal spikelets formed about 14 April *vs* 5 April). Anthesis of the early-sown crops was about 15 June and of the later-sown about 19 June.

Wheat on both soils benefited from winter N but the effect on ear-bearing shoots at anthesis was significant only on sandy soil. On the sandy-clay soil, where most shoots (1480 m^{-2}) were counted in December, only 600 m^{-2} remained after anthesis with the early N, 510 m^{-2} with the later N in spring. Corresponding LAIs on 21 June were 9·5 and 8·5. On sandy soil, although maximum shoot numbers were less, many fewer died and by anthesis 550 m^{-2} ear-bearing shoots remained with winter N, 450 m^{-2} without (timing of spring N had no significant effect). LAIs were 8·3 and 6·9; adequate to utilize

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the incident radiation, although slightly less than on the more fertile soil. Both sites therefore reached anthesis with similar ear numbers and leaf areas on their best treatments. Smaller yields on the sandy-clay soil resulted from lighter grains and fewer grains per spikelet.

The plots were first irrigated on 17 June; on 18 July both total and ear dry matter yields were greater from irrigated plots, but by final harvest only straw and chaff were increased and numbers of grains per ear were less. There was no increase in grain yield from irrigation probably because much rain fell until early June, with consequently little water stress before anthesis, and then a further 29 mm fell on 6 July.

Aldicarb had no significant effect on the sandy-clay soil. After winter N on sandy soil it decreased shoot numbers, dry weight and LAI in March. It decreased ear numbers, dry weight and (residual) LAI at the July sampling also, and may have affected the whole of the grain growth period. These effects were not expected and reasons for them are not obvious. (Welbank, Mullen and Wood, Physiology and Environmental Physics; Widdowson, Penny, Darby and Hewitt, Soils and Plant Nutrition)

Factors limiting yield of winter barley

Seven factors (Table 9), each at two levels, were tested in factorial combination (2^7) using a half-replicate design, arranged in two blocks of 32 plots. Also included were plots of the two sowing dates used given none of the treatments.

Nitrogen in the soil. Because the barley followed early potatoes the soil was expected to contain more than 100 kg NO_3-N ha^{-1} to 90 cm. However, on 5 October (emergence of first sowing) there were only 58 kg NO_3-N ha^{-1}.

The soils were sampled again on 2 February, 3 March and 12 April. On each occasion there was less NO_3-N under the September- than the October-sown plots, presumably reflecting the greater growth of the early-sown crop. By 12 April little NO_3-N remained under either sowing (1 *vs* 7 kg ha^{-1} early and late respectively). Small residues were associated with soils that were at field capacity in autumn, and then received above average rainfall (452 mm from 1 October to 30 March). Accordingly the rates of nitrogen tested were 50 kg ha^{-1} greater than in the previous year. Differences in soil NO_3-N values under the early and later sowings were reflected in different NO_3-N concentrations in stem sap. Thus on 18 February relative values were 125 *vs* 900 ppm and on 28 March 40 *vs* 500 ppm, falling to zero in both crops by 25 April. (Widdowson, Penny, Darby and Hewitt, Soils and Plant Nutrition)

Growth of the crop. Plant establishment was not changed by 'Baytan' (triadimenol plus fuberidazole) or aldicarb (243 plants m^{-2} were established from 300 seeds sown),

TABLE 8

Changes with time in total dry weight (g m^{-2}), numbers of plants and shoots (m^{-2}) of Igri winter barley sown on 15 September (E) or 26 October (L). Means over all other treatments

		Sampling date				
		5 October (E) 19 November (L)	9 March	12 April	24 May (E) 6 June (L)	28 July
Total dry weight	E	—	130	318	800	1172
	L	—	53	113	841	1114
Numbers of plants	E	253	216	232	—	—
	L	233	236	249	—	—
Numbers of shoots	E	—	1588	1507	1132	—
	L	—	1211	1742	817	—

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but more were established on the early- than the later-sown plots (253 *vs* 233 m^{-2}). Dry weight, shoot and plant number were assessed on three occasions (Table 8). On 9 March shoot number was significantly increased by early sowing, decreased by 'Baytan', total dry weight was increased by both. By 12 April shoot number was smaller on the early-sown than on the later-sown plots, but was significantly increased by N given in March. Total dry weight was increased by early sowing, by 'Baytan' and by early N. At ear emergence ear number was significantly increased by early sowing (1132 *vs* 817) but not by any other treatment except nitrogen. Total dry weight was increased by fungicidal sprays and by nitrogen, but not by early sowing.

The growth regulator was applied at Zadoks growth stage 31–32, on 27 April to the early sowing and on 11 May to the later-sown plots. By 5 July it had reduced straw length (to base of ear) from 102 to 93 cm and from 104 to 93 cm on the two crops respectively. Despite the dry summer the barley lodged before harvest, significantly more with later sowing than early, with 150 than 100 kg N ha^{-1} and very significantly less (1% *vs* 24%) with the growth regulator. A cage was erected and a net put over the experiment on 25 and 26 May. This prevented damage by sparrows and other birds. (Widdowson, Penny, Darby and Hewitt, Soils and Plant Nutrition)

Development of the crop and yield components. The early-sown crop developed rapidly and by 22 December the apex of the main stem was at the double ridge stage. The later-sown plants did not reach this stage until 4 March but thereafter development was rapid so that all floret parts had been formed and the uppermost spikelets had begun to die by 6 May compared with 21 April for the early sowing. Maximum spikelet number was the same (41) for both sowings and in both the spikelets began to die soon after the stem started to elongate. In December the 'Baytan' seed dressing gave plants with fewer leaves and fewer primordia on the apex on the later-sown but not on the early-sown plots, these differences had gone by early March. Later nitrogen application did not affect the rate of development or the maximum number of spikelets produced, but degeneration of the apex and spikelet death began sooner. However, at maturity both spikelet and grain numbers per ear were the same for both dates of application.

The components of yield were examined on small samples at maturity. Nitrogen timing and aldicarb had only small effects. Sowing date did not significantly affect straw or grain yield, but grain yield components were affected. The early-sown crop produced more ears (+19%) but the mean grain weight was much smaller (−19%), indicating that both crops produced similar amounts of assimilate during the grain-filling period, but this was distributed among the larger number of grains in the earlier sowing (22 300 compared with 19 800 m^{-2}). The larger nitrogen rate generally improved crop growth; the weights of straw and grain were increased and more shoots survived to form ears (+18%). Neither numbers of grains per ear nor mean grain weight were affected. The larger leaf area apparently provided more assimilate which allowed the larger grain number to fill. The growth regulator increased yield by increasing grains per ear (+15%), even though the grains were smaller (−3%). The growth regulator was applied when the upper spikelets were beginning to degenerate, the extra assimilates made available by decreased stem growth may have allowed more spikelets to develop and produce grains. (Wood and Lawlor, Physiology and Environmental Physics)

Yields at maturity. Yields of the two sowing dates are again shown separately (Table 9) because this factor not only had a large effect but also interacted strongly with the other factors. Thus, as hitherto, aldicarb significantly increased the yield of the early-sown crop (+0·32 t ha^{-1}), but had a negligible effect on the later sowing (+0·08 t ha^{-1}); benefit from the 'Baytan' seed dressing was mainly to the earlier sowing

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TABLE 9

The effects of six factors on the grain yield (t ha^{-1}) of Igri winter barley, sown on 15 September or on 26 October. Means over all other treatments

	Sowing date	
	15 September	26 October
(1) Aldicarb (5 kg a.i. ha^{-1}) to seedbed		
Without	7·72	7·66
With	8·04	7·74
(2) Seed treatment ('Baytan')*		
Without	7·71	7·68
With	8·05	7·71
(3) Fungicide sprays†		
Without	7·37	7·32
With	8·39	8·07
(4) Nitrogen timing		
10 March	7·73	7·67
12 April	8·03	7·73
(5) Nitrogen amount (kg ha^{-1})		
100	7·92	7·64
150	7·84	7·75
(6) Growth regulator ('Terpal')‡		
Without	7·78	7·41
With	7·98	7·98
SED 0·102 (34 d.f.)		
Mean yield (SED 0·072)	7·88	7·70
Untreated	4·98	4·20

* 'Baytan', a.i. triadimenol+fuberidazole
† 'Calixin', a.i. tridemorph on 21 January and 18 March; 'Cosmic', a.i. maneb+tridemorph+carbendazim on 26 April and 23 May
‡ 'Terpal', a.i. mepiquat chloride+ 2-chloroethylphosphonic acid

(0·34 *vs* 0·03 t ha^{-1}). The loss in yield from not applying the four fungicidal sprays between January and May was far larger on the early than on the later sowing (1·02 *vs* 0·75 t ha^{-1}). Leaf diseases were therefore much the most important factor limiting yield in 1983, especially when the crop was early-sown. Nitrogen timing was much less important, although as expected early nitrogen was inferior to the late, particularly on the early-sown barley; this despite symptoms of severe nitrogen deficiency in March. The growth regulator again increased yields, but this year more on the longer-strawed, but thinner, later sowing than the denser but shorter-strawed early sowing. Grain size was increased by sowing later and by pathogen control, either early or late. It was decreased by nitrogen and by the growth regulator. By contrast grain number was increased by early sowing, by pathogen control and both by nitrogen and the growth regulator. Of the factors tested, only spring and summer fungicides increased both grain size and grain number. (Widdowson, Soils and Plant Nutrition; Jenkyn and Plumb, Plant Pathology; Lawlor and Wood, Physiology and Environmental Physics; Ross, Statistics and Scott, Insecticides and Fungicides)

Fungal diseases. Powdery mildew (*Erysiphe graminis* f.sp. *hordei*) was again common but leaf blotch *(Rhynchosporium secalis)* became much more severe than in the previous two years.

Slight mildew was observed on the early-sown barley in late October. Thereafter it increased rapidly so that by early December it was causing much senescence of the lower leaves. However there was very little mildew in plots sown with 'Baytan'-treated

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seed. Mildew was only slight on the later-sown barley, which did not emerge until November, and it was completely controlled by the 'Baytan' seed treatment. By late January mildew was severe in the untreated, early-sown barley and it had also increased considerably in the 'Baytan'-treated plots (22·2 *vs* 8·6%, respectively, on third youngest leaves). There was still less mildew on the later-sown barley than on the early-sown and in the later-sown it was well controlled by the 'Baytan' seed treatment (8·7 *vs* 0·2% on third youngest leaves). By early March mildew had become more severe on the later-sown than the early-sown barley. The seed treatment was still controlling the disease in later-sown plots (20·6 *vs* 1·8% on third youngest leaves) but not in the early-sown (11·5 *vs* 11·7%, respectively). The average effect of the tridemorph spray applied on 21 January was to decrease the disease on third youngest leaves from 15·3 to 4·7%. By mid-May mildew had declined but continued to be more severe on the later-sown crop. It was decreased by the fungicide sprays but apparently increased by the 'Baytan' seed treatment. It was more severe in plots given the larger N dressing and the earlier timing. Mildew was common at the final assessment in June, more severe on the later-sown but less severe than in the previous two years. It was decreased by the fungicide sprays (from 1·6 to 0·2% on second youngest leaves of early-sown and from 5·7 to 2·0% on later-sown) but, without sprays, there was, inexplicably, more with 'Baytan' treatment than without (3·8 and 2·4% respectively, on second youngest leaves). Mildew was again increased by extra nitrogen (from 2·3 to 3·9% on second youngest leaves from plots given no fungicide sprays) but there was no significant effect of nitrogen timing.

Very little leaf blotch *(Rhynchosporium secalis)* was seen until early March when it was more common in early- than later-sown plots. It was decreased by the 'Baytan' seed treatment, even in the early-sown plots where it no longer had detectable effects on mildew. Subsequently the pathogen was favoured by frequent rain and in contrast to mildew it continued to increase. In late May the disease remained more severe on the early-sown than on the later-sown barley. It was decreased by the fungicide sprays (from 3·3 to 1·7% on third youngest leaves) and by the 'Baytan' seed treatment, which decreased it to 0·8%. At Zadoks growth stage 75, leaf blotch was again more severe on the early-sown than the later-sown and was decreased by the fungicide sprays (from 8·2 to 2·9% on second youngest leaves of early-sown and from 1·1 to 0·4% on those from later-sown). It was decreased slightly by the 'Baytan' seed treatment but only in later-sown plots. Effects of the nitrogen treatments were small and not significant.

Net blotch *(Pyrenophora teres)* and brown rust *(Puccinia hordei)* also occurred but were very slight. Loose-smut *(Ustilago nuda)* was found on some ears, completely controlled by 'Baytan' seed treatment.

As expected in barley following potatoes stem base diseases were slight. Eyespot *(Pseudocercosporella herpotrichoides)* was found, less in later-sown than in early-sown plots. The fungicide sprays decreased numbers of straws infected from 9·3 to 4·3% in early-sown and from 6·4 to 0·2% in later-sown. Straws affected by brown foot rot (*Fusarium* sp.) were very few, decreased by later sowing and by the fungicide sprays. (Jenkyn and Feekins, Plant Pathology)

Infertile spikelets. Samples, each of *c.* 100 ears, were taken from all plots shortly before harvest and numbers of grains and infertile spikelets counted. As in 1982, average numbers of grains per ear were decreased by aldicarb, from 19·2 to 18·7 (−2·6%). In contrast to the previous year, however, numbers were also affected by other treatments, being increased by later sowing (+15·3%), by the 'Baytan' seed treatment (+6·6%) and by the growth regulator (+3·8%).

Numbers of infertile spikelets were most affected by sowing date and of the total

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potential grain sites, 9·9 and 5·8% failed to produce grain in the early- and later-sown plots, respectively. At anthesis the positions of apparently infertile spikelets in a total of 50 ears were mapped, in each of five early-sown plots. In total, 193 spikelets were judged to be possibly infertile on 10 June. Of these 99 (51%) failed to produce grain but the remainder did, so that these spikelets evidently appeared infertile because development was delayed, perhaps because of delay in fertilization. Eighty-three of these late-developing grains were harvested individually and their dry weights compared with those taken from corresponding positions on the opposite side of the rachis. Their average dry weight was 40·3 mg, 8% less than that of the early-developing grains. (Jenkyn, Plant Pathology)

Aphids. The first vacuum samples were taken in January and showed *Sitobion avenae* to be the most abundant species throughout. *Rhopalosiphum padi* numbers became very few by late April but *Metopolophium festucae* increased during the same period. Total aphid numbers in early-sown plots without aldicarb were much larger than in 1982, reaching a peak of 41·9 m^{-2} on 1 March, before declining to 18·9 m^{-2} on 18 March and 7·5 m^{-2} on 13 April and then increasing again in late April to 22·5 m^{-2}. Although aldicarb significantly reduced aphid numbers in the early-sown plots they remained relatively large (5·5 m^{-2} on 11 January and 6 m^{-2} on 1 March). Numbers in the later-sown plots were very much less (between 1 and 2·5 m^{-2}) until 28 April when they increased sharply to 10·5 m^{-2} probably because of interplot migration. (Dewar, Entomology)

Barley yellow dwarf virus (BYDV). As predicted (*Rothamsted Report for 1982*, Part 1, 195–196) there was more infection by BYDV than last year, but less than in 1981. Because of the exceptionally mild conditions in January, plants obviously infected by BYDV were visible by 1 February. By late April symptoms of BYDV were widespread with conspicuous yellowing and stunting. Some plants showed an unusual striping, which was positively associated with BYDV infection. Early-sown plots without aldicarb had most infection (2·5%) early in May but it was well-controlled by aldicarb (0·2%). There was negligible infection on later-sown plots. The significant 0·32 t ha^{-1} yield increase from aldicarb on early-sown plots was in accordance with expectation based on virus incidence. (Plumb and Lennon, Plant Pathology)

Other insect pests. Eggs and larvae of several species of Diptera were found in soil samples taken in October but damage by these pests never exceeded 1% of shoots. (Scott, Insecticides and Fungicides)

Winter and spring field beans *(Vicia faba)*: effects of pests and pathogens

As hitherto the experiments compared the effects of three sets of crop protection treatments: current standard practice, economically enhanced practice, which included only additional treatments likely to give economic responses, and full control which included all treatments likely to give the best crop irrespective of cost.

For winter beans standard practice was the application of foliar sprays of benomyl (0·56 kg ha^{-1}) on 26 May and 23 June and pirimicarb (0·14 kg ha^{-1}) on 23 June. 'Economic' control included these sprays plus seed treatment with benomyl and thiram (at 1·1 g of each per kg of seed) and phorate (2·2 kg ha^{-1}) as granules on 14 April. 'Full' control included all these foliar sprays and the seed treatment plus aldicarb (10 kg ha^{-1}) worked into the seedbed, carbofuran (2·2 kg ha^{-1}) as granules on 14 April and

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TABLE 10

Effects of pest and pathogen control on grain yield (t ha^{-1}) of Minden (spring) and Throws M.S. (winter beans)

	Pest and pathogen control		
	'Standard'	'Economic'	'Full'
Winter beans			
Unirrigated	3·6	3·9	4·0
SED 0·11 (10 d.f.)			
Spring beans			
Unirrigated	3·2	3·5	3·9
Irrigated	4·8	5·1	5·4
SED 0·13 (12 d.f.)			

additional foliar sprays, of fosetyl-Al (2·0 kg ha^{-1}) on 7 March, benomyl (0·50 kg ha^{-1}) on 7 March and 26 April and propiconazole (0·13 kg ha^{-1}) on 28 June and 11 July. The treatments were arranged in six randomized blocks of three plots.

For spring beans standard practice was pirimicarb (0·14 kg ha^{-1}) on 13 June. 'Economic' control included this spray and phorate (2·2 kg ha^{-1}) combine-drilled with the seed and an additional foliar spray of maneb plus mancozeb (each at 0·8 kg ha^{-1}) on 18 July (a planned late spray of benomyl was not applied because of early senescence). 'Full' control included all these treatments plus aldicarb (10 kg ha^{-1}) worked into the seedbed and additional foliar sprays, of fosetyl-Al (2·0 kg ha^{-1}) on 5 May, benomyl (0·50 kg ha^{-1}) on 5 July and 4 August, and maneb plus mancozeb (each at 0·8 kg ha^{-1}) on 26 July and 4 August. A test of irrigation was also included, to lessen a soil moisture deficit of 50 to 25 mm before pods were set, 80 to 55 mm thereafter, a total of 138 mm was applied. The treatments were arranged in four blocks of two plots, for irrigation, split into three sub-plots for chemical treatments.

Grain yields (Table 10) of both winter and spring beans were increased by 0·3 t ha^{-1} by 'economic control', a similar additional increase was caused by 'full' control on spring beans but not on the winter crop. Irrigation increased yields of spring beans by 1·6 t ha^{-1} and this increase was independent of the other treatments. (Bardner, Entomology; McEwen and Yeoman, Field Experiments; Griffiths, Insecticides and Fungicides; Beane, Williams and Webb, Nematology and Bainbridge, Cockbain and Lapwood, Plant Pathology)

Plant growth. Both experiments were sown at Rothamsted; the winter bean cv. Throws M.S. on 24 September, the spring bean cv. Minden on 9 March. Winter beans and unirrigated spring beans were harvested on 12 August, irrigated spring beans on 22 August.

The seed dressing used on the winter beans affected the flow of the seed through the drill, consequently both 'economic' and 'full' treatments had only 28 plants m^{-2} compared with 46 m^{-2} on the untreated plots of 'standard' when counted in November. Many plants on all treatments lost their growing points to unidentified bird or animal attack in spring and as a result branching was encouraged and at maturity the average number of pod-bearing stems was 72 m^{-2} irrespective of treatment. Total above-ground dry matter, measured on 5 July, was 11·7 t ha^{-1} from 'standard' and 'enhanced', 10·5 t ha^{-1} from 'full'.

Spring beans established quite well with a mean population in May of 46 plants m^{-2}, unaffected by treatments. The soil moisture deficit for unirrigated spring beans increased steadily from none at the beginning of June to 190 mm at maturity. Irrigation

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was applied on six occasions between 1 July and 14 August. Total above-ground dry matter, measured on 2 August, showed a mean increase from 7·4 to 9·7 t ha^{-1} by irrigation. 'Economic' and 'full' treatments did not affect total dry matter of the unirrigated plots but increased that of the irrigated plots by 2·6 and 1·6 t ha^{-1} respectively. (McEwen and Yeoman, Field Experiments)

Weevils *(Sitona lineatus)*. Winter beans on 'standard' plots had 12 larvae per plant on the roots on 5 July. Numbers were halved by 'economic' and virtually eliminated by 'full'. Spring beans had 8 larvae per plant on untreated plots on 6 July, increased by irrigation to 14 presumably because of a better developed root system, but almost none with 'economic' and 'full' control. (Bardner, Entomology)

Viruses and vectors. Virus symptoms were few in the winter beans and a detailed assessment was not made.

In the spring beans, bean leaf roll virus and its vector the pea aphid, *Acyrthosiphon pisum,* were less common than in 1982. At the end of May the numbers of adult *A. pisum* (alatae and apterae) ranged from 0·6 to 1·9 m^{-1} row in 'standard' and 0–0·3 m^{-1} in 'economic' and 'full'. In mid-July bean leaf roll affected 5% of plants in 'standard', 1·6% in 'economic' and 0·3% in 'full'; corresponding results for bean yellow mosaic and pea enation mosaic viruses were, respectively, 1·0, 0·9 and 0·3%, and 0·8, 0·5 and 0·8%. Virus incidence was not affected by irrigation. The bean flower weevil, *Apion vorax,* was very common in May (a mean of 3·1, 1·4 and 0·8 adults m^{-1} in 'standard', 'economic' and 'full' treatments respectively) but no weevil-borne viruses were detected. (Cockbain, Plant Pathology)

Foliar fungi. Chocolate spot *(Botrytis fabae)* on winter beans was favoured by the wet spring. Assessment on 29 April showed 9% of the area of lower leaves was affected by 'aggressive' lesions on 'standard' plots, lessened to 2·5 and 0·3% by 'economic' and 'full' respectively. Generally dry weather in summer together with the two benomyl sprays applied to all plots prevented aggressive lesions on the upper leaves. Because home-saved seed was used, without seed testing, *Ascochyta* was commoner than usual. When assessed in March plants given the seed dressng had only a quarter of the number of lesions of those untreated but by late April this effect had gone; at this time *Ascochyta* on the lower and middle leaves had been partially controlled on plots given foliar benomyl in March. Rust *(Uromyces fabae)* was first seen on 20 June, quite well controlled by the propiconazole sprays in 'full'.

On spring beans chocolate spot was first assessed on 22 June when only the lower leaves showed significant amounts, up to 8% leaf area affected by aggressive lesions. Although the disease was present on the upper leaves by 28 July it did not become aggressive even with irrigation. Rust was first found on 15 July; unlike chocolate spot it was much increased by irrigation, reaching 6% of leaf area of upper leaves affected on irrigated 'standard' plots on 11 August, lessened to 3% and 1% by 'economic' and 'full' respectively. (Yeoman, Field Experiments; Bainbridge and Lapwood, Plant Pathology)

Root fungi. In March and April about 15% of the root area of winter beans was affected by root blackening with little effect from treatments. This had increased to 58% on 'standard' plots on 20 June, lessened to about 40% by 'economic' and 'full'.

On spring beans root blackening on untreated plots increased from 11% of the root area affected on 20 June to 82% on 3 August. At the latter date damage was halved by both 'economic' and 'full' and still further lessened by irrigation, the least (27%), was found with the combination of irrigation and 'economic'. (Lapwood, Plant Pathology)

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Nematodes. On winter beans *Pratylenchus* spp. (mainly *P. neglectus*) were fewer than in recent years, 13 g^{-1} of fresh root, 190 l^{-1} of soil in May, and were not significantly affected by treatments. *Helicotylenchus* spp., whose pathogenicity is uncertain, increased during the season to 1040 l^{-1} of soil at maturity on 'standard', lessened to 410 l^{-1} on 'full' but increased to 1683 l^{-1} on 'enhanced' perhaps as a result of improved growth from treatments that were not nematicidal.

On spring beans *Pratylenchus* spp. (also mainly *P. neglectus*) were present at 30 g^{-1} of fresh root in May and July. They were almost eliminated by 'full' and numbers were halved by 'economic'. Populations of *Helicotylenchus, Tylenchorhynchus* and *Tylenchus*/*Ditylenchus* spp. increased markedly throughout the season, each exceeding 1500 l^{-1} of soil post harvest all well controlled by 'full'. (Beane and Williams, Nematology)

Conclusions. Because the winter bean experiment did not test irrigation the effect of the summer drought on yield was not measured. Earlier work suggests that the yield restriction would have been less than that recorded on the spring crop and indeed the yield of untreated winter beans was the largest recorded in this series of experiments, slightly exceeding that of spring beans for the first time. Responses of winter beans to 'economic' and 'full' were small but might have been greater if plant populations had been as 'standard'. The cost of 'economic' was £34 ha^{-1} more than standard and gave 0·3 t ha^{-1} more grain, worth at least £54. 'Full' cost a further £770 ha^{-1} without giving significantly more yield. The incidence of viruses, root fungi and nematodes was probably too small to have affected yield and control of rust by 'full' clearly did not. Accordingly it appears that the yield increase recorded for 'economic' was a result of controlling *Sitona* weevils, although the even greater control by 'full' might have been expected to have given a further increase.

Irrigation gave the largest treatment effect, of 1·6 t ha^{-1}, on spring beans and this was in accordance with expectation from previous work for the soil moisture deficit attained. 'Economic' control cost only £23 ha^{-1} more than 'standard' and as with winter beans gave 0·3 t ha^{-1} more grain, worth at least £54. This increase is attributed to control of weevils and perhaps also of rust and root fungi. 'Full' control cost an additional £668 ha^{-1} and gave a further increase of about 0·4 t ha^{-1} attributed to better control of rust and to good control of nematodes.

Peas: effects of pests and pathogens

The completion of work on leafless peas (*Rothamsted Report for 1982,* Part 1, 36–39) allowed work to be started on a series of factorial experiments concerned primarily with the control of pests and pathogens on the roots of leafy peas. All combinations of three two-level factors were tested: with and without aldicarb at 5 kg ha^{-1} combine-drilled with the seed to control a wide range of nematodes and insects; with and without tolclofos methyl at 50 kg ha^{-1} worked into the seedbed to control soil-borne fungi particularly *Fusarium,* with and without permethrin at 0·15 kg ha^{-1} applied to foliage on 11 May and 13 June to control invasion of root nodules by larvae of the *Sitona* weevil. All seed was treated with metalaxyl to control downy mildew *(Peronospora schactii)* and the crop was sprayed with pirimicarb at 0·14 kg ha^{-1} on 13 June to control aphids.

The experiment was sown to cv. Progreta on 16 March at a seed rate of 290 kg ha^{-1}. Establishment counts on 11 May showed a mean population of 87 plants m^{-2}.

Plots given none of the factorial treatments yielded 5·0 t ha^{-1} and the treatments did not significantly affect this yield. (Bardner, Entomology; McEwen and Yeoman, Field Experiments; Green, Webb and Whitehead, Nematology; Cockbain and Lapwood, Plant Pathology)

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Weevils ***(Sitona lineatus).*** An assessment on 8 July showed untreated plots with an average of only two larvae per root. They were almost eliminated by aldicarb but not significantly affected by permethrin. (Bardner, Entomology)

Nematodes. Both in the seedbed and in early June plant parasitic nematodes were few, the commonest being *Pratylenchus* spp. with about 240 per litre of soil, lessened to 70 l^{-1} by aldicarb. (Green, Nematology)

Fungi. The fungi most frequently isolated from root and stem segments were *Fusarium solani, F. avenaceum* and *F. tabacinum.* Occurrence was not affected by treatments. (Green, Nematology)

Viruses. On 9 July 3·5% of untreated plants had pea enation mosaic virus and 1·1% bean yellow mosaic virus with little or no effect from treatments. (Cockbain, Plant Pathology)

Conclusions. The treatments did not affect yield partly because pests and diseases under study were of limited occurrence this year, partly perhaps because of leaching of aldicarb in the very wet spring.

Yields of 5·0 t ha^{-1} in the dry summer were greater than expected and for the first time on our clay-with-flints soil yields of peas were greater than those of field beans treated comparably.

Intensive potato production

The experiment described in 1982 (*Rothamsted Report for 1982,* Part 1, 39–41) was continued for its second year on the same sandy loam site at Woburn. Treatments, which do not yet include frequency of potato cropping, were all combinations of three two-level factors: with and without the nematicide oxamyl at 5 kg ha^{-1} worked into the seedbed, with and without a combined fungicide treatment to the seed of imazalil at 10 g and tolclofos-methyl at 250 g $tonne^{-1}$ of tubers, with and without the molluscicide methiocarb at 0·22 kg ha^{-1} on each of six occasions from July to September. (Whitehead, Williams and Beane, Nematology; Hide, Lapwood and Govier, Plant Pathology; Henderson, Entomology; Scott and Etheridge, Insecticides and Fungicides; Addiscott, Soils and Plant Nutrition)

Potato cyst nematodes and tuber yields. As in 1982, numbers of potato cyst nematode eggs varied greatly between sub-plots (0·2–62·9 eggs g^{-1} dry soil before planting in 1983). In untreated sub-plots, yields of total tubers decreased with increase in nematode

TABLE 11

Effects of treatments on yield of Désirée potatoes and on potato cyst nematode

Treatment	Tubers (t ha^{-1})	Nematode increase*
Untreated	34·9	26·6
Methiocarb (M)	37·3	24·2
Imazalil + tolclofos methyl (I)	32·7	11·6
M+I	26·5	20·5
Oxamyl (O)	46·6	0·4
O+M	49·7	0·3
O+I	46·8	0·8
O+M+I	44·9	0·9
SED	3·3 (35 d.f.)	9·8 (35 d.f.)

* Nematode eggs g^{-1} dry soil after harvest: before planting.

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numbers from about 41 t ha^{-1} in the least-infested to about 17 t ha^{-1} in the most heavily-infested sub-plots. Similarly, the proportion of small tubers increased with increase in nematode numbers. Pitting and russet-brown discolouration of tubers, caused by nematode attack, was less than in 1982. In untreated sub-plots, numbers of potato cyst nematodes increased considerably, the increase being inversely related to the numbers in the soil at planting. Oxamyl incorporated in the seedbed prevented nematode injury to both roots and tubers and increased the mean yield of tubers from 32·8 to 47·0 t ha^{-1}, irrespective of nematode numbers (Table 11). (Whitehead, Williams and Beane, Nematology)

Aphids. Phorate to the seedbed and pirimicarb to the foliage almost eliminated aphids. No adult apterous aphids were found and on only one occasion were alates found in any number. (Etheridge, Insecticides and Fungicides)

Slugs. No slugs were found in slug traps between July and September and no slug damage was observed on harvested tubers. (Scott, Insecticides and Fungicides; Henderson, Entomology)

Virus diseases. In July no virus infection was found in the 3000 plants inspected. Volunteers were few but two Maris Piper plants infected with potato virus Y were found among them. (Govier, Plant Pathology)

Fungus diseases. Tubers of the 1982 crop, from plots which had been treated with oxamyl, had a lower dry matter content (20·4%) than tubers from untreated plots (21·4%). Silver scurf *(Helminthosporium solani),* scarce at harvest (2% of tubers affected), increased during storage and was significantly decreased by seed tuber treatment (46% in treated; 63% in untreated) and by oxamyl (50% in treated; 59% in untreated). Black dot *(Colletotrichum coccodes)* was unaffected by seed treatment but was increased by oxamyl; it did not increase during storage.

The 1983 seed treatment lessened stem canker *(Rhizoctonia solani),* which was less prevalent than in 1982. Common scab *(Streptomyces scabies)* was controlled by irrigation. (Hide and Lapwood, Plant Pathology)

Conclusions. As in 1982, the principal pests in the experiment were potato cyst nematodes, which again reduced yield and quality of harvested tubers. Oxamyl again controlled the nematodes well and greatly increased tuber yield and quality. Virus diseases, late blight, aphids and slugs were rare, or well-controlled by basal applications. Stem canker, less prevalent than in 1982, was lessened by seed treatment and common scab was controlled by irrigation. Despite all these control measures and ample irrigation (+175 mm), tuber yields were, on average, 18% less than in 1982.

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