HGCA

PROJECT REPORT No. 232

EVALUATION OF POTENTIAL VARIETIES OF WINTER OATS FOR IMPROVED ECONOMIC COMPETITIVENESS

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by

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This is the final report of a three year project which started in May 1995. In view of the preliminary nature of the information, a two year moratorium on publication was agreed between HGCA and other sponsors (MAFF and Semundo) of the IGER oat breeding and research programme. As a result, IGER has included an updated section which indicates the subsequent development of genetic material mentioned in the report. The work was funded by a grant of £242,401 from Home-Grown Cereals Authority (project no. 1666).

EVALUATION OF POTENTIAL VARIETIES OF WINTER OATS FOR IMPROVED ECONOMIC COMPETITIVENESS

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Excellent progress was made in developing good all-round competitive varieties of husked winter oats for human and animal consumption. Earlier work that resulted in the release of the varieties Gerald, Chamois, Emperor, Viscount and Kingfisher has brought benefits to growers and end-users, in terms of increased competitiveness, ease of production and quality. Two closely related lines 87-42CnI/2/2/1 and 87-42CnI/2/2/2, the culmination of a complex series of crosses initiated in 1980, were entered into 1997 NL1 trials. 87-42CnI/2/2/1 proceeded to 1998 NL2 trials and was named Millennium, as an expression of IGER's confidence that this variety represents a major improvement in the oat crop.

91-33Cn4 represents a further advance over Gerald in shortness of straw and lodging resistance. It was about 9cms shorter than Gerald in 1996 and 2cms shorter in 1997. The line has large grains and high kernel content.

In a trial in 1995 of near-isogenic lines with and without the *DW6* dwarf gene, husked dwarf oats outyielded tall lines by 5.3%. Further testing of dwarf lines was undertaken in 1996 and 1997, but no varieties were at the time considered to meet the standards necessary for submission to National List trials.

Millennium was virtually completely dehulled in 40 seconds, Viscount in 70 seconds and 90-98Cn4/1 in 120 secs. In other words, it took three times as long to remove husks from 90-98Cn4/1 as from Millennium, which would have considerable energy and throughput implications.

The husks of Millennium, being so well-filled, are also readily removed during combining. It will therefore be necessary for advice to be given on combine settings for this variety in order to capitalise on its value to the milling industry.

The use of oats for animal feed is also an important market for oats, as for cereals in general. Since winter oats generally have lower husk contents and higher oil levels than spring oats, in which most work has been done in the past, we determined differences in predicted metabolisable energy between 10 advanced varieties at three locations in 1996. Results indicate a range in variation from 13.2 for Mirabel to 13.8 for Millennium and 14.0 for 87-42CnI/2/2/2, a difference of 0.8MJ/kg.

Considerable scope remains for developing new oat germplasm that will present farmers and end-users with valuable new options.

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Considerable scope remains for developing new oat germplasm that will present farmers and end-users with valuable new options.

Introduction

The objectives of this project were to develop competitive varieties of husked winter oats for human and animal consumption. Good all-round varieties are required. The breeding programme has to take into account quality characteristics sought in the market place as well as production aspects. Reduced husk content and higher metabolisable energy will also be valuable for feeding to ruminants.

For the genetic improvement of oats, pre-competitive research at IGER is funded by MAFF and BBSRC. The work reported here, which is aimed at bringing material to a stage to which it can be developed, is funded by HGCA, while the near-market development of varieties is funded by industry. Past experience has shown that the uptake of previous work in terms of bringing promising lines to commercial development is high.

Numbers of potential winter oat varieties tested - 'conventional height' material

88 conventional height lines (excluding controls) were tested in 1995, of which 21 were selected for further testing in 1996. A total of 88 lines (21 from 1995 and 67 new entries were tested in 1996, of which 16 were selected for further testing in 1997. 53 lines (including 37 new entries) were tested in 1997, of which 14 were selected for further testing in 1998. Higher discard rates in 1996 and 1997, and fewer new entries into 1997 trials reflect a) excellent conditions for selection for stiffer-strawed varieties and b) the high standard of yield, agronomic and quality characters set by Millennium identified in this project (see below).

Earlier work which has now reached fruition

Gerald has gained market share from 35.7% in 1995-96 to 47.8% in 1996-97 and 58.5% in 1997-98 plantings. This is a much larger share of its market than any other cereal of any significance, a measure of its popularity with growers (by virtue of its short, stiff straw) and millers.

Chamois (81-40Cn5/1) has high milling quality, good resistance to oat mosaic virus (OMV) and the PAV isolate of barley yellow dwarf virus (BYDV), but tall straw. After being fully recommended on the UK Recommended List since 1994, seed sales of remained low, and the variety was removed from the List in 1998.

Emperor has given high levels of yield in fungicide-untreated trials and has good resistance to mildew and crown rust, but had like Chamois, has not proved as popular with farmers as Gerald, and after two years of provisional recommendation, was moved to the outclassed category in 1998.

Kingfisher (89-26Cn6/1) and **Viscount** (89-26Cn14/1) involving Gerald and an immediate progenitor of Chamois in their parentage were added to the National List in 1997 and are in

Recommended List trials in 1998. Viscount has short straw (as short as Gerald) and early maturity.

Genetic advances in winter oats during the project

The two closely related lines 87-42CnI/2/2/1 and 87-42CnI/2/2/2, are the culmination of a complex series of crosses initiated in 1980 aimed at combining high grain numbers and resistance to mildew from Bardsey with the grain characteristics and resistance to diseases including oat mosaic virus and crown rust from Lustre and agronomic characters from a sister line of Craig and from Rosette. They performed extremely well in breeders' trials in 1995 and 1996, yielding 6-9% more than Gerald, with similar short straw, and in addition, high disease resistance, high kernel content (mean of 76.2% compared to 73.1% for Gerald) and large grains (39.3g compared to 33.0g for Gerald). Both were entered into 1997 NL1 trials, and on the basis of the 1997 results, 87-42CnI/2/2/1 proceeded to 1998 NL2 trials. 87-42CnI/2/2/1 has been named **Millennium**, as an expression of IGER's confidence that this variety represents a major improvement in the oat crop. The grain characteristics of Millennium will be considered in later sections.

The line 91-33Cn4 represents a further advance over Gerald in shortness of straw and lodging resistance. It contains in its parentage a sister selection of the 87-42Cn lines mentioned above and a source of semi-dwarf habit from the USA not previously used in the UK. It was about 9cms shorter than Gerald in 1996 and 2cms shorter in 1997. The line has large grains (TGW of 37.2g in 1996 compared to 37.2g for Gerald in 1996 and 45.1g compared to 37.5g for Gerald in 1997). It also has high kernel content (mean of 76.9% compared to 73.4% for Gerald). Sieving losses through a 2.1mm sieve (7.5%) are surprisingly high, although still below the normal standard of 10% required by oat millers (Anon, 1998).

Mildew, crown rust and oat mosaic virus are the main diseases for which resistance is being sought.

A number of lines containing PC 54, an extremely effective source of adult plant resistance, are at earlier stages in the breeding programme (Clothier, Roderick & Valentine, 1995).

Crown rust has become more important in south-west England and could become more important generally if the climate becomes warmer. The 87-42Cn lines were resistant to crown rust in a naturally occurring infection in trials in Cornwall and in artificially inoculated tests at IGER in 1995 using the most prevalent simple race found in UKCPVS surveys (Jones & Clifford, 1996). In 1996, a mixture of races were used. This attacked all lines proceeding to 1997 trials, though some lines with low percentage infection, namely the 87-42Cn lines have levels of moderate resistance (6 or 7 on the NIAB scale). This level of resistance is defined as 'Disease may develop under favourable conditions but yield is unlikely to be substantially reduced' (Anon 1998). New highly effective sources of resistance have been introduced into the programme.

For oat mosaic virus, most lines have high levels of resistance. This is in sharp contrast to the equivalent mosaic diseases in barley. A notable exception is Gerald, although the variety is certainly more resistant than the old variety Maris Osprey and probably more resistant than Peniarth. Yield reductions could occur if oats were grown too frequently in the rotation.

Dwarf winter oats

A promising open-panicled dwarf mutant, OT207, was described in 1980 (Brown, McKenzie and Mikaelson, 1980). It has a dramatic effect on plant height (20-50 cm reduction) which would make the oat crop far easier to manage. The gene, designated *Dw-6* (Simons *et al*, 1978), is dominant and does not incidentally suppress the naked oat characteristic so that it is also feasible to breed a dwarf naked oat. In Australia, cultivars of husked oats (Echidna and Dolphin) and naked oats (Bandicoot) containing this gene have been produced and have been very well received by farmers.

Work in the Cytogenetics Group has shown this gene is located on chromosome II (Mia, 1984). Various sources of this gene in spring oat backgrounds have been used in the winter programme. A number of crosses have been performed in order to increase the contribution of adapted genes and decrease the contribution of unadapted genes. Initial material was particularly susceptible to mildew, oat mosaic virus, leaf browning and winter-kill.

Seven pairs of related tall and dwarf lines and control varieties Solva and Gerald were included in a trial to quantify the effect of the dwarf gene *DW6* on yield and other characteristics in 1995. (Table 1).

For the six husked oats comparisons, dwarf lines yielded a mean of 104.1% and tall lines 98.9% relative to Gerald at 100%. This corresponded to a yield advantage resulting from the incorporation of the dwarf gene of 5.25%. The three best dwarf lines gave yields of over 109% relative to Gerald.

The most promising pair of related lines (92-88ACnI dwarf and tall) were also entered into trials at Gogerddan and Berriew in 1996. Yield and other characteristics are shown in Table 2.

Table 1 Characteristics of related tall (dw6) and dwarf (DW6) lines compared to Solva and Gerald

	Pedigree	Ear emergence			Height (cms)				Lodging	Yield (t/ha)				Yield (%)			
		1993	1995	Mean	1993	1995		Mean	1993	1993	1995		Mean	1993	1995		Mean
		w	w		w	w	B		w	w	w	b		w	w	b	
Solva	(Pennal x (Padam x Nelson)) x Oyster	9.0	8.3	8.6	171	113	142	142	58	[5.57][1]	5.05	9.05	[6.56][1]	[71][2]	116	99	[96.5][2]
Gerald	Bulwark x 76-17Cn26	9.0	9.7	9.3	146	88	127	120	0	7.84	4.33	9.10	6.80	100	100	100	100.0
89-158ACn5 dwf	S x F_3 86-97Cn (= S^2 x Pa8494-1936)	9.0	6.7	7.8	107	83	110	100	0	7.73	5.37	8.23	7.11	99	124	90	104.6
Tall		4.3	3.7	4.0	180	142	155	159	58	6.07	4.28	7.68	6.01	77	99	84	88.4
89-158ACn9 dwf		12.0	13.0	12.5	112	76	109	99	0	7.45	5.57	9.29	7.44	95	128	102	109.4
Tall		6.0	5.3	6.1	178	133	147	153	75	6.45	5.28	9.09	6.94	82	122	100	102.1
89-158ACn14 dwf		12.3	7.3	9.8	105	72	102	93	0	8.37	5.60	8.57	7.51	107	129	94	110.4
Tall		5.3	6.0	5.6	177	130	148	152	62	6.69	5.07	8.14	6.63	85	117	89	97.5
89-166ACnI/1 dwf naked	83-87CnII/1/1 x F_3 86-97	10.3	7.3	8.8	97	67	97	87	0	6.17	3.92	6.44	5.51	100	90	71	81.0
Tall		3.7	3.0	3.3	159	124	135	139	29	6.95	3.65	6.52	5.71	82	84	71	84.0
91-59ACnII dwf	S^3 x 86-97Cn (= S^4 x Pa8494-1936)	-	14.0	14.0	-	65	96	80	-	-	4.51	8.19	6.35	-	104	90	93.4
Tall		-	7.3	7.3	-	105	128	116	-	-	4.39	8.26	6.32	-	101	91	92.9
92-86ACnII dwf	S^4 x 86-97Cn (= S^5 x Pa8494-1936)	-	14.0	14.0	-	62	97	79	-	-	5.28	7.93	6.60	-	122	87	97.1
Tall		-	6.7	6.7	-	112	136	124	-	-	5.05	8.92	6.99	-	116	98	102.8
92-88ACnI dwf	$Emperor^2$ x (S^2 x F_3 86-97Cn) (= $Emperor^2/S^3$ x Pa8494-1936)	-	14.0	14.0	-	67	102	84	-	-	6.07	8.84	7.45	-	140	97	109.6
Tall		-	8.0	8.0	-	119	137	128	-	-	5.67	9.21	7.44	-	131	101	109.4
Mean dwf		10.9	10.9	10.9	105	70	102	90		7.43	5.19	8.21	6.86	94.8	119.9	90.2	100.9
Mean tall		4.8	5.7	5.4	173	124	141	142		6.54	4.77	8.26	6.52	83.4	110.2	90.8	95.9
Variety																	
Prob		<.001	<0.001		<0.001	<.001	<.001		<0.001	0.018	<0.001	<0.001		-	-	-	
SED		0.50	0.69		3.4	5.1	3.9		28.3	0.717	0.292	0.330		-	-	-	

______ = naked [ ][1] grain lost due to bird damage

Table 2 Characteristics of 92-88ACn1 dwarf and tall in 1996

	Ear emergence[1]		Height	Lodging[2]		Yield (t/ha)	Yield %
	w	b		w	b	w	w
Solva	48.3	58.7	142	4.3	8.0	8.46	94.8
Gerald	48.0	60.3	127	2.0	7.0	8.92	100.0
92-88ACn1 dwarf	53.0	62.0	90	1.0	1.0	9.55	107.1
92-88ACn1 tall	47.0	59.0	147	7.7	8.0	8.10	90.8

w = Plas Gogerddan, Aberystwyth; b=Berriew (Powys)
[1] - days after May 1; [2] – 1=no lodging; 9=completely lodged

In addition to generating and selecting breeding material containing the dwarf gene, 11 lines were tested in 1996 in fungicide-treated trials. Of these, two lines (91-61Cn4/1 and 92-88Cn) were selected to proceed to 1997 trials. Results are shown in Table 3. 92-88Cn was much stiffer than Solva and Gerald. It yielded 10.05t/ha, 17.5% more than the mean of Gerald and Solva at Gogerddan in 1996, but less well in 1997. Notably, 92-88Cn had better resistance to mildew than either Solva or Gerald. The initial problems of susceptibility to mildew, oat mosaic virus and adverse winter conditions appeared to have been overcome. However, poor extrusion of the panicle from the flag leaf was noted in 1997. Although results from these trials were ambiguous, it was considered that this line did not meet the standard to be submitted to National List trials. Further testing of dwarf oats is required. 23 dwarf winter oats are being tested in 1998.

Table 3 Summary of husked dwarf winter oats proceeding to 1998 trials

	Ear emergence			Height			Lodging
	1996	1997	Mean	1996	1997	Mean	1996
Solva	55.0	32.7	43.8	151	145	148	6.9
Gerald	55.6	32.8	44.2	125	128	127	6.5
86-97Cn4/1	55.5	33.3	44.4	108	104	106	5.8
91-61ACn4/1	57.0	35.5	46.3	110	90	100	5.5
92-88Cn	56.6	36.2	46.4	106	92	99	3.0

	Grain yield t/ha			Grain yield (relative to Gerald)		
	1996	1997	Mean	1996	1997	Mean
Solva	7.95	7.18	7.37	87.0	84.3	85.0
Gerald	9.15	8.51	8.67	100.0	100.0	100.0
86-97Cn4/1	8.98	7.73	8.04	98.1	90.9	92.8
91-61ACn4/1	8.73	8.25	8.35	95.4	96.7	96.3
92-88Cn	10.05	7.99	8.51	109.8	93.9	98.1

Oats for milling

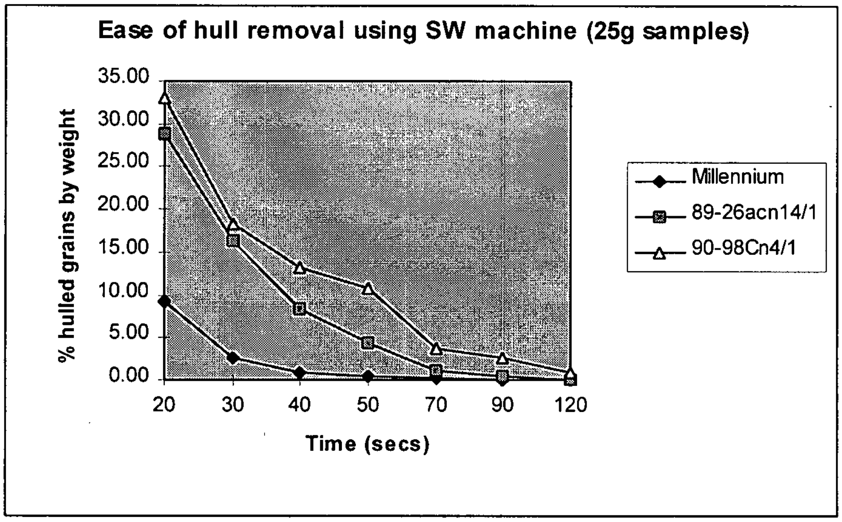
Husked oats are the preferred form of the crop for milling for human consumption. The husk forms a protective cover round the oat kernel or groat. It is a physical barrier to infection by groat-blackening fungi, particularly *Alternaria* and *Fusarium* (Thinlay, 1987). In addition to causing deterioration in appearance, these fungi produce natural mycotoxins. An association exists between the gape between lemma and palea and degree of blackening (Valentine and Clothier, 1992). Severe discoloration is proving to be a serious quality problem in Scotland in recent years.

A number of quality characteristics have been determined. Milling for human consumption is a major market. As in wheat and barley, milling quality in oats is a composite character

The proportion of husk is an important determinant of milling yield. Husks are costly to remove, requiring specialised equipment and expertise, they may incur disposal costs and husks can be regarded as a contaminant of the finished product. As indicated above, significant differences exist for 'hullability', the ease of husk removal. The difficulty of removal of the husk of the early, high yielding variety Mirabel, introduced from France, led to it not being acceptable for milling, and ultimately its removal from the UK Recommended List.

We have measured the ease of hull removal using a new machine. 25g triple replicated samples were being subjected to hull removal from 0-120 seconds. The percentages of dehulled grains by weight were recorded. Three contrasting potential varieties were examined. These were Millennium, Viscount and 90-98Cn4/1, which, like Mirabel, has thick husks and has the French variety Fringante in its parentage. Results are shown in Figure 1.

Figure 1



Millennium was virtually completely dehulled in 40 seconds, Viscount in 70seconds and 90-98Cn4/1 in 120 secs. In other words, it took three times as long to remove husks from 90-98Cn4/1 as from Millennium, which would have considerable energy and throughput implications.

Our only reservation is that the husks of Millennium, being so well-filled, are also readily removed during combining. Combining Millennium at three different drum speeds in 1997 yielded the following results: 1000rpm 4.8%, 1100 8.0% and 1200 13.2% dehusked grains. A leading miller has reported that the high kernel content of Millennium could make this oat of great value to millers, but that a high groat (ie dehulled grain) content could result in damage to the free groat at the hulling stage or upset the split in the mill between small and large grains. It will therefore be necessary for advice to be given on combine settings for this variety in order to capitalise on its value to the milling industry.

Another important milling quality characteristic is sieving %, the proportion of grain passing through a 2mm sieve. This is an indicator of the proportion of screenings. The normal standard required by millers is less than 10%; the French variety Aintree on the current RL is poor (13.2%) in this respect. Differences between varieties were taken into account in choosing potential varieties for advancement.

Varietal differences in specific or hectolitre weight are poor indicators of milling quality.

Predicted metabolisable energy of oats for feed.

The use of oats for animal feed is also an important market for oats, as for cereals in general. Whereas naked oats are being used increasingly in non-ruminant diets, husked oats are mostly fed to ruminants. Since winter oats generally have lower husk contents and higher oil levels than spring oats, in which most work has been done in the past, we determined differences in predicted metabolisable energy between 10 advanced varieties at three locations in 1996. While fibre fractions are low in metabolisable energy, oil contains 2.25 times as much energy as starch. Digestible fibre was determined as NCDG% using the neutral detergent cellulase technique. Oil levels were measured using the rapid cold Soxhet technique.

Results (Table 4) indicate a range in variation from 13.2 for Mirabel to 14.0 for 87-42CnI/2/2/2, a difference of 0.8MJ/kg. Most of the variation was associated with variation in NCDG% but the attraction of combining low fibre and above-average oil is obvious.

Table 4 Chemical composition, including neutral detergent cellulase technique (NCDG) and predicted me, of husked winter oats, 1996

	Protein (DM%)				Oil (DM%)			
	Gogerddan	Abbots	Heytesbury	Mean	Gogerddan	Abbots	Heytesbury	Mean
Solva	12.20	11.98	12.10	12.09	6.80	7.26	6.98	7.01
Image	12.16	12.88	12.19	12.41	7.31	7.61	7.57	7.50
Gerald	11.78	12.32	11.68	11.93	8.80	7.15	6.43	7.46
Mirabel	13.53	12.67	10.95	12.38	8.14	6.79	7.09	7.34
Chamois	12.09	13.04	11.16	12.10	6.37	6.98	7.24	6.86
Emperor	11.61	12.15	12.05	11.94	6.94	7.27	6.78	7.00
89-26ACn6/1	11.75	12.29	11.84	11.93	7.05	7.01	7.14	7.07
89-26ACn14/1	11.87	12.49	12.07	12.14	7.56	7.32	7.27	7.38
87-42CnI/2/2/1	11.09	12.52	11.67	11.76	7.24	6.37	6.52	6.71
87-42CnI/2/2/2	10.52	11.85	11.00	11.12	7.64	6.81	6.73	7.06
Mean	11.86	12.42	11.67	11.98	7.39	7.06	6.97	7.14
Prob	NS (0.536)	(0.005)	(0.010)		(0.010)	*(0.033)	**(0.007)	
SED	1.162	0.211	0.289		0.519	0.256	0.209	

Table 4 (contd).

	ME (MJ/kg DM)				Ash (DM%)			
	Gogerddan	Abbots	Heytesbury	Mean	Gogerddan	Abbots	Heytesbury	Mean
Solva	13.65	13.10	13.48	13.41	3.148	3.546	3.748	3.481
Image	13.67	13.48	13.63	13.59	2.812	2.880	3.803	3.165
Gerald	13.79	13.43	12.96	13.39	2.816	2.929	3.553	3.099
Mirabel	13.22	12.99	13.29	13.17	3.214	3.004	3.726	3.315
Chamois	13.58	14.05	13.77	13.80	3.180	3.008	3.765	3.318
Emperor	13.06	13.57	13.41	13.35	3.949	3.241	3.927	3.706
89-26Acn6/1	13.72	13.45	13.95	13.71	3.165	3.207	3.784	3.385
89-26Acn14/1	13.39	13.68	13.38	13.48	3.118	3.174	3.556	3.283
87-42CnI/2/2/1	13.80	13.64	13.94	13.79	3.471	2.974	3.942	3.462
87-42CnI/2/2/2	14.00	13.84	14.03	13.96	3.128	3.007	3.675	3.270
Mean	13.59	13.52	13.58	13.56	3.200	3.097	3.748	3.348
Prob	*(0.021)	**(0.002)	*(0.021)		**(0.004)	**(0.006)	NS(0.875)	
SED	0.232	0.157	0.235		0.2206	0.1128	0.2769	

Predicted ME (MJ/kg DM) = 0.25 oil + 0.14 NCDG (Thomas et al., 1988; Haigh and Bradshaw, 1998)

Technology Interactions

The work is 3-5 years from the market. This period is the time it takes to complete National List and Recommended List trials and produce commercially significant quantities of seed. Semundo are proving to be particularly effective at distributing and marketing varieties emanating from the programme. An important condition of the existing IGER/Semundo contract allows IGER to seek alternative marketing arrangements in the event that Semundo proves ineffective in that respect.

Further down the marketing chain, we are in close contact with end-users in order to exactly meet their needs. We have had useful feedback from millers on the quality of IGER varieties. It is considered vital in considering end-uses that the genetic dimension is not ignored (cf. malting and bread-making quality in barley and wheat).

In relation to exploiting major opportunities for new and existing end-use characteristics.

1. Written and oral presentations were given to the Technology Foresight Food and Drinks Cereals Sub-Group on 'The relevance of Oat Breeding to the Food Industry.
2. We are closely involved with the OATEC and HGCA-funded INNOVATIONS Projects.

3. We are part of a consortium developing a proposal (QUAFFO – Quality Feed From Oats) for feeding oats in place of soya. A MAFF-commissioned report (ENTEC, 1997) highlighted naked oats as the only cereal capable of fulfilling this role, with complementary amino-acid profile to legume protein.

4. We are also involved in the CCFRA Cereal Variety Working Party, in the present context in discussing with the food industry their technological needs in relation to quality characteristics. Dr Valentine gave a presentation to the Working Party on Oat Quality- The Breeders' Perspective. Interested parties included representatives from European Oat Millers/ BOBMA (British Oat and Barley Milling Association), United Biscuits Ltd and Weetabix Ltd.

Discussion

Excellent progress continues to be made on increasing the economic competitiveness and acceptability of winter oats in order to compete with other crops. The increase can be attributed to a combination of improved IGER varieties and good husbandry. Oats have actually outyielded barley in England and Wales in four of the last five years.

In the LIFE project in 1996, Gerald, the most widely grown oat in the UK, had a higher yield, lower variable costs and a higher monetary return than the winter wheat Genesis, released in the same year (1993) as Gerald (Table 5).

Table 5 Comparison between performance of Gerald winter oat and Genesis winter wheat in the LIFE project 1996

	Gerald winter oat	Genesis winter wheat
Yield (t/ha)	9.24	9.14
Variable costs (£/t)	124	173
Gross margin	1215	1016

Source: Vic Mason and Jo Hutcheon (personal communication)

Further varieties are needed with higher yield, good all-round agronomic and disease characteristics and improved fit for end-use applications. In this respect, the production of Millennium and the good progress being made in the breeding of dwarf oats are significant steps. Very good progress is being made in combining high grain yield with other characters particularly stiffness of straw (eg 91-33Cn4 containing a new source of shortness), resistance to mildew, resistance to crown rust, oat mosaic virus and high milling quality. Significant variation in predicted metabolisable energy for feeding to ruminants has also been demonstrated.

There is considerable interest at the present time in oats in a European effort to increase consumption of oats in human foods by virtue of their wholegrain image, taste, and health benefits. Considerable scope exists for new products such as fat mimetics and for replacing imported cereals in breakfast cereals. As an example of the importance of added-value cereal markets, the value of the UK retail breakfast cereal market is about £1 billion per annum, while the estimated annual production of breakfast cereals in the UK, including exports, was 335,000t in 1995, smaller than the annual UK production of oats. The genetic variation of oats is considered to be an essential element of any future study in this direction. Examining a single variety would be quite misleading, comparable with, for instance, considering the suitability for bread-making in a high amylase feed wheat. Genetic variation for most characters exists in the IGER oat programme and in the oat gene pool.

New varieties and markets present farmers with a wider range of options which are likely to become particularly attractive as subsidies decline. It is important to maintain the production and quality advantages of UK oats; substitution by imports would lose farmers a market worth £65m. Wider perspectives of the oat breeding programme in a European context have been outlined by Valentine (1996).

Update

Since writing the original report, work in a number of areas has come to fruition.

Gerald remained highly popular with growers and millers. It was the most widely grown oat variety in the last decade. This was reflected in the fact that in a poll to determine the winner of the NIAB Cereal Cup, Gerald came third, behind Consort winter wheat and Regina winter barley, and in font of all other wheat, barley and oat varieties.

Emperor was removed from the UK Recommended List in 1999.

Kingfisher (89-26Cn6/1) and **Viscount** (89-26Cn14/1) involving Gerald and an immediate progenitor of Chamois in their parentage were added to the Recommended List trials for 1999 in the PG and PS categories respectively. Viscount has short straw (as short as Gerald) and early maturity. Kingfisher has high yield in fungicide-treated and untreated trials. It has tall but stiff straw and, at the present time, it is attracting interest from organic growers as it is better able to compete with weeds than Gerald.

Millennium became the first variety to be added to the UK Recommended List of cereals in the new millennium. Originally deferred in November 2000, this decision was reversed by NIAB Council after consultations with industry. It has a number of valuable characteristics that confer excellent milling quality. The thin husk of Millennium and higher levels of energy-rich oil than wheat or barley makes the grain highly desirable for feeding to ruminants.

91-33Cn4/1 is currently in its first year of National List trials. It has proved exceptionally stiff-strawed, on of only four non-dwarf varieties not to lodge in 1998. This stiffness is derived from a winter oat line from Harold Marshall in Pennsylvania. It has large grains, like Millennium.

At the same stage, **93-76Cn1** is the first dwarf husked winter oat to be submitted to National List trials.

Although the genetic improvement of naked oats were not funded by HGCA during the period of this report, several developments in this area are relevant. **Grafton** is a relatively short high-yielding winter oat that was added to the UK Recommended List for 2000. It is a much needed improvement in lodging resistance over Krypton and Lexicon. **Icon** is the first dwarf oat to enter Recommended List trials. It has done much better in fungicide-treated trials, reflecting its poor disease resistance. Its significance lies in the opportunity to apply additional and late urea nitrogen fertiliser in order to raise yield and protein levels. This has raised considerable interest in the poultry industry. After an initial approach by the British Poultry Meat Federation to IGER, a LINK scheme has been proposed in order to address a number of issues related to the inclusion of naked oats in commercial poultry diets. We have released seed of Icon to ADAS for use in HGCA funded agronomic trials and two experimental high oil lines to other consortium participants.

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