FACTORS AFFECTING YIELD AND QUALITY OF OATS

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SUMMARY

Quality evaluation of oats relies primarily on hectolitre weight and, while it is an important characteristic, work carried out at Oak Park and elsewhere has shown that it does not accurately measure grain quality. Consequently, the selection of oat lots and varieties which have a high milling value has been limited, as present techniques fail to accurately determine the characteristics most closely related to milling quality. In this regard the kernel content and the ease of husk removal, termed the hullability, are the most important. This study has developed a new test for assessing oat kernel content, which is more rapid and cheaper than techniques currently available. Despite its obvious importance, oat hullability has not been assessed to date in quality evaluation due to the absence of a test procedure. However, this obstacle has now been overcome. The results of this work also provide a much better understanding of how hullability of individual varieties can be assessed, as well as investigating how this could be manipulated at field level. Using the methods developed, the selection of varieties with enhanced processing characteristics can now be carried out more precisely for Irish conditions. The field trials conducted to evaluate the effect of agronomic practices on quality indicated that the effect of factors such as nitrogen rate and seed rate was small in comparison to variety, which had the largest and most consistent effect. The variation in quality could not be completely explained by variation in the panicle characteristics studied. Increasing the nitrogen rate increased yield with the optimum being 160 kg N/ha in 1998 and 1999. However, lodging became a very significant factor at nitrogen rates above 100 kg N/ha in 1998, although it did not occur in 1999. This work supports the current Teagasc nitrogen recommendations for oats where levels of 110-140 kg N/ha (Soil Index 1) are advised.

INTRODUCTION

In Ireland, oat crops are grown mainly for the horse feed and milling markets. Both require well-filled grains that are sound and free from contamination, although the particular requirements vary between both markets. For the horse feed sector, grain must have a minimum hectolitre weight of 52 kg/hl and be free from diseases with good colour. For the milling market, oats should have a high hectolitre weight, high kernel content, good hullability and low screenings, as well as minimum kernel blackening and breakage. In order to meet these requirements,

it is essential for modern varieties to have, in addition to suitable quality characteristics, a high yield and stiff straw, as well as good resistance to diseases, particularly mildew, crown rust and oat mosaic virus.

Recent work at Oak Park has focused on exploiting the potential of oats as a break crop in integrated crop production systems, as well as elucidating the factors involved in the production of high yielding and enhanced quality oat crops. This latter work was conducted in a collaborative research programme with Queen's University Belfast at the Department of Applied Plant Science, Plant Testing Station, Crossnacreevy.

METHODS AND RESULTS

The assessment of milling quality

Hectolitre weight

Current quality evaluation relies mainly on measuring the hectolitre weight of the grain. Hectolitre weight is a measure of the density or specific weight and is thought to be an indicator of grain quality, particularly potential extract yield. However, it is not a direct measure of a processing characteristic and has been shown by Meyer and Zwingelberg (1981) to be unsuitable for the prediction of extract yield. McGarel and White (1996) reported that hectolitre weight only accounted for 19% of the variation in kernel content across a range of varieties. In this research, a relationship was found between hectolitre weight and milling quality, particularly kernel content, within each variety but a poor relationship was found between the two when comparing between varieties Fig.1. For any given hectolitre weight variety A had a higher kernel content to that of variety B illustrating the failure of hectolitre weight to accurately measure milling quality.

The failure to assess characteristics directly related to value for milling, such as kernel content and the ease of husk removal, termed the hullability, is related to the absence of rapid and reliable tests. The poor relationship between quality and hectolitre weight between varieties presents particular difficulties in the selection and recommendation of oat varieties, where hectolitre weight is one of the main selection criteria as it does not necessarily mean the variety will have good milling quality. The milling industry is interested in methods for better defining and assessing quality purchasing criteria to better quantify the impact the purchased oats will have on mill efficiency.

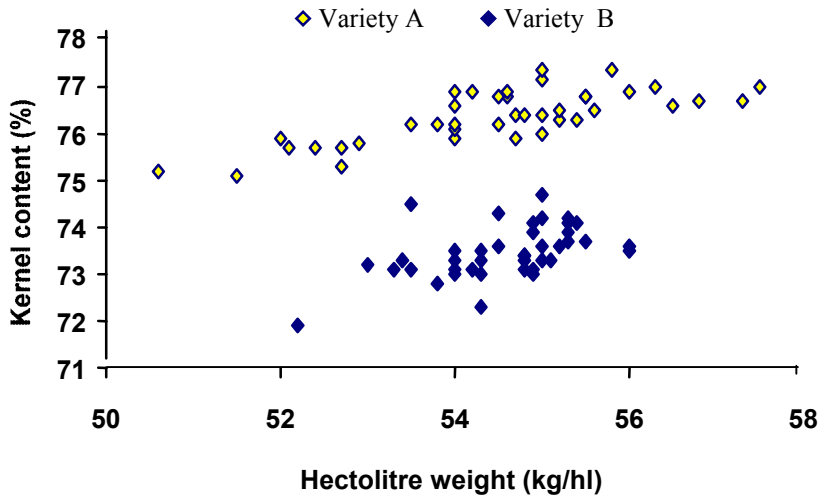

Fig. 1: Relationship between hectolitre weight and kernel content

The first priority of this research was to develop and assess methods to more accurately determine milling quality. A laboratory dehuller (Streckel and Schrader KG, Model BT459/e) was utilised to mimic the dehulling stage of the milling process. With this, a protocol was developed to provide a rapid method by which kernel content and hullability could be assessed. Test milling was carried out over a range of varieties. The kernel contents obtained from the dehuller were compared with the current standard method of hand determination, and the hullability, which could not previously be assessed, was compared to millers' observations of particular varieties.

Kernel content

Kernel content is the characteristic most closely related to the millers' extract yield of product. The current hand method of kernel content determination is too time-consuming and expensive to perform on commercial samples. There was a high positive correlation between the hand and dehuller methods of kernel content determination (r^2=0.90) (Fig. 2) and, therefore, confirmed the suitability of the dehuller for use as an alternative method of kernel content determination. However, the dehuller kernel contents were consistently about 1 to 2% lower than those determined by hand, due to abrasion of the kernel that occurred in the dehuller. There were significant differences between varieties in kernel content. Barra had the highest, while Aberglen, Aintree and Gerald were among the lowest.

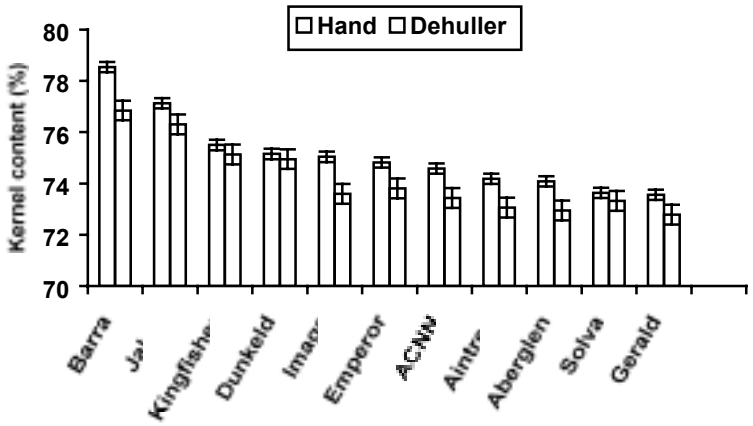

Fig. 2: Comparison of hand and dehuller methods of kernel content determination

Hullability

Hullability, or the ease of husk removal, has important implications for mill efficiency. A variety with poor hullability will require greater impact speeds within the dehuller during milling and result in greater kernel breakage, thereby depressing the miller's extract yield. In extreme cases, varieties, such as Mirabel, may even be unmillable because the husk is so difficult to remove. Hullability was assessed as the percentage of grain remaining unhulled after test milling. A high percentage of grain remaining unhulled indicates that the husk was difficult to remove and, therefore, has poor hullability. The percentage of grain remaining unhulled, of a range of varieties, after test milling using the protocol developed, is presented in Fig. 3. Barra has particularly good hullability, with a low percentage of grain remaining unhulled, Image was intermediate, while the varieties Gerald, ACNN and Kingfisher had poor hullability and, therefore, poorer milling quality.

The methods developed provide a useful tool for the evaluation of quality, in particular by breeders developing new varieties and in the evaluation of varieties

within variety testing for Recommended List status. It also offers the prospect of millers using these methods to improve quality evaluation.

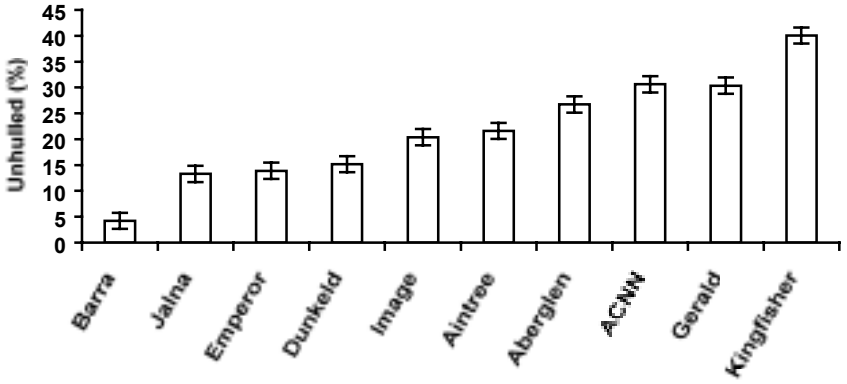

Fig. 3: Effect of variety on hullability assessed by test milling

Effect of agronomic factors

Agronomic guidelines for the oat crop are well-established in terms of yield and lodging. However, the effects of agronomic factors on quality are less clear due to the absence of methods to assess the processing characteristics directly related to value for milling. Field experiments were conducted at Oak Park to investigate the effect of agronomic factors on quality, using both the novel methods developed and conventional methods of quality evaluation.

Factorial field experiments were conducted in 1998 and 1999, investigating the effect of five nitrogen rates: 70, 100, 130, 160 and 190 kg/ha, two seed rates 200 and 300 seeds/m^2, on two commercially important varieties, Aberglen and Barra. The nitrogen rates were selected to give a range from low to high fertility and the seed rate to give a recommended rate of 300 seeds/m^2 (Laverick, 1997) and a lower seed rate. The effects of seed rate on yield, lodging and quality were small and are, therefore, not presented here.

Yield and lodging

Increasing the nitrogen rate increased yield with the optimum being 160 kg N/ha in both years. However, lodging became a very significant factor at nitrogen rates above 100 kg N/ha in 1998, although it did not occur in 1999 (Table 1). In 1998, it must be noted that although lodging levels were high, weather conditions were good and all plots were harvestable. However, if conditions were poorer, this could have translated into considerable harvesting problems and reductions in yield and quality. Current recommendations for winter oats are 110-140 kg N/ha (Soil Index 1). Aberglen out-yielded Barra in 1998 but had a similar yield in 1999. Care should be taken in comparing the relative yield of these two varieties, as it is just over two seasons at one site. More comprehensive yield performance data is available from the Recommended List published by the Department of Agriculture, Food and Rural Development, Backweston, Co. Kildare.

Table 1: Yield (t/ha at 15 % moisture content) and lodging index, Oak Park 1998 and 1999

	Oak Park 1998		Oak Park 1999	
N (kg/ha)	**Yield (t/ha)**	**Lodging index**	**Yield (t/ha)**	**Lodging index**
70	7.34[a]	0.0[a]	8.48[a]	-
100	8.22[b]	5.0[a]	9.14[b]	-
130	8.62[c]	28.5[b]	9.82[c]	-
160	8.94[d]	64.6[c]	10.15[d]	-
190	9.08[d]	86.7[d]	10.32[d]	-
LSD	0.31	9.1	0.26	
Variety				
Aberglen	9.14	34.3	9.74	-
Barra	7.74	39.7	9.43	-
LSD	0.17	NS	NS	-

Kernel content

The effects of nitrogen rate and variety on grain quality at Oak Park 1998 and 1999 are presented in Table 2. The kernel content, while statistically significant, was only 0.5% lower at the highest rate of nitrogen than at the lowest rate of nitrogen. Nitrogen rate did not significantly affect the kernel content at Oak Park 1999. In both years, Aberglen had a significantly lower kernel content than Barra by 2.9% and 3.0% in 1998 and 1999, respectively.

Table 2: Effect of nitrogen rate and variety on grain quality, Oak Park 1998 and 1999

N (kg/ha)	Oak Park 1998				Oak Park 1999			
	Kernel content (%)	Unhulled grain (%)	Screenings (%)	Hectolitre weight (%)	Kernel content (%)	Unhulled grain %	Screenings (%)	Hectolitre weight (%)
70	75.1[a]	21.5	5.16[a]	55.3[a]	74.4	20.0[a]	3.61[a]	57.4[a]
100	75.0[a]	22.5	5.77[a]	55.0[a]	74.5	17.8[b]	4.20[b]	56.9[ab]
130	74.9[a]	22.1	5.55[a]	54.6[ab]	74.5	16.2[c]	5.18[c]	55.9[bc]
160	75.0[a]	21.3	5.62[a]	54.3[b]	74.5	14.4[d]	6.31[d]	55.4[c]
190	74.6[b]	21.1	6.81[b]	53.5[c]	74.5	14.2[d]	6.39[d]	55.3[c]
LSD	0.3	NS	0.80	0.5	NS	1.4	0.59	1.2
Variety								
Aberglen	73.5	34.0	6.58	54.6	73.0	25.3	6.80	55.3
Barra	76.4	9.40	4.98	54.5	76.0	7.7	3.48	57.0
LSD	0.2	0.8	0.43	NS	0.3	2.2	0.44	0.8

[a,b,c,d] **Means with different superscripts in the same column are significantly different (P<.05)**

Hullability

The percentage of grain remaining unhulled after test milling was significantly reduced at the higher rates of nitrogen at Oak Park 1999, as at Crossnacreevy 1999, therefore improving the hullability, but was not significantly affected at Oak Park 1998. The percentage of grain unhulled in Barra was lower than that of Aberglen in all experiments, in agreement with previous observations of the hullability of these varieties.

Hectolitre weight and screenings

Hectolitre weight declined and screenings increased in both years at the higher rates of nitrogen (Table 2). Aberglen had higher screenings than Barra. The hectolitre weight of Aberglen varied relative to that of Barra. At Oak Park 1998, Aberglen had a lower hectolitre weight, while at Oak Park in 1999 they were

similar. Overall, Aberglen was consistently poorer in the characteristics directly related to value for milling.

The higher rates of nitrogen had a negative effect on quality in respect of kernel content, screenings and hectolitre weight but did improve hullability, although the magnitude of the changes in quality were small, especially when considered within the normal ranges of production. Agronomic practices at present, which are tailored to achieving a balance between yield and lodging, are therefore appropriate to achieve both yield and quality. Variety had the largest and most consistent effect on quality and is the key to producing quality oats.

Panicle conformation and implications for quality

In order to further our understanding of variation in grain quality between varieties and due to agronomic practices, the conformation of the oat panicle was investigated. The oat spikelet contains basal, secondary and tertiary grain. Within the spikelet, the basal grain is larger (Tibelius and Klinck, 1986) and has a lower kernel content (Hutchinson, Kent and Martin, 1952). The basal grain was also found to have poorer hullability. Variation in the percentage of basal grain was therefore investigated to evaluate its implications for quality and whether changes in the percentage of basal grain and changes in grain weight, within each population, explained variation in quality.

At Oak Park 1999, the variety Aberglen had a lower percentage of basal grain (Fig. 4) than Barra but had poorer hullability, although the differences in the percentage of basal grain were small. Despite Aberglen having higher screenings, it had a higher basal grain weight (Fig. 5) and a higher, but not significantly, secondary grain weight. Therefore, the percentage of basal grain and the grain weight within the grain populations between varieties are not adequate to fully explain variation in screenings, although they are likely to have some influence. Further work is necessary to identify the characteristics that determine quality, such as screenings, to allow breeders to develop suitable varieties.

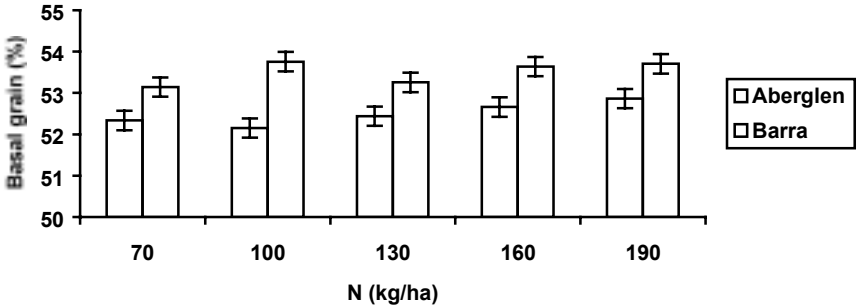

Fig. 4: Effect of nitrogen rate and variety on the percentage of hand harvested grain composed of basal grain, Oak Park 1999

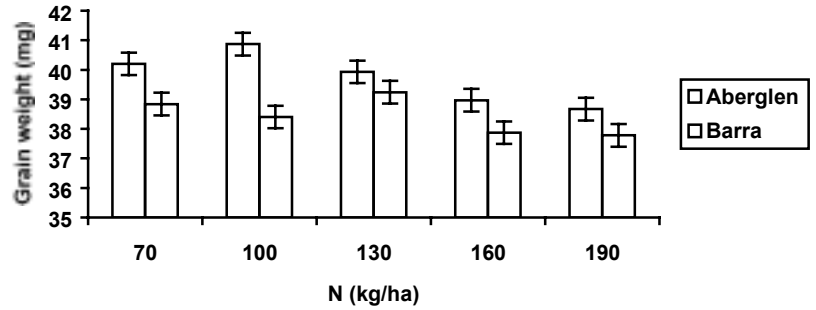

Fig. 5: Effect of nitrogen rate and variety on the basal grain weight, Oak Park 1999

Characteristics of an ideal variety

As the effects of agronomic practices on quality were small variety selection is the key to producing high quality oats. An ideal variety should have a high kernel content, good hullability and low screenings. A high hectolitre weight is also required, as it is the primary indicator of quality used at present. It is also essential for modern varieties to have high yield, stiff straw as well as good resistance to diseases. It is proving difficult to find a replacement variety for Barra with comparable milling quality, and it will be necessary to measure other

parameters, as discussed in this paper, such as kernel content and hullability, to actively select for a high quality variety and to prevent unsuitable varieties making it through the evaluation system. Further consideration must be given to the use of hectolitre weight, as it may prevent otherwise suitable varieties, in terms of grain quality and agronomic characteristics, achieving Recommended List status.

CONCLUSIONS

- Hectolitre weight is not an accurate predictor of milling quality.
- This study has developed a new test for assessing oat kernel content, which is more rapid and cheaper than that currently available.
- Despite its obvious importance, oat hullability has not been assessed to date in quality evaluation, due to the absence of a test procedure. However, this obstacle has now been overcome.
- Using the tests developed for kernel content and hullability, the selection of varieties with enhanced processing characteristics can now be carried out more precisely for Irish conditions.
- There were significant varietal differences in kernel content and hullability.
- Variation in hullability and screenings could not be completely explained by variation in the percentage of basal grain and grain weight.
- Agronomic studies indicated that nitrogen level and seed rate effects on quality were small.
- Variety had the largest and most consistent effect on quality and is, therefore, the key to the production of high quality oats.

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