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The influence of different establishment methods on performance of early-drilled winter wheat

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ABSTRACT

The increased popularity of earlier drilling dates in the autumn for winter wheat crops has resulted in the use of lower seeding rates. These lower seeding rates have highlighted the fact that many conventionally drilled crops have quite uneven seed, and subsequent plant distribution, along the drill rows.

This project investigated the impact of different establishment methods, conventional drilling, precision drilling and broadcasting on plant distributions and subsequent yield performance.

Spatial assessments of plants and general visual observations indicated that, whilst precision drilling produced the most uniform plant distribution along rows the most effective spatial arrangements (equal distances between plants in all directions) were produced by the broadcasting methods. However, there did not appear to be a consistent relationship between any of the spatial arrangements and subsequent yield performance. Eight establishment methods were evaluated at two locations in each of the three seasons. The control establishment method was a conventional air-assisted drill, using 200 seeds/m^2 with a drilling speed of 6 to 9 kph. A total of 16 of the 42 treatments produced yields which were significantly different from that of the control treatment in the six trials. However, only three of those significant responses were increases in yield and 13 of them were significant yield decreases compared to the control treatment.

Margins (£/ha) were calculated for each of the treatments on the basis of the cost of the establishment method plus the cost of the seed subtracted from the value of the grain yield (valued at £65/tonne). Over the three seasons margins ranged from £490 to £769/ha. The two treatments which produced the overall highest margins (averaged across the six trials) were broadcasting using 100 seeds/m^2 and broadcasting using 200 seeds/m^2. Precision seeding (at 200 seeds/m^2) was the third highest average margin and the control treatment produced the fourth highest margin.

Many growers will criticise the broadcasting method as it does not have good depth control of seed, can compromise autumn herbicide decisions and does not have the same pleasing appearance as drilled crops. However, there is no escaping the fact that it can be significantly cheaper to broadcast rather than drill crops.

There has been a marked lack of investment in broadcasting methods by the industry. This study suggests that broadcasting does present opportunities for cost saving and that further development investment should be considered.

Introduction

Many cereal growers are now using seed rates which are significantly lower than those used a decade ago. The drivers of change have mainly been threefold. Firstly, the move towards planting seed by number, rather than seed weight, highlighted the fact that many growers often used too much seed if they did not allow for variations in thousand grain weight of the seed lot being sown.

Secondly, seed cost became an increasingly important factor as margins in the cereal sector tightened and the opportunity to save seed by reducing seed rates was taken by many growers.

Thirdly, and perhaps most importantly, planting dates for autumn-sown cereals have moved earlier in the season and now it is very common for large areas of cereals to be planted by mid September. Not many seasons ago that would have been a target date for many growers to have commenced planting. There are very good technical reasons for reducing seed rates, particularly as planting dates became earlier, as higher seed rate, early-drilled crops are invariably rather thick in the autumn and spring, and can lodge badly and generate more disease.

The use of lower seed rates has highlighted a potential problem that has always been apparent in crops planted by conventional row drill techniques. As the coulters move through the seed bed the seed flow is controlled to varying extents within the drill mechanism but the flow is not uniform, unless of course a precision seeding drill is being used. The imprecise flow can result in an uneven distribution of seed along a drill row. The problem of uneven distribution can be exacerbated by movement of the coulter in the seed bed, sinking deeper in a fine tilth or bouncing out if clods are present. The result of both these actions is the creation of gaps between established plants along rows.

As seed rates have been reduced the gaps in drill rows have become more obvious and have raised questions over their influence on crop performance. At higher seed rates the assumption is that the gaps are less frequent, and less important, as there are more seeds available to reduce the size of gaps.

The first objective of this project was therefore to explore the importance of these gaps in crops. Clearly, one obvious way to reduce gaps in drill rows was to use a precision seeding drill. The

mechanisms within these drills are designed to release seeds in a controlled manner so that they are presented to the seedbed through the coulter at virtually equidistant intervals. A second possible technique to reduce gaps in drill rows would be to reduce the forward speeds of conventional drills. This should maintain the coulter in a more uniform position in the seedbed, reducing the possibility of seed being planted too deep or being delivered onto the surface of the seedbed if the coulter bounced out.

A third alternative to try and reduce gaps in crops would be to move away from drilling in rows and seek a more radical approach to an ideal spatial arrangement for seeds, by using broadcasting. In theory, broadcasting seed should place seeds onto the soil surface with almost equal distances, in every direction, between seeds. In practice, many growers have tried broadcasting cereal crops but the overwhelming majority have undertaken the technique as a last resort. It has been viewed as the only way of establishing the crop, for instance in a wet autumn, when normal equipment cannot prepare a seedbed or travel on the ground to drill the crop. This project investigated broadcasting as the first choice for establishing a crop, primarily because it should present the most uniform spatial arrangement of seeds, and therefore plants, of any method of establishment.

Whilst the project was initially targeted at the potential problems of lower seed rates and the non-uniform distribution of seeds it was inevitable that comparisons between establishment techniques became possible.

Three methods of establishing cereal crops were compared, conventional drilling, precision drilling and broadcasting and they were all conducted at two seed rates to accentuate any potential problems caused by gaps in plant populations. As these techniques have fundamentally different cost structures it presented an excellent opportunity to consider the costs of crop establishment in relation to subsequent yield performance. There have been numerous studies on reducing the costs of crop establishment, primarily focussing on minimal cultivation techniques. This project contained a slightly different approach to reducing the costs of crop establishment: consider broadcasting as the first, rather than the last, option.

The trials were conducted at two locations, Louth in Lincolnshire and Bainton in East Yorkshire and used farm-based equipment on large treatment areas, ensuring that the results had relevance to the on-farm situation.

Methods

The trials were conducted at two locations, Louth, on the Lincolnshire wolds, and Bainton in East Yorkshire. The soil types at the two locations were

Louth - Carstens (wold land, silty and clayey with flints)

Bainton - Panholes (well drained calcareous silty soil over chalk)

The trial plots were each 24m by 34m the size being dictated by the fact that all cultivations and drillings were undertaken using farm machinery. Each plot was replicated twice and the treatment plots were randomised.

The three techniques of establishment were used at both locations for all three seasons. Two seed rates were also used with each establishment technique, 100 and 200 seeds/m^2.

The establishment techniques were as follows:-

Conventional The land was ploughed, disced and then drilled with either a Vicon Air drill or a KPM pneumatic drill. Two forward speeds were also employed for drilling at both seed rates in the conventionally drilled plots.

Precision The land was ploughed, then disced and in 2002 and 2003. A Rau Advancem precision drill was employed. In 2001 an alternative precision drill had been arranged but the manufacturers did not make it available. This unfortunately delayed drilling in autumn 2001 until a replacement, experimental precision drill was located and used.

Broadcast The two locations employed marginally different techniques. At Louth the process began with a power harrow and was then followed by a Tive Bamlett fertiliser spreader to broadcast the seed. The final pass to cover the seed was made by a Wyberg harrow.

In contrast at Bainton the process began with a harrow, followed by a Nodet fertiliser spreader to broadcast the seed. The final pass to cover the seed was made with a power harrow.

A summary of the varieties, planting dates and establishment techniques is presented in Table 1.

Table 1 - Details of the establishment methods used at the two locations over the three seasons.

Louth						
Year	**Variety**	**Date of Planting**	**Broadcast**	**Conventional**	**Precision**	**Speeds for Conventional**
2002	Consort	28th September 2001	Power Harrow + Tive Bamlett + Wyberg Harrow	Vicon LZ520 Air Drill	Modified sugar beet drill	4.7 kph + 8.1 kph
2003	Claire	11 September 2002	Power Harrow + Tive Bamlett + Wyberg Harrow	Vicon LZ520 Air Drill	Rau Advancem	4 kph + 7.5 kph
2004	Claire	12th September 2003	Power Harrow + Tive Bamlett + Wyberg Harrow	Vicon LZ520 Air Drill	Rau Advancem	5 kph and 9 kph

Bainton						
Year	**Variety**	**Date of Planting**	**Broadcast**	**Conventional**	**Precision**	**Speeds for Conventional**
2002	Claire	3rd October 2001	Harrow + Nodet + Power Harrow	KRM pneumatic	Modified sugar beet drill	3 kph + 6kph
2003	Claire	11th September 2002	Harrow + Nodet + Power Harrow	KRM pneumatic	Rau Advance m	3 kph + 6kph
2004	Claire	12th September 2003	Harrow + Nodet + Power Harrow	KRM pneumatic	Rau Advance m	3 kph + 6kph

The costings used for margin calculations were derived from average figures produced by TAG Consulting 2004 Ltd and are presented in Table 2.

Table 2 - The costs (£/ha) of the different establishment methods.

Method of Establishment	Drill Speed	Seeds/m2	Plough	Disc	Drill	Seed	Total
Broadcast		100	-	40	11	15	66
Broadcast		200	-	40	11	30	81
Conventional	Normal	100	35	20	30	15	100
Conventional	Normal	200	35	20	30	30	115
Conventional	Slow	100	35	20	39	15	109
Conventional	Slow	200	35	20	39	30	124
Precision		100	35	20	30	15	100
Precision		200	35	20	30	30	115

The seed cost is halved in the reduced seed rate treatments.

The slower drilling speeds were estimated to produce a small increase in cost per hectare from £30 to £39/ha, for the conventional drills.

The different establishment techniques ranged from £66 to £124/ha

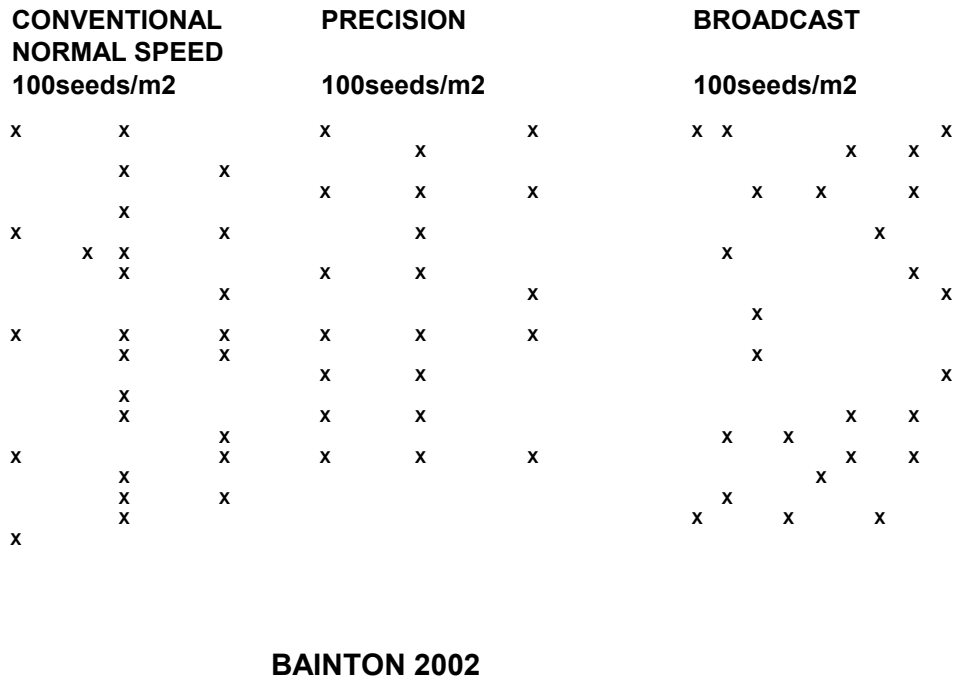
The final margin calculations assumed a grain price of £65/t.

Results

The target drilling date was prior to the middle of September which would realistically require reduced seed rates to be used. This was achieved in the second and third seasons but in the first year of trials (autumn 2001) the planned access to a precision drill did not materialise and the drilling was delayed until late September. It was decided to maintain the seed rates at 100 or 200 seends/m^2 as to increase them would have reduced the need to obtain accurate spatial arrangement from a precision drill.

Once the crops had established they were mapped on a very precise matrix to determine the spatial arrangement of emerged plants in each method of establishment (Graph 1)

Graph 1. The spatial arrangement of plants derived from three of the different establishment methods.



The three treatments illustrated were all drilled at 100 seeds/m^2 at the Bainton location in the 2001/2 season. The map on the left in Graph 1 shows three rows of plants drilled with the conventional drill (KRM pneumatic) at normal speed (6kph). The centre row has quite regular plant spacing but several gaps. On the left, the row is very gappy.

The map in the centre is the precision planted crop and this illustrates the most uniform plant spacing down the rows. However, the row on the right of the three rows does show a considerable number of gaps.

The right hand map is the broadcast crop and this is very different from the other two crops. There are clearly no rows visible and whilst there are areas where the plants are very uniformly separated there are also some gaps. Broadcasting does not produce the 'regimented' rows of plants, with greater distances between rows than between plants within rows, and it does not totally remove gaps in plant populations.

The other results are presented on a location basis.

LOUTH

The % establishment levels obtained from the majority of treatments in autumn 2001 and from the broadcasting treatments in autumn 2003 were rather low (Table 3). The results for 2001 are understandable in that the crop was planted later than anticipated. The lower values for broadcast crops in autumn 2003 were not related to any specific problems.

Table 3 - Plants/m^2 and % establishment values

		2002		2003		2004	
	Seeds/ m^2	**Plants/ m^2**	**% establishment**	**Plants/ m^2**	**% establishment**	**Plants/ m^2**	**% establishment**
Broadcast	100	55	55	53	53	34	34
Broadcast	200	100	50	86	43	67	33.5
Conventional - Normal	100	39	39	50	50	74	74
Conventional - Normal	200	64	32	102	51	110	55
Conventional - Slow	100	36	36	56	56	73	73
Conventional - Slow	200	60	30	82	41	101	50.5
Precision	100	29	29	76	76	67	67
Precision	200	64	32	130	65	106	53

It is not possible to identify any trends in higher or lower levels of establishment associated with different establishment techniques.

The ears/m^2 were assessed prior to harvest (Table 4).

Table 4 - Ears/m^2

	Seeds/m^2	**2002**	**2003**	**2004**
Broadcast	100	638	360	272
Broadcast	200	677	468	336
Conventional - Normal	100	457	374	392
Conventional - Normal (c)	200	476	356	400
Conventional - Slow	100	449	394	384
Conventional - Slow	200	439	392	360
Precision	100	363	378	296
Precision	200	356	366	384

It is noticeable that the season that produced the lower plant populations, 2002, also produced the highest ear populations indicating the compensatory ability of the crop.

Yields in all these seasons were excellent, the averages across all eight treatments being.

2002 - 10.40 t/ha
2003 - 11.70 t/ha
2004 - 10.80 t/ha

The conventional drill (Vicon) at 200 seeds/m^2 with a forward speed of about 8-9 kph was used as the control treatment (Table 5). Seven of the treatments produced yields which were significantly different from the control treatment.

Table 5 - Yield (t/ha) and % of control treatment

		2002		2003		2004	
	Seeds/m^2	**Yield t/ha**	**% of Control**	**Yield t/ha**	**% of Control**	**Yield t/ha**	**% of Control**
Broadcast	100	11.53	111.7*	11.13	92.2*	9.86	89.8*
Broadcast	200	10.91	105.7	11.90	98.6	10.00	90.1
Conventional - Normal	100	9.79	94.9	11.87	98.3	11.61	104.6
Conventional - Normal	200 (c)	10.32	100	12.07	100	11.10	100
Conventional - Slow	100	9.22	89.3*	11.10	92.0*	11.02	99.3
Conventional - Slow	200	10.87	105.3	12.04	99.8	11.21	101.0
Precision	100	9.36	90.7*	11.40	94.4	11.02	99.3
Precision	200	11.17	108.2*	12.12	100.4	10.92	98.4
CV		8.57%		3.33%		7.02%	
LSD		0.67 t/ha		0.74 t/ha		1.12 t/ha	

Broadcasting seed, at 100 seeds/m^2, produced significant yield differences in three seasons. However, in 2002, it was a significant yield improvement +11.7% whereas in 2003 and 2004 there were significant yield decreases of -7.8% and -10.2%. Interestingly the plant populations in these three seasons were 55 plants, 53 plants and 34 plants /m^2 so clearly plant population alone was not the key to the significant yield response in 2002.

The conventionally drilled, 100 seeds/m^2, slow forward speed treatment produced significant yield reductions in 2002 (-10.7%) and 2003 (-8.0%) but a yield very similar to the control treatment yield in 2004.

The precision drilled treatments exhibited two significant yield responses, both in the 2002 season. The 100 seeds/m^2 produced a significant yield decrease of -9.3% but the 200 seeds/m^2 was 8.2% higher than the control treatment.

The number of grains per ear varied dramatically in 2002 but less in 2003 (Table 6). In 2004 they were all much lower than the previous two seasons and only varied across the eight treatments from 54 to 61 grains/ear. In contrast, in 2002, the range was 58 to 88 grains/ear.

The thousand grain weight of the seeds from the eight treatments showed little variation but were markedly lower in 2004 than 2003. Unfortunately samples were not tested in 2002.

Table 6 Grains/ear and TGW (GMS)

	Seeds/m^2	**2002**		**2003**		**2004**	
		Grains /ear	**TGW**	**Grains /ear**	**TGW**	**Grains /ear**	**TGW**
Broadcast	100	75	-	78	47	58	41
Broadcast	200	58	-	66	47	59	42
Conventional - Normal	100	73	-	76	46	54	41
Conventional - Normal	200 (c)	67	-	65	48	58	40
Conventional - Slow	100	88	-	75	48	61	41
Conventional - Slow	200	73	-	70	46	61	41
Precision	100	86	-	67	45	54	42
Precision	200	65	-	65	46	56	42

The specific weights in the 2004 season were much lower than those produced in either 2002 or 2003 (Table 7). However, there were no trends relating specific weights, either higher or lower, to particular establishment treatments.

Table 7 - Specific weights (kg/hl)				
	Seeds/m^2	**2002**	**2003**	**2004**
Broadcast	100	76.0	76.0	65.6
Broadcast	200	76.7	76.1	66.5
Conventional - Normal	100	74.6	73.4	66.9
Conventional - Normal (c)	200	76.3	76.5	66.1
Conventional - Slow	100	72.9	76.0	67.5
Conventional - Slow	200	76.6	74.7	66.0
Precision	100	74.4	74.2	66.0
Precision	200	76.5	76.0	66.4

In three seasons of trials at this location, five treatments produced yields which were significantly less than that of the control treatment (conventional drill, 200 seeds/m^2, normal forward speed). However, a further two treatments produced yields that were significantly higher than the control treatment.

BAINTON

The lowest establishment levels at Bainton were produced from the 2003 trials, the highest plant population being only 96 plants/m^2 from the precision drilled, 200 seeds/m^2 (Table 8). In comparison treatments in 2002 and 2004 produced up to 144 and 208 seeds/m^2 from specific treatments.

The broadcast treatment in 2004 appeared to give plant populations higher than the number of seeds sown. This is probably the result of bunching, produced by the post-broadcasting power harrow treatment.

Table 8 - Plants/m^2 and % establishment values

		2002		2003		2004	
	Seeds/ m^2	**Plants/ m^2**	**% establishment**	**Plants/ m^2**	**% establishment**	**Plants/ m^2**	**% establishment**
Broadcast	100	74	74	48	48	145	100+
Broadcast	200	110	55	72	36	208	200+
Conventional - Normal	100	89	89	50	50	71	71
Conventional - Normal	200	144	72	74	37	136	68
Conventional - Slow	100	81	81	41	41	72	72
Conventional - Slow	200	144	72	70	35	143	71.5
Precision	100	62	62	63	63	94	94
Precision	200	110	55	96	48	168	84

The impact of the lower establishment levels in 2003 is clearly seen in a comparison of the range of plant populations in the three different seasons

2002 62 to 144 plants/m^2
2003 41 to 96 plants/m^2
2004 71 to 208 plants/m^2

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The ear populations in 2003 were lower than 2002 or 2004 reflecting the lower initial plant populations (Table 9).

Table 9 - Ears/m^2				
	Seeds/m^2	**2002**	**2003**	**2004**
Broadcast	100	355	262	647
Broadcast	200	458	300	666
Conventional - Normal	100	365	293	411
Conventional - Normal	200	423	337	469
Conventional - Slow	100	367	340	430
Conventional - Slow	200	425	377	419
Precision	100	323	288	418
Precision	200	477	348	420

The Bainton location also produced excellent yields, the averages for the three years being.

2002 - 11.9 t/ha

2003 - 11.4 t/ha

2004 - 12.2 t/ha

The lower plant populations and ear populations are perhaps reflected in the lower overall yields in 2003.

A total of nine significant yield differences were produced over the three seasons of trials but only one of them was a significant yield increase over the control treatment of conventional drill (KRM pneumatic), 200 seeds/m^2 with a forward speed of 6 kph (Table 10).

Table 10 Yield (t/ha) and % of control treatment							
		2002		**2003**		**2004**	
	Seeds/m^2	**Yield t/ha**	**% of Control**	**Yield t/ha**	**% of Control**	**Yield t/ha**	**% of Control**
Broadcast	100	11.37	92.6*	11.57	94.8	12.71	105.6*
Broadcast	200	11.79	96.0*	11.98	98.1	12.17	101.1
Conventional - Normal	100	12.21	99.4	9.76	79.9*	11.77	97.8
Conventional - Normal	200 (c)	12.28	100	12.21	100	12.04	100
Conventional - Slow	100	12.22	99.5	11.29	92.5*	12.09	100.4
Conventional - Slow	200	12.07	98.3	11.26	92.2*	12.55	104.2
Precision	100	11.58	94.3*	10.82	88.6*	12.11	100.6
Precision	200	11.93	97.1*	12.17	99.7	12.16	101.0
CV		1.45%		2.66%		3.76%	
LSD		0.24 t/ha		0.89 t/ha		0.66 t/ha	

The broadcasting treatment produced two significant yield reductions, both in 2002 from the 100 and 200 seeds/m^2 and a significant yield increase in 2004 from the 100 seeds/m^2.

The conventional drilling produced three significantly lower yielding treatments, all in the 2003 season. Both 100 seeds/m^2 treatments were significantly lower yielding as was the 200 seeds/m^2 at the slower drilling speed.

The precision drilling also produced three significantly lower yielding treatments, two in 2002 (100 and 200 seeds/m^2) and the 100 seed/m^2 in 2003.

In both 2002 and 2003 no treatments outyielded the control treatment and in both seasons four treatments produced significantly lower yields. In contrast, in 2004, only one treatment was lower yielding than the control (and it was not a significant yield reduction) and one treatment produced a significant yield increase.

The grains/ear were again lowest in 2004 as they were at the Louth location (Table 11). The broadcast, 100 seeds/m^2 treatment produced some of the lowest grains/ear counts, but there were no other clear trends relating grains/ear to specific treatments.

Thousand grain weights were not assessed in 2002, but in 2003 (Table 11); they were substantially lower than 2004.

In both seasons the range was only 4 gms across the eight treatments.

Table 11 Grains/ear and thousand grain weight (gms)

		2002		2003		2004	
	Seeds/m^2	**Grains /ear**	**TGW**	**Grains /ear**	**TGW**	**Grains /ear**	**TGW**
Broadcast	100	71	-	80	51	63	58
Broadcast	200	61	-	63	50	53	55
Conventional - Normal	100	64	-	75	51	66	59
Conventional - Normal	200 (c)	63	-	66	51	57	58
Conventional - Slow	100	60	-	77	52	62	58
Conventional - Slow	200	64	-	64	50	56	57
Precision	100	76	-	76	54	58	58
Precision	200	66	-	71	51	60	57

Specific weights were lowest in the 2004 season (Table 12), which again agrees with the Louth data. However, in all three seasons the variations across the eight treatments were small and did not indicate any trends relating to treatments.

Table 12 - Specific weights (kg/hl)

	Seeds/m^2	2002	2003	2004
Broadcast	100	77.6	77.1	70.9
Broadcast	200	77.4	77.1	70.9
Conventional - Normal	100	76.4	76.1	71.1
Conventional - Normal	200	76.8	76.9	70.9
Conventional - Slow	100	76.6	76.8	71.4
Conventional - Slow	200	76.6	77.3	70.5
Precision	100	75.4	76.1	71.4
Precision	200	77.2	77.2	71.1

The yield performance over the two locations and three seasons is summarised in Table 13.

Table 13 - Yield performance (as a % of the control establishment method) in the six trials

Method of Establishment		Bainton			Louth		
	Seeds/m^2	2002	2003	2004	2002	2003	2004
Broadcast	100	93*	95	106*	112*	92*	89*
Broadcast	200	96*	98	101	106	99	90
Conventional - Normal	100	99	80*	98	95	98	105
Conventional - Normal	200 (c)	100	100	100	100	100	100
Conventional - Slow	100	100	92*	100	89*	92*	99
Conventional - Slow	200	98	92*	104	105	100	101
Precision	100	94*	89*	101	91*	94	99
Precision	200	97*	100	101	108*	100	98
*significantly different from control treatment							

A total of 16 treatments produced yields which were significantly different from those of the control treatment of the conventional drill, 200 seeds/m^2 at the faster forward speed. Three of the significant yields were higher than the control treatment.

Broadcast	100 seeds/m^2	-	2002	Louth	(55 plants)
	100 seeds/m^2	-	2004	Bainton	(145 plants)
Precision	200 seeds/m^2	-	2002	Louth	(64 plants)

The actual numbers of plants/m^2 from these three locations are presented in brackets. The range is considerable - from 55 to 145 plants/m^2.

A total of 13 of the 16 significant yield differences were actually lower yielding than the control treatment.

Broadcast		100 seeds/m^2	-	2002	Bainton
		100 seeds/m^2	-	2003	Louth
		100 seeds/m^2	-	2004	Louth
		200 seeds/m^2		2002	Bainton
Conventional	Normal	100 seeds/m^2	-	2003	Bainton
	Slow	100 seeds/m^2	-	2002	Louth
	Slow	100 seeds/m^2	-	2003	Louth
	Slow	100 seeds/m^2	-	2003	Bainton
	Slow	200 seeds/m^2		2003	Bainton
Precision		100 seeds/m^2	-	2002	Louth
		100 seeds/m^2	-	2002	Bainton
		100 seeds/m^2	-	2003	Bainton
		200 seeds/m^2		2002	Bainton

The 100 seeds/m^2 seed rate accounted for 10 of the 13 significant yield reductions that were recorded. However, the significantly lower yielding treatments were found in all three establishment techniques.

The margins for each treatment were calculated using the figures indicated in Table 2 and a grain price of £65/t. The significant yield responses are also indicated in the same presentation (Table 14).

Table 14 Margins (£/ha)

Method of Establishment		Bainton			Louth			
	Seeds/m^2	2002	2003	2004	2002	2003	2004	Mean
Broadcast	100	682-*	695	769+*	692+*	666-*	590-*	682
Broadcast	200	685-*	698	710	628	693	569	664
Conventional - Normal	100	694	534-*	665	536	672	655	626
Conventional - Normal	200 (c)	683	679	668	556	670	607	644
Conventional - Slow	100	685	625-*	677	490-*	613-*	607	616
Conventional - Slow	200	661	608-*	692	583	659	605	634
Precision	100	644-*	594-*	678	499-*	632	607	609
Precision	200	660-*	676	675	611+*	673	595	648

(c) Control
*- produced a significant yield reduction compared to control treatment
*+produced a significant yield increase compared to control treatment

Generally the lowest margins were produced from the Louth 2002 location (£490 to £692) and the overall spread in margins was £279 from £490 to £769.

When averaged across the six trials, the margins ranged from £609 (Precision, 100 seeds/m^2) to £682 (Broadcast, 100 seeds/m^2). The two broadcasting treatments (at 100 and 200 seeds/m^2) produced the highest margins of all eight treatments. This was in spite of the fact that at Louth in 2004 they were the two treatments which produced the lowest margins.

The two treatments that produced the overall lowest margins were Precision (100 seeds/m^2) and Conventional (slow, 100 seeds/m^2). In theory those two treatments should have produced some improved spatial arrangements of plants but the yield performances did not suggest they were beneficial approaches.

The rank orders of margin performance are presented in Table 15 and indicate the consistent superiority of broadcasting as a cost-effective approach. Broadcasting was 1st (100 seeds/m^2) and 2nd (200 seeds/m^2) in the rank order. The control treatment, (conventional, normal, 200 seeds/m^2) was 4th overall in the rank order with an average margin across the six trials of £644. The third

placed treatment was precision (200 seeds/m^2) but dropping the seed rate to 100 seeds/m^2 reduced its rank order to 8th.

Table 15 Rank order of margins								
Method of establishment		**Bainton**			**Louth**			
	Seeds/m^2	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**Mean**
Broadcast	100	5	2	1	1	5	7	1
Broadcast	200	2	1	2	2	1	8	2
Conventional - Normal	100	1	8	8	6	3	1	6
Conventional - Normal	200 (c)	4	3	7	5	4	2	4
Conventional - Slow	100	2	5	5	8	8	2	7
Conventional - Slow	200	6	6	3	4	6	5	5
Precision	100	8	7	4	7	7	2	8
Precision	200	7	4	6	3	2	6	3

Discussion

The original objective of this project was to explore how different techniques of establishment influenced the spatial arrangements of plants and subsequently the yield performance of those crops, in particular at lower seed rates.

Lower seed rates produce crops where gaps in rows, where seeds are missing, are more obvious and larger. This naturally inferred to many growers that yield potential was being eroded. Could the extent of gaps in crop be markedly influenced by establishment technique? Another driving force behind the project was the cost of establishing crops. Many growers have addressed these costs by moving towards minimum cultivation techniques but there has been very little development work in the area of either extremely precise planting techniques (precision drilling) or randomly distributed low cost establishment (broadcasting) in cereal crops.

By comparing conventional establishment techniques with precision drilling and broadcasting, this project has investigated their effects upon plant spacing, yield performance and margins (£/ha).

There is no doubt that the crops produced by the different establishment techniques had very contrasting appearances. The most uniform plant spacing, along the drilled rows, was created by the precision drill. However, the row format was of course still retained and therefore a totally random spatial arrangement could not be achieved by that technique. The same was true for the conventional drilling approaches. It was felt that by reducing the forward speed at drilling the arrangement of seeds (and therefore plants) along the drill rows would be more even. There was again some indication that this had been achieved but once again the row format eliminated the possibility of a totally random spatial arrangement.

Broadcasting of seed on the other hand does not restrict seed placement to rows. Ideally the technique should produce a totally random distribution of seeds on the surface of the seedbed. Whilst this may actually be achieved at the time of broadcasting, the process of covering the seeds after broadcasting, in these trials by harrowing or power harrowing, can actually realign the seeds in a more regular pattern, lining up with tines for example. There was some evidence in one of the trials, Bainton 2004, that the post-broadcasting cultivation using a power harrow created some seed bunching.

Overall there were some indications that using a precision drill or reducing the forward speed of a conventional drill did reduce the amount and size of 'gaps' along drill rows. However, mapping of emerged plants demonstrated that the most random spatial arrangement, with the most similar distances between plants in all directions, was produced by broadcasting.

Apart from the previously mentioned trial (Bainton), where the possibility of seed bunching produced apparent high levels of plant establishment from broadcasting, there were only two other indications of establishment technique influencing establishment levels. Both also occurred with broadcasting but produced conflicting results. At Louth (2002) the highest levels of establishment, 11% to 26% higher than any other technique of establishment, were obtained from the two broadcasting treatments. However, at the same location in 2004 the same two treatments of broadcasting were 17% to 41% lower establishing than other techniques. Once again there could be the impact of bunching as a result of post-broadcasting cultivations. However, the techniques employed to assess plant populations, random counts over several points in each replicate block, were adopted to eliminate these occurrences.

At first sight the yield data would suggest that a large proportion of the establishment techniques used in the trials were unsuccessful as 13 of the total of 42 alternative treatments were significantly lower yielding than the conventional approach. Only three treatments produced yields significantly greater than the control establishment technique of conventional drill, normal forward speed with 200 seeds/m^2 and 10 of the 13 significantly lower yielding treatments were at the lower seed rate of 100 seeds/m^2. In the 2001/2 season, when planting was delayed until late September/early October as a result of unavailability of the precision drill, the reduced seed rate would have been a higher risk strategy. In fact, four of the significant yield reductions were generated in the 2001/2 season from seed rates of 100 seeds/m^2. In 2002/3 and 2003/4 the planting dates were 11th and 12th of September, when agronomically 100 seeds/m^2 would be more suitable than when later planted. However the 100 seeds/m^2 also produced significant yield reductions in those two seasons. In 2002/3 5 trials using 100 seeds/m^2 were significantly lower yielding than the control treatment and in 2003/4 one trial was significantly lower yielding.

2002/3 - 5 trials
2003/4 - 1 trial

These 10 significant yield reductions would suggest that it was the seed rate rather than the method of establishment that was the more influential factor on yield performance.

However, this hypothesis is not totally sound as two of the three significant yield improvements were produced by establishment techniques involving 100 seeds/m^2.

The most interesting results relate to the final costings associated with the different techniques of establishment. The costs used in those analyses, that ranged from £66/ha to £124/ha (when seed is included in the costings) do refer to the variable costs of establishing the crops. They do not include any costs relating to the depreciation of equipment (this would be particularly relevant for the precision drilling approach) or for the fact that drills are already present of farms. A number of growers, who have been involved in discussing these preliminary results from these trials, have indicated that if one moved, for example to broadcasting, then cost savings would only result if the other drills on farm were sold. This will be referred to again later in this discussion.

It is also clear that within each type of establishment technique it was not possible within this project, to evaluate a number of different approaches. There was a single method of seed bed preparation, prior to precision drilling or conventional drilling. Prior to broadcasting seed the two locations did adopt slightly different techniques but they were consistent at each location over the three seasons of trials.

It is accepted that there are potentially a large number of alternative soil cultivation techniques that could have been used prior to each method of establishment. Within the confines of this project it was only feasible to adopt one approach.

Accepting the limitations placed on the project it is nevertheless very interesting that the most cost-effective treatments, averaged across the six trials, were the two broadcasting treatments. Broadcasting was used in 12 treatments (2 locations x 3 years x 2 seed rates) and on eight occasions it produced the first or second most cost effective establishment method of the eight techniques evaluated. At 200 seeds/m^2 it produced a margin £20/ha in excess of conventional drilling and at 100 seeds/m^2 the comparison with conventional drilling (at 100 seeds/m^2) produced a £56/ha increased margin.

Precision drilling did produce disappointing results in particular at 100 seeds/m^2 where on the six occasions it was evaluated it was either seventh or eighth in rank order of margin/ha. The margin

did not reflect any costs associated with acquiring a precision drill which would also impact to an extent on the returns from the technique.

It is very clear that broadcasting, used as the first option to establish a crop, not as the last resort when all else fails, produced extremely interesting results in this project. The information should not be interpreted as a signal for all growers to opt for broadcasting and dispose of their more conventional establishment techniques. However, it does suggest that the technique should be evaluated more seriously by those growers who wish to address their costs of establishing crops. It will not be the correct option in all situations. Broadcasting does not present tramlines in the manner that virtually all current drilling techniques achieve. It can also compromise some weed control choices as the depth of seed may preclude some chemical approaches. There is also a view from some current users of broadcasting techniques that slightly higher seed rates should be used, a factor that was not considered in this project. These are valid criticisms of broadcasting but criticisms that can be addressed by further studies.

It is interesting to speculate upon the level of investment that has taken place over the past decade on effectively preparing seed beds and drilling crops using conventional drilling techniques. In contrast, how much money and research time has been invested in improving methods of broadcasting seed to establish cereal crops? Almost every grower has had experience of broadcasting seed. When questioned, the vast majority will accept that it was the only way that a crop could have been established as conditions at the time did not allow drilling to take place. Very few growers have ever used broadcasting as the first option. The results from these studies indicate that broadcasting has potential advantages in reducing the establishment costs of cereal crops. The visual appearance of the crop may not be as attractive as the perfect symmetry of rows of plants in a conventionally-drilled crop. The broadcast crops may not always be the highest yielding crops. However in margin terms it would appear that broadcasting has several attractions to growers and should be more widely evaluated.

Appendix 1

An aerial view of the Bainton trial location in 2002. Note the size of the establishment plots, in the Centre of the photograph in comparison to conventional replicated trial plots (12m long x 2m wide) at the top right, and extreme right centre of the photograph.