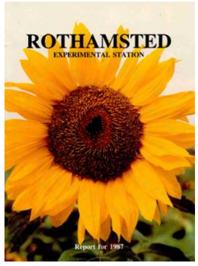
ROTHAMSTED RESEARCH

Rothamsted Experimental Station Report for 1987



Multidisciplinary Agronomy

Rothamsted Research

Rothamsted Research (1988) *Multidisciplinary Agronomy ;* Rothamsted Experimental Station Report For 1987, pp 17 - 28 **- DOI: https://doi.org/10.23637/ERADOC-1-28**

MULTIDISCIPLINARY AGRONOMY

A new series of multidisciplinary field experiments was started to study some of the factors affecting a malting quality winter barley. The multidisciplinary experiment on winter rape was modified to include a low glucosinolate cultivar. Experiments on potatoes and cereal straw incorporation continued. The series of winter wheat experiments testing previous cropping, sowing dates and times of applying nitrogen was completed.

Factors limiting yield and quality of winter barley

The experiment in 1987, the first of a new series, was sown with the malting cultivar Magie. It compared two cropping sequences, (1) barley–barley–barley and (2) barley–oats–barley, in combination with the five other factors shown in Table 1 (i.e. a single replicate of 2^6). Additional plots allowed some comparisons with a third cropping sequence (barley–fallow–barley) while other plots in sequence (1) received either no nitrogen fertilizer or the 'winter' nitrogen treatment supplemented with an extra 25 kg N ha^{-1} in November. These plots were all sown on 18 September 1986 and were sprayed with cypermethrin on 31 October. A further set of plots in sequence (1) allowed comparisons over a restricted set of treatments with barley that was not sprayed with cypermethrin and was sown either on 18 September or 17 October. Quality of the grain is being measured by the Brewing Research Foundation.

Nitrogen in the soil. On 29 September, soon after emergence of the early-sown barley, the soil after barley or oats contained 48 and 49 kg NO_3-N ha^{-1} respectively, to a depth of 90 cm. Without 'winter' N amounts had declined to 40 and 31 kg ha^{-1} respectively, by 18 November and to 30 and 24 kg ha^{-1} by 3 February. Most of the loss was from the 30–60 cm horizon. However, a greater proportion of the NO_3-N in the 60–90 cm horizon had gone following oats than following barley.

'Winter' N, as urea, was applied at 26 kg ha^{-1} on 17 November, to bring the total supply from soil and fertilizer up to 75 kg ha^{-1}, followed by a further 25 kg ha^{-1} on 16 February. On 30 October NO_3-N concentrations in stem sap, which were measured at approximately fortnightly intervals, averaged 542 μg ml^{-1}. Without 'winter' N they declined to 360 μg ml^{-1} on 7 January but then rose to 483 μg ml^{-1} on 10 February before declining rapidly in mid-March when the growth rate increased. Where 'winter' N was applied concentrations increased to 854 μg ml^{-1} on 10 December and declined only slowly from early February, reaching 285 μg ml^{-1} on 8 April when measurements ceased. (Darby, Soils and Crop Production)

Development and tillering. Phenological development of the early-sown barley resembled that of crops grown in 1984 and 1985, contrasting with the delayed development observed in 1986. The double-ridge stage was reached by the end of November (one week earlier in 'Baytan'-treated plots) and glume and awn primordia had formed by mid-February and mid-March, respectively. Anthesis (50%) was on 27 May after oats but a week later after barley, and all treatments were mature by 19 July.

Numbers of shoots, which were counted frequently in measured row lengths in selected plots, reached their maximum in late February. Although there were more shoots after oats than after barley, the proportions that subsequently died during March were greater after barley than after oats where no 'winter' N was applied (24 vs. 10%) but were similar where 'winter' N was applied (8%). Unusually, numbers of shoots increased again after the

https://doi.org/10.23637/ERADOC-1-28

application of spring N in March or April, especially where no 'winter' N had been applied. (Mullen and Rainbow, Soils and Crop Production)

Growth and yield. Samples taken in December showed that, in contrast to the previous two years, seedlings grown after oats were larger than those grown after barley (151 vs. 106 mg per plant). On 16 March numbers of shoots and dry weights were similarly much larger after oats than after barley (1137 vs. 790 shoots m^{-2} and 88 vs. 60 g m^{-2}) and were also larger where 'winter' N had been applied than where it had not (1067 vs. 859 shoots m^{-2} and 86 vs. 61 g m^{-2}). Similar effects were apparent on 13 April when dry weights had increased by about 49% but numbers of shoots had changed very little.

TABLE 1

The effects of six factors on the grain yield (t ha^{-1}), and on some of the yield components, of Magie winter barley

		Ears m^{-2}	Mean grain weight (mg)	Grain yield
(1)	Previous crop			
	Barley	610	32.9	5.23
	Oats	753	34.8	6.70
(2)	Seed treatment ('Baytan')*			
	Without	698	33.8	5.97
	With	665	33.9	5.95
(3)	Fungicide sprays** in spring and summer			
	Without	683	32.8	5.55
	With	680	34.9	6.38
(4)	Winter nitrogen*** (51 kg N ha^{-1} as urea)			
	Without	638	33.6	5.58
	With	724	34.2	6.35
(5)	Spring nitrogen (kg N ha^{-1})			
	105	656	34.3	5.77
	155	706	33.4	6.16
(6)	Timing of spring nitrogen			
	16 March	695	35.7	6.39
	14 April	668	32.1	5.54
	SED	19.2	0.25	0.101

* 'Baytan' a.i. triadimenol + fuberidazole

** 'Sportak Alpha' a.i. prochloraz + carbendazim plus 'Calixin' a.i. tridemorph on 15 April; 'Tilt' a.i. propiconazole plus 'Calixin' on 27 May.

*** 26 kg ha^{-1} on 17 November plus 25 kg ha^{-1} on 16 February.

On 1 June, the numbers of ear-bearing stems (Table 1) and dry weights were greater after oats and with 'winter' N. The numbers of ear-bearing stems were also greater with extra N in spring but were little affected by its timing. In contrast, dry weights were on average little affected by amounts of N in spring but were much larger with March than April N (717 vs. 532 g m^{-2}) particularly without 'winter' N (687 vs. 432 g m^{-2}).

https://doi.org/10.23637/ERADOC-1-28

At harvest on 6 August grain yields (Table 1) were increased most by growing the barley after oats instead of barley (+ 1.47 t ha^{-1}). They were also increased by the fungicide sprays (+ 0.83 t ha^{-1}) but, in contrast to the previous three years, were unaffected by 'Baytan'. On average, there was a smaller response to extra N in spring (+ 0.39 t ha^{-1}) than to 'winter' N (+ 0.77 t ha^{-1}) and also a considerable advantage in applying the spring N in March instead of April (+ 0.85 t ha^{-1}). However, the benefits of 'winter' N were much smaller where the spring N was applied in March than where it was applied in April. The benefits of applying the spring N in March were much larger after barley than after oats (+ 1.16 vs. + 0.54 t ha^{-1}). The unusually large responses to early applications of N may be associated with unusually warm temperatures during the second half of April (mean maximum and minimum temperatures between 16 and 30 April were 17.8 and 6.7°C, respectively, compared with the 30-year means for April of 12.0 and 3.4°C, respectively).

In March, barley after fallow had produced more shoots and much more dry matter (1327 shoots and 133 g m^{-2}) than had any of the barley after either barley or oats. Nevertheless, numbers of ears in June and final grain yields were similar for barley grown after a fallow, and barley grown after oats and given 'winter' N (767 vs. 802 ears m^{-2} and 7.06 vs. 7.07 t grain ha^{-1}). Barley sown on 17 October after barley had made relatively little growth by 16 March (526 shoots and 19.3 g m^{-2}) and produced only 524 ears m^{-2}. It nevertheless gave slightly more grain (5.42 t ha^{-1}) than the early-sown barley after barley probably because it had less take-all. (Jenkyn, Carter, Kerry, Gutteridge and Plumb, Crop and Environment Protection; Christian, Darby, Harper and Mullen, Soils and Crop Production; Ross, Biomathematics)

Fungal diseases. Powdery mildew (*Erysiphe graminis* f.sp.*hordei*) was always the most prevalent disease affecting the leaves. It was more severe after oats than after barley in December (2.1 vs. 1.2% area affected on second seedling leaves) and in March (4.5 vs. 2.0% on second youngest leaves) but in June was more severe after barley than after oats (8.2 vs. 4.0% on second youngest leaves from plots without fungicide sprays). The disease was increased by 'winter' N in December (1.9 vs. 1.3%) and March (3.7 vs. 2.4%) but not in June. On the latter date it was increased by applying extra N in spring (8.0 vs. 4.1% in plots without fungicide sprays) but the timing of that N had inconsistent effects. 'Baytan' decreased mildew in December (1.3 vs. 1.9%) but thereafter had no effect. Overall, the fungicide sprays decreased mildew on second youngest leaves in June from 5.8 to 0.6%.

Leaf blotch (*Rhynchosporium secalis*) was slight but in March was more prevalent after barley than after oats (1.1 vs. 0.3% on second youngest leaves). In June it was decreased by fungicide sprays (0.1 vs. 1.5%) but was not significantly affected by other treatments.

Brown rust (*Puccinia hordei*) in June was also decreased by the fungicide sprays (0.1 vs. 0.9% on second youngest leaves) and in plots without fungicides was more severe after oats than after barley (1.8 vs. 0.5%) perhaps because they had less mildew.

Take-all (*Gaeumannomyces graminis* var. *tritici*) in the early-sown barley after barley was more severe than in any of the previous three years and much more severe than where the barley followed oats or where it was sown later after barley (take-all ratings in mid-June of 207, 40 and 112, respectively). 'Baytan' always decreased the disease, although not significantly, in December. In March 'Baytan' decreased the mean numbers of infected roots from 2.2 to 1.9 per plant and in June the mean take-all ratings from 133 to 114. Take-all was unaffected by 'winter' N in December or March but in June it was decreased by 'winter' N (mean take-all ratings of 115 vs. 132) and by applying spring N in March instead of April (114 vs. 134).

The proportions of shoots affected by eyespot (*Pseudocercosporella herpotrichoides*) in March were smaller after oats than after barley (17.4 vs. 54.5%) and were less with 'winter'

https://doi.org/10.23637/ERADOC-1-28

N (29.5 vs. 37.5%). In June these treatments had little effect but the disease was decreased by applying extra N in spring (12.0 vs. 21.9% of straws with moderate or severe symptoms in plots without fungicide sprays) or by delaying the application of that N until April (13.4 vs. 19.8%). Overall, the fungicide sprays decreased the proportions of straws with moderate or severe symptoms in June from 16.3 to 4.5%.

Sharp eyespot (*Rhizoctonia solani*) and brown foot rot (*Fusarium* spp.) were negligible. (Jenkyn, Gutteridge and Martin, Crop and Environment Protection)

Aphids and barley yellow dwarf virus (BYDV). The autumn migration of *Rhopalosiphum padi* continued until mid-November and early- but not later-sown plots were colonized. However, the numbers migrating to cereals were small, few aphids were found in the plots and the predicted risk from BYDV was low (Infectivity Index = 12). As expected, negligible infection with BYDV was seen in spring and summer, and yield was not increased by applying cypermethrin in autumn. (Carter, Morgan and Plumb, Crop and Environment Protection)

Other pests. Shoots damaged by stem borers in March were less common after oats than after barley (1.6 vs. 4.5% shoots affected) and also with 'winter' N, especially in barley after barley (3.2 vs. 6.4%). On average, only about half as many plants were damaged in the later-sown barley as in the comparable early-sown (10.5 vs. 18.1%) but, because the later-sown tillered less, the proportions of shoots affected were similar. Adult flies reared from larvae in damaged plants were identified as wheat bulb fly (*Delia coarctata*). (Carter, Gutteridge, Jenkyn and Payne, Crop and Environment Protection)

Females of the cereal cyst nematode (*Heterodera avenae*) were found in the roots in August and were equally common after barley or oats. However, numbers were small (*c.* 100 per m of row) and are unlikely to have affected yields. (Kerry, Crop and Environment Protection)

Factors limiting yield of winter oilseed rape

The third experiment of the series continued on a site following winter barley adjacent to that used in 1986. Seven factors (Table 3) were tested in factorial combinations (2^7) in a half replicate design of 64 plots. New factors included a comparison of cv. Bienvenu with the low glucosinolate cv. Ariana and triapenthenol as growth regulator. Forty-eight extra plots were included to test an extended range of granular nitrogen applications, seedbed nematicide, foliar sprays of nitrogen, micronutrients and sulphur and for detailed sampling. Some plots were given no inputs other than seedbed nitrogen.

TABLE 2

Changes with time in total dry weight (g m^{-2}), number of plants m^{-2} and leaf area index of Ariana and Bienvenu winter oilseed rape sown early (E, 14 August) or later (L, 4 September)

	Dry weight				Number of plants				Leaf Area Index			
	Ariana		Bienvenu		Ariana		Bienvenu		Ariana		Bienvenu	
	E	L	E	L	E	L	E	L	E	L	E	L
25 November	192	109	182	80	80	91	87	81	1.9	1.4	2.0.	1.3
24 February	208	130	202	124	79	78	78	86	1.2	0.8	1.4	1.0
27 April	524	464	573	558	80	90	89	88	4.7	4.3	5.2	5.5
8 June	878	954	1094	985	73	74	78	73	4.6*	4.7*	4.9*	5.3*
30 July	1142	1156	1348	1346	73	78	71	74	—	—	—	—

(* Data from extra plots only, others from main factorial)

https://doi.org/10.23637/ERADOC-1-28

TABLE 3

Factors tested and their effects on combine harvest seed yield (t ha^{-1} at 90% DM) of Ariana and Bienvenu winter oilseed rape

		Ariana	Bienvenu
(1)	Sowing date		
	14 August	3.66	3.91
	4 September	3.78	4.10
(2)	Spring nitrogen rate (kg N ha^{-1})		
	150	3.65	3.90
	250	3.78	4.11
(3)	Spring nitrogen timing		
	All on 16 February	3.67	4.07
	One-third on 16 February, two-thirds on 16 March	3.77	3.94
(4)	Insecticide*		
	Without	3.64	4.04
	With	3.80	3.97
(5)	Fungicide**		
	Without	3.53	3.82
	With	3.90	4.19
(6)	Growth regulator***		
	Without	3.49	3.60
	With	3.94	4.40
	SED	0.131	0.131

* 'Decis' a.i. deltamethrin on 3 October and 20 November + 'Hostathion' a.i. triazophos on 15 June.

** 'Sportak' a.i. prochloraz on 17 November and 10 April + 'Rovral Flo' a.i. iprodione on 15 June.

*** 'UK244a' a.i. triapenthenol on 10 April.

Growth and development. Unlike previous years, establishment was similar on early (E) and later-sown (L) plots (Table 2), allowing our first comparisons of sowing dates at similar population densities. Autumn growth was rapid giving dense leaf canopies on E plots of both cultivars with similar dry matter (DM) and leaf area (LA) in November. Values for DM and LA of Bienvenu were much greater and on L plots more than double those obtained last year. Growth then slowed but few plants or leaves were killed and total DM changed little. Rapid growth resumed in spring and by the end of April DM and LA on E and L plots were similar, but greater on Bienvenu than Ariana until July. Fungicide increased DM and LA of leaves on the main stem and the number of branches. Growth regulator decreased the height and DM of main stems but increased the number, area and DM of branches in both cultivars. On Bienvenu fungicide increased the number of fertile pods (6738 vs. 7950 m^{-2}), the dry weight of pods (738 vs. 927 g m^{-2}) and harvest index (26.0 vs. 29.7). Growth regulator increased the number of fertile pods (6849 vs. 7839 m^{-2}), but had little effect on harvest index. Yield components for Ariana were affected by shedding during hand harvest. (Leach, Mullen and Rainbow, Soils and Crop Production)

Seed and oil yield. Both cultivars were combine harvested on 4 August after desiccation. Wet weather prevented an earlier harvest of the earlier-maturing Bienvenu. Bienvenu yielded more than Ariana on E and L plots (mean 4.00 vs. 3.72 t ha^{-1}) (Table 3). The mean benefit

https://doi.org/10.23637/ERADOC-1-28

from the larger rate of spring nitrogen was small, although 0.4 t ha^{-1} greater on E plots. Fungicide increased yields by 0.4 t ha^{-1}, more on L plots and with the smaller rate of nitrogen. Growth regulator increased yield of Bienvenu and Ariana by 0.8 and 0.5 t ha^{-1} respectively. The increase was greater on E than L plots for both cultivars (1.1 vs. 0.5 for Bienvenu and 0.8 vs. 0.1 t ha^{-1} for Ariana) probably because growth was more advanced on E plots at the time of application. Oil content of seed and oil yield was greater in Bienvenu than Ariana (44.5 vs. 41.8% at 90% DM and 1786 vs. 1552 kg ha^{-1} respectively). Oil content was decreased from 43.8 to 42.5% by the larger amount of nitrogen, but both content and oil yield were increased by fungicide and growth regulator (43.0 vs. 43.3% for each treatment, 1585 vs. 1753 kg ha^{-1} with fungicide 1528 vs. 1810 kg ha^{-1} with growth regulator); growth regulator increased oil yield more in Bienvenu than Ariana (increases of 377 and 189 kg ha^{-1} respectively. Glucosinolate contents are awaited. (Rawlinson, Evans and Williams, Crop and Environment Protection; Digby, Biomathematics; Darby, Leach and Yeoman, Soils and Crop Production)

Nitrogen in soil. On 5 September soil contained 51 kg NO_3-N ha^{-1} to a depth of 90 cm, increased by seedbed N to 99 kg ha^{-1}. The latter value had declined more on E than L on 28 October (22 vs. 80 kg ha^{-1}) and on 6 February (5 vs. 17 kg ha^{-1}).

Nitrogen content in plants. The percentage of N in dry matter on 25 November was larger in L plants (4.03 vs. 3.38%) but the greater growth on E plots gave larger N uptake (63 vs. 38 kg N ha^{-1}). On 24 February, eight days after application of spring nitrogen, the percentage of N remained greater in L plants (4.09 vs. 3.82%) and was greater in Bienvenu than Ariana (4.03 vs. 3.89%); N uptake was greater from E plots (78 vs. 52 kg N ha^{-1}) with similar values for both cultivars.

Nitrogen in plant sap. The concentration of NO_3-N in the petiole of the youngest expanded leaves of E and L plants declined from 30 October to 10 December (500 to 71 μg ml^{-1} in E, 1000 to 425 in L plants without seedbed N, 700 to 300 and 1000 to 521 μg ml^{-1} in E and L plants given seedbed N). By 11 March there was none in E and 21 μg ml^{-1} in L plants. Where nitrogen fertilizer was applied on 16 February this caused a rapid increase to more than 900 μg ml^{-1} in both E and L plants on this date. (Darby and Hewitt, Soils and Crop Production)

Foliar nutrients. Eight L plots (4 each of Bienvenu and Ariana), all given 250 kg N ha^{-1}, insecticide and fungicides, were sprayed additionally with ammonium nitrate and urea (1), or with the same nitrogen plus Mg, Mn, Cu, Fe, B, Zn, Mo and micronized elemental sulphur (2) and compared with plots given the same basal applications but no foliar nutrients. Yields, oil content and mineral components of seed were not significantly affected but Ariana had higher concentrations of P, K, Mg, Fe, Cu and less Ca and Mn than Bienvenu. (McGrath, Soils and Crop Production)

Root growth. Root growth was measured in May at mid-flowering (when shoot DM was 704 and 871 g m^{-2} for Bienvenu and Ariana respectively) on E plots given 250 kg N ha^{-1}, insecticide and fungicides. Root length in the top 20 cm soil layer was 25% greater in Bienvenu than Ariana (16.3 vs. 13.0 km m^{-2}), but the difference was small in all other layers down to the maximum sampling depth of 1m. The difference in rooting density in the top layer was unlikely to have had a significant effect on crop nutrition in such a fertile soil. (Barraclough, Soils and Crop Production)

https://doi.org/10.23637/ERADOC-1-28

Insect pests. In autumn adult cabbage stem flea beetles (*Psylliodes chrysocephala*) were few and subsequent larval damage was small. On 4 March there were more larvae per plant on E than L plots (2.6 vs. 0.5) and more damaged petioles per plant (3.4 vs. 0.9). Larval infestation and damage were similar on E plots of both cultivars but on L plots was greater on Bienvenu than Ariana (0.9 vs. 0.03 larvae per plant, 1.7 vs. 0.2 petioles per plant). Insecticide decreased the mean number of larvae and damaged petioles per plant to 0.1 and 0.3 respectively. Pollen beetles (*Meligethes aeneus*) became numerous during the prolonged flowering period which began on E Bienvenu and ended on L Ariana. On 27 April beetles were more numerous on Ariana than Bienvenu (11.2 vs. 3.5 per plant) and on 9 June Ariana plants had more short pedicels without pods than Bienvenu (27 vs. 15%); some of this damage may have been caused by pollen beetles. On 22 July few pods contained larvae of seed weevil (*Ceutorhynchus assimilis*) or pod midge (*Dasineura brassicae*) (mean of 0.6 and 4% pods infested respectively) and triazophos had little effect on their numbers. (Williams and Martin, Crop and Environment Protection)

Nematodes. Four extra plots of Ariana tested oxamyl applied to the seedbed. This decreased numbers of *Pratylenchus* spp. (mostly *P. neglectus*, a species unlikely to have caused damage) in November from 82 to 34 per g of root. Mean yield of untreated plots was 3.95 and with oxamyl 3.80 t ha^{-1}. (Evans, Crop and Environment Protection)

Diseases. The main diseases were downy mildew (*Peronospora parasitica*, light leaf spot (*Pyrenopeziza brassicae*), grey mould (*Botrytis cinerea*) and dark leaf and pod spot (*Alternaria* spp.). Unlike 1985 and 1986 light leaf spot was severe and dark pod spot prevalent. Up to 5% of plants had *Phoma* leaf spot and slight stem canker lesions (*Leptosphaeria maculans*) and occasional plants had stem rot (*Sclerotinia sclerotiorum*. In November the incidence of downy mildew and dark leaf spot was greater on Bienvenu than Ariana (68 vs. 55% and 5 vs. 1% plants infected respectively), no other diseases were detected. In February downy mildew, dark leaf spot, *Phoma* and grey mould were rare (mean incidence of 1.0, 0.5, 0.5 and 5% plants respectively), but light leaf spot was common with more on E than L plots (53 vs. 36% plants). Autumn fungicide decreased light leaf spot from 66 to 23% plants infected. In April downy mildew was again common but dark leaf spot, *Phoma* and grey mould still rare (on 95, 5, 5 and 1% plants respectively). Light leaf spot remained the most severe disease but was decreased by autumn plus spring fungicide from 79 to 32% plants infected. In June light leaf spot, downy mildew, dark pod spot and grey mould were common and stem canker rare (mean incidence of 55, 56, 60, 63 and 4% plants infected respectively. There was more downy mildew and dark pod spot but less grey mould on Bienvenu than Ariana (63 vs. 49, 69 vs. 51 and 46 vs. 79% plants infected respectively). Autumn plus spring fungicide decreased light leaf spot and dark pod spot from 87 to 23 and from 69 to 51% plants infected respectively; the growth regulator, which has additional fungicidal activity, also decreased incidence of these diseases slightly. In July light leaf spot became severe on pods but was decreased by autumn plus spring plus summer fungicide from 40 to 4% pod area infected. Dark pod spot was prevalent but did not become severe except on E plots of Bienvenu given no inputs (10% pod area infected); fungicide decreased mean severity from 3 to 0.3% pod area infected. Grey mould colonized maturing pods during prolonged wet weather before harvest and was unaffected by fungicide. (Rawlinson, Church, Inman and Wilson, Crop and Environment Protection)

The superficial microflora of leaves and pods. Microbial colonization of leaves and pods was similar to 1986. Only bacteria (10^6 colony-forming units (CFU) g^{-1} tissue) and yeasts (10^4 CFU g^{-1}) were present on uppermost main leaves in mid-April but filamentous fungi

https://doi.org/10.23637/ERADOC-1-28

were always present subsequently. Bacteria increased to 10^8 g^{-1} of tissue as leaves senesced, yeasts to 10^6 CFU g^{-1} and filamentous fungi, mostly *Cladosporium*, *Phoma*, *Alternaria* and *Botrytis* to 7×10^5 CFU g^{-1}. Bacteria on pods increased to 10^9 CFU g^{-1} at harvest, yeasts and filamentous fungi each to 10^6 CFU g^{-1}. *Alternaria* spp. were always among the filamentous fungi, up to 10^4 on leaves and 10^5 CFU g^{-1} on pods; most isolates were *A. alternata* or the *Alternaria* anamorph of *Pleospora infectoria*, but *A. brassicae* was isolated from a third of the total and *A. brassicicola* once at harvest. Fungicide decreased fungi on leaves but much less on pods. Yeasts on leaves fell to 17% of untreated the day after application but the difference had gone after six weeks. Filamentous fungi were still 36% less six weeks after application but differences with *Aureobasidium pullulans* numbers had gone after only two weeks. There were often more yeasts on pods in the six weeks following fungicide application but *A. pullulans* populations were unaffected. Filamentous fungi were consistently 35-40% fewer on treated plots, *Alternaria* spp. were decreased by 55-70% and *A.brassicae* by 85-90%. Numbers of fungi were little affected by other treatments and none affected bacteria. *Alternaria* spp., including *A. brassicae*, were isolated from 4.5% of surface sterilized seed in mid-July, this increased to 60% at harvest when about half were *A. brassicae*. Fungicide delayed detection by one week and decreased incidence at harvest to 21%, 4% of these being *A. brassicae*. Fewer seeds of Ariana than Bienvenu (30 vs. 51%) carried *Alternaria* spp. at harvest, the difference in incidence of *A. brassicae* (15 vs. 21%) was smaller. (Lacey and Nabb, Crop and Environment Protection)

Winter wheat: sowing dates and times of nitrogen application

The experiment made in 1986 (*Rothamsted Report for 1986*, 31-33) was repeated on a new site in 1987 with a test of sowing date instead of a test of summer N. The cultivar Avalon was used again. Five factors at two levels were tested in all combinations: (1) previous crop: spring oilseed rape or spring oats, (2) sowing date: 18 September or 16 October, (3) winter N: 0 or 40 kg ha^{-1}, (4) spring N: single 200 kg ha^{-1} application or four 50 kg ha^{-1} applications, (5) spring N timing: normal or late. Winter N (urea) was applied on 20 November. Spring N ('Nitro-Chalk') was applied on 6 April or 5 May (single application at normal or late times respectively) and on 12 February, 11 March, 6 April, 5 May or 11 March, 6 April, 5 May and 27 May (divided application at normal or late times respectively).

Yield of grain at maturity. The mean of all plots was 8.44 t ha^{-1}, 0.8 t less than in 1986. Without winter N, mean yield after rape (8.57 t ha^{-1}) was significantly larger than after oats (8.15 t). After rape, winter N decreased yield of the September-sown wheat, probably because of lodging, and was of little benefit to the October-sown. After oats, however, winter N was consistently beneficial and increased mean yield to the same as that after rape without winter N. The benefit from sowing in September (mean, 0.2 t ha^{-1}) was small. Where N was applied at the normal time the single and divided treatments gave the same yield (8.49 t ha^{-1}). Where applied late the single dressing was less effective (8.14 t ha^{-1}) and the divided application was best (8.64 t ha^{-1}). (Penny, Thorne, Milford, Prew and Darby, Soils and Crop Production; Todd, Biomathematics)

Growth and development. Weather during autumn and winter was not exceptional and the phenological development of the crop was normal. September-sown plants reached the stages of double-ridges, terminal spikelet and anthesis by 2 March, 24 April and 17 June respectively, and October-sown plants by 6 April, 1 May and 18 June. Grain was hard and green leaf area had gone by 17 August in all crops. A similar number of plants was established at each sowing (269 m^{-2}), but a greater maximum number of shoots had been produced by the September-sown crop (1370 m^{-2}) at the time of the application of N in April than by

https://doi.org/10.23637/ERADOC-1-28

the October-sown crop (1087 m^{-2}). Increases from early sowing in dry weight (126 vs. 53 g m^{-2}) and leaf area index (1.9 vs. 0.7) in April had largely disappeared by anthesis. (Milford, Mullen, Rainbow, Stevenson and Thorne, Soils and Crop Production)

Nitrate-N in the soil. Only the soil under the September-sown wheat was sampled. On 2 October 1986 it contained 60 kg NO_3-N ha^{-1} after rape and 21 kg after oats to 90 cm depth. This difference determined the choice of 40 kg ha^{-1} of fertilizer N as the winter N treatment. On 2 February the amount of NO_3-N had fallen to 29 kg ha^{-1} after rape but there were still 21 kg ha^{-1} after oats.

Nitrate-N in wheat shoots. Only the September-sown crop was sampled. Without fertilizer N the sap of the lower parts of the wheat shoots always had a larger concentration of NO_3-N after rape than after oats. On 27 November, 10 December and 7 January the sap contained, after rape and oats respectively, 920 vs. 670, 790 vs. 580 and 710 vs. 580 μg ml^{-1} NO_3-N. Concentration of NO_3-N then increased and by 26 February there were 920 μg ml^{-1} after rape and 630 after oats. Concentrations then fell rapidly and on 11 March, 24 March, 8 April and 22 April, after rape and oats respectively, the sap contained 580 vs. 430, 230 vs. 220, 70 vs. 20 and 30 vs. 10 μg ml^{-1} NO_3-N. Winter N increased the concentration of NO_3-N, especially after oats, and delayed the rapid fall in spring. On 24 March, after rape and oats respectively, there were still 670 vs. 630 μg ml^{-1} of NO_3-N in the sap, but on 8 April and 22 April values had fallen to 330 vs. 140 and 80 vs. 20 μg ml^{-1}.

Nitrogen contents of crops. Previous crop did not consistently affect percentage of N in the dry matter but uptake of N was always larger after rape than after oats (32 vs. 27 kg N ha^{-1} in March, 52 vs. 44 in April, 100 vs. 86 in May, 190 vs. 171 at anthesis in June, 156 vs. 150 in the grain at maturity).

September-sown wheat had a smaller percentage of N and a larger uptake than October-sown until anthesis, but sowing date did not affect percentage of N in the grain (mean 2.13%) or final uptake (mean 153 kg N ha^{-1}).

Winter N increased percentage of N until May but had no effect in June and little in the mature grain. It always increased uptake of N after oats but not after rape. The similarity of uptake after oats with winter N, and after rape without, again supported the method of determining the winter N rate (31 vs. 31 kg ha^{-1} respectively in March, 51 vs. 52 in April, 95 vs. 94 in May, 178 vs. 184 in June, 156 vs. 156 in mature grain).

Percentage of N in June was usually larger, and in the grain at maturity always larger, with a single than with a divided dressing and with late than with normal timing. At maturity uptakes of N in the grain did not differ consistently with division of N but were consistently larger, though seldom significantly, with the late than with the normal time of application. (Penny, Darby and Hewitt,Soils and Crop Production)

Straw incorporation

The multidisciplinary experiments were again sown to winter wheat cv. Mission, with the exception of the Whaddon site which was sown to oilseed rape cv. Bienvenu.

Comparison of straw incorporation methods on different soil types

Yields. The yields were considerably less than in the two previous years. The best yields at Rothamsted (R) came from straw incorporation with shallow tillage and from straw burnt

https://doi.org/10.23637/ERADOC-1-28

and ploughed. At Woburn (W) tined plots were best, particularly where straw was incorporated (Table 4). (Prew, Moffitt, Christian, Goss, Johnston and Harper, Soils and Crop Production; Jenkyn, Gutteridge, Powell, Henderson and Kerry, Crop and Environment Protection).

TABLE 4

Effects of cultivation and straw treatments on grain yield (t ha^{-1}) of winter wheat

	Shallow tillage 10 cm	Deep tillage 20 cm	Shallow tillage + plough	Plough 20 cm
Rothamsted				
Straw burnt	6.04	5.67	5.92	6.36
Straw chopped	6.24	5.48	5.80	5.86
Woburn				
Straw burnt	4.34	4.17	3.78	3.90
Straw chopped	4.80	4.45	3.75	3.63

Growth. As in 1986, winter growth was poor (R 51, W 40 g dry matter m^{-2}). Dry weights in April and at anthesis were larger after burning on deep tillage plots on both sites and ploughed plots at Rothamsted. There were no consistent differences in shoot or fertile ear numbers at either site.

Volunteers. The percentage of Avalon volunteers (1985 crop) was again less on the ploughed plots (burnt R 0.8, W 0.3 or straw-incorporated R 1.5, W 1.4) than on the tined plots (burnt R 1.9, W 1.3 or straw-incorporated R 10.0, W 6.7). (Christian, Bacon and Prew, Soils and Crop Production)

Pests and soil fauna. The percentage of plants attacked by stem borer (*Opomyza florum*) was again less on unploughed than ploughed plots, especially where straw was incorporated (burnt 29 vs. 41 or straw- incorporated 8 vs. 40). However at Woburn there were no differences between treatments. Numbers of overwintering blossom midges (*Sitodiplosis mosellana*) in the top 15 cm of the soil were 50% (R) and 34% (W) fewer with ploughing. Soil mesofauna (Collembola, mites, insect larvae) in spring were 30% more abundant on straw-incorporation plots, with all cultivation systems at Rothamsted, and 19% greater with tining at Woburn. (Powell, Ashby and White, Crop and Environment Protection)

Diseases. Take-all was common at both sites and very severe in places, largely accounting for the poor yields. Detailed assessments are not yet available. (Gutteridge and Jenkyn, Crop and Environment Protection).

Effects of shallow straw incorporation

Yields. In contrast to 1986 the burnt plots yielded least. Yields were consistently greater in the presence of fungicide; other treatments having relatively small effects with the exception of the early timing of cultivations when straw was chopped and incorporated (Table 5). (Prew, Moffitt, Christian, Bacon and Johnston, Soils and Crop Production; Jenkyn, Gutteridge, Powell and Henderson, Crop and Environment Protection).

https://doi.org/10.23637/ERADOC-1-28

TABLE 5

Factors tested and their effect on grain yield (t ha^{-1}) of winter wheat

	Straw treatment		
	Burnt	Baled	Chopped
	6.14	6.81	6.36
Effect of:			
Early cultivation	+0.09	−0.05	+0.93
Autumn N	+0.14	+0.25	−0.10
Fungicides	+0.57	+0.75	+0.65
Insecticides	+0.30	+0.05	+0.18

Growth. More plants were present in December and April on the baled (BA) and chopped (C) plots than on the burnt (BU) probably because of more volunteers. However, in April shoot numbers were smaller on chopped plots (BU 792, BA 803, C 711 shoots m^{-2}) as were dry weights. At anthesis the baled treatment had retained the most shoots (BU 569, BA 646, C 558 fertile ears m^{-2}).

Volunteers. The percentage of fertile ears derived from Avalon volunteers (1985 crop) was much less on burnt plots (BU 4.0, BA 20.5, C 16.2), the earlier cultivation also decreased numbers. (Christian, Bacon and Prew, Soils and Crop Production)

Pests. The percentage of plants attacked by stem borer was again greater on the burnt plots (BU 21, BA 8, C 8). (Powell, Ashby and White, Crop and Environment Protection)

Diseases. The yield benefit from the fungicide treatment came mainly from the control of *Septoria* spp. and eyespot (*Pseudocercosporella herpotrichoides*). Only traces of *Septoria* spp. were present in November but by April *S. tritici* was common, with 2.6% on second youngest leaves. The third youngest leaves were very senescent, but on these the disease appeared to be worst on BU plots. In July *Septoria* spp., mainly *S. tritici*, affected 17.0 and 44.6% of the area of second and third youngest leaves without fungicide, a little more on BU plots. Fungicides decreased *Septoria* to 1.0 and 10.4% on second and third leaves respectively. Eyespot was present in April (BU 39, BA 22, C 19% shoots infected) and increased without fungicide (BU 51, BA 53 and C 36% in July) but with fungicide was decreased to 6%. A little brown foot rot was present in July with 2% stems infected. Take-all (*Gaeumannomyces graminis* var. *tritici*) was common but less severe than in 1986. Throughout the season burnt plots had least, with take-all ratings in July of BU 73, BA 125, C 163. No other treatment affected final ratings. (Jenkyn and Gutteridge, Crop and Environment Protection)

Straw incorporation on a heavy wet site

Yield. The oilseed rape yields were poor, mainly because of large shedding losses in a very difficult season. Both ploughed, straw chopped and unploughed, straw burnt gave 1.59 t ha^{-1}; ploughed, burnt and unploughed, chopped 1.40 t ha^{-1}.

Growth. Plant establishment was best on unploughed, burnt (172 m^{-2}) with less on ploughed treatments (155 m^{-2}) and least on unploughed, chopped (136 m^{-2}). However, by

https://doi.org/10.23637/ERADOC-1-28

spring all treatments had 138 plants m^{-2}. Dry matter production in March and June was slightly more on the chopped plots than on the burnt. (Christian, Bacon and Prew, Soils and Crop Production)

Intensive potato production

The experiment described in 1982 (*Rothamsted Report for 1982*, 39-41) continued for its sixth year on the same sandy loam site at Woburn with the second of three crops of potatoes testing the cropping frequencies and nematicide shown in Table 6. Sub-plots tested the combinations of two two-level factors: with and without the nematicide oxamyl at 5 kg ha^{-1} worked into the seedbed and with and without a combined fungicide treatment to the seed of tolclofos-methyl (250 g t^{-1}) plus prochloraz (35 g t^{-1}). As in 1986, all plots were cross-worked with a Bomford 'Earthquake' deep-tine cultivator to lessen soil compaction. In the wet season of 1987, the plots needed irrigating only twice, with 12.5 mm of water, to prevent the soil moisture deficit exceeding 25 mm.

Potato cyst-nematodes and tuber yields. There was less infestation with potato cyst-nematodes (predominantly *Globodera rostochiensis*) this year than in 1986 (Table 6). Désirée yielded more in the untreated very lightly infested seven-course plots than in the untreated lightly infested four-course and two-course plots. Oxamyl gave excellent control of *G. rostochiensis* in all rotations and greatly increased tuber yields of the two-course and four-course plots.

TABLE 6

Effects of previous cropping, cultivar and nematicide on yield of tubers t ha^{-1}

Cultivar sequence*			Tuber yields 1987		Nematodes spring 1987 eggs g^{-1} soil
1983	1985	1987	None	Oxamyl	
—	—	Désirée	57.3	60.4	1
Désirée	—	Désirée	37.6	55.8	15
Désirée	Désirée	Désirée	34.8	53.5	10
Désirée	Maris Piper	Désirée	37.0	49.1	12

SED (44 d.f.) 2.4 t between sequences, 2.4 t within sequences.

* All were in potatoes Pentland Crown in 1980, all spring barley in other years.

Tuber diseases. The fungicides applied to the seed tubers of the 1986 experiment decreased the incidence of skin spot and silver scurf on stored progeny tubers. Stem canker and black scurf caused by *Rhizoctonia solani* were uncommon in the six-course rotation (stem canker index 2; tubers with black scurf 2%) but prevalent in the third Désirée crop of a two-course rotation (respectively 33, 75%) and were not decreased by fungicide treatment.

Conclusions. In soil infested with *G. rostochiensis*, Désirée grew as well in a four-course as in a seven-course rotation, when the seedbed was treated with an effective nematicide. Decreasing the length of the rotation increased stem canker and black scurf. Treating seed tubers with fungicides decreased the incidence of skin spot and silver scurf on stored progeny tubers. (Whitehead, Hide, Govier, Read and Webb, Crop and Environment Protection; Addiscott, Soils and Crop Production)

https://doi.org/10.23637/ERADOC-1-28