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The Brimstone Farm Experiment

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3: Crop Yields and Uptake of Nitrogen

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3. CROP YIELDS AND UPTAKE OF NITROGEN

3.1 RESULTS FOR PHASE I

3.1.1 Agronomy

After the uniformity trials in 1978/79 and 1979/80 when all plots were tine cultivated, 10 plots were ploughed each year, their seedbeds prepared with equipment appropriate for the soil conditions and seed was sown on a common date for all plots. Conventional sowing methods were used on ploughed land except in the wet autumn of 1982, when seed was broadcast in November, because the soil would not support a tractor without suffering severe wheel marking. Crop residues were burnt *in situ* after each harvest, but the burn was incomplete in 1983 and 1986, so the remainder was then incorporated by shallow tillage.

Winter wheat was grown in the uniformity trials of 1978/79 and 1979/80 and in the two following years. It had also been grown by the farmer in 1977/78, so by 1982 take-all was affecting the crop. Thereafter rotational cropping was adopted (Table 4).

Table 4. Agronomic details Phase I and Phase II

Phase 1				Spring Nitrogen		
Year	Crop (autumn sown)	Sowing date	Autumn fertilizer NPK kg/ha	Date of 1st application	Amount kg/ha and splits ( )	Total N for crop kg/ha
1978/79	Wheat	2 Oct. 78	17 26 21	7 March 89	116 (3)	133
1979/80	Wheat	5-9 Oct. 79	24 21 0	11 April 80	140 (2)	164
1980/81	Wheat	1-2 Oct. 80	0 25 0	1 April 81	149 (2)	149
1981/82	Wheat	8 Oct. 81	24 21 0	24 March 82	148 (3)	172
1982/83	Oats	11 Nov. 82	30 26 0	8 March 83	111 (3)	141
1983/84	Wheat	17 Sept.83	17 25 0	5 April 84	223 (3)	240
1984/85	Oilseed rape	1 Sept.84	46 16 30	11 March 85	239 (2)	285
1985/86	Wheat	10 Oct. 85	0 29 54	30 April 86	130 (1)	130
1986/87	Oats	15 Oct. 86	0 29 55	10 April 87	100 (2)	100
1987/88	Wheat	12-13 Oct. 87	-	12 April 88	194 (2)	194
Phase II				**Spring Nitrogen**		
Year	Crop	Sowing date	PK fertilizer kg/ha	Date of 1st application	Amount kg/ha and splits ( )	Total N for crop kg/ha
1988/89	Grass	21 Sept.88				
	White mustard	21 Sept.88	29.55	14 March 89	100 (3)	100
	Winter oats	5 Oct. 88	5 May 89			
	Spring wheat	28 Mar.89				
1989/90	Winter wheat	6 Oct. 89	-	8 March 90	150 (2)	150
	Winter barley	9 Oct. 89	-			

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Crop protection chemicals and growth regulators have been used since 1978. Sprays and fertilizers are applied using tramlines re-established in the same positions each year. Amounts of fertilizer applied were assessed from soil analyses for P and K and by the index system of MAFF (1973) for N (Table 4). To assess plant populations, shoot density, components of yield and nutrient content of aerial dry matter, plants were collected from 6 locations in each plot. Grain yields were measured in four cuts 2.2 m wide and 24 m long across each plot, and adjusted to 85% dry matter for cereals and 86% dry matter for oilseed rape.

3.1.2 Yields in uniformity trials

Because of the cultivation pan (Section 1.2) there was no significant difference in grain yields between the drained and undrained plots (all tine cultivated) in 1978/79. After disruption of the pan, the yield at harvest 1980 was 6% greater on drained than on undrained plots (Table 5).

Table 5. Yield of winter wheat grown during the uniformity trial period 1979-80

Harvest Year	Cultivation	Yield (t/ha 85% DM) Drained	Undrained	SED
1979	Tine 25cm Disc Harrow	5.20	5.14	0.110
1980	Progressive Tine Cultivation to 25cm	7.33	6.52	0.139 ***

*** = Statistically significant $P < 0.001$

3.1.3 Effects of drainage on yield, harvests 1981-88

Averaged over the 8 years of the drainage/cultivation comparison in Phase I, drainage had a greater influence on yield than did cultivation. Cereal yields of drained land were significantly greater than those of undrained land at harvest 1982, 1983 and 1988 (Table 6). In 1982 this was a result of better root and shoot growth in early spring, and in the other two years when the soil had been waterlogged in the previous autumn periods there were more plants on the undrained plots.

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Table 6. Effect of Drainage on crop yield after Ploughing (P) or Direct Drilling (DD)
Results based on 16 plot comparison, Phase I.

		Treatment				Statistical Significance (FTEST)			
Harvest Year	Winter Crop	Cultivation	Drained t/ha	Undrained t/ha	Percent change due to drainage	Between drainage treatments	Between cultivation treatments	Cultivation and drainage interaction	SED
1981	Wheat	P	8.01	8.17	- 2	N.S.	N.S.	N.S.	0.316
		DD	8.58	7.90	9				
		Mean	8.29	8.03	3				
1982	Wheat	P	6.91	5.62	23	* * *	* *	N.S.	0.208
		DD	7.95	6.00	32				
		Mean	7.43	5.81	28				
1983	Oats	P	7.17	5.89	22	* * *	* *	* *	0.450
		DD	7.04	3.19	121				
		Mean	7.11	4.54	57				
1984	Wheat	P	11.41	11.42	-	N.S.	N.S.	*	0.221
		DD	11.96	11.19	7				
		Mean	11.68	11.30	3				
1985	Oilseed Rape	P	3.84	3.51	9	N.S.	N.S.	*	0.112
		DD	3.44	3.57	- 4				
		Mean	3.64	3.54	3				
1986	Wheat	P	7.49	7.99	- 6	N.S.	N.S.	*	0.167
		DD	7.83	7.74	1				
		Mean	7.66	7.86	- 2				
1987	Oats	P	6.02	6.60	- 9	N.S.	N.S.	* * *	0.128
		DD	6.70	6.23	8				
		Mean	6.36	6.42	- 1				
1988	Wheat	P	7.55	7.33	3	*	*	N.S.	0.353
		DD	7.22	6.13	18				
		Mean	7.39	6.73	10				

N.S. = Not significant; * P = < 0.05; ** P = < 0.01; *** P = < 0.001.

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3.1.4 Effects of cultivation on yield, harvests 1981-88

Yields were greater on direct drilled plots in five years (Table 6) when rainfall in the preceding autumn was equal to or less than average, and were greater on ploughed plots in three years (1983, 1985, 1988), all of which were preceded by wet autumns.

After the poor burn in 1986, volunteer wheat affected the subsequent crop of winter oats, and was especially abundant on direct drilled plots. At harvest 1987 the contamination of the grain was 20% on direct drilled plots and only 3% on ploughed plots. Ploughing had buried the unburnt residues and therefore limited the problem of volunteers. But, as elsewhere (Christian and Bacon 1990), cultivation otherwise had very little effect on yield.

3.1.5 Interaction between drainage and cultivation

The benefit of drainage to yield was greater for direct drilled crops (mean of 1.12 t/ha/yr) than for crops established after ploughing (0.23 t/ha/yr), and was greater for oats than for wheat or oilseed rape. This was because sowing of the first of the two oat crops in 1982 was delayed by wet weather, which prevented the preparation of seedbeds on ploughed plots. The late sowing penalized the direct drilled crop, especially on undrained plots where waterlogging probably caused many seeds and seedlings to die (Cannell and Belford 1982). Without the restriction of a common sowing date for all treatments, the direct drilled crop could have been sown earlier and might not have suffered in this way.

3.1.6 Nitrogen uptake

Table 7. The nitrogen content of shoots (kg/ha) before nitrogen fertilizer was applied and at harvest

	Drained		Undrained		
	Plough	Direct drill	Plough	Direct drill	SED
1985/OSR[a]					
Spring	119	126	117	129	28.8
Harvest[b]	262	220	245	210	30.6
1986/WW[a]					
Spring	35	37	25	26	2.2
Harvest	220	223	233	202	18.6
1987/WO[a]					
Spring	48	56	34	48	3.7
Harvest	144	124	141	121	5.4
1988/WW[a]					
Spring	25	20	16	10	4.4
Harvest	254	239	231	213	13.2

[a] OSR = winter oilseed rape; WW, winter wheat, WO, winter oats
[b] Total in grain and straw

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Uptake of nitrogen in the last four years of Phase I was usually greater on drained plots than undrained (Table 7). Uptake by oilseed rape over the winter of 1984/5 was several times that by winter cereals in the three following years. The rape received 46 kg N/ha in autumn and the cereals all received no autumn N, but the increased uptake by oilseed rape was approximately twice its seedbed dressing in autumn, so the rape made greater demands on non-fertilizer sources of N than did the cereal crops. However, at maturity differences in N content between crops and treatments had decreased, and total uptakes exceeded amounts applied as fertilizer (cf. Tables 4 and 7).

Results for winter oats in 1986/87 are confused by the presence of volunteer wheat plants. The spring N content includes both sown and volunteer plants, but the amounts at maturity are for areas where volunteers had been removed by hand roguing in the early summer.

3.2 RESULTS FOR PHASE II

3.2.1 Agronomy

The different crop rotations on the 14 plots used in Phase II are shown in Table 1. Different methods of tillage and straw disposal were also involved (Table 8). The policy of crop protection was continued but modified to suit the pesticide leaching studies (Section 5). Cereal yields were estimated as in Phase I (Section 3.1.1) and grass growth was estimated by cutting the sward on several occasions each year.

3.2.2 Crop yields

The autumn of 1988 was very dry (Fig. 12), so crop establishment was slow. For example on Plot 1 the grass grew more slowly than on Plot 15, and by July 1989 there was a 40% difference in dry matter production (Table 8). This difference had narrowed to 5% by spring 1990. On Plot 14 patches of sterile brome affected the growth of winter oats; as this would have jeopardized future experimentation on the plot, all the vegetation was killed by spraying in spring and the plot was resown to spring oats. Yields on the remaining 7 plots carrying winter oats averaged 5.75 t/ha and were not influenced by secondary drainage, tillage or method of straw disposal (Table 8).

Two pairs of plots were used to assess nitrate leaching under winter cover crops. In the winter of 1988/89 Plots 7 and 9 were sown with white mustard and the other pair (5 and 16) was fallow. The mustard established slowly. It was killed by spraying in late February 1989 but wet weather prevented the sowing of spring wheat for three weeks. The average yield of spring wheat after the cover crop was 8% heavier than after fallow.

In autumn 1989 all plots except those in grass (1 and 15) were sown with either winter wheat or barley. The average yields of these crops was 7.5 t/ha and 5.4 t/ha, respectively (Table 8). The average yield of Plots 7 and 9 (cover crops in 1988/89) was 12% more than on Plots 5 and 16 (winter fallow in 1988/89); this increase probably resulted from the nutrients released from residues of the winter cover crop.

For each of the crops involved the plots which had been direct drilled in Phase I (1980-88) yielded more in 1989 and 1990 than those that had been ploughed.

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Table 8. Phase II yield of crops and uptake of nitrogen 1989 and 1990

Plot number	Mole drainage treatment	Tillage methods	Straw disposal	Crop 1989	Yield	Nitrogen uptake kg/ha		Crop 1990	Yield	Nitrogen uptake kg/ha		Previous drainage/tillage
						Spring[c]	Harvest			Spring	Harvest	
1 15	Gravel filled	-	-	grass	3.49 4.88	12 22	62 108	grass	4.30 4.54	11 9	32 36	D[e]-P D-DD
5 16	Frequent moling	tine	burnt	fallow/ spring wheat	3.46 2.77	-	158 138	winter barley	5.31 4.18	12 5	136 100	UD-DD D-P
7 9	Closed spaced drainage	tine	burnt	white mustard/ spring wheat	3.22 3.53	23[a] 26[a]	111 148	winter barley	5.31 5.83	7 9	105 143	D-P D-DD
10 20	moled, no expander	plough	burnt	winter oats	5.70 5.96	31 29	122 121	winter wheat	7.64 7.44	7 7	172 182	D-P UD-DD
6 19	moled, large expander	plough	incorporated	winter oats	6.05 5.60	25 21	128 120	winter wheat	7.64 7.19	7 5	192 148	D-DD UD-P
4 18	moled conventional	tine	burnt	winter oats	5.88 5.21	24 30	94 93	winter wheat	7.64 7.19	7 7	170 166	D-DD UD-P
14	undrained	direct-drilled	burnt	spring oats[f]	-	19[b]	68	winter wheat	7.81	5	185	UD-DD
17	moled extended interval	tine	burnt	winter oats	5.86	16	117	winter barley	6.45	6	157	D-DD

[a] N in white mustard when it was incorporated
[b] N in vegetation when killed in spring
[c] Assessment made before nitrogen was applied in spring.
[e] D denotes drained; UD = undrained; P = ploughed; DD = direct drilled
[f] Originally sown with winter oats

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3.2.3 Nitrogen uptake

Because the white mustard cover crop established poorly in autumn 1989, the amount of N it took up was less than that taken up by winter oats (Table 8), even though the oats had been sown one week later. The difference in N uptake between the two grass plots (1 and 15) in 1988/89 reflected the better establishment and growth on the plot which had been direct drilled in Phase I. By harvest 1990 the difference in N uptake had almost disappeared.

In 1988/89 and 1989/90 the total amount of nitrogen in crops (Table 8) exceeded the amounts applied as fertilizer (Table 4), except on Plots 4 and 18 in 1988/89 (winter oats) and 5, 7, 16 and 19 in 1989/90 (winter barley). Although winter wheat and winter barley received the same amount of N in spring 1990, there was more N in the wheat crop.

Greater N uptake occurred on several plots which had been direct drilled in Phase I than on plots that had been ploughed.

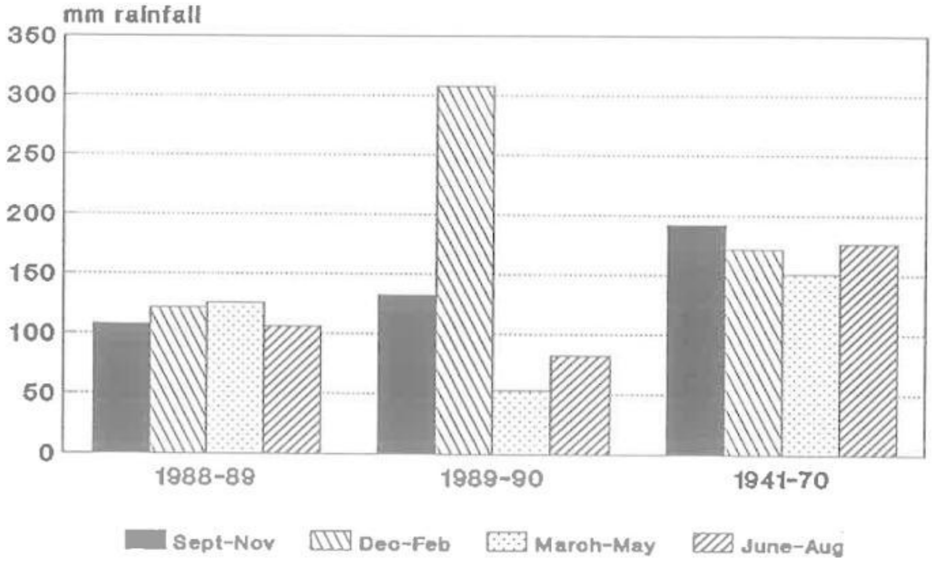

Fig.12. Seasonal rainfall (mm) 1988 - 90 and long term average 1941 - 70.

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