PROJECT REPORT No. 241

ASSESSMENT OF POTENTIAL VARIETIES OF WINTER OATS FOR IMPROVED ECONOMIC COMPETITIVENESS AND END-USE CHARACTERISTICS (1998-2000)

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ASSESSMENT OF POTENTIAL VARIETIES OF WINTER OATS FOR IMPROVED ECONOMIC COMPETITIVENESS AND END-USE CHARACTERISTICS (1998-2000)

by

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Home Grown Cereals Authority (HGCA) Project 1664

Evaluate potential varieties of winter oats for improved economic competitiveness and end-use characteristics

A.A. Cowan, J.Valentine, D.M. Jones and B.T. Middleton

Abstract

The aims of this HGCA funded project were to assess breeding lines of winter husked and naked oats in order to develop economically competitive varieties that would meet the foreseeable demands of the major end users. Oats are a valuable crop due to their unique properties resulting in various end uses. This report concentrates on improvements in economic competitiveness and end-use characteristics of oats for human consumption, oats for ruminant feed and oats for poultry feed. A common requirement for all these areas are improvements in agronomic characteristics e.g. grain yield, increased resistance to lodging, and greater pest and disease resistance. More specifically for oats for human consumption, millers require high kernel content, low screenings, uniformity of size, tight husk enclosure, low breakage and low grain discoloration (British Oat and Barley Millers Association, 2000). For ruminants, thin-husked oats with a high metabolisable energy are required if oats are to regain their former importance as a feed, while naked oats have a high potential for feeding to monogastrics (poultry, pigs).

During this project (July 1998 to September 2000), over 596 potential varieties have been assessed for various agronomic and quality characters. Kingfisher, Viscount, Millennium and Grafton (naked oat) have been added to the Recommended List. The attributes of these varieties will make significant differences to the oat industry's profitability and productivity. Kingfisher and Viscount were added to the 1999 Recommended List. Kingfisher has high yield and kernel content but has tall though stiff straw. Viscount is slightly lower yielding, (not statistically significant) with short stiff straw, earliness of ripening and good resistance (9) to crown rust. Grafton a naked oat with similar straw characters to Gerald was added to the 2000Recommended List. Millennium, with agronomic characters similar or better than Gerald and with exceptional milling characteristics, was recommended in January 2000 after initially being deferred. Its thin husk conferring high predicted metabolisable energy make it an ideal feed for ruminants.

The dwarf naked oat Icon is in 2000 Recommended List trials. This type of variety will revolutionise parts of the feed industry since its dwarf habit permits targeted N applications resulting in larger yield of high protein grain for feeding to monogastrics without the risk of lodging. The introduction of dwarf naked oats is a core aspect of the AFENO project, funded by HGCA in conjunction with MAFF and the poultry industry.

The availability of new varieties, diversity of end uses, market opportunities and environmental benefits from this versatile crop provide growers and processors with a wider range of options. Oats are a sustainable low input cereal with gross margins greater than wheat or barley. They fit well into rotational systems and are an ideal break crop for take-all. Use of oats as an on-farm feed will improve product quality and traceability, there is also evidence of improved animal welfare and well being. Changes in GATT and CAP mean that oats are becoming a more attractive option. It is important to maintain the production and quality advantages of UK oats; substitution by imports would lose farmers a market worth £65m. Industrial usage and development of functional food from oats is an emerging but dynamic market. Continued breeding effort is necessary to maintain the economic and environmental benefits of oats and to ensure that as a crop they are favourable positioned to make the most of the current and emerging market opportunities.

HGCA Project 1664

Evaluate potential varieties of winter oats for improved economic competitiveness and end-use characteristics

Introduction

The aims of this HGCA funded project were to assess breeding lines of winter husked and naked oats in order to develop economically competitive varieties that would meet the foreseeable demands of the major end users. This project ran between 1/7/1998 and 30/9/2000.

The project is a major contribution to the Institute of Grassland and Environmental Research (IGER) oat breeding programme. The partnership between the Ministry of Agriculture, Fisheries and Food (MAFF), the Home-Grown Cereals Authority (HGCA) and Semundo Ltd, with underpinning research funded by the Biotechnology and Biological Sciences Research Council (BBSRC), has been particularly successful in maintaining breeding programmes at IGER which are responsive to the needs of growers and industry. By way of illustration, Gerald, a product of previous work at IGER, has been the most widely grown oat of the last decade. Gerald by virtue of its short stiff straw has transformed oat growing in the UK. It came 3rd, above all but one wheat (Consort) and one barley (Regina), in the NIAB Cereal Cup award 2000 for the cereal variety that in the opinion of farmers has done most to improve profitability on UK farms.

The aim of the breeding project is to produce varieties with improved economic competitiveness that met the end use requirements. Good all-round varieties are required but there is also scope for specific niche market varieties e.g. for poultry feed or organic farming. In order to maintain the crop area and develop new markets, continued production of new varieties that have improved economic competitiveness and fulfil the end-use requirements is essential.

A mark of success of the current and previous HGCA projects are the IGER winter oat varieties on the current Recommended List 2000 shown in table 1. There are 4 husked and 2 naked entries on the list. Gerald was first added to the List in 1993 and has been the most widely grown oat in the UK over the last decade. The naked oat Lexicon was added in 1997. Kingfisher and Viscount were added to 1999 list and Millennium and Grafton (Naked oat) were added to the 2000 list.

Table 1. IGER varieties on current 2000 UK Recommended List of Winter Oats

Recommendation **G**= general use **P**= provisional **S**= special use	Husked oats				Naked oats	
	Gerald **G** 1993	Kingfisher **PG** 1999	Millennium **PG** 2000	Viscount **PS** 1999	Lexicon **G** 1997	Grafton **PG** 2000
Yield as % treated Control (7.38t/ha)						
Treated	101	102	100	99	75	75
Untreated	87	92	92	89	68	68
Standing power	8	6	8	7	5	8
Shortness of straw	8	4	7	8	5	7
Earliness of ripening	6	7	6	8	6	7
Winter Hardiness	6	6	6	6	6	6
Resistance to disease						
Mildew	4	6	5	3	7	3
Crown Rust	6	7	9	9	7	6
Stem eelworm	res	-	-	-	res	-
Quality						
Kernel content (%)	73.7	75.9	77.6	74.9	-	-
Specific wt (kg/hl)	52.7	52.2	52.6	52.0	63.6	64.8
1000 grain wt (g)	33.3	36.9	42.0	34.2	25.4	26.6
Sieving %<2.0mm	5.8	5.5	4.4	5.8	-	-

The numbers of lines entering the replicated trials are shown in table 2. HGCA has funded the evaluation of test lines and then industry funded the development of promising lines with a further year of seed production to have enough seed for two years of National List trials after which promising lines become varieties. Entries that pass the National List trials are then submitted for Recommended List trials.

Table 2. Selection of trial lines from within the project.

Season	Number of test lines in trial				
		HC	HD	NC	ND
1998/ 1999	SP 2nd yr 1st yr	1 3 (2) 73 (9)	2 1 (1) 4 (2)	1 5 (1) 55 (31)	3 5 (1) 67 (0)
1999/ 2000	SP 2nd yr 1st yr	2 9 (3) 115 (20)	1 2 (1) 13 (3)	1 31 (1) 23 (15)	1 0 (0) 0 (0)
2000/ 2001	SP 2nd yr 1st yr	3 20 145	1 3 0	1 15 83	0 0 8

HC= husked conventional height; HD = husked dwarf

NC= naked conventional height; ND = naked dwarf

SP=Seed Production to bulk seed for National List trials

2nd yr= Second year in trials

1st yr = First year in trials

Figures in brackets refer to number of lines progressing to trials the following year e.g. 9 of the 73 first year husked conventional entries in 1998-1999 were tested for a 2nd year in 1999-2000. In 1999-2000, three of the 9 were selected for further testing, while there were 115 new varieties of which 20 were selected for further testing. In 2000/2001, 145 potential varieties were sown for testing.

Economic competitiveness of oats in sustainable agricultural systems.

Attributes that are desirable in all varieties include improved yield, agronomic characteristics including increased resistance to lodging, and greater pest and disease resistance. Potential varieties are tested over 4-6 sites in replicated trials against the current master control varieties Gerald, Image and Jalna.

Lodging has traditionally been a major barrier to oat growing. It causes both loss of yield and decreases grain quality as well as increasing the costs and time required for harvesting. The introduction of Gerald, which has short stiff straw, has made oat growing easier and more profitable as there are fewer problems with lodging and associated poor grain quality. There are two means of improving lodging resistance, either by incorporation of dwarfing genes (e.g. Dw6) to provide shorter straw or selection for shorter, stiffer straw. Breeding lines are assessed for height and their lodging resistance and discarded if too tall or prone to lodging. Those possessing other useful characters may be utilised as parents in the breeding programme. However reducing plant height is normally associated with decreased yields, and this process requires intensive effort to produce a variety with improved lodging resistance whilst providing a reasonable yield. Improved lodging resistance offers the opportunity to apply late N fertiliser to boost the protein content of the grain, thus a high quality grain could offset a small reduction in yield. It is likely that dwarf oats will transform oat growing in a similar fashion to the introduction of dwarf wheat in the 60's.

Maturity (as indicated by ear emergence) is an another useful agronomic criterion that is assessed. Early ear emergence is a desirable trait. Late lines are usually discarded.

During crop development, natural infections of pests and disease are recorded. The two major disease problems in the UK are crown rust and mildew. In addition, the test lines are inoculated with known pathogen races and disease resistance assessed in special disease nurseries located at IGER.

Amongst the agronomic characters yield is probably the most important factor in determining the value of potential varieties. Trial plot yields and areas are recorded and yield in t/ha calculated. Relative yields against the three master controls are also calculated and these yield figures in conjunction with other agronomic and quality data are used to decide on which lines to discard. Over the course of the project (1998-2000), 596 lines have been tested for agronomic characters as shown in the table 2.

There has been a concentrated effort to reduce plant height as shown by the high discard rates of entries from first year trials into second year trials, (Table 2). Lines that were taller than Emperor or Kingfisher were discarded. Reduction in plant height is usually associated with increased lodging resistance and thus improved grain quality. Increased lodging resistance also has the additional benefit of allowing targeted late applications of fertiliser to boost yield and protein content. Reduction in plant height is however often associated with reduced yield and this has required considerable breeding effort to break this negative association. Table 3a shows the range of values observed in the trials compared to various control varieties. Table 3b shows the data for potential varieties progressing to further trials. Thirty-three of the conventional height potential varieties in trials in 2000 had yield values similar or greater than Gerald. Of these, 10 were discarded because of tall thin straw, poor disease or poor quality characteristics. In general it can be seen that the naked lines were taller than the husked lines

Table 3a Range of values observed in potential varieties assessed in 1999-2000 season
Conventional height husked oat trials 1-6

Relative Yields (as percentage of the mean of 3 control varieties Gerald, Image and Jalna)

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**92.2**	**113.5**	**105.4**	**96.2**	**98.4**	**101.2**
2	**92.5**	**109.4**	**105.8**	**98.2**	**95.8**	**102.6**
3	**84.0**	**108.1**	**105.1**	**98.4**	**96.8**	
4	**88.2**	**108.8**	**107.2**	**97.8**	**95.2**	
5	**94.6**	**109.8**	**105.6**	**95.8**	**98.6**	
6	**85.1**	**106.3**	**103.3**	**100.4**	**96.3**	**101.7**

Straw height (cm)

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**113**	**131**	**117**	**130**	**121**	**115**
2	**116**	**133**	**121**	**129**	**120**	**118**
3	**122**	**137**	**124**	**136**	**130**	
4	**123**	**140**	**123**	**132**	**130**	
5	**116**	**141**	**120**	**137**	**125**	
6	**120**	**143**	**124**	**134**	**128**	**123**

Heading date days after 1st May

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**34**	**43**	**41**	**39**	**41**	**39**
2	**36**	**43**	**41**	**38**	**40**	**40**
3	**37**	**43**	**41**	**38**	**40**	
4	**37**	**44**	**41**	**38**	**41**	
5	**31**	**42**	**41**	**38**	**40**	
6	**25**	**44**	**42**	**39**	**41**	**40**

Mildew cumulative infection score over time

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**1**	**26**	**7**	**14**	**26**	**1**
2	**0**	**30**	**4**	**10**	**23**	**0**
3	**1**	**33**	**9**	**19**	**17**	
4	**0**	**40**	**16**	**41**	**33**	
5	**5**	**50**	**39**	**48**	**51**	
6	**0**	**46**	**27**	**26**	**47**	**13**

Crown rust infection score over time

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**40**	**94**	**63**	**85**	**77**	**72**
2	**35**	**87**	**68**	**67**	**67**	**86**
3	**33**	**82**	**51**	**82**	**75**	
4	**38**	**92**	**43**	**92**	**67**	
5	**43**	**82**	**67**	**75**	**81**	
6	**43**	**79**	**43**	**77**	**66**	**60**

Disease nursery scores were taken after inoculation with a complex mixture of races of pathogens. Mildew and Crown rust were recorded as percentage infection on 3 different dates. These readings were plotted to give an area under a curve and this is the figure expressed, the lower the figure, the better the resistance.

Table 3a Range of values observed in potential varieties assessed in 1999-2000 season
Conventional height husked oat trials 1-6
Quality assessment on surplus seed sown in Oct 1999

Thousand grain weight (g)

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**34.7**	**49.7**	**35.2**	**39.8**	**34.7**	**46.7**
2	**32.4**	**42.9**				
3	**36.0**	**43.8**				
4	**36.9**	**47.9**				
5	**37.0**	**45.2**				
6	**36.1**	**44.5**				

Dehusked grains (numbers/100)

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**0**	**32**	**0**	**0**	**0**	**32**
2	**4**	**34**				
3	**3**	**19**				
4	**2**	**22**				
5	**6**	**26**				
6	**3**	**45**				

Kernel content % machine derived

Trial	min	max	Gerald	Image	Jalna	Millennium
1	**70.3**	**79.5**	**70.2**	**78.2**	**76.2**	**76.9**
2	**73.1**	**79.7**				
3	**74.7**	**80.6**				
4	**75.0**	**79.8**				
5	**73.0**	**80.7**				
6	**72.1**	**81.9**				

Table 3a Range of values observed in potential varieties assessed in 1999-2000 season
Conventional height naked oat trials 7-9

Relative Yields (percentage of the mean of 3 control varieties Gerald, Image and Jalna)

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon
7	**73.5**	**89.4**	**106.6**	**94.9**	**98.6**	**75.0**	**75.0**
8	**62.8**	**91.5**	**106.2**	**95.2**	**98.5**	**76.5**	*
9	**53.1**	**82.5**	**105.6**	**95.6**	**98.6**	**71.9**	**75.8**

Straw height (cm)

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon
7	**129**	**148**	**125**	**135**	**125**	**125**	**134**
8	**118**	**144**	**125**	**136**	**129**	**123**	*
9	**126**	**147**	**122**	**133**	**125**	**126**	**133**

Heading dates (days after 1st May)

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon
7	**35**	**40**	**40**	**37**	**39**	**35**	**37**
8	**34**	**40**	**40**	**37**	**39**	**36**	*
9	**35**	**40**	**40**	**37**	**39**	**36**	**37**

Cumulative mildew score

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon
7	**2.5**	**38**	**38**	**39**	**43**	**10**	**3**
8	**0**	**51**	**28**	**46**	**51**	**15**	*
9	**9**	**70**	**62**	**70**	**47**	**63**	**36**

Cumulative crown rust score

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon
7	**39**	**84**	**59**	**80**	**74**	**83**	**49**
8	**33**	**89**	**63**	**81**	**79**	**85**	*
9	**0**	**87**	**65**	**79**	**67**	**79**	**55**

Disease nurseries scores were taken after inoculation with a complex mixture of races of pathogens. Mildew and Crown rust were recorded as percentage infection on 3 different dates. These readings were plotted to give an area under a curve and this is the figure expressed, the lower the figure, the better the resistance.

Quality analysis on surplus seeds after 1999 sowing
Thousand grain weight

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon	Icon
7	**23.9**	**32.4**				**26.6**	**25.9**	
8	**26.9**	**41.4**						
9	**21.5**	**43.8**						**26.9**

Oil content determined by NIR

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon	Icon
7	**6.81**	**8.38**				**7.16**	**7.18**	
8	**6.04**	**7.39**				**7.16**		
9	**6.03**	**11.38**						

%nakedness

Trial	min	max	Gerald	Image	Jalna	Grafton	Lexicon	Icon
7	**95.4**	**100**				**99.7**	**95.4**	
8	**98.3**	**100**				**99.7**		
9	**98.3**	**100**						**99.7**

Table 3b **Potential varieties selected for further testing in 2000-2001 season**
Trials 1-6 Husked oats

Trial 1 **Relative yields (Gerald, Image, Jalna)** **Quality Data**

2000 Code	Selection	Relative Yield (%)	Height (cm)	Heading date	Mildew	Crown rust	TG W(g)	dehusked/ 100 grains	Kernel Content (%)
1	Gerald	**105.4**	116.8	41.2	7.4	63.0	35.23	0	70.24
2	Image	**96.2**	129.5	38.6	14.0	84.9	39.77	0	78.22
3	Jalna	**98.4**	121.3	40.9	26.4	77.3	34.70	0	76.25
5	Viscount	**101.5**	118.4	38.2	11.6	48.4	36.27	0	75.13
6	Millennium	**101.2**	115.4	39.4	0.7	72.0	46.73	32	76.87
8	91-33Cn 4/1	**99.2**	113.6	39.2	10.7	82.7	44.97	8	77.11
10		**109.0**	117.9	39.5	8.4	60.0	42.63	11	77.62
14		**113.5**	128.2	41.1	22.0	43.7	39.57	8	76.60
16		**106.9**	121.6	40.7	1.7	42.9	36.63	6	75.22
17		**106.4**	127.2	39.2	10.7	62.7	37.00	5	73.05
23		**107.5**	130.2	35.1	9.9	55.0	49.70	14	75.39
25		**107.5**	127.6	41.9	10.0	40.4	34.83	4	73.89

Trial 2

26	Gerald	**105.8**	121.2	40.9	3.5	67.5			
27	Image	**98.2**	129.4	38.3	10.0	66.5			
28	Jalna	**95.8**	120.4	40.0	22.5	66.5			
36		**103.5**	125.0	41.8	5.0	55.0	37.17	7	73.13
45		**98.9**	120.8	42.0	10.5	82.5	37.57	4	76.25

Trial 3

51	Gerald	**105.1**	124.3	40.7	8.5	51.0			
52	Image	**98.4**	136.4	38.0	19.0	81.5			
53	Jalna	**96.8**	130.2	40.2	16.5	74.5			
57		**108.1**	127.4	41.9	8.5	54.5	37.23	3	76.35
58		**107.8**	128.6	42.2	16.0	52.0	36.80	11	75.50
65		**103.7**	129.7	39.3	11.5	75.0	40.57	14	77.23

Trial 4

76	Gerald	107.2	122.9	41.4	15.5	42.5			
77	Image	97.8	132.4	38.3	40.5	91.5			
78	Jalna	95.2	130.4	41.0	32.5	67.0			
86		108.8	135.5	41.7	13.5	54.5	38.67	2	75.59
88		105.6	133.1	42.1	0.0	54.5	39.00	7	77.49

Relative yields calculated as (yield /(average yield of Gerald,Image and Jalna))*100
Heading date number of days until ear emergence after 1st May
Crown rust and Mildew are derived by plotting % infection over the season and calculating the area under the curve. Lower values equal greater resistance

Table 3b cont'd **Potential varieties selected for further testing in 2000-2001 season**
Trials 1-6 Husked oats

Trial 5 **Relative yields (Gerald, Image, Jalna)** **Quality Data**

2000 Code	**Selection**	**Relative Yield (%)**	**Height (cm)**	**Heading date**	**Mildew (%)**	**Crown rust (%)**	**TG W(g)**	**dehusked/ 100 grains**	**Kernel Content (%)**
101	Gerald	**105.6**	120.5	40.8	39.0	66.5			
102	Image	**95.8**	136.7	38.3	48.0	75.0			
103	Jalna	**98.6**	124.7	40.2	50.5	81.0			
106		**100.0**	125.8	41.0	35.5	57.5	44.37	9	76.53
111		**103.7**	122.2	38.0	23.5	72.0	37.27	14	79.33
112		**109.2**	121.7	37.7	48.0	69.0	36.97	8	76.17
114		**103.7**	131.3	37.7	46.0	54.5	38.33	6	75.94
115		**103.5**	131.5	37.1	31.0	47.0	43.20	14	77.17
120		**109.8**	132.3	38.7	12.5	66.5	45.23	11	77.70
121		**107.4**	126.8	41.3	17.5	75.0	43.40	14	77.77
124		**107.6**	136.0	39.7	22.5	72.5	43.20	12	76.23

TRIAL 6

126	Gerald	**103.3**	123.6	41.5	26.5	43.0			
127	Image	**100.4**	133.6	38.7	26.0	76.5			
128	Jalna	**96.3**	128.3	40.6	46.5	65.5			
138		**106.3**	128.9	42.2	23.5	73.0	36.13	3	74.29
140		**104.2**	129.1	41.6	4.0	54.0	41.27	11	75.43
143		**102.4**	129.7	41.1	15.5	59.5	42.33	13	79.92

Dwarf lines **Husked oats**

TRIAL 10 **Quality Data**

226	Gerald	**104.7**	124.4	40.2	31.0	65.0			
227	Image	**96.8**	133.6	37.5	48.0	87.5			
228	Jalna	**98.5**	127.1	40.1	52.0	75.0			
230	86-97Cn 4/1	**99.7**	114.3	41.7	17.5	35.5	41.50	2	71.78
232	93-76Cn 1/1	**100.8**	111.6	43.3	64.0	53.5	40.47	1	72.91
234		**102.1**	116.1	41.6	30.5	79.0	35.57	8	74.23

Table 3b cont'd **Potential varieties selected for further testing in 2000-2001 season**
Trials 7-9 Naked oats

TRIAL 7 **Quality Data**

2000 Code	Selection	Relative Yield (%)	Height (cm)	Heading date	Mildew	Crown rust	% oil	% naked	T.G.W (g)
151	Gerald	**106.6**	124.8	39.8	38.0	59.0			
152	Image	**94.9**	134.9	36.7	39.0	80.0			
153	Jalna	**98.6**	125.3	38.5	43.0	73.5			
154	Krypton	**84.0**	140.4	35.7	5.0	39.0		97	24.10
155	Lexicon	**75.0**	133.5	36.6	2.5	49.0	7.19	95	25.90
156	Grafton	**75.0**	125.2	35.0	10.0	83.5	7.16	100	26.57
157	93-122Cn 5/1/2	**85.9**	132.6	35.4	18.5	46.5	7.14	100	29.77
158		**82.4**	139.9	38.2	12.5	46.0	8.38	100	25.90
159		**83.5**	136.9	37.7	15.0	44.0	7.94	97	27.40
160		**79.2**	134.9	37.4	26.0	44.5	7.58	100	30.30
171		**89.4**	148.3	38.3	7.5	58.0	7.71	100	25.83
172		**86.9**	142.9	38.4	17.5	57.5	7.69	99	24.43
175		**73.5**	136.1	36.8	38.0	66.5	7.39	99	25.10

TRIAL 8 **Quality Data**

2000 Code	Selection	Relative Yield (%)	Height (cm)	Heading date	Mildew	Crown rust	% oil	% naked	T.G.W (g)
176	Gerald	**106.2**	125.1	39.6	28.0	63.0			
177	Image	**95.2**	136.2	37.1	45.5	81.5			
178	Jalna	**98.5**	129.1	39.4	50.5	79.0			
179	Grafton	**76.5**	126.1	35.6	15.0	80.5	7.16	100	
180		**80.5**	135.4	38.3	51.0	34.5	7.17	100	28.07
195		**74.1**	118.3	35.3	26.0	82.5	6.69	100	31.53
197		**91.5**	132.0	37.7	12.5	41.5	6.50	100	27.17
200		**72.6**	133.1	38.4	11.0	82.5	6.38	100	39.00

TRIAL 9 **Quality Data**

2000 Code	Selection	Relative Yield (%)	Height (cm)	Heading date	Mildew	Crown rust	% oil	% naked	T.G.W (g)
201	Gerald	**105.6**	121.7	40.4	61.5	65.0			
202	Image	**98.6**	132.7	37.1	70.0	79.0			
203	Jalna	**95.6**	125.2	39.1	46.5	66.5			
204	Grafton	**71.9**	123.4	35.8	62.5	78.5			
208		**53.1**	146.9	35.8	41.0	0.0	11.38	99	21.53
210		**72.0**	126.2	35.3	38.0	80.0	6.03	99	35.77
216		**75.2**	133.4	35.1	54.0	57.5	7.65	99	29.53
220	Harpoon	**73.0**	139.1	35.7	59.5	86.5		100	30.57
221	Krypton	**82.5**	143.3	35.9	33.0	42.0			
222	Lexicon	**75.8**	133.1	36.7	36.0	54.5			
223	Icon	**70.1**	103.2	44.1	104.0	70.5		100	26.93
224	93-85ACn 5/2/2	**73.2**	95.4	40.0	62.0	76.5		98	23.77
225		**71.7**	99.6	36.3	98.0	78.0		99	28.47

Table 3b cont'd **Potential varieties selected for further testing in 2000-2001 season**

TRIAL 10 **Trials 10 Dwarf Naked oats**

2000 Code	Selection	Relative Yield (%)	Height (cm)	Heading date	Mildew	Crown rust
226	Gerald	**104.7**	124.4	40.2	31.0	65.0
227	Image	**96.8**	133.6	37.5	48.0	87.5
228	Jalna	**98.5**	127.1	40.1	52.0	75.0
229	Icon	**70.1**	104.7	44.8	96.5	75.0
246	Lexicon	**72.7**	131.9	37.2	25.0	49.0
247	Grafton	**73.4**	123.4	35.4	26.0	85.5
248	93-85ACn 5/2/2	**73.6**	98.3	39.6	27.5	83.0
249		**74.5**	98.4	37.7	57.0	71.5

and this is a reflection of the smaller size of the naked oat breeding programme compared to that of husked oats.

93-76Cn1/1 is the first dwarf husked line to enter National List trials. In 2000 NL1 trials, it yielded 116% of the controls. This line is a major achievement in oat breeding by breaking the negative association between short height and poor yield. It entered its second year of National List trials in autumn 2000.

Oats as a crop are extremely well suited to use in rotational systems and are an excellent break crop for take-all in wheat. Rotational systems form the basis of sustainable agriculture and current changes in policies regarding subsidies and arable aid are making oats a more attractive financial option. The use of oats as an on farm feed for livestock would have many environmental benefits in addition to economic ones. Firstly there would be reduced transport costs. Some livestock farmers reckon it is no longer cost effective to have feed delivered to the farm. It would also increase crop biodiversity and the subsequent benefits to the environment in terms of habitat etc. Oats are a low input crop which require less fertilisers than other cereals, this may in part be due to the more prolific root structure enabling more efficient gathering of resources.

These attributes have made oats a crop that is well received by the organic sector. Kingfisher is a favoured variety. It is a paradox that for organically grown oats, the straw is often of more financial value than the grain. At present, research into organic cereal systems able to deliver higher yields than the present 3-4t/ha is required. Changes in policy-making bodies for organic livestock production will mean that any feed will have to have been organically produced to enable the meat to have an organic label. This offers additional opportunities for the use of oats as an organic animal feedstuff.

End Use Characteristics

Oats for human consumption

Oats are a nutritious food which provide dietary energy, good quality protein, various minerals and vitamins. Oats have many established health benefits including cholesterol lowering, modulating blood glucose and improving gut transit/faecal bulk as shown in the USA by the FDA health claims in 1997 and 1999. The major component thought to be responsible for the health benefits is soluble fibre beta-glucan, however there are also a number of antioxidants, which could contribute to the beneficial effects of oats. There are also some as yet unproven health benefits from oats which include: reducing risk of hypertension, clotting and heart disease, reducing the incidence of diabetes and some cancers, useful for coeliac disease sufferers diets and can improve gut health and immune function. The emergence of functional foods provides many opportunities for growers and millers and processors.

After assessing the yield and agronomic data, the quality aspects of the trial lines are also assessed. The miller's requirements are for an oat variety that provides good yield of acceptable milling quality and enables the miller to satisfy the needs of the end user. Ideally they want varieties which are easily hulled, with a high groat content, of uniform size with low breakage and low groat staining. In addition to requiring oats of these standards in terms of yield and quality, millers are increasingly likely to require grain, which has been produced using minimal agrochemical input to maintain the wholesome and natural image of oats. Following on from this theme, they only want new varieties that are produced by conventional breeding methods.

Millennium, a major break through in oat breeding, demonstrates how the project has responded to the miller's requirements.

Millennium scores better than all other recommended varieties on a number of ways.
First, it has large grains, hence there are less screening losses i.e. fewer grains which are too small to use.

Varieties in rank order of grain size

	1000 grain weight (g)	Screenings (%<2.0mm sieve)
Millennium	42.0	4.4
Kingfisher	36.9	5.5
Jalna	34.8	8.5
Gerald	33.3	5.8
Image	32.9	6.2
Aintree	28.4	10.7

(Source: UK Recommended List 2000)

Secondly, its hullability or ease of husks removal is better than all other varieties. Using a dehulling machine, Millennium was virtually completely dehulled in 40 seconds, Viscount in 70 seconds and 90-98Cn4/1 in 120 seconds. 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 for the miller (Valentine et al., 2000).

This ease of hullability of Millennium could present problems, as millers specify a maximum of 5 dehulled per 100 grains sample. Thus greater attention to the combine drum speed is necessary when harvesting Millennium. The combine drum speed should be set as low as possible consistent with good threshing to achieve an acceptable number of dehulled grains in the sample.

Thirdly, the husks are thin so that the proportion of kernel to total grain is higher.

Varieties in rank order of kernel content %

	Kernel content %
Millennium	77.6
Jalna	76.7
Image	76.6
Kingfisher	75.9
Aintree	74.0
Gerald	73.7

(Source: UK Recommended List 2000)

Fourthly, the flakes themselves are larger, ideal for premium 'jumbo' flakes. The following table shows the higher proportion of large grains in Millennium compared to other varieties.

Varieties ranked according to the percentage of grain of passing over a 2.8mm sieve.

	>2.8 mm	>2.5 mm	>2.3 mm	>2.1 mm	<2.1 mm
Millennium	32.9	43.6	20.2	0.4	2.9
Image	15.7	47.7	31.5	0.6	4.4
Jalna	4.8	43.3	46.6	0.8	4.5
Gerald	4.7	51.0	38.8	0.6	4.9

(Source: Breeder's mean data from three sites in 1999.)

The decision on whether Millennium should be added to the Recommended List 2000 was deferred while further information was obtained. A previous yellow husked oat Mirabel had caused millers many problems due to its thick husk, which resulted in it being dropped from the Recommended List. Since Millennium is a yellow husked oat it was also mistakenly thought likely to be problematic for the millers. As part of providing further information, 1kg samples of Millennium were sent to 12 UK millers and processors for assessment. In general the consensus was favourable and the large grains and thin husks impressed them. After this positive feedback, Millennium became the first variety to be added to the Recommended List this millennium. This is the first year when millers are likely to see bulk samples of Millennium, so a complete full-scale assessment will be forthcoming. Until now Image has been used as the reference sample for milling quality in oats, but it is becoming outclassed and suffering from grain blackening, which is a major current concern to millers. One of the millers' objectives is for varieties with minimal or no grain blackening, as high levels of grain blackening make the crop unsuitable for milling and results in many farmers crops being rejected.

In this year's trials, there were 5 potential varieties that had TGW greater than Millennium (46.7g) and 36 with values between 46.7 and 41.0 of which 7 are progressing to further testing. Similarly 59 had kernel contents greater than that of Millennium and 7 of these are entered for further testing. In addition, we also have potential varieties entered for further testing which have kernel contents and thousand grain weights closer to those of Gerald (70.2%, 35.2g).

Animal Feed

Feed for ruminants

Oats are a valuable and suitable concentrate for feeding to cattle and sheep (Cuddeford, 1995) (Tables 4a,b). Ruminants are better able than non-ruminants to utilise the husk of oats. However as the level of fibre increases, the nutrient digestibility value for ruminants decreases. A comparison of the composition of oats, wheat and barley shows the merits of oats as an animal feed. Since oats belong to a different tribe to wheat and barley they have a better protein ratio and higher oil content which makes them ideally suited as a feed stuff.

In contrast to the rest of Europe, only 39% of the oats in the UK are used for animal feed (49 % for human consumption, HGCA; Valentine and Mattsson, 2000) thus the production of thin-husked winter oats with a high metabolisable energy value could increase the amount of oats used as an animal feedstuff and also the area acreage grown in the UK. Use of oats as an animal feed would also have other economic and environmental benefits. The new varieties of oats have out yielded barley in 4 of the last 6 years, they are an excellent break crop and subsequent wheat crops can have a considerable yield improvement. Oats fit extremely well into rotational systems and sustainable agricultural system being a low input crop. Use of oats as a feed provides greater traceability and product safety. There is also evidence to show improved meat and milk quality when oats are included in the diet as well as improved animal

Table 4a Chemical composition of naked oats, husked oats, wheat and barley

	Chemical composition (g/kg dry matter)			
	Naked Oat	Wheat	Barley	Husked Oat
Oil (ether extract)	83-97	19	13	43 (30-84)
Crude protein	119-150	123	128	116
Crude fibre	28-45	20	50	105
Neutral detergent fibre	141	166	234	283
Acid detergent fibre	51	32	30	147
Cellulose	36	29	54	105
Lignin	18	11	16	36
Starch	386	660	528	480

From Valentine 1995

Table 4b Calculated feed energy values of naked oats, husked oats, wheat and barley.

	Energy (MJ/kg Dry matter)			
	Naked Oat	Wheat	Barley	Husked Oat
Gross energy	19.9	18.2	18.4	19.5
Metabolizable energy (cattle)	14.7	13.6	12.8	11.5-12.4
Digestible energy (pigs)	16.0	14.7	13.0	11.9-13.3
Apparent metabolizable energy (poultry)	16.5	15.0	14.2	11.9-14.7

Source Valentine 1995

welfare and well being. Another additional benefit is that the high oil content of the oats has been implicated in reducing methane production by the ruminant.

A two stage screening process has been used during the project to assess the breeding lines for their predicted metabolisable energy (ME) values. This was calculated using the formula described by Thomas et al., 1988: ME=(0.14 x NCGD)+(0.25 x oil). The predicted ME value was calculated using NCGD analysis and cold Soxtec oil extract and ash dry weight.

Initially the grains were mechanically dehulled and a kernel content was derived, then using NIR techniques, oil and protein contents were determined. At this stage a fresh sample of whole grains was taken from lines with either >78% kernel content or >7.5% oil. These samples were milled and then analysed by the NCGD (Neutral Detergent Cellulase Gamanase Digestibility) method, in addition oil and ash content were determined and using the formula described by Thomas et al., 1988 the predicted ME values (MJ/kg DM) was calculated.

From the equation, it is clear two factors are influencing the predicted ME, NCGD value and oil content. An initial study to correlate the effect of kernel content, NCGD and oil content to identify the major contributor to predicted ME values was completed. The biggest contributor to predicted ME was the NCGD value. Kernel content had the highest correlation (0.65, P>0.001) to NCGD whilst oil content had very little effect. The possibilities for producing oats with improved metabolisable energy by selecting lines with high oil content and thin husks look promising. The exact determination of constituents of predicted ME requires further investigation.

Although the actual predicted ME values varied depending on the harvest year (Table 5), the trends remained similar and Millennium consistently had a greater ME value than Gerald. In both years in which it was tested, Kingfisher has had the greatest predicted ME values. Other promising lines having high ME values included 91-33Cn 4/1, 95-56ACn 2 and 95-56ACn 3. 91-33Cn4/1 is a compact panicled short (semi dwarf) line in which the adverse association with late maturity has been broken. It has many excellent agronomic and quality characteristics for both animal feed and human consumption, including very short stiff straw making it almost totally resistant to lodging, a high kernel content, large grains and a higher predicted ME value than Millennium. However, it failed National List 2000 trials because segregated for yellow and white grains and lower yield than existing varieties in 2000 trials. Two other lines 95-56ACn 2 and 95-56ACn 3 had predicted ME values greater than that of 91-33Cn4/1. 95-56ACn 3 has been entered into NL1 trials for 2000-2001.

Table 5. Predicted metabolisable energy (MJ/kg DM) of standard varieties and breeding lines.

	Harvest year 1996			Harvest year 1998			Harvest year 1999		
Name	Oil % DM	NCGD % DM	ME	Oil % DM	NCGD %DM	ME	Oil % DM	NCGD % DM	ME
Gerald	7.5	82.3	13.4	5.8	72.5	11.6	5.7	74.3	11.8
Image	7.5	83.8	13.6	6.7	75.2	12.2	6.5	77.3	12.5
Jalna				6.2	74.7	12.0	6.0	77.0	12.3
Kingfisher	7.1	85.3	14.0				6.0	80.9	12.7
Millennium	6.7	86.6	13.9	5.7	76.3	12.1	5.8	77.9	12.4
Mirabel	7.3	81.0	13.2						
Viscount	7.4	83.1	13.4	6.6	73.9	12.0			
91-33Cn4/1				6.2	77.3	12.4	5.7	79.7	12.6
92-72Cn1/1/1				6.5	75.9	12.3			
93-76Cn1/1				6.6	73.3	11.9	6.5	75.3	12.2
94-16Cn2/1				6.7	78.8	12.7	6.2	77.9	12.5
95-14Cn4							6.2	79.1	12.6
95-56ACn3				6.0	79.7	12.6	5.8	79.1	12.5
95-174Cn2							5.7	78.7	12.4
95-176Cn1							7.3	77.7	12.7

DM = dry matter
NCGD= neutral detergent cellulase gamanase digestibility
Values are means of two replicates over two different sites for each year

The limitations of this NCGD method are that it is both time-consuming and expensive, this severely limits the number of sample that can be processed. Currently we are developing an NIR method that will be assessed for reliability to see if we can increase the through put to allow screening of more lines.

We have also investigated another possible method of assessing cereal feed value using a method produced by the Animal science and Microbiology department in IGER. This method involved measurement of anaerobic gas production by ruminant micro-organisms when milled cereals were used as a substrate (Theodorou et al 1994; Davies et al 1999). The theory is that the more digestible the sample, the faster that gas is produced by the microbes. Samples of oats that had originally been assessed for predicted ME values together with some naked oats and samples of feed wheat and feed barley of known ME were analysed. ADAS Feed Evaluation and Nutritional Studies supplied samples of wheat and barley with known ME values. Two indicators of digestibility can be extracted from this data, 1) the amount of dry matter disappearance and 2) final volume of gas produced. The amount of material left after digestion was measured (Fig 1), almost all the wheat, barley and naked oat samples had virtually disappeared. For the naked oats only approximately 5-9% of the initial sample remained; between 6 and 9% of the wheat remained; between 9-12% of the barley remained; the greatest spread was seen in the husked oats with between 18-28% remaining. Using rate of dry matter disappearance to rank digestibility, the order would be- naked oats, feed wheat,

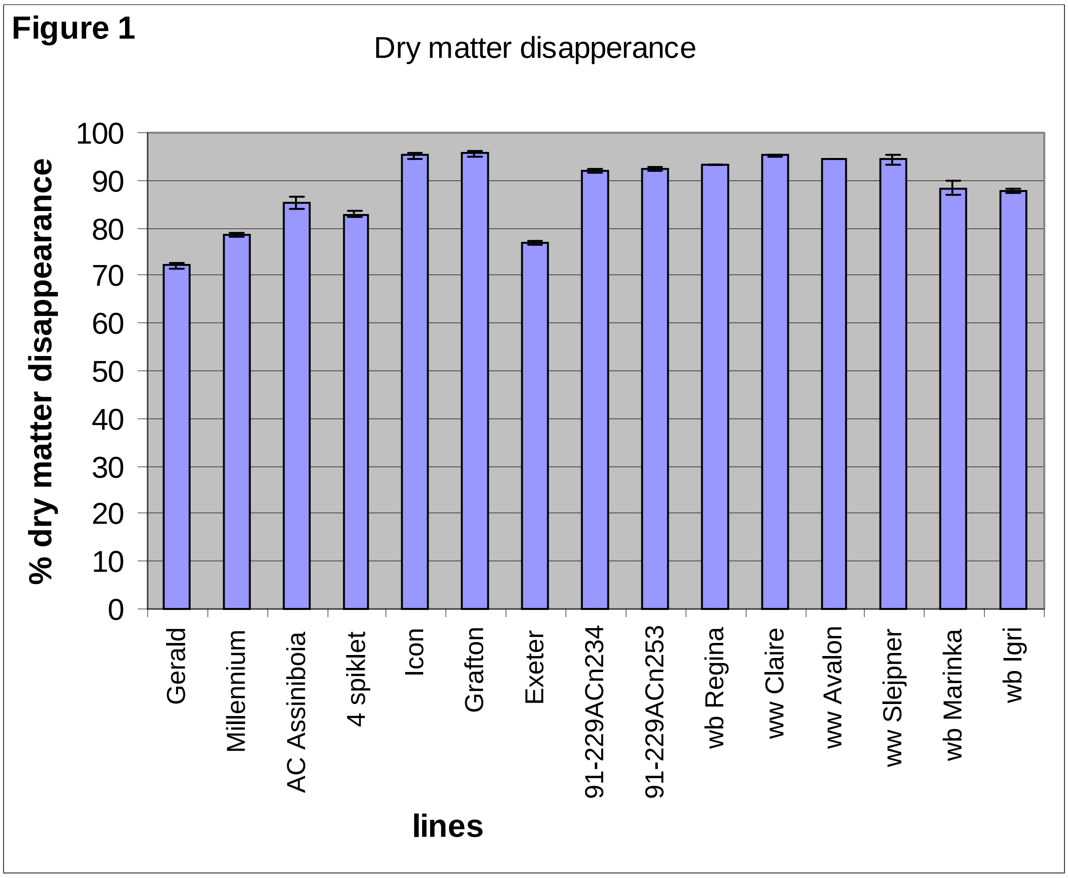
Figure 1
Dry matter disapperance
% dry matter disappearance
100
90
80
70
60
50
40
30
20
10
0
Gerald
Millennium
AC Assiniboia
4 spiklet
Icon
Grafton
Exeter
91-229ACn234
91-229ACn253
wb Regina
ww Claire
ww Avalon
ww Slejpner
wb Marinka
wb Igri
lines

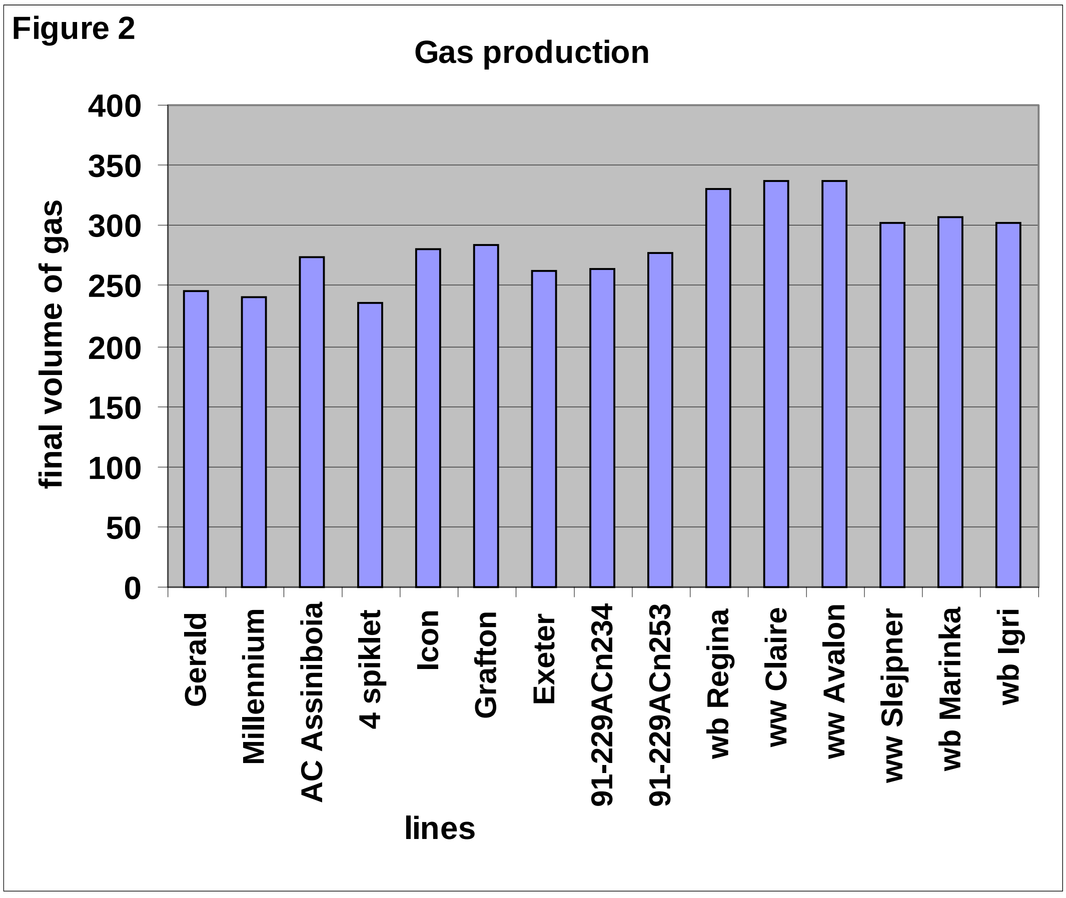
Figure 2
Gas production
final volume of gas
400
350
300
250
200
150
100
50
0
Gerald
Millennium
AC Assiniboia
4 spiklet
Icon
Grafton
Exeter
91-229ACn234
91-229ACn253
wb Regina
ww Claire
ww Avalon
ww Slejpner
wb Marinka
wb Igri
lines

feed barley, and lastly husked oats. When final gas volume (Fig 2) was used a different pattern emerged: feed wheat, feed barley, naked oats and then husked oats.

Within the husked oats some differences were also observed, Gerald had the greatest amount of dry matter remaining following anaerobic digestion, Millennium was intermediate and AC Assiniboia had the least. This relates well to the quantity of lignin present in the husks, since Millennium has a thinner husk than Gerald and AC Assiniboia is a low lignin line. A division in gas production was also observed with AC Assiniboia producing most gas and little difference between Gerald and Millennium. The results for AC Assiniboia were closer to the naked oat varieties than the husked oats, confirming the low lignin content in the husk. Exeter, a low oil husked oat, had the second highest dry matter remaining although in terms of gas production it was only exceeded by AC Assiniboia among the husked oats. This implies that oil content is interfering with the gas production (see Table 4a), oats in general have between 2-6 times the quantity of oil compared to wheat or barley. The animals would be able to utilise the oil content in the oats further down their digestive system so the additional energy derived from the oil is not reflected by this method of determining feed value. Other evidence suggests that oil content can reduce the amounts of gases emitted by ruminants, this offers opportunities of further study, as gases produced by ruminants are a major source of greenhouse gases.

The main conclusions from this preliminary study were that differences can be identified between the cereals but total feed value is not expressed. No clear link could be made with the previously determined predicted ME value. A comparison of the relative feed values of cereals is clearly an area that would benefit from further research. Much of the current data has been amassed from older varieties and oats in particular are suffering as a result.

Another significant advance in the use of oats for use as ruminant feed may come from the Canadian variety AC Assiniboia that has been found to have a low lignin husk content. Stored seed of this variety was tested this year for predicted ME value and was found to be one of the lowest results. A possible reason is the lower oil content found in spring oats. This variety has been multiplied in the field 2000 season and should be available for further testing. The introduction of low lignin content into a thin-husked high oil content winter oat would offer considerable benefits to ruminant industry.

Feed for poultry

Another area of considerable interest is the development of naked oat varieties as an animal feed. Naked oats were introduced by the IGER oat breeding programme in the mid-1980’s and occupy an important market niche. Naked oats have the highest energy values of all cereals since they do not have a fibrous husk (Table 4b). The lack of husk also means a lower yield when compared to a husked variety (Table 3b). There is considerable interest in developing naked oats as a feed for poultry and pigs. High energy values and high levels of essential amino acids mean they can act as both an energy and protein source. Currently potential varieties are screened using NIR technique to determine oil and protein content. Other analyses include assessment of % nakedness, freedom from hairs and grain blackening.

The work completed in this project has led to some major advances in naked oat production. Grafton added to the Recommended List 2000 has short stiff straw similar to Gerald. Icon, a dwarf naked oat, is currently in Recommend List trials 2000 and this could revolutionise the feed market for poultry and pigs. The dwarf nature of Icon will allow targeted late N fertiliser applications to boost the protein content of the grain making it even more attractive as a feed stuff. Other even more promising dwarf and conventional naked lines are continuing through the programme (Table 3b).

Two naked lines 93-85ACn5/2 (dwarf) and 93-122Cn5/1 which are being testing in 2^{nd} and 1^{st} year National List trials respectively (sown autumn 2000- harvested summer 2001), these are likely to play an important role in improving the productivity and profitability of naked oats in the future.

93-85ACn5/2 is a dwarf naked oat, which is 5 days earlier and has relative yields 3% greater than Icon (Table 3ci). It is in its second year of National List trials. The dwarf nature allows targeted N applications to boost the protein content of the grain. This line will form an important part of the AFENO project see below.

93-122Cn5/1 is a conventional height naked oat with many attributes (Table 3bi-iii). It has good yields for a naked oat, 10% up on Grafton and Lexicon. It is more lodging resistant than Lexicon but not as good as Grafton. The quality data is also impressive with a thousand grain weight nearly 4 g heavier than Lexicon and Grafton.

HGCA is a funder of the agronomy work in a new project. The aims of this project are to address the diverse agronomic, nutritional and economic issues needed to realise the commercial potential of naked oats in the UK poultry industry. IGER will contribute advanced material for testing to ensure rapid development of varieties tailor-made for poultry feed. AFENO is entirely reliant on the progress made in the development of naked oat varieties at IGER. While IGER is not a direct participant of the project, it is funded by MAFF for 2000-2001 only to determine lines with high oil content and to examine the genetic and environmental effects on oil contents and associations with yield in order to provide information that will improve prospects for take-up by the industry. Industry funding will be needed in order to continue the identification of optimum new varieties tailored to the needs of the poultry industry. Initial observations suggest that dwarf oats may be able to optimise protein levels, but they may have lower oil contents than conventional height oats. Therefore breeding research is needed to break this adverse association.

Given the importance of having the right genetic material in the project, John Valentine was invited to be on the AFENO Project Management Group. This had its first meeting on 6th October 2000. If AFENO is successful it is likely to double the area of oats grown in the UK.
Currently commercial naked oats, the dwarfs Icon, 93-85ACn5/2 and experimental high oil lines are being used in the agronomy trials of AFENO.

Beta-glucans have already been identified as beneficial in dietary terms for humans. However low levels are required in feed for monogastrics. Table 6 shows the levels of beta-glucans present in the advanced lines.

Table 6 Beta-glucan content of advanced naked lines.

Line	Harvest year 1998	Harvest year 1999
	% Beta-glucan fresh wt basis	% Beta-glucan fresh wt basis
Gerald (husked control)	2.10±0.819	
Krypton (naked control)	2.28±0.075	3.15±0.072
Lexicon (naked control)		2.90±0.170
Icon (naked dwarf control)		3.44±0.127
91-229ACn234	3.20±0.109	
91-229ACn253	3.82±0.054	
92-151 ACn22	3.42±0.109	
92-157 ACn42	3.38±0.252	
92-157 ACn44	3.62±0.257	
92-173 Cn11	2.84±0.126	
92-173 Cn15	3.39±0.035	
92-173 Cn2	3.04±0.192	
92-128 Cn7/1/1		2.78±0.065
93-122Cn5/1		3.38±0.260
93-85ACn5/2 (dwarf)		3.34±0.164
93-85ACn7/1 (dwarf)		3.33±0.100

Means of 3 reps

Increasing protein levels have been associated with increased beta-glucan concentration (Peterson and Wood, 1997). Part of a BBSRC project is investigating the genetic control of beta-glucan levels in diploid oats. The results of this study could have important implications for industrial fractionation and functional foods. For oats used as animal feed, enzymes can be added to degrade beta-glucan levels (Chesson 1993, Bedford 1995, Marquardt et al 1996)

Conclusions

It is clear that this programme has made significant contributions towards improving both the economic competitiveness and improved the end-use characteristics of oats. The addition of the IGER varieties to the Recommended List over the years has contributed significantly to improving yields, grain quality and economic returns to the farms and processors, starting with Gerald in 1993 through to the present 2000 list of Kingfisher, Viscount, Millennium and Grafton. It is vitally important to continue the production of new varieties to successfully maintain the economic competitiveness of oats in relation to other cereals and to satisfy the end use requirements. It is clear that genetic improvements brought about by plant breeding far exceed any changes obtained through advances in crop husbandry.

Future plans for oat breeding research at IGER

Future work concentrating on naked oats will be jointly funded, and will utilise the results of downstream MAFF and BBSRC work concerned with selecting novel germplasm from cultivated and wild species and will include as far as possible, the use of biotechnology e.g. marker assisted selection and genomics. Biotechnology currently used in other cereals is likely to become applicable to oats, allowing greater use of the existing diverse wild oat gene pool. This contains many useful characteristics such as improved drought tolerance, improved pest and disease resistance.

We will continue to interact with end-users, commercial companies and others to optimise the limited effort on oats. We will attempt to realise the potential of oats with enhanced nutritive quality in order to improve economic and environmental sustainability in animal production systems. This is a major opportunity for creating a new market for quality oats.

Provided that new funds can be obtained, the IGER breeding programme seeks to build on the large gains made in economic competitiveness and quality for new and existing varieties. In the next decade, major achievements could include:

-dwarf oats with high yield and nutrient delivery in milling and feed markets.

-the production and use of naked oats with high protein and oil which will be used in the poultry industry.

-thin-husked winter oats with high ME for use in ruminant feeds with advantages in terms of animal health (e.g. reduced acidosis) and improved product quality (e.g. high monounsaturated fatty acids).

The advent of functional foods offers the oat industry tremendous potential in terms of human consumption. As more health benefits are conclusively proved, the consumption of oats is likely to increase. Advances in plant biotechnology are likely to be promote the use of marker assisted selection which should enhance development of high or low oil or beta-glucan lines. These may lead to high beta-glucan varieties and also low fat (oil) varieties to further the marketing of oats as a healthy option choice.

Developments of varieties especially suitable for organic production systems and for use in organic meat production or dairy herds are likely to occur.

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Sue Lister for NIR results of oil and protein content

Dave Davies and Alison Brooks for digestibility studies

Out puts from project HGCA 1664 1998-2000

New Varieties

Varieties added to UK Recommended List 2000

Millennium (87-42CnI/2/2/1) - Very high yielding winter oat variety with short stiff straw, high resistance to crown rust, very large grains with thin husks conferring high value for milling and feed use.

Grafton (89-226Cn1/2) - high yielding naked oat variety with appreciably shorter straw than currently available varieties.

Varieties added to UK Recommended List 1999

Kingfisher (89-26Cn6/1) - highest yielding winter oat variety in both treated and untreated trials. Large grain giving low screening losses. Tall but stiff straw.

Viscount (89-26Cn14/1) - high yielding early winter oat variety with short straw. Specially recommended for areas where crown rust prevalent. Low screening losses.

Varieties added to National List 2000

Icon

Varieties added to National List 1999

Millennium (87-42CnI/2/2/1) - Very high yielding winter oat variety with short stiff straw, high resistance to crown rust, very large grains with thin husks conferring high value for milling and feed use.

Grafton (89-226Cn1/2) - high yielding naked oat variety with appreciably shorter straw than currently available varieties.

Shows

Joint demonstration exhibition with Semundo at Cereals 99 and Cereals 2000. These included demonstration plots of Millennium and Icon.

Stand at the ADAS Rosemaund open day on 23rd June. 1999
Part of IGER stand at Royal Welsh Show 1999, 2000

Web sites

http://www.iger.bbsrc.ac.uk/igerweb/plantbreeding/plant-home-page/plant-top.html *Web page*
http://www.london.press.net/issues/9/104/pageseven.htm. *Web page* issue 104 Farming and Agricultural Developments in Britain "Oats could be vital feed ingredient for livestock feed" BAN 9/104/1

Technical articles

J. Valentine and J M Leggett (1999) *CAB International Global Compendium for Crop Protection* 11pp

J Valentine (1999) Is there a role for cereals in sustainable local development. *The Biognosis Bulletin*, No 1, 19- 23.

Presentation and Poster at Sixth International Oat Conference New Zealand, Nov 2000

Technical Presentations

Oat quality. *Presentation to CCFRA Cereal Variety Working Party.*
Improving the Oat Presentation *to 2nd European Oat Conference 28th 29th October 1999 Cambridge*
Review of HGCA 1664 project at MAFF review on Oat Research and Development 30th *November 1999*

Oat forward look meeting, MRC 11 August 2000
[Convened a meeting bringing all sides of oat users, growers, researchers, millers processors, together to identify ways ahead. Over 60 discussions with various oat users have occurred during the project]

Popular articles
' It's official - daily oats are good for you'. *Press release*

An article in Farmers Weekly in January 1999 entitled 'Grower cash gives fillip to oat work' highlighted oat varieties and breeding objectives. The article started thus:
Profits from oats are set for a boost thanks to HGCA-funded work.

A subsequent article in April concentrated on the scope for oats as a replacement of bought-in proteins and energy for livestock feeding. The backing of the research by MAFF, HGCA, BBSRC and Semundo was emphasised.
There have been a number of articles in the Farming press throughout the year which have highlighted the benefits of oats and discussed varieties and their attributes, these include:
Home grown oats –sustainable protein source *Western Mail 5/3/99*
Now new oats stage comeback *in Farmers Weekly 16/4/99*
Master Oats *in Arable Farming 12/6/99*
Variety Icon discussed *in Farmers Weekly 25/6/99*
Winter and Spring Oats *in Arable Farming 28/6/99*
Making a meal of oats *in Farmers Weekly 3/7/99*
Future prospects *in Farmers Weekly 3/7/99*
Varieties Viscount and Millennium described in *Arable Farming 16/10/99* p14-15 "Drill fillers"

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Theodorou MK, Williams BA, Dhanoa MS, McAllan AB, France J. (1994) A simple gas production method using pressure transducer to determine the fermentation kinetics of ruminant feeds. Animal Feed Sciences and Technology 48,185-197

Thomas PC, Robertson S, Chamberlain DG, Livingstone RM, Garthwaite PH, Dewey PJS, Smart R, and Whyte C. (1988). Predicting the metabolizable energy (ME) content of compound feeds for ruminants in Recent Advances in Animal Nutrition Eds. W.Haresign & DJA. Cole Butterworths, London 127-146

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