EFFECTS OF REDUCING PESTICIDE INPUTS IN THE FIRST FOUR YEARS OF TALISMAN

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ABSTRACT

TALISMAN (Towards A Lower Input System Minimising Agrochemicals and Nitrogen) was started in autumn 1990 at three ADAS Research Centres. Standard and alternative six-year rotations are being tested under a Current Commercial Practice (CCP), applying full recommended rates of pesticides and nitrogen, and Low Input Approach (LIA) in which 50% of the nitrogen and a maximum of 50% of the pesticide amounts are used. The design allows the effect of reducing the rate of herbicide, fungicide, insecticide and nitrogen to be assessed separately. During the first four years the crops grown included most major combinable crops in rotations appropriate to the soil type of the centre concerned. Reduced rates of pesticides produced variable yield responses in cereals and the effects upon yields in other crops were small. Margins over pesticides and nitrogen costs in cereals increased most with reductions in herbicides at the full rates of nitrogen. Changes in margins with beans and linseed were small with reduced pesticide inputs.

INTRODUCTION

A major, multi-disciplinary project to investigate the environmental and economic effects of pesticide use in intensive cereal production was carried out at ADAS Boxworth in 1981 - 1988; this study became known as the Boxworth Project (Greig-Smith *et al., 1992*). The results from the Boxworth Project provided a basis for further research to be funded by the Ministry of Agriculture, Fisheries and Food (MAFF) including TALISMAN which commenced with sowing in autumn 1990 and will continue for at least six years.

TALISMAN, (Towards A Lower Input System Minimising Agrochemicals and Nitrogen) was designed to measure the economic, agronomic and, to a lesser extent, the environmental effects of adopting cropping systems which use lower levels of agrochemicals and nitrogen than conventional cropping systems. Crop inputs, yields and economic results from the first four years of TALISMAN are presented in this paper.

MATERIALS AND METHODS

The sites for TALISMAN are at ADAS Boxworth (well-structured clay), ADAS Drayton (heavy clay) and ADAS High Mowthorpe (silty clay loam). Standard and alternative six course rotations are being tested under a Current Commercial Practice (CCP) approach for pesticides and nitrogen and a Lower Input Approach (LIA) in which 50% of the nitrogen rate applied to CCP is used and a maximum of 50% of the pesticide rates. The standard rotations are typical for the individual sites and the alternative rotations are based predominantly on spring crops which have an inherently lower requirement for pesticides and nitrogen (Table 1).

TABLE 1. TALISMAN rotations at each site.

Year	Boxworth	Drayton	High Mowthorpe
Standard Rotations			
1	w. oilseed rape	w. oilseed rape	w. oilseed rape
2	w. wheat	w. wheat	w. wheat
3	w. wheat	w. wheat	w. wheat
4	w. beans	w. beans	w. beans
5	w. wheat	w. wheat	w. wheat
6	w. wheat	w. wheat	w. barley
Alternative Rotations			
1	linseed	s. beans	s. beans
2	w. wheat	triticale	w. wheat
3	s. wheat	triticale	s. barley
4	s. beans	s. oats	linseed
5	w. wheat	triticale	w. wheat
6	s. wheat	triticale	s. barley

Products used in CCP are those most widely used by farmers as indicated in the Pesticide Usage Survey Reports for Arable Crops (Davis *et al.*, 1992). The manufacturers' recommended label rates are used. During the experiment some recommendations, rates or active ingredients may be superseded and CCP evolves to reflect these changes. Nitrogen rates are determined using "Fertiplan", which is a fertiliser planning service based on previous cropping, soil type and yield prediction.

Wherever possible, the reduction in LIA pesticides is being achieved by omitting applications altogether. However, if it is estimated that the loss of crop value would be greater than 10% by withholding the agrochemical, then up to half of the rate applied to CCP can be used. A full rate application is allowed in very exceptional instances when there is already conclusive evidence that less than the full rate would result in a crisis. The cultivars, cultivations and sowing dates are the same in both CCP and LIA.

The experiment is designed to compare the individual effects of herbicides, fungicides and insecticides at CCP and LIA rates at normal and half rates of nitrogen in two rotations. TALISMAN has a split-plot design with rotation and nitrogen rate as main treatments and pesticides as sub-treatments. Combinations of the CCP and LIA rates of herbicides, fungicides and insecticides are represented in 5 sub-treatments so that the effect of reducing the rate of each pesticide can be assessed. The sub-treatments are: all pesticides applied at CCP rate; all pesticides applied at LIA rate; and three combinations of only herbicide, fungicide or insecticide at the LIA rate with the remaining two pesticide components at the CCP rate.

Main plots are 24m x 24m and divided into 5 equal sub-plots. There are three or four replicates at each site and an additional replicate without sub-treatments adjacent to a field boundary is used to monitor arthropods. The effects of pesticides on invertebrates and non-target soil micro-organisms are being studied in the SCARAB (Seeking Confirmation About Results At Boxworth) project (Bowerman, 1993).

Each rotation has two phases (except for the alternative rotation at ADAS Boxworth). Phase 1 started at the first year in the rotation and Phase 2 started at year 4.

RESULTS

The pesticide levels applied in the first four harvest years are shown in Table 2. The applications of a label recommended rate for herbicide, fungicide or insecticide (including molluscicide) has been taken as 1 pesticide unit, and half-rate applications as 0.5 unit.

TABLE 2. Pesticide units applied (mean per crop 1991-94).

Crop (No. in brackets)		CCP	LIA
First w. wheat	(9)	6.1	2.9
Second w. wheat	(5)	8.0	4.0
Spring wheat	(1)	4.0	2.5
Winter barley	(1)	3.0	1.5
Spring barley	(3)	4.0	2.3
Spring oats	(1)	2.0	1.0
Triticale	(2)	5.5	1.5
Oilseed rape	(6)	4.2	1.6
Linseed	(3)	1.7	1.0
Winter beans	(6)	3.0	1.0
Spring beans	(5)	3.0	1.0
TOTAL		44.5	20.3

TABLE 3. Mean yields of cereals and field beans (t ha^{-1} at 85% DM), and oilseed rape and linseed (t ha^{-1} at 91% DM) at full rates of nitrogen and pesticides, and differences of other treatments.

Crop (no. in brackets)	Nitrogen rate	Pesticide inputs: All high	Low herbicide	Low fungicide	Low insecticide	All low
			(a) ± 0.094		(b) ± 0.232	
First	100%	7.80	+ 0.05	-0.05	- 0.27	- 0.60
W. wheat (9)	50%	- 0.23	- 0.39	- 0.28	- 0.32	- 0.65
			(a) ± 0.085		(b) ± 0.181	
Second	100%	7.70	- 0.03	- 0.17	- 0.09	- 0.64
W. wheat (5)	50%	- 1.78	- 1.64	- 1.71	- 1.76	- 1.89
			(a) ± 0.199		(b) ± 0.252	
S. wheat (1)	100%	6.34	- 0.02	+ 0.05	+ 0.20	+ 0.12
	50%	+ 0.26	- 0.05	- 0.26	+ 0.30	- 0.14
			(a) ± 0.185		(b) ± 0.372	
W. barley (1)	100%	8.11	+ 0.03	- 0.01	- 0.40	- 0.70
	50%	- 1.68	- 2.85	- 2.32	- 1.63	- 1.93
			(a) ± 0.202		(b) ± 0.299	
S. barley (3)	100%	6.17	- 0.14	- 0.24	+ 0.09	- 0.14
	50%	- 0.98	- 0.85	- 0.68	- 0.11	- 0.99
			(a) ± 0.168		(b) ± 0.235	
S. oats (2)	100%	4.93	-0.08	-0.21	+0.02	-0.54
	50%	+0.01	-0.18	-0.32	-0.34	-0.08
			(a) ± 0.171		(b) ± 0.288	
Triticale (2)	100%	4.97	+ 0.09	- 0.12	+ 0.23	- 0.12
	50%	+ 0.03	+ 0.56	- 0.18	+ 0.51	+ 0.27
			(a) ± 0.081		(b) ± 0.108	
Oilseed rape (6)	100%	2.23	- 0.19	- 0.06	- 0.04	- 0.39
	50%	- 0.53	- 0.69	- 0.42	- 0.37	- 0.64
			(a) ± 0.032		(b) ± 0.046	
Linseed (3)	100%	2.03	- 0.09	+ 0.06	- 0.01	- 0.03
	50%	- 0.06	- 0.15	- 0.02	- 0.05	- 0.10
			(a) ± 0.075		(b) ± 0.078	
W. beans (6)	100%	4.32	+ 0.16	+ 0.04	- 0.11	+ 0.08
	50%	- 0.04	+ 0.01	+ 0.12	- 0.01	- 0.08
			(a) ± 0.110		(b) ± 0.127	
S. beans (5)	100%	3.47	- 0.12	0 .00	- 0.07	- 0.25
	50%	- 0.08	- 0.30	- 0.09	- 0.23	- 0.35

(a) SE for comparisons at same level of nitrogen.
(b) SE for comparisons between levels of nitrogen and interactions.

TABLE 4. Prices and area payments, 1994.

Crop	Price £/t	Area payment £/ha
Wheat	108	193.53
Barley	100	193.53
Oats	98	193.53
Triticale	95	193.53
Oilseed rape	175	436.54
Linseed	135	481.06
Beans	100	359.41

TABLE 5. Margins over costs of pesticides and nitrogen (£ ha^{-1}) for full rates of nitrogen and pesticides, including area payments, and differences of other treatments.

		Pesticide inputs				
Crop	Nitrogen rate	All high	Low herbicide	Low fungicide	Low insecticide	All low
First W. wheat	100%	885	+22	+14	-28	-25
	50%	+1	+2	+13	-8	-4
Second W. wheat	100%	799	+40	+16	+4	+14
	50%	-166	-110	-126	-150	-97
S. wheat	100%	755	+5	+13	+22	+29
	50%	+48	+22	0	+52	+21
W. barley	100%	895	+13	+17	-40	-42
	50%	-141	-248	-187	-136	-138
S. barley	100%	703	+5	-19	+20	+12
	50%	-79	-46	-44	-80	-54
S. oats	100%	608	0	- 12	+4	-33
	50%	+16	+4	-9	-18	+27
Triticale	100%	522	+31	+27	+34	+60
	50%	+18	+89	+37	+74	+112
Oilseed rape	100%	662	-6	+4	+8	-6
	50%	-62	-64	-28	-19	-19
Linseed	100%	701	-4	+7	-3	+5
	50%	+3	0	+8	+5	+7
W. beans	100%	734	+44	+24	-1	+49
	50%	+5	+29	+32	+10	+33
S. beans	100%	647	+9	+13	-1	+15
	50%	-8	-9	+3	-16	+6

Overall, the level of pesticides in LIA was reduced to 46% of that in CCP (Table 2); achieved mainly by reducing application rates rather than by omitting applications. The reductions with herbicides were less than those with either fungicides or insecticides indicating a greater availability and confidence in thresholds for disease and pest problems than for weeds. Crops grown in the standard rotations have had a greater requirement for nitrogen and pesticides than those in the alternative rotations.

Yields were significantly reduced in second winter wheat at full rate of nitrogen with the all low pesticide treatment compared to all the other combinations of pesticide input levels except low fungicide, and at the half rate of nitrogen with the same pesticide treatment but only compared with the low herbicide treatment ($P = 0.05$) (Table 3).

Based upon 1991-94 yields, mean margins for crop output less pesticide and nitrogen costs were calculated using commercial prices for inputs. The crop prices and area payments are shown in Table 4.

In the first and second winter wheat crops, which are the cereals on which most data is available, margins increased most with the reductions in herbicides at the full rates of nitrogen (Table 5). Reduction of pesticide inputs to beans and linseed gave increased or slightly reduced margins. Winter oilseed rape crops were redrilled with spring rape at ADAS Boxworth and ADAS Drayton in 1994 because both of the autumn crops were killed by pigeon and slug attacks.

Margins per year for the standard and alternative rotations at each site, presented in Table 6, were based upon the yields achieved with full rate of nitrogen (none for beans), and full rates of pesticides (except those for cereals and beans which were at the LIA rate for herbicides). It should be noted that no allowance has been made for the reduced area as a result of the set-aside requirement.

TABLE 6. Margins per year (£ ha^{-1}) of standard and alternative rotations at each site at 1994 price regimes.

Site	Standard rotation	Alternative rotation
Boxworth	684	656
Drayton	726	628
High Mowthorpe	977	775

DISCUSSION

Reductions in pesticide use have been achieved more frequently by the prudent use of reduced rates than the omission of applications. The effects on yields and margins of reducing nitrogen rates by 50% were greater than the effects of reductions in levels of pesticides used.

Cereals, in particular spring and winter wheat, have shown variable responses to reduced inputs. Yields of first winter wheats in 1992 at ADAS Boxworth and Drayton were greater with LIA nitrogen rates than with CCP rates. This was probably an effect of crops being unable to utilise the higher rate of nitrogen to fill grains because of the weather conditions, particularly a shortage of water; a phenomenon that occurred in other experiments in that year. One of the largest responses to reduced pesticide input to a cereal crop occurred at High Mowthorpe in the first winter wheat in 1991/92 where there was a late season infestation of grain aphid (*Sitobion avenae*) and rose grain aphid (*Metopolophium dirhodum*). At the CCP rate of nitrogen, an application of dimethoate to the CCP at the early dough stage (GS 83) resulted in yield increases in both phases of 7 and 8% compared with nil insecticide to the LIA. Smaller increases in yield were achieved with the same treatment at the LIA nitrogen rate.

The yield responses to reduced rates of pesticides in the other crops were usually small which indicate that it was possible to reduce the rates of application of herbicides, fungicides and insecticides by half, or to omit them at most sites.

Winter oilseed rape was vulnerable to the effects of reduced pesticide applications as it is a low yielding crop and problems can be damaging. Yield reductions appeared to be associated with poorer control of volunteer wheat at ADAS Boxworth (Clarke *et al.*, 1993; Cook *et al.*, 1995). In addition, the reduced rate of nitrogen on rape in LIA allowed greater competition from weeds.

Weed counts in successive crops have often shown higher weed numbers with treatments with reduced rates of nitrogen or herbicides or both. Weed seedbank numbers were higher at High Mowthorpe and Boxworth with reduced rate herbicide treatments after only three years of the rotations (Lawson, personal communication).

The margins of the standard rotations were greater than those of the alternative rotations at all of the sites. At Boxworth, the low margin of the standard rotation was mainly the effect of poor yields of rape in 1991 and 1994 and the first winter wheat crops in 1992.

TALISMAN is indicating that there are potential savings to be made with inputs to combinable crops, but large penalties can be incurred from omitting or reducing key inputs. The effects of reducing inputs to the various crops are discussed in more detail by Young *et al.*, 1994. The skill required to get the correct balance of inputs is likely to become greater as the pressure to reduce inputs increases. Rotations of combinable crops based upon those sown in the autumn produce higher margins than rotations which are based predominantly on spring sown crops.

ACKNOWLEDGEMENTS

The authors are grateful to many ADAS colleagues for their help. Financial support for this work from the Ministry of Agriculture, Fisheries and Food (MAFF) is gratefully acknowledged.

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THE EFFECTS OF REDUCED FERTILIZER AND HERBICIDE INPUT SYSTEMS ON THE YIELD AND PERFORMANCE OF CEREAL CROPS

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ABSTRACT

Results are presented from the first four years of a nine year project in Northern Ireland in which crops under six course arable and arable/grass rotations are treated with full rates, 50% rates or minimum rates of fertilizers and pesticides. Monitoring of the effects on yields, weeds, diseases, profitability, invertebrates and soil mineral status is being carried out. Soil fertility was high at the start and yields with full and half rate inputs with spring and winter barley were similar so that the reduced input plots had higher gross margins. With time the fertility of the reduced input plots has declined and the full rate fertilizer plots have become more profitable. However, the use of half rate herbicides have been sufficient in most cases to give adequate control of weeds. There is evidence of higher weed levels where crop competition has been poorer with reduced herbicide rates.

INTRODUCTION

The Reduced Input Systems of Cropping (RISC) experiment is a nine year project now completing its fifth season at two sites in Northern Ireland. The economic performance of full rate fertilizer and pesticide inputs is being compared with half rates for crops grown under six course arable and arable/grass rotations. The protocol being used is similar to that of the ADAS 'TALISMAN' project in which 'Current Farming Practice' levels of inputs are being compared with 50% rates (Bowerman, 1993), but additional 'Integrated' and 'Minimum' input treatments have been included in the present study. The arable/grass rotation includes four years arable cropping and two years ley and is an alternative rotation representative of Northern Ireland agriculture. Through monitoring changes in the weed burden, the invertebrate population and the soil mineral N content the project aims to investigate not only the economic aspects but also the sustainability of the systems and the environmental effects of adopting lower input strategies.

In this paper only the performance of the cereal crops will be considered with particular reference to the plots which received full rate N (CFP), 50% rate N (LIA) and no N (MIN) together with a) full rate herbicide, fungicide and insecticide, b) half-rate sprays, c) half-rate herbicide with full rates of other sprays, or d) no sprays.

MATERIALS AND METHODS

Replicated field experiments were laid out in 1991 at Hillsborough and 1992 at Greenmount in which two six course rotations are being compared. Each rotation is represented at two phases (Table 1). Rotation A represents a mixed arable system with a two year ley followed by potatoes, winter wheat, spring barley and with the early harvest of winter barley allowing a reseed into ley. In this rotation cattle slurry is normally applied prior to ploughing. In Rotation B oilseed rape and potatoes are the break crops which follow two years of cereals. The Hillsborough soil is a sandy clay loam which had been under ley for a number of years while the Greenmount soil is a clay loam which had been under arable cropping.

TABLE 1. *Rotations used in the RISC experiment at both Hillsborough and Greenmount sites*

Rotation	1991	1992	1993	1994	1995	1996	1997
Phase 1							
Rotation A	S Barley	W Barley	Grass	Grass	Potatoes	W Wheat	S Barley
Rotation B	S Barley	Potatoes	W Wheat	W Barley	W OSR	W Wheat	S Barley
Phase 2							
Rotation A	Grass	Potatoes	W Wheat	S Barley	W Barley	Grass	Grass
Rotation B	S Barley	OSR	W Wheat	S Barley	Potatoes	W Wheat	W Barley

Within each rotation there are four levels of input, Current Farming Practice (CFP), Low Input Approach (LIA), Integrated Low Inputs (ILI) and Minimum Inputs (MIN) but the ILI treatment is not considered further in this paper. All input levels are represented in Phase 2, but only the CFP and LIA in Phase 1. The protocols for the CFP and LIA are based on surveys of current usage of pesticides and recommended fertilizer levels, with the use of 50% rates of these inputs in the LIA treatment. In the MIN treatment no fertilizer has been applied and pesticides have only been used to prevent crop failure. As well as agronomic data on yield and components of yield, weed biomass, levels of disease, soil mineral N and nitrogen uptake are monitored. Weekly monitoring of invertebrate species, mainly ground beetles, also takes place. Comparison of the economic performance of the treatments is made on the basis of gross margin (GM) analyses using costs and output values derived from current commercial values and relevant area payments under the full arable aid scheme.

In three of the four replicate blocks, the main 10 m by 20 m plots are divided into five 10 m by 4 m sub-plots to which reduced rates of herbicide, fungicide and insecticide are applied individually or in combination. The sub-plots therefore allow the effects of reduced rates of each of these components to be studied at both full and half rate nitrogen levels.

RESULTS

Spring and winter barley

The spring barley in the first year after grass ley at Hillsborough showed no yield response to fertilizer nitrogen or weed control and the yield of 6.4t ha^{-1} with CFP inputs was no higher than that with MIN inputs (Table 2). As a consequence the GM of £597 ha^{-1} with CFP inputs was £43 ha^{-1} less than with the use of MIN inputs (Table 3). The principal weeds present were knotgrass (*Polygonum aviculare)* and couch grass (*Elymus repens)*. In the MIN plots to which metsulphuron methyl was applied at 1/8th rate the knotgrass dry weight at harvest was 60g m^{-2} compared with 28g m^{-2} with the full rate application on the CFP plots (Table 4).

TABLE 2. Spring barley grain yields (t ha^{-1})

Site	Nitrogen	Spray applications			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1991 Spring barley,		s.e.m. 0.35	6 d.f.		
Hillsborough	Full N	6.4	6.6	6.4	-
	Half N	6.3	6.3	6.3	-
	No N	-	-	-	6.5
b) 1994 Spring barley		s.e.m. 0.40	46 d.f.		
Hillsborough	Full N	6.4	6.4	6.2	
	Half N	5.0	5.0	5.0	
	No N	-	-	-	3.5
Greenmount	Full N	5.3	5.0	5.1	
	Half N	3.7	3.8	3.3	
	No N	-	-	-	2.9

When spring barley was grown in the same plots in 1994 at Hillsborough yields with the CFP treatments were very similar to those in 1991, but where half rate N had been used yields were much lower (Table 2). However the use of half rate metsulphuron methyl or all sprays at half rate had no significant effects on yields at either site. The GM was consistently lower at the lower N level, but was not significantly affected by the reduced rate spray treatments (Table 3). There was no evidence that weed competition had become any worse between 1991 and 1994 where half rate sprays had been used, but weed biomass at harveste tended to be greater at Greenmount (Table 4). On the plots at Hillsborough with no herbicide or fertilizer, broad leaved weed biomass was 100 g m^{-2} compared with 60 g m^{-2} in 1991.

In the 1991/92 season, winter barley with CFP inputs yielded 7.8 and 6.6 t ha^{-1} at Hillsborough and Greenmount respectively and yields were reduced by no more than 1.2 t ha^{-1} where the half rate fertilizer was used (Table 5). In most cases 50% rate inputs improved the GM in 1992, but the profitability of the plots with full rate N and half rate sprays was poorer

TABLE 3. Spring barley gross margins (£ ha^{-1})

Site	Nitrogen	Spray applications			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1991 Spring Barley					
Hillsborough	Full N	597	622	625	-
	Half N	604	637	637	-
	No N	-	-	-	639
b) 1994 Spring barley					
Hillsborough	Full N	856	868	848	-
	Half N	693	705	698	-
	No N	-	-	-	490
Greenmount	Full N	777	760	765	-
	Half N	539	569	507	-
	No N	-	-	-	396

TABLE 4. Broad leaved weed biomass in spring barley (g $0.5m^{-2}$)

Site	Nitrogen	Spray application			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1991 Spring barley			s.e.m. 3.02	6 d.f.	
Hillsborough	Full N	14.3	-	20.5	-
	Half N	9.0	-	17.9	-
	None	-	-	-	23.2
b) 1994 Spring barley after winter wheat			s.e.m. 3.06	46 d.f.	
Hillsborough	Full N	0.2	0.8	0.9	-
	Half N	0.8	3	3.6	-
	None	-	-	-	50.9
Greenmount	Full N	8.8	14.9	12.2	-
	Half N	3.1	5.7	10.8	-
	None	-	-	-	78.1

at Greenmount (Table 6). However, in the 1994 winter barley crops at both sites, although the CFP treatments had similar yields to 1992, the yield reduction with 50% N was consistently over 2 t ha^{-1} with the consequence that GMs were higher with full rate N (Table 6). The effects of reduced rate herbicide (isoproturon + trifluralin at Hillsborough and isoproturon + diflufenican at Greenmount) or other sprays on yields were small in comparison and generally non significant. At Hillsborough yield was reduced significantly with the combination of low N and half rate sprays (LIA treatment), or with no N or sprays (MIN). However at Greenmount, the results were more variable, but the MIN treatment was very low yielding. Weed competition was light at Hillsborough, but was significantly greater at Greenmount where half rate herbicide was used (Table 7). In 1994 all the low N plots had poor GMs (Table 6).

TABLE 5. Winter barley grain yields (t ha^{-1})

Site	Nitrogen	Spray applications			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1992 Winter Barley		s.e.m. 0.66	46 d.f.		
Hillsborough	Full N	7.8	8.1	7.4	-
	Half N	7.8	7.7	6.6	-
	No N	-	-	-	5.5
Greenmount	Full N	6.6	6.0	5.6	
	Half N	6.0	6.0	6.5	
	No N	-	-	-	4.4
b) 1994 Winter barley		s.e.m. 0.38	46 d.f.		
Hillsborough	Full N	7.7	7.2	7.0	
	Half N	5.1	5.3	5.0	
Greenmount	Full N	6.7	7.1	6.9	
	Half N	4.8	4.8	4.3	

TABLE 6. Winter barley gross margins (£ ha^{-1})

Site	Nitrogen	Spray applications			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1992 Winter Barley					
Hillsborough	Full N	742	803	764	-
	Half N	834	823	740	-
	No N	-	-	-	732
Greenmount	Full N	519	477	455	-
	Half N	511	542	634	-
	No N	-	-	-	539
b) 1994 Winter barley					
Hillsborough	Full N	969	857	855	
	Half N	619	637	657	
Greenmount	Full N	835	905	903	
	Half N	588	572	608	

TABLE 7. Broad leaved weed biomass in winter barley (g 0.5 m^{-2})

Site	Nitrogen	Spray application		
		Full-rate	Half-rate herbicide	All sprays half-rate
1994 Winter barley		s.e.m. 3.06	46 d.f.	
Hillsborough	Full N	0.0	0.0	0.9
	Half N	0.1	0.0	0.9
Greenmount	Full N	4.7	7.4	8.8
	Half N	9.2	20.6	13.6

Winter wheat

The winter wheat following oilseed rape in the autumn of 1992 yielded up to 7.5 t ha^{-1} at Hillsborough but yields at Greenmount were poorer (Table 8). The use of half rate herbicide (metsulphuron methyl) did not significantly increase the weed biomass at Hillsborough, but at Greenmount there was a significant increase with high N plots. Yields were not affected, however, and at the higher N level at both sites the higher GM were with the use of half rate herbicide, or half rate sprays (Table 9). At Greenmount, however, the combination of half rate sprays with half rate fertilizer was less profitable

Sowing of the winter wheat after potatoes was delayed until late January 1993 due to the late harvest of the potatoes and the wet autumn conditions. Establishment at both sites was very poor with a spring plant count of only 50 to 60 m^{-2}. This wheat did not mature until early

TABLE 8. Winter wheat grain yields (t ha^{-1})

Site	Nitrogen	Spray applications			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1993 Wheat after OSR		s.e.m. 0.45	46 d.f.		
Hillsborough	Full N	6.5	6.6	7.4	-
	Half N	6.0	5.8	6.2	-
	No N	-	-	-	4.0
Greenmount	Full N	5.8	6.5	6.1	-
	Half N	5.4	5.0	5.0	-
	No N	-	-	-	3.1
b) 1993 Wheat after potatoes		s.e.m. 0.45	46 d.f.		
Hillsborough	Full N	3.9	3.3	3.3	
	Half N	2.5	2.4	2.5	
Greenmount	Full N	3.6	3.5	3.0	
	Half N	4.4	4.0	4.0	

TABLE 9 Winter wheat gross margins (£ ha^{-1})

Site	Nitrogen	Spray applications			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1993 Wheat after OSR					
Hillsborough	Full N	725	747	864	-
	Half N	720	694	766	-
	No N	-	-	-	578
Greenmount	Full N	625	733	695	-
	Half N	631	587	602	-
	No N	-	-	-	466
b) 1993 Wheat after potatoes					
Hillsborough	Full N	360	306	322	
	Half N	236	245	264	
Greenmount	Full N	303	312	273	
	Half N	451	421	445	

TABLE 10 Broad leaved weed biomass in winter wheat (g 0.5 m^{-2})

Site	Nitrogen	Spray application			
		Full-rate	Half-rate herbicide	All sprays half-rate	No sprays
a) 1993 Wheat after OSR		s.e.m. 15.23		d.f. 64	
Hillsborough	Full N	4.8	2.1	1.2	-
	Half N	1.8	2.5	3.8	-
	None	-	-	-	7.9
Greenmount	Full N	6.1	40.0	26.3	-
	Half N	5.3	9.4	11.5	-
	None	-	-	-	41.0
b) 1993 Wheat after potatoes		s.e.m. 31.42		d.f. 64	
Hillsborough	Full N	15.8	48.8	73.4	
	Half N	28.9	109.8	80.8	
Greenmount	Full N	174.2	237.1	189.3	
	Half N	21.9	74.7	80.0	

October and yields of only 3.7 t ha^{-1} with CFP inputs and 2.8 t ha^{-1} with the LIA inputs were were achieved (Table 8). The poor stand of wheat was a poor competitor against weeds and relatively high weed biomasses were recorded at harvest. Weed biomass increased significantly where reduced rate herbicide was used (isoproturon + bromoxynil + ioxynil), and the weed problem was particularly severe with the high N plots at Greenmount (Table 10). A wide range of weed species were present including chickweed *(Stellaria media)*, fumitory *(Fumaria officinalis)*, hemp-nettle *(Galeopsis tetrahit)* and redshank *(Polygonum persicaria)*, and grass weeds also made a significant contribution. The yields, which were already low, were not reduced any further by the use of half rate herbicide alone, but the yields and GMs were lower when all sprays were applied at half rate.

DISCUSSION

In the first two seasons the application of 50% less N only led to slight reductions in yield due to the high initial fertility of the sites. The use of the half rate herbicides also did not lead to significant reductions in yield as weed control remained adequate. The GM of spring barley in 1991 and winter barley in 1992 therefore tended to be highest with the LIA treatment which included both half rate N and sprays. Even the minimum input treatments had a GM not far below the CFP treatments in some cases. In the 1993 and 1994 crops, however the pattern began to change and the yields of the lower input crops have been falling behind those of the CFP treatments. Weed problems were not particularly evident in early sown wheat after OSR, but the 50% N significantly reduced yields. The GMs were therefore higher with reduced sprays, but at the higher N level. The results from the late sown wheat after potatoes serve mainly as a reminder of how important crop competition is in suppressing weeds. The spring and winter barley crops in 1994 were high yielding only where the full N levels were applied and the continued use of half rate herbicide and other pesticides was sufficient to maintain these yields and thus to give similar or higher GM in most cases.

These results from Northern Ireland are similar to the inital results from the TALISMAN project (Clarke *et al*, 1993). While it would be unwise to extrapolate the results of the first three years into the longer term due to the likely build up of weed problems, and the steady decline in fertility with reduced fertilizer inputs, it is clear that the scope for reducing agro-chemical inputs without significantly reducing profitability may be considerable. Data is being collected on the soil seed bank from samples taken at the start of the project and from samples to be taken at the mid-point and end of the project.

ACKNOWLEDGMENTS

The monitoring of the crops and recording of diseases, pests and weeds has been carried out by staff of the D.A.N.I. Science Service and their contribution is gratefully acknowledged, along with the assistance of staff of the Agricultural Economics and Biometrics Divisions in the interpretation of the results.

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