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Future Developments in the Grain Market

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INTRODUCTION

The current grain market is poised between the depression of surpluses over the last four years and some prospect of firmer prices as a result of falling grain stocks over the next two years. Brussels is taking a 'back-seat' in market management and the new emphasis is on environment and health issues, with some focus on the Eastern European countries waiting to join the EU. So what does this mean in the markets?

SHORT TERM

Wheat

Forward prices on the international market are higher than for the current delivery position and, with crop prospects in Northern Europe weakened by the atrocious rains this winter, total world demand rates, particularly for wheat, are likely to exceed supply again during 2001/2. This will reduce stock around the world, with a positive impact on world prices. The EU crop prospects can be typified by the slow plantings seen in the UK, where the area of wheat is expected to be down by perhaps 300/350,000 ha.

Maize and barley

World maize stocks have stopped rising and although US stocks still reflect the record crop seen this year, rising feed demand is accelerating usage so the stock problem is beginning to be less of a burden on the market. Barley prices have been steady for some time, largely as a result of Saudi demand. But now we are beginning to see a recovery in the malting/brewing sector that is supporting demand for malting barley also.

Currency

The strength of sterling has impacted on demand for UK wheat over the last few years and recently this has reversed, with positive effects on UK market prices. Simultaneously, over the last year, sterling and the euro have also weakened against the dollar. This has also been supportive to interior prices and has permitted Brussels to export large quantities of grains without export subsidies.

2000/01 exports from UK

The large 2000 crop in the UK brought concerns about the difficulties of exporting large quantities and caused weakness in prices in October. Since then, good amounts have moved and the market has been boosted significantly, helped by a stronger euro. This export demand was helped by the poor crops in importing regions like North Africa and Eastern Europe and the poor quality of the French crop. Barley prices were boosted by the cut back in spring plantings last year. This will be reversed this year. Malting barley outlook is also boosted by the strong demand for beer in Asia and South America and mediocre crops in Australia and Canada.

The 2001/2 season

Everything will change next year. There will be dramatically less wheat in Europe, especially in the UK, with some increase in spring barley (especially in the UK). Producers revenues are looking better than last year, based on forward prices, supported by the good carry-charges in the world/US markets.

LONGER TERM

CEEC

While there are some prospects for steadier prices in the world, the most significant fact looming in the EU is the impending membership of all the CEEC countries. These countries are dwarfed by the EU, but have a huge political importance. This means that Brussels and the EU politicians are keen to see accession of these States accelerated, or at least guaranteed. This will, in the end, produce greater export surpluses of grain from the EU, since the land area suitable for arable crops has greater potential to produce than the relatively small population has to consume. Yields in the CEEC are poor currently but so is finance availability. Once membership is achieved, the banks will be keen to finance CEEC farmers and yields will improve. They also have the potential to increase their exports of organic crops. In any event, surpluses will rise.

Other EU policy developments

Brussels is slowly retreating from market management and is increasing its activity in the environmental and health areas. EU farmers need to understand that if they are to maintain their incomes they will need to tap most of these 'initiatives'. Specifically in the grain business, traceability and quality assurance schemes will become almost obligatory over the next few years, as EU law institutes more and more requirements designed to guarantee the health and safety of the general population.

Food demand

Asia is the key, and here we expect to see steadily rising standards of living and increasing food consumption. This could be particularly interesting as China adapts to WTO membership and relaxes its desire to be self sufficient in food.

CONCLUSION

The points to look for over the next few years are:

- Intervention price cut again - and again?
- World prices for UK wheat, feed-grains and barley seem steadier
- Much depends on world price prospects
- But grain price outlook generally cautiously positive
- Currency is wild card: $ vs Euro and £ vs Euro
- Quality of UK crop is critical: food or feed
- Malting barley prices helped by strong demand
- CEEC is coming
- WTO will involve environmental issues

Cropping Choices in the Wake of a Difficult Autumn

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ABSTRACT

The record rainfall levels during the last four months of 2000 severely disrupted the sowing of winter cereals, with an estimated shortfall of 60,000, ha in the area planted, compared with the previous year. A major shift to spring barley would not be desirable from a national point of view, given that this country is already a net exporter of barley and a large net importer of wheat. Such a shift would also be undesirable from a grower's point of view because of the likely downward price pressure on barley. Winter wheat varieties can quite safely be sown up to mid-February but late harvesting is a risk in northern areas. There is renewed interest in protein crops but seed supplies of field beans are limited. Voluntary set-aside is an option on land damaged from harvesting root-crops or on land totally unsuited to spring barley production.

INTRODUCTION

In this paper I will

- Review the current situation regarding winter sowings
- Examine the cereal supply balance in this country
- Outline the options available to growers
- Options examined will include spring-sown wheat, spring barley, alternative crops and set-aside

Winter Sowings

The first harvest of the new millennium proved to be outstanding with record yields across the full range of crops. The weather pattern was ideal with warm sunny weather alternating with periods of rainfall.

Towards the end of the harvest, however, the weather deteriorated. The autumn of 2000 proved to be the wettest on record in places, with rainfall levels well over 50% above normal in many places.

As a consequence, the sowing of winter cereals was seriously disrupted. The estimated area sown is outlined in Table 1 along with the actual area sown in 1999/2000.

Table 1: Area (ha) under winter cereals in 1999/2000 and 2000/2001 (estimated)

	1999/2000	2000/2001 (est.)	% change
Winter wheat	62,700	25,000	-60%
Winter barley	24,600	12,300	-50%
Winter oats	10,200	3,000	-70%

The total shortfall amounts to almost 60,000 ha and decisions are now being taken as to the most profitable use of this land in the current year.

Cereal Supply Balance

In any discussion on the relative profitability of the various options available, it is important to focus on the cereal supply balance within the country in order to estimate the impact of any major shift between crops.

Over the last couple of seasons, this country has been marginally in over-supply of barley and has been a huge net importer of wheat (Table 2).

Table 2: Cereal supply balance 1999/2000 (‘000 tonnes)

	Barley	Wheat
Production	1,278	597
Domestic use	1,190	1,142
Exports	105	15
Imports	17	560

The surplus barley largely goes into intervention or is exported to Northern Ireland, with the price being determined by the price of grain delivered to the port from the UK.

Over the past couple of seasons there was only a small differential between the price of wheat and barley. This was largely due to the fact that the price of barley was underpinned by the intervention support price. It needs to be remembered that, for the coming season, the intervention support price for barley will have fallen by 15% to £79.79/tonne. This equates to a green barley price of £63/tonne. While it is not anticipated that the full extent of this reduction in price support will impact on the market place, any further oversupply of barley will increase the downward pressure.

Options for Growers

The principal options available to growers this Spring are as follows:

- Spring-sown wheat
- Spring barley
- Protein crops
- Other alternatives
- Voluntary set-aside

Before discussing each of these options the gross margins achievable from some of these options at target yields are outlined in Table 3.

Table 3: Gross margins at target yields for various crop options, £/ha (£/ac)

Crop	Target yield t/ha (t/ac)		Gross margin £/ha (£/ac)	
Spring wheat	8.75	(3.5)	435	(176)
Spring barley	7.5	(3.0)	418	(169)
Spring beans	5.0	(2.0)	375	(152)
Spring rape	2.0	(1.0)	234	(95)
Set-aside	-	-	272	(110)

Source: Teagasc Crop Costs and Margins, J. O'Mahony

Gross margin is defined as margin over materials and all machinery costs. Other fixed costs need to be deducted to arrive at net margin. These vary widely from farm to farm but usually amount to at least £100/ha (£40/ac).

(a) Spring-sown wheat

Given the very large import requirement for wheat it is in the national interest to produce as much wheat as possible. It should also be in the interest of individual growers if reasonable yields can be achieved.

For the purpose of this exercise, wheat sown in the new year, whether winter or spring varieties, is treated as spring wheat. Yield expectations are similar whether winter or spring varieties are used but are somewhat lower than autumn-sown wheat. However, costs are also somewhat lower in terms of nitrogen, herbicide, fungicide, insecticide and interest charges. As shown earlier, an 8.75 t/ha (3.5 t/ac) crop should give a gross margin of £435/ha (£176/ac).

The principle concern with sowing true winter wheat varieties in spring is the whole question of vernalisation, a process that requires periods of low temperatures followed by exposure to extended periods of light.

Work by Dr. J. Burke at Oak Park has shown that all varieties can be safely sown up to mid-February while a number of varieties can be safely sown up to 21 February (Table 4).

Table 4: Winter wheat varieties suitable for spring sowing

Variety	Up to 14 February	Up to 21 February
Madrigal	Yes	NS
Marshall	Yes	NS
Falstaff	Yes	Yes
Savannah	Yes	Yes[1]
Claire	Yes	Yes
Soissons	Yes	Yes
Rialto	Yes	Yes
Reaper	Yes	Yes
Brigadier	Yes	NS
Buchan	Yes	Yes

[1]Slow ripening variety
NS = not suitable

Location in the country is also a factor with a higher chance of low temperature events in more northerly areas. This should be balanced, however, by the fact that late sowing in northerly areas can lead to very late harvests.

In any event, caution is required in southerly areas where the likelihood of low temperatures is less and in these areas the dates in Table 4 should be brought forward by a week.

After these dates growers should revert to spring varieties or some alternative cropping strategy. It is estimated however, that there is only enough spring wheat seed available to sow 25,000 hectares compared with last year's area of 21,600 ha.

(b) Spring barley

The margin shown earlier of £418/ha (£169/ac) for spring barley was based on a 7.5 t/ha (3 t/ac) crop with a feed price of £76/t including VAT.

In switching to spring barley two factors need to be considered; soil suitability and cereal supply balance. A lot of excellent winter wheat ground is unsuitable for spring barley and unless yields in excess of 6.25 t/ha (2.5 t/ac) can be anticipated, other options should be considered.

In relation to cereal supply balance, it has been shown that this country is already in oversupply of feed barley. If half the unsown winter area were sown to spring barley, this could add a further 200,000 tonnes to the barley supply. While it is impossible to quantify the effect of this, there is no doubt but that it would put considerable downward pressure on the market price for feed barley.

(c) Protein crops

The ban on meat and bone meal and the traceability problems associated with genetically modified soya, have greatly increased the interest in and demand for home-grown protein sources. The field bean area has dropped from a peak of over 4000 ha in the mid-nineties to under 1000 ha in 2000. This reduction is due to the variability in yield and the £50/ha (£20/ac) fall in arable aid. The increased demand, however, has seen the price increase by over £15/t to £106/t. At this price level, a 5 t/ha (2 t/ac) crop will leave a respectable margin and this level of yield is quite achievable. The rotational benefits are also significant.

Unfortunately, for the current season seed availability is limited to 300 tonnes or enough to sow 1600 hectares.

Lupins are a higher source of protein than beans but, when sown in autumn, are still a risky proposition. It is hoped that spring varieties will soon be available which will make the crop a much more viable proposition.

The demand for protein has also led to a renewed interest in protein peas and forage peas.

The problems encountered in the previous incarnations of these crops may be overcome by the whole-crop or crimping option.

(d) Other alternatives

Maize, as a cash crop for tillage farmers, has definite potential and will be dealt with later by Jim Crowley. The area under oil seed rape and linseed fell dramatically last year and is set to fall again this year, with the arable aid falling to £373/ha (£151/ac) and £368/ha (£149/ac) respectively. By 2000 the rate of arable aid for these crops will be the cereal rate i.e. £301/ha (£122/acre) [see Appendix I].

Crushed oilseed rape is a protein source but that is not much use in this country, as the crop has to be exported for crushing.

(e) Set-aside

This leads me to the thorny issue of voluntary set-aside. As you are aware, the level of voluntary set-aside has been increased by 10% for 2000/2001, as a once off measure, in recognition of the difficult planting conditions last back-end. For the coming season this means a minimum level of 10% set-aside and a maximum level of 30% set-aside. The actual average rate of set-aside in 2000 was 11.6% or just above the minimum rate of 10% (see Appendix II). This is a reflection of the general dislike growers have for set-aside and, also, the £55/ha (£22/ac) reduction in the rate of set-aside payments.

Hopefully the improved weather and soil conditions earlier in January will have helped to redress some of the shortfall, but nonetheless there is still a lot of land out there which is available to be set-aside.

The gross margin outlined for set-aside of £272/ha (£110/ac) is based on set-aside payments of £306/ha (£124/ac) and a maintenance cost of £35/ha (£14/ac).

There are two situations where voluntary set-aside should be considered.

- Where yield expectations are so low as to expect a lower margin than that generated by set-aside. This is most likely to arise on heavy wheat land, unsuited to other crops, or on land damaged by potatoes or sugar-beet harvesting.

- Where contractors are used and fixed costs are low. In this scenario, crops and set-aside can be compared on a straight gross margin basis. In situations, however, where a substantial proportion of machinery is owned and/or where fixed costs are high, it should be remembered that any reduction in the sown area will increase the costs and thereby reduce the margin on the sown area.

REPS

The removal on the ban on growth regulators in REPS will facilitate small to medium-sized winter cereal growers entering the scheme. The 40 ha (100 ac) limit on payments still applies and this will limit the attractiveness of the scheme to growers above 80 ha (200 ac) or those with a lot of conacre in the mix. Nevertheless, as margins tighten, every income earning opportunity should be explored.

There are many share farming arrangements in place which allows one of the partners to work off-farm while availing of REPS and arable aid while allowing the other partner to achieve economies of scale particularly in relation to machinery.

CONCLUSIONS

- Autumn/winter plantings are down from 98,000 ha in 1999/2000 to an estimated 40,000 ha in the current season.
- A major shift to spring barley would be undesirable given that in the last full marketing year we exported 88,000 tons of barley and imported 545,000 tons of wheat.
- Winter varieties can be safely sown, from a vernalisation viewpoint, up to mid-February and later in the case of some varieties. Late harvesting could be a risk in northern areas.
- Prices for protein crops have hardened but seed supply of beans is limited. Lupins are still problematic, from a management point of view, but spring varieties are being developed.
- Voluntary set-aside may be an option on damaged land or on land unsuited to spring barley. The fixed cost structure on the farm needs to be considered.

Appendix I: Arable Aid payments (£/ac)

	1999	2000	2001	2002
Cereals	111	118	124	122
Set-aside	140	118	124	122
Proteins	160	145	143	140
Linseed	214	177	149	122
Oilseeds	188	173	151	122
Maize	106	112	118	116

Appendix II: Utilisation of National Base Area

The Barley Leaf Spot Problem - Causes and Control

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ABSTRACT

The barley leaf spot problem, which causes necrosis and chlorosis of leaves, leaf sheaths and awns, poses considerable difficulties for spring barley production and is, therefore, the focus of intensive research at Oak Park. Results indicated that the problem comprises of two components, parasitic and non-parasitic spotting, both of which can occur independently. The parasitic type is caused by the fungus Ramularia collo-cygni. The cause of the non-parasitic spotting is thought to be a physiological response to stress factors such as high solar radiation. Field trials in 2000 examined a wide range of factors including fungicide use. Fungicide effects on non-parasitic spotting were small in 2000 and, therefore, it was difficult to determine its effect on yield. However, experiences from previous years indicate that non-parasitic spotting can cause yield reductions. Yield responses to fungicide in 2000 are attributed largely to prolonged green leaf retention and to Ramularia control. A two-spray programme (T_1 at G.S. 29-31 and T_2 at G.S. 37-39) gave best control of spotting and conventional diseases with optimum yield response. The T_2 spray is the most important for spotting control and yield enhancement and should include a strobilurin. Differences between fungicidal products, in terms of spot control and yield response, were generally small.

INTRODUCTION

Spring barley production is an important activity of Irish arable farming, accounting for 55% of the area devoted to cereals and comprises 49% of total cereal output. Ireland has a justifiable reputation for the production of high yields of high quality malting and feed barley, both for the home and export trade. Consequently, it is essential that guidelines are in place, which allow the crop to be produced efficiently and cost effectively while taking account of the increasingly stringent standards demanded by the market. Achievement of these goals is being made increasingly more difficult as a result of increasing input costs combined with decreasing product prices. However, by practical implementation of guidelines derived from intensive research into spring barley production systems, these goals can be achieved.

Since 1997 Irish spring barley growers have encountered a new problem in the form of a leaf spotting disorder, which causes brown spotting of the leaves, leaf sheaths and awns of a range of varieties. This phenomenon was severe on many crops particularly in 1998 and 1999. It is not confined to spring barley grown in Ireland; it has been reported in a number of European countries including Scotland, England, Germany, Austria and Norway. Similar spotting has also been reported on species other than barley e.g. wheat, oats and couch grass.

Since it initially became prominent leaf spotting has become the focus of intensive research at the Crops Research Centre, Oak Park. This work has led to the introduction of guidelines on the most appropriate strategies to alleviate the effects of the problem. It has been found that the newer strobilurin fungicides are more effective than the older triazole fungicides while the research has also pinpointed the critical importance of applying fungicide at the time of flag leaf emergence (G.S. 37-39). In 2000 research into the problem was continued at Oak Park so as to:

1. Identify the agent or agents causing leaf spotting in spring barley
2. Determine the effect of the spotting on yield
3. Determine the relative susceptibility of barley varieties to spotting and their yield response to fungicide application
4. Identify the relative efficacy of fungicides for the control of spotting
5. To determine fungicide strategies which give effective control of the phenomenon

In this paper the main findings from field trials carried out at Oak Park on leaf spotting and its control in 2000 are presented and strategies which maximise returns from fungicide use in spring barley are outlined.

RESULTS AND DISCUSSION

Spot Development and Varietal Susceptibility

Spotting was observed on the most exposed areas of the upper surfaces of third leaves of the varieties Cooper, Century and Optic during the second week of June. It was also observed at very low levels on other varieties including Fractal, Canasta, Lambda, Laird and Tavern. It progressed up the plant from the third leaf to the second leaf and then to the flag leaf at intervals of 7-10 days.

When spotting first appeared on a leaf, the fungal pathogen *Ramularia collo-cygni*, which is thought to have been responsible for much of the leaf spotting in the 1999 season, was not visually apparent on the leaves nor could it be isolated from affected leaves in the laboratory. Conventional barley pathogens were also ruled out as being responsible. Therefore, it was concluded that the initial spotting observed was non-parasitic i.e. not caused by a pathogen. The cause of this non-parasitic spotting is not clearly understood but it is thought to be a physiological response to stress factors such as high solar radiation.

There were considerable varietal differences in susceptibility to the non-parasitic spotting. Its severity, soon after its appearance and before *Ramularia* became prevalent, on the second leaf in unsprayed plots of ten varieties, is illustrated in Fig. 1. At the time of assessment Cooper was the worst affected and had a significantly higher level of spotting than all other varieties. Century and Optic were also susceptible. There was little difference between the remaining varieties with Lux, Crusader and Lambda appearing the most resistant.

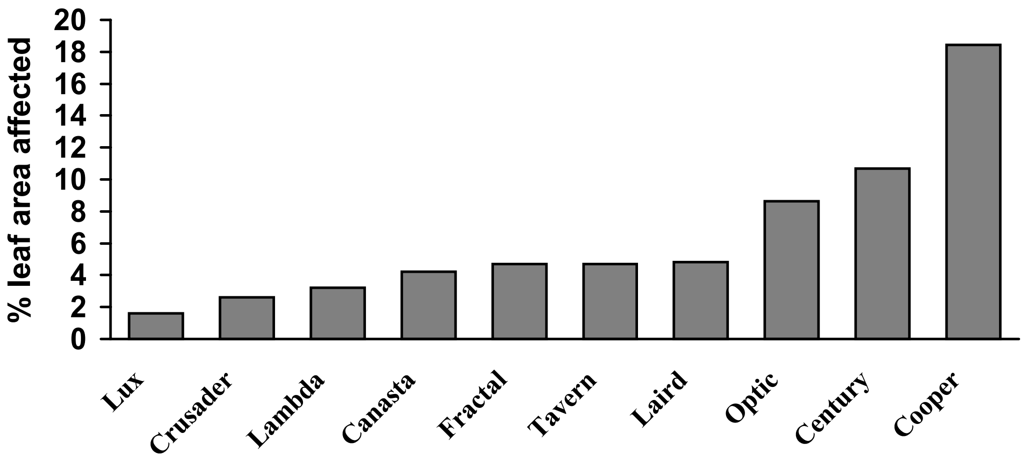

Fig. 1: Varietal susceptibility to non-parasitic spotting

Although no fungal pathogen was found to be associated with the spots initially, the fungus *Ramularia collo-cygni* subsequently developed on these leaves, after a period of 10-14 days, and by mid-July was found freely sporulating on the undersides of most leaves. While the presence of the non-parasitic spotting possibly predisposed leaves to infection by *Ramularia*, leaves which had only low levels of non-parasitic spotting were also infected, indicating that *Ramularia* can infect leaves in its own right, rather than being solely a secondary invader of already damaged tissue.

Non-parasitic spots and those caused by *Ramularia* were often similar in appearance and distinguishing between the two types of spot in the field with confidence is not practicable. Since non-parasitic spotting was generally present before *Ramularia* infected the crop it was not feasible to determine the proportion of spots present on a particular leaf attributable to *Ramularia*. Therefore, any assessment of varietal susceptibility to *Ramularia* must be treated with caution. However, it appeared that there were differences between varieties in terms of susceptibility to *Ramularia* with varieties such as Century, Tavern and Canasta appearing most susceptible while varieties such as Crusader and Fractal appeared more resistant.

Control of Spotting

(a) Non-parasitic spotting

The effect of a robust strobilurin [T1: Amistar Pro (1.3 l/ha), T2: Amistar Pro (2.0 l/ha)] and a non-strobilurin [T1: Punch C (0.625 l/ha) + Fortress Duo (1.5 l/ha), T2: Charisma (1.5 l/ha)] fungicide programme on non-parasitic spotting of the second leaf of Cooper, Century and Optic is illustrated in Fig. 2. While both fungicide programmes did reduce spotting the level of control achieved was small. The low level of control achieved may have been due to the timing of fungicide application relative to the onset of spotting which, in turn, may be related to climatic conditions. Previous experience at Oak Park and from abroad suggests that fungicides can reduce non-parasitic spotting with consequent yield benefits. Assessment of the effect of non-parasitic spotting on yield in 2000 was not possible due to the lack of a suitable comparison, which was as a direct result of the low level of control achieved.

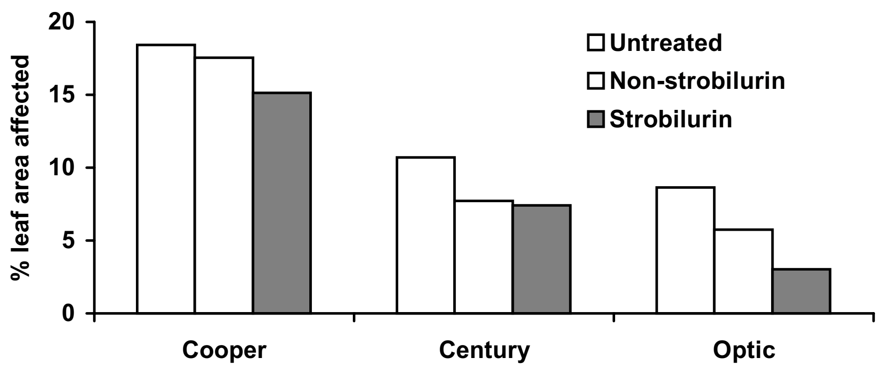

Fig. 2: Effect of fungicide on severity of non-parasitic spotting

Trials which examined the efficacy of some of the main fungicide products available on the market and newer products not yet available (when applied as a second spray in a two-spray programme) also found that while all products reduced spotting the level of control was small (Fig. 3).

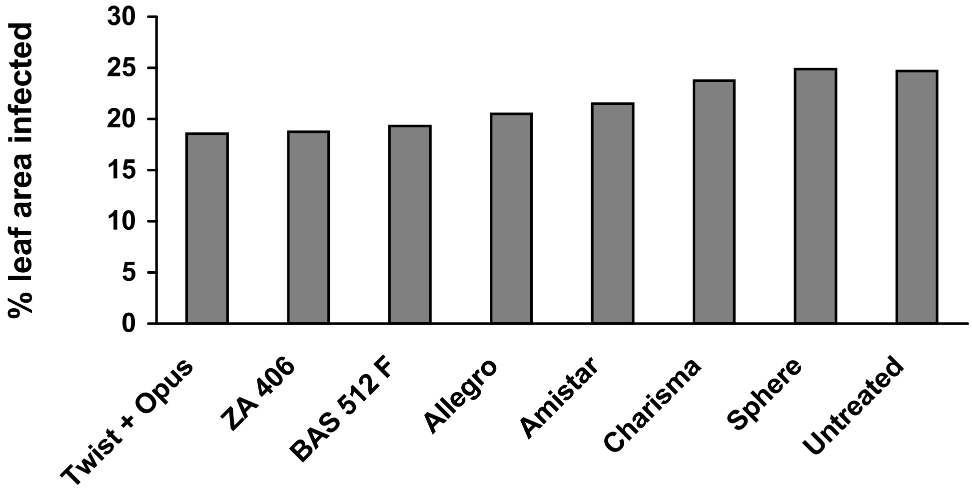

Fig. 3: Effect of fungicide product on non-parasitic spotting

(b) Ramularia control

Determination of the level of *Ramularia* control by fungicide programmes was rendered difficult due to the presence of non-parasitic spots, which were similar in appearance to spots caused by *Ramularia*. However, an assessment of spotting on the flag leaf of four varieties in mid-July, when *Ramularia* was prevalent in the crops, indicated that both a non-strobilurin and a strobilurin-based programme reduced spotting considerably, the strobilurin programme being the more effective of the two programmes (Fig. 4). This reduction occurred both in varieties which were susceptible (e.g. Cooper and Century), and those which were less susceptible (e.g. Canasta and Tavern), to non-parasitic spotting. It was concluded that this was largely due to the control of *Ramularia*. The limited effect of fungicide on non-parasitic spotting in 2000 further supports this conclusion.

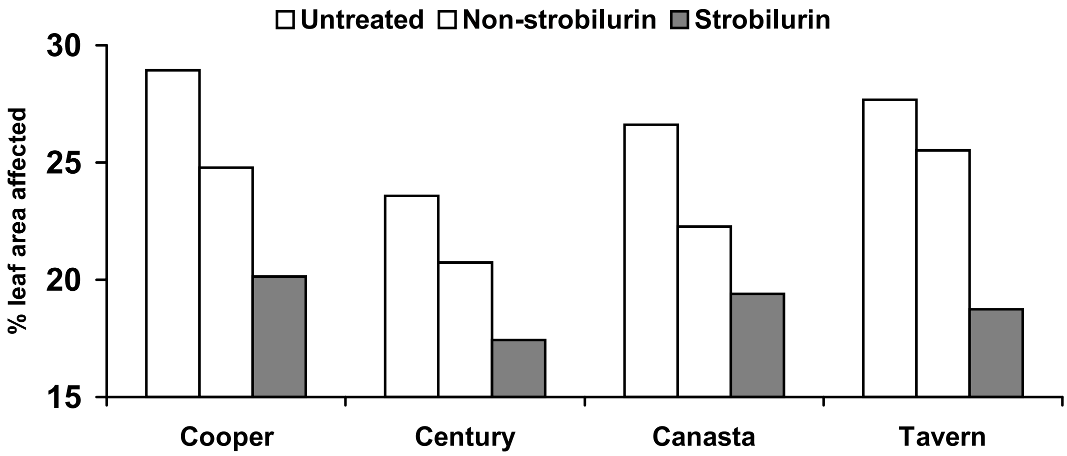

Fig. 4: Effect of fungicide programme on spotting on July 17

Yield Responses to Fungicides

A series of trials examined the effect of variety, time of application, fungicide programme, spray frequency, product choice and fungicide spend on the yield response of spring barley to fungicide. Traditional barley diseases (Rhynchosporium, net blotch and mildew) were low throughout the trials in Oak Park in 2000 and, therefore, it is suggested that the control of spotting (both parasitic and non-parasitic) and prolonged green leaf retention accounted for much of the yield responses obtained. As it was difficult to distinguish between the two types of spot, the effect of fungicides on green leaf, which contributes to yield, is presented rather than their effect on spotting.

Variety effects

The effect of two contrasting fungicide programmes (as outlined earlier) relative to an unsprayed treatment on grain yield of ten varieties is presented in Fig. 5. Yields were high throughout the trial with untreated yields of up to 8.77 t/ha recorded. Both programmes increased yield significantly over the untreated in the varieties Cooper, Lux, Optic, Tavern, Fractal and Crusader. With the exception of Lambda, only the strobilurin programme increased yield over the untreated in the remaining varieties. There was generally no significant difference between the two programmes. Trends in yield generally reflected trends in green leaf retention i.e. higher levels of green leaf retention resulted in higher yields. The greater green leaf retention was due, in part, to the previously described reduction in spotting and in the case of the strobilurin treatments the ‘strob effect’ may also have contributed.

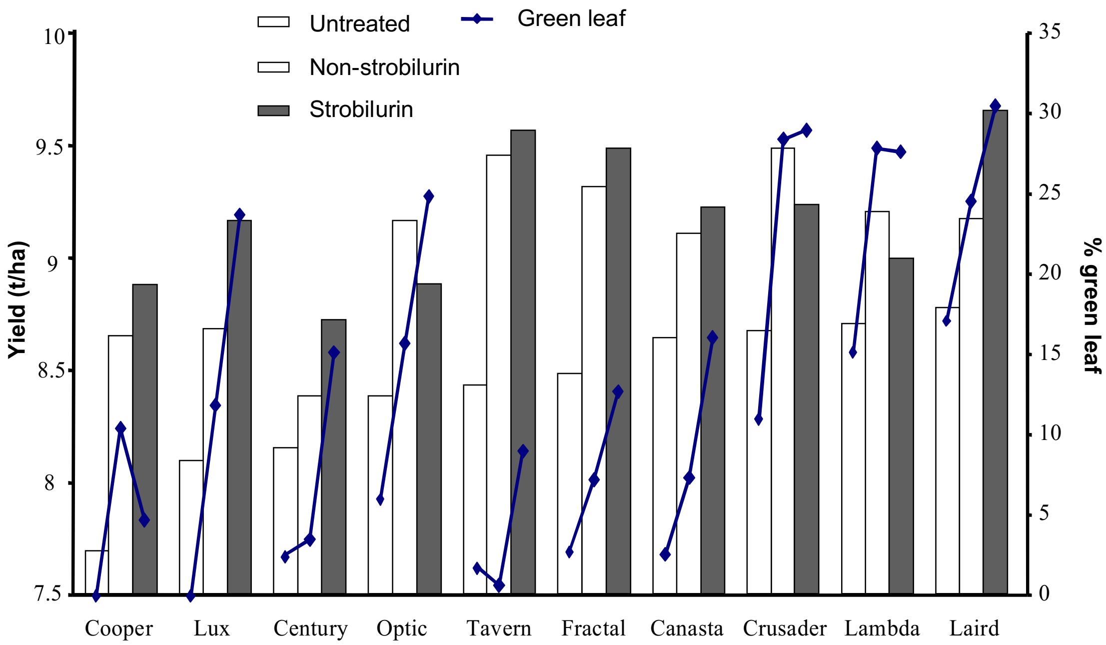

Fig. 5: Effect of fungicide programme on yield and green leaf retention of ten varieties of spring barley

Fungicide type

A comparison of the main fungicides available on the market and some newer fungicides not yet on the market was carried out on the variety Cooper. All were applied at full rates as a second spray in a two-spray programme following a common first spray. Yields are presented in Fig. 6. All products significantly increased yield over the untreated. In general the strobilurin fungicides, particularly the newer products, gave higher yield responses, although not always significantly higher, than non-strobilurin products.

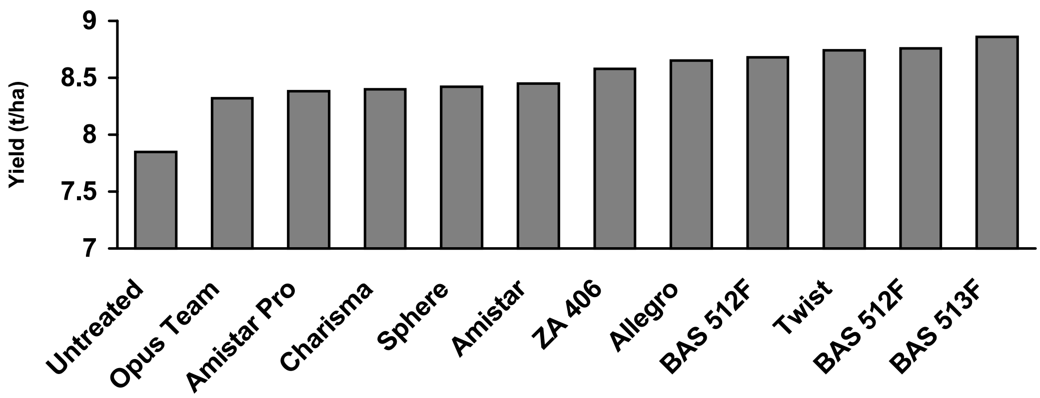

Fig. 6: The effect of fungicide product on grain yield at Oak Park in 2000

Fungicide timing

While timing of fungicide had no significant effect on grain yield in 2000 it was evident that yields tended to be higher and spotting lower where all or part of the total amount of fungicide was applied at GS 39 (Fig. 7). The application of strobilurin fungicides at this stage of growth will also give effective control of other barley diseases, when present, and maximise the yield enhancement properties of the strobilurins. Applying all the fungicide at GS 31 gave lower yields and reduced control of spotting (Fig. 7).

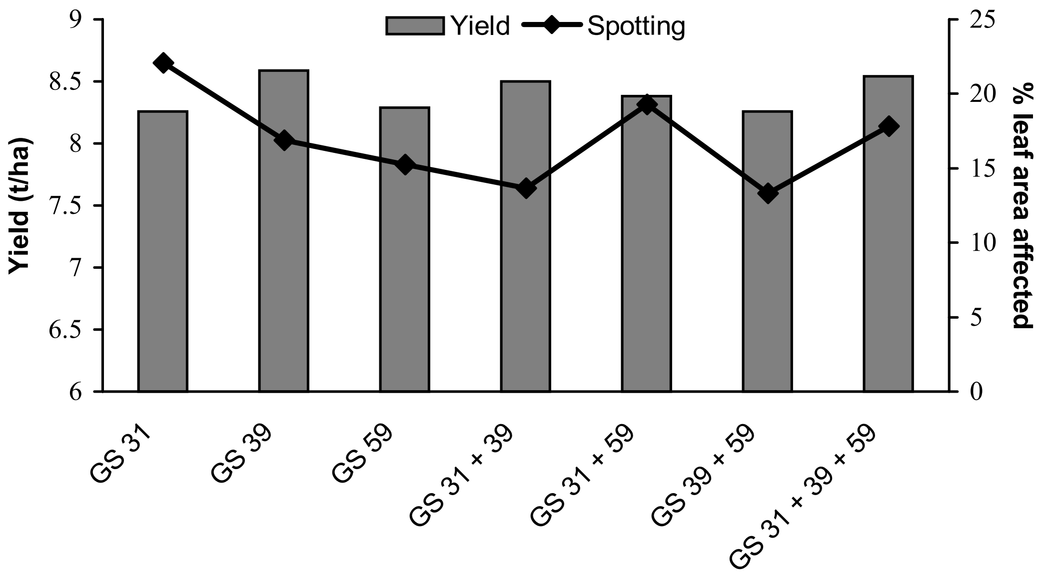

Fig. 7: Effect of fungicide timing and splitting (Allegro @ 1 l/ha) on grain yield and non-parasitic spotting of the second leaf of Cooper

Fungicide costs and number of applications

A fungicide cost benefit trial on the variety Century compared £30/ha and £50/ha triazole (Punch C) and strobilurin (Allegro) programmes applied in one, two or three applications. While increasing fungicide spend from £30/ha to £50/ha did increase yield in some instances the effect was not consistent. Therefore, under the conditions encountered in the trial, there was generally no economic benefit to be derived from increasing fungicide spend from £30/ha to £50/ha (Fig. 8).

Increasing spray frequency from one application to two did increase yield, particularly when the strobilurin was used. However, there was little additional benefit derived by splitting the fungicide into three applications (Fig. 8).

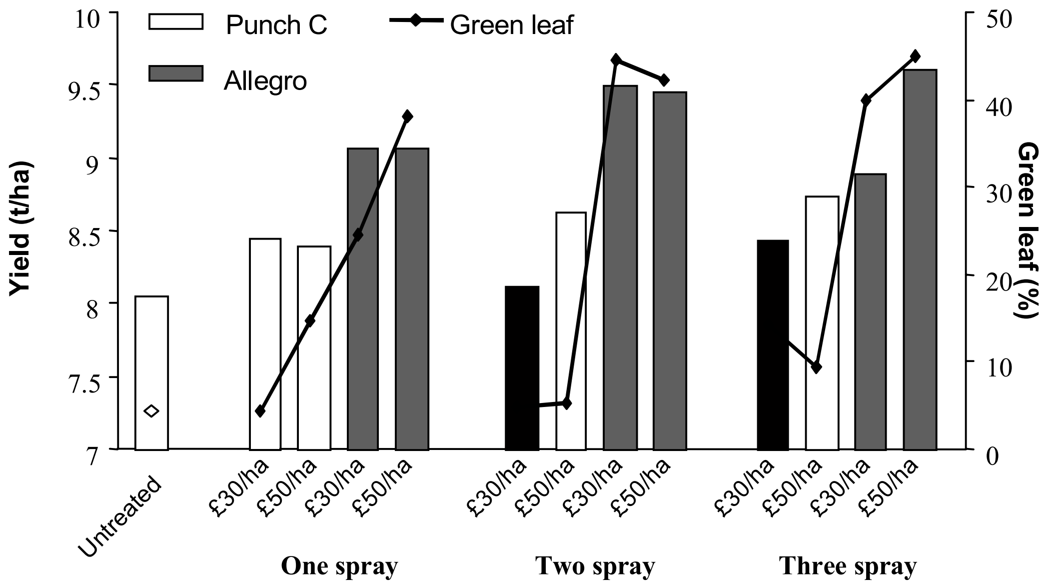

Fig. 8: Effect of fungicide chemistry, cost and number of applications on green leaf area and grain yield of Century spring barley at Oak Park in 2000

Fungicide programmes

Twelve two-spray fungicide programmes were evaluated on the variety Cooper. Seven of the programmes had the same non-strobilurin treatment at the first application (G.S. 31) to study the performance of a range of strobilurin and non-strobilurin fungicides when applied as the second spray (G.S. 39). Non-strobilurins were substituted with strobilurin fungicides and a mildewicide (Fortress Duo) as the first spray in the remaining programmes. Trial treatments and their effect on yield, spotting and grain quality are presented in Table 1.

All fungicide programmes significantly increased grain yield over the untreated (Table 1); differences between programmes were generally not significant. Conventional barley diseases were at a very low level and it was considered that they contributed little to loss of yield. An assessment of non-parasitic spotting on the second leaf, before *Ramularia* spotting became prevalent on that leaf, indicated only limited control of the non-parasitic spotting by any of the programmes. Therefore, much of the yield enhancement due to fungicide application is attributed to prolonged green leaf retention and the control of *Ramularia* later in the season.

Where the first spray was kept constant (i.e. Sanction 0.3 l/ha + Corbel 0.5 l/ha), differences between the products available on the market were generally small (< 0.3 t/ha) when applied as a second spray. The two new second generation strobilurins (ZA 406 and BAS 512F) gave higher yields, but not significantly higher, than the older strobilurins.

Table 1: Treatments - fungicide trials, Oak Park, 2000

Treatment No.	T_1 Application (G.S. 31)	T_2 Application (G.S. 39)	Grain yield (t/ha)	% Necrotic spotting Leaf 2 (10/07/00)	Hectolitre weight (kg/hl)	Screenings < 2.2 mm (%)	1000 grain wt. (g)
					Grain quality		
1	Allegro (0.3 l/ha)	Allegro (0.7 l/ha)	9.41	19.50	68.0	4.42	46.92
2	Amistar Pro (0.6 l/ha)	Amistar (0.7 l/ha)	9.18	22.75	66.8	9.28	44.83
3	Allegro (0.3 l/ha)	Amistar (0.7 l/ha)	9.16	22.63	67.2	8.07	46.75
4	Fortress Duo (1.0 l/ha)	Amistar (0.7 l/ha)	9.15	19.90	67.5	7.17	47.00
5	Allegro (0.3 l/ha)	Charisma (1.5 l/ha)	9.21	14.78	67.2	8.08	47.00
6	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	Allegro (0.7 l/ha)	9.05	20.50	67.7	9.22	46.58
7	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	Amistar (0.7 l/ha)	9.03	21.48	66.7	7.42	46.25
8	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	ZA 406 (1.0 l/ha)	9.34	18.78	68.1	4.78	47.17
9	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	Charisma (1.5 l/ha)	8.85	23.78	65.8	12.81	44.67
10	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	BAS 512F (1.5 l/ha)	9.22	19.33	67.0	8.83	46.17
11	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	Sphere (1.0 l/ha)	9.06	24.85	65.9	11.70	45.58
12	Sanction (0.3 l/ha) + Corbel (0.5 l/ha)	Twist (1.5 l/ha) + Opus (0.5 l/ha)	9.11	18.56	66.7	8.37	46.92
13	Unsprayed	Unsprayed	8.36	24.70	66.1	13.78	44.17
L.S.D. (5%)			0.46	7.60	1.7	5.10	2.54

Using a strobilurin fungicide as the first spray had no advantage in terms of yield response or for the control of necrotic spotting.

All fungicide programmes reduced screenings relative to the untreated, with the higher yielding programmes tending to have the greatest effect. Fungicides increased the 1000-grain weight, although not always significantly. Hectolitre weight was significantly increased over the untreated by only two of the programmes (Table 1).

CONCLUSIONS

- The spotting complex occurred in all spring barley varieties in 2000. The spotting occurred mostly on the upper leaf surfaces on leaf 1, leaf 2 and leaf 3, on the awns and on the upper leaf sheaths.
- The spotting complex was found to consist of two components; a parasitic component and a non-parasitic component, both of which could occur independently of each other.
- The parasitic component consisted of the fungus *Ramularia collo-cygni* which was initially detected using a laboratory assay in late June and was found freely sporulating on the undersides of leaves by mid-July.
- The cause of the non-parasitic spotting is thought to involve a physiological response by the plant to one or more stress factors including light.
- There is considerable similarity between the parasitic and non-parasitic spots and distinguishing between the two in the field is very difficult.
- There are considerable differences in varietal susceptibility to both types of spot.
- Fungicidal control of non-parasitic spotting in 2000 was limited rendering it difficult to determine its effects on yield. Previous results suggest that non-parasitic spotting can cause yield losses.
- Fungicide programmes significantly increased grain yield in most instances, which is attributed for the most part to prolonged green leaf retention and control of *Ramularia*.
- A two-spray fungicide programme (T_1 at G.S. 30 and T_2 at G.S. 39) gives best control of spotting and conventional diseases with optimum yield response.
- In the fungicide programmes trial strobilurins gave a greater yield response than non-strobilurin fungicides when used as the 2nd spray. No significant differences in terms of grain yield were detected between strobilurin fungicides and triazole fungicides when used as the first spray. The 2nd spray in spring barley is the more important in terms of the control of leaf necrosis and yield enhancement.

Fungicide Programmes in Cereals

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ABSTRACT

Trials comparing various fungicide programmes in winter wheat, winter barley and spring barley were carried out on a number of locations in 2000. All programmes in winter wheat gave significant yield increases and reduced disease levels. Strobilurin fungicides, applied at T1, gave a slight yield improvement over non-strobilurins. New strobilurin fungicides gave excellent control of net blotch in spring barley.

INTRODUCTION

There are a number of diseases which cause problems in cereals every year. On wheat the main foliar disease is Septoria and fungicide programmes are targeted at controlling this disease. Three sprays are applied to winter wheat, with Septoria as the major target, but there are other diseases to be considered as well. At the T1 spray timing eyespot has to be considered. Yellow rust has made an unwelcome return in the last three years and if the variety sown has some susceptibility to this disease the product used at T1 must also have efficacy against this disease.

The T2 spray, which is probably the most yield-enhancing of the three sprays, is aimed primarily at Septoria and will be a mixture of a triazole and a strobilurin. The T3, or post-heading spray, builds on the earlier sprays and keeps the crop disease free until harvest. A major consideration at this timing is fusarium and if the risk is high then a fungicide such as Caramba or Folicur, which have an effect against this disease, should be included in the final spray mixture.

Winter barley requires a two-spray programme, with both rhynchosporium and net blotch as the main target diseases, and powdery mildew as less serious but frequently occurring problem.

Since the arrival of the strobilurins disease control in cereals has improved but they must be mixed with other fungicides to get the maximum value from them. Triazoles and morpholines are used, either in pre-formulated or tank mixtures, to enhance and extend the properties of the strobilurins.

There are new strobilurin containing fungicides which will be available in the near future and they are giving excellent results against Septoria on wheat and net blotch on barley.

The topics to be covered in this paper are:

a) The response to fungicide programmes in winter wheat, winter barley and spring barley.
b) The performance of a number of fungicide products in 2000.

Winter Wheat Fungicide Programmes

Trials were carried out in Co. Cork, Co. Meath and Co. Kilkenny to examine the responses from a number of fungicide programmes.

The standard spray programme consisted of Unix plus Opus at growth stage 31 (T1), Opus plus Amistar at growth stage 39 (T2) and Amistar at growth stage 59 (T3). The remainder of the programmes substituted various fungicides at each of these three growth stages in order to compare their performance against the standard programme. Two reduced-rate programmes were also included in the treatments. Full details of the spray programmes are shown in Appendix 1.

Growth Stage 31 fungicides (T1)

Seven different fungicides were used at this spray timing. The T2 and T3 sprays were the standard treatments. Yield and disease data for the T1 treatments are shown in Table 1.

Table 1: Effect on yield and disease of various fungicides applied at growth stage 31

Fungicide Applied at T1 (T2 and T3 common)	Belgooly Co. Cork			Duleek Co. Meath	Kildalton Co. Kilkenny	
	% Septoria 2nd Leaf	% Green area 2nd Leaf	Yield t/ha @ 15%	Yield t/ha @ 15%	% Green area Flag Leaf	Yield t/ha @ 15%
Unix + Opus	7.5	25.9	12.34	9.89	40	11.22
Sportak	6.3	25.8	11.40	9.43	42	10.85
Allegro	3.0	35.6	12.07	9.62	63	11.44
Sportak + Allegro	2.9	35.9	11.72	9.71	44	11.42
Flamenco Plus	8.7	26.3	11.85	9.52	65	11.47
Flamenco Plus +Amistar	4.5	30.4	11.68	10.11	46	11.52
Unix + Allegro	3.7	39.5	12.36	10.63	53	10.96
Unsprayed	94.8	0	8.51	7.85	0	5.13
L.S.D.	5.0	8.2	0.6	0.7	21	0.5

Yield responses to treatments were very high at Kildalton (averaging 6.0 t/ha over the untreated) and moderate at Belgooly and Duleek (3.4 t/ha and 2.0 t/ha respectively). Sportak was the lowest-yielding treatment at all three sites, being significantly lower yielding than many other fungicides at Belgooly and Kildalton.

All treatments reduced the percentage Septoria at Belgooly and increased the percentage green leaf area at Belgooly and Kildalton over that of the untreated plots. There were differences between treatments but they were small.

Growth Stage 39 fungicides (T2)

Five different fungicides were used at this spray timing. The T1 and T3 sprays were the standard treatments. Yield and disease data for the T2 treatments are shown in Table 2.

All T2 treatments gave significantly higher yields and significantly lower disease levels than the untreated. However, there was very little difference between the treatments in terms of yield or disease control.

Table 2: Effect on yield and disease of various fungicides applied at growth stage 37/39

Fungicide Applied at T2 (T1 and T3 common)	Belgooly Co Cork			Duleek Co. Meath	Kildalton, Co. Kilkenny	
	% Septoria 2nd Leaf	% Green area 2nd leaf	Yield t/ha @ 15%	Yield t/ha @ 15%	% Green area Flag Leaf	Yield t/ha @ 15%
Opus + Amistar	7.5	25.9	12.34	9.89	40	11.22
Allegro	2.6	32.9	12.02	10.17	62	11.64
Twist + Opus	0.8	27.7	12.00	10.18	76	11.25
Flamenco + Amistar	4.7	23.7	12.08	9.93	-	-
BAS 512F	2.1	30.3	11.90	10.0	71	11.38
Unsprayed	94.8	0	8.51	7.85	0	5.13
L.S.D.	5.0	8.2	0.6	0.7	21	0.5

Growth Stage 59 treatments (T3)

There were three different growth stage 59 treatments with the T1 and T2 treatments remaining standard. Results are shown in Table 3.

Table 3: Effect on yield of various fungicides applied at growth stage 59

Fungicide applied at T3 (T1 and T2 common)	Belgooly Co Cork			Duleek Co. Meath	Kildalton, Co. Kilkenny	
	% Septoria 2nd Leaf	% Green area 2nd leaf	Yield t/ha @ 15%	Yield t/ha @ 15%	% Green area Flag leaf	Yield t/ha @ 15%
Amistar	7.5	25.9	12.34	9.89	40	11.22
Twist + Opus	2.4	29.9	12.30	10.03	78	10.92 (no Opus)
Caramba + Amistar	1.7	33.8	12.11	9.57	59	11.33
Unsprayed	94.8	0	8.51	7.85	0	5.13
L.S.D.	5.0	8.2	0.6	0.7	21	0.5

There was no significant difference in yield or disease levels between any of the post-heading treatments at the three sites, which is understandable in view of the dry weather in June and July.

Reduced rate treatments

Two reduced-rates were compared with the standard treatment. One of the treatments consisted of two-thirds the standard while the second reduced-rate treatment was a half-rate strobilurin at each spray timing. The spray additive Arma was used with each of the reduced-rate treatments. Results are shown in Table 4.

Table 4: Yield and disease levels of reduced rate programme compared with standard programme

Fungicide	Belgooly Co Cork			Duleek Co. Meath	Kildalton, Co. Kilkenny	
	% Septoria 2nd Leaf	% Green area 2nd leaf	Yield t/ha @ 15%	Yield t/ha @ 15%	% Green area Flag leaf	Yield t/ha @ 15%
Unix + Opus Opus + Amistar Amistar	7.5	25.9	12.34	9.89	40	11.22
Allegro + Arma Allegro + Arma Amistar + Arma	1.3	28.1	11.88	9.07	58	11.35
Unix + Opus Opus + Amistar + Arma Amistar + Arma	3.5	22.9	12.08	9.97	46	11.27
Unsprayed	94.8	0	8.51	7.85	0	5.13
L.S.D.	5.0	8.2	0.6	0.7	21	0.5

There were no significant differences between the reduced-rate treatments and the standard-rate treatment, in either disease control or yield, with one exception. At Duleek the half-rate strobilurin was significantly lower yielding than the standard treatment or the two-thirds rate treatment.

Winter Barley Programmes

A trial comparing fungicide programmes was carried out on winter barley variety Regina at Oak Park. Treatments and results are shown in Table 5.

Table 5: Yield and disease results. Winter barley variety Regina

T1	T2	% Rhyncho 2nd leaf	Yield t/ha @ 15%
Allegro 1.0 l/ha	Allegro 1.0 l/ha	8.0	10.66
Stereo 1.8 l/ha	Allegro 1.0 l/ha	16.8	10.57
Punch C 0.8 l/ha	Allegro 1.0 l/ha	14.3	10.49
Charisma 1.5 l/ha	Allegro 1.0 l/ha	12.5	10.47
Amistar Pro 2.0 l/ha	Allegro 1.0 l/ha	6.5	10.79
Twist 1.0 l/ha + Stereo 0.25 l/ha	Allegro 1.0 l/ha	11.6	10.29
Unix 0.067kg/ha + Opus 0.5 l/ha	Allegro 1.0 l/ha	13.9	10.75
Allegro 0.8 l/ha + Corbel 0.2 l/ha	Allegro 1.0 l/ha	3.2	10.72
Sphere 1.0 l/ha	Allegro 1.0 l/ha	8.3	10.56
Stereo 1.8 l/ha	Amistar Pro 2.0 l/ha	12.7	10.47
Stereo 1.8 l/ha	Sphere 1.0 l/ha	13.3	10.61
Stereo 1.8 l/ha	Twist 1.2 l/ha + Menara 0.25 l/ha	13.0	10.51
Stereo 1.8 l/ha	Charisma 1.0 l/ha + Allegro 0.4 l/ha	10.9	10.70
Untreated		36.7	9.06
LSD		4.1	0.3

The trial had nine different T1 sprays which had a common T2 (Allegro) and four different T2 sprays with a common T1 (Stereo).

All programmes significantly outyielded the control with the average response over all treatments being 1.5 t/ha. There were significant yield differences between treatments.

The main disease on the crop was Rhynchosporium which was present at a high level in May. All programmes gave significantly lower levels of Rhynchosporium than the untreated, and there were also significant differences between treatments, with the Allegro + Corbel followed by Allegro giving the lowest level of Rhynchosporium.

Fungicide Comparison Trials

Winter wheat

Fungicide evaluation trials were carried out on winter wheat, variety Madrigal, at Kildalton, Co. Kilkenny and at Warrenstown, Co. Meath. Ten fungicide treatments were compared with an untreated control in six-fold replicated trials. The fungicides were applied at growth stages 39 and 59. There were high levels of Septoria at Kildalton and moderate levels at Warrenstown. Results from the trial at Kildalton are shown in Table 6.

Yield response to treatment was very high in this trial. All treatments were significantly higher-yielding than the untreated. There were also significant yield differences between treatments.

Septoria levels were very high in this trial. As there was not a T1 spray applied in this trial there was a high level of Septoria in the crop at the time the sprays were applied. The fungicide treatments significantly reduced the level of Septoria over that of the untreated but there were also significant differences between the treatments.

Table 6: Two-spray fungicide trial on winter wheat Kildalton 2000

Treatment	Rate l/ha	% Septoria Flag Leaf	% Septoria 2nd Leaf	Kg/hl	Yield t/ha @ 15%
Amistar+Opus Amistar	0.8 + 0.5 1.0	25.1	70.0	75.1	12.04
Amistar+Opus Amistar	1.0 + 1.0 1.0	7.1	43.0	75.8	12.87
Sphere Sphere	1.0 1.0	6.3	62.1	74.4	12.56
Twist+Opus Twist+Opus	1.5 + 1.0 1.5 + 1.0	5.7	38.9	74.7	12.68
Charisma+Allegro Amistar	1.25 + 0.4 1.0	18.5	62.3	75.1	12.14
Charisma+Allegro Amistar	1.5 + 0.8 1.0	10.0	55.3	75.3	12.46
Flamenco+Amistar Amistar	0.75 + 0.8 1.0	23.7	70.3	74.5	12.15
Flamenco+Amistar Amistar	1.5 + 1.0 1.0	15.9	52.0	75.5	12.46
BAS 512F Amistar	1.5 1.0	6.3	37.2	74.5	12.78
Allegro Amistar + Opus	1.0 0.5 + 0.3	15.0	69.0	74.9	12.25
Untreated		100	100	65	6.95
L.S.D.		8.6	10.6	1.2	0.34

While this paper deals with fungicide performance on foliar diseases there are other diseases, which cause problems in cereals.

Take-all

Take-all causes yield losses every year. Take-all risk is a major factor in deciding a cereal cropping programme in any season. Rotation is the main approach to reducing the damage caused by take-all. There are now fungicide seed treatments available, which are effective in reducing the losses, caused by take-all. The seed dressing should be used as a component of a number of control measures which include husbandry and rotational practices. Seed should be dressed when the take-all risk to the crop is deemed to be high e.g. second and third cereal crops in a rotation. The yield response to take-all seed dressing in wheat is 1.0 to 1.5 t/ha. In many situations this response is sufficient to give an economic return. However, there are many soils in which the economic response will not be adequate and barley can be grown as an alternative.

If winter barley is grown in these high-risk seasons then it should also be seed dressed.

Information on the yield response to seed dressing on spring barley is scarce. It is not possible to give a firm recommendation as to the benefits of dressing spring barley in these high-risk conditions but spring barley has given a yield response to seed dressing in a number of trials.

When wheat is reintroduced to the cropping sequence, after a number of years of barley crops, then the seed should be dressed in the first year. Recent work from Rothamsted has shown that the first wheat after a succession of barley can often have high levels of take-all and it is, therefore, advisable to use a seed dressing to reduce the take-all risk.

Eyespot

Slight eyespot probably has little effect on cereal yields. Severe eyespot, however, can cause yield losses and can result in lodging with even higher harvest losses. In an intensive cereal rotation fungicides with good efficacy against eyespot should be used at the growth stage 31 (T1) spray timing.

If there is a major eyespot risk to the crop then a product with good efficacy against eyespot must be included in the fungicide mixture. If the risk is severe then Unix should be a component of the spray. If the risk is moderate many of the other products, such as Allegro, will provide adequate control.

CONCLUSIONS

- Strobilurin containing fungicides at G.S.31 gave lower levels of Septoria and higher green leaf areas than non-strobilurin products.
- Reduced rate programmes in winter wheat gave yields equivalent to full rate programmes.
- Strobilurin containing fungicides gave good control of Rhynchosporium in winter barley.
- New strobilurin fungicides performed well.

Appendix 1: Fungicide treatments on winter wheat

Treatment	Timing	Rate l/ha
Unix + Opus Opus + Amistar Amistar + Caramba	31/32 37/39 59	0.5 + 0.5 0.3 + 0.8 0.8 + 1.0
Allegro Opus + Amistar Amistar	31/32 37/39 59	1.0 0.3 + 0.8 0.8
Sportak Opus + Amistar Amistar	31/32 37/39 59	0.9 0.3 + 0.8 0.8
Sportak + Allegro Opus + Amistar Amistar	31/32 37/39 59	0.45 + 0.5 0.3 + 0.8 0.8
Flamenco Plus Opus + Amistar Amistar	31/32 37/39 59	2.3 0.3 + 0.8 0.8
Flam Plus + Amistar Opus + Amistar Amistar	31/32 37/39 59	1.5 + 0.5 0.3 + 0.8 0.8
Unix + Allegro Opus + Amistar Amistar	31/32 37/39 59	0.5 + 0.5 0.3 + 0.8 0.8
Unix + Opus Opus + Amistar+ Ar Amistar + Arma	31/32 37/39 59	0.5 + 0.5 0.2+0.5+0.1% 0.8 + 0.1%
Unix + Opus BAS33F Amistar	31/32 37/39 59	0.5 + 0.5 1.5 0.8
Unix + Opus Opus + Amistar Amistar	31/32 37/39 59	0.5 + 0.5 0.3 + 0.8 0.8
Unix + Opus Opus + Twist Amistar	31/32 37/39 59	0.5 + 0.5 0.3 + 1.2 0.8
Unix + Opus Opus + Amistar Twist + Opus	31/32 37/39 59	0.5 + 0.5 0.3 + 0.8 1.2 + 0.3
Unix + Opus Flamenco + Amistar Amistar	31/32 37/39 59	0.5 + 0.5 0.75 + 0.8 0.8
Allegro + Arma Allegro + Arma Amistar + Arma	31/32 37/39 59	0.5 + 0.1% 0.5 + 0.1% 0.5 + 0.1%
Unix + Opus Allegro Amistar	31/32 37 + 45 59	0.5 + 0.5 0.8 0.8
Unsprayed		

Getting Yield and Quality from Oats

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ABSTRACT

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 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. 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.

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.

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.

The first priority of this research was to develop and assess methods to more accurately determine milling quality. A laboratory dehuller 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. 1) 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.

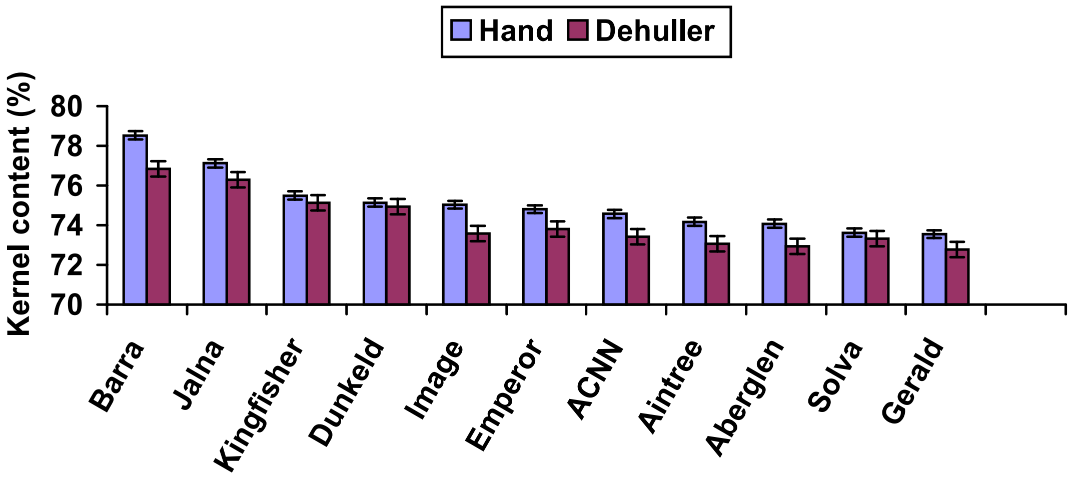

Fig. 1: Comparison of hand and dehuller methods of kernel content determination

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. 2. 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.

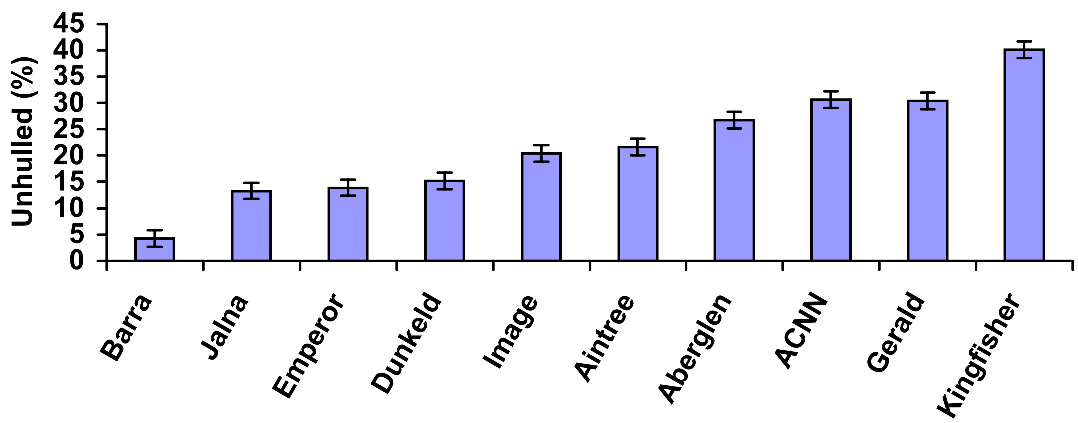

Fig. 2: Effect of variety on hullability assessed by test milling

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 and the D.A.R.D. N.I. Plant Testing Station at Crossnacreevy, Belfast 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 at Oak Park 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. A similar spring-sown experiment was conducted at Crossnacreevy in 1999. 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 120 kg N/ha. 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.

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.

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. 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, at Oak Park 1999 they were similar, but at Crossnacreevy 1999 Aberglen had a higher hectolitre weight. However, 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. 3) 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. 4) 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.

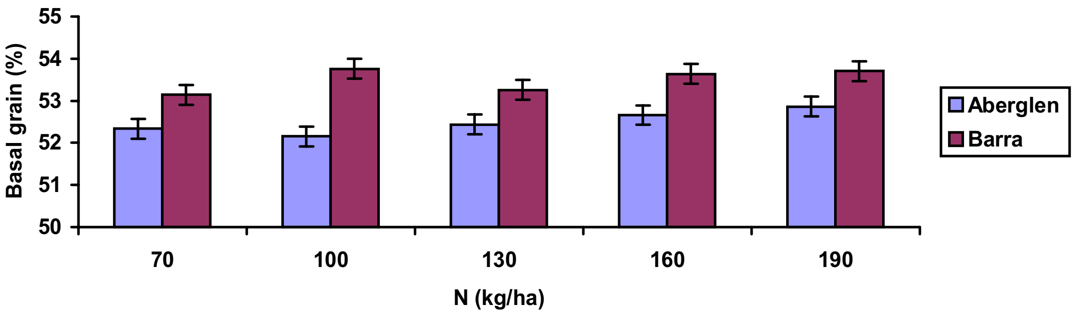

Fig. 3: Effect of nitrogen rate and variety on the percentage of hand harvested grain composed of basal grain, Oak Park 1999

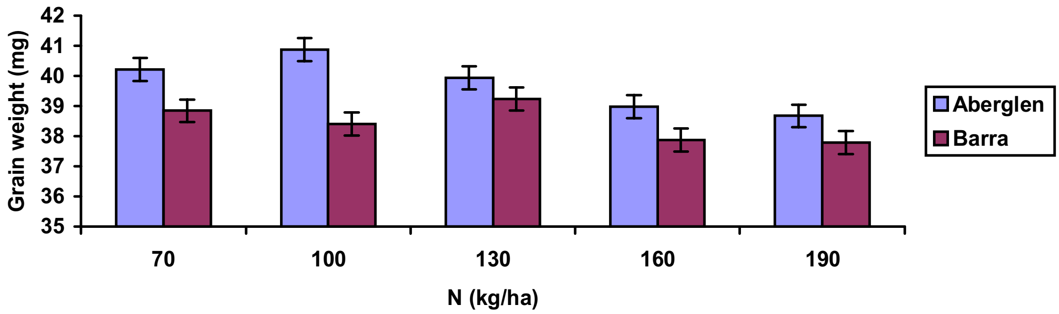

Fig. 4: Effect of nitrogen rate and variety on the basal grain weight, Oak Park 1999

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 qualtiy 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.
- Agronomic studies indicated 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.
- Variation in hullability and screenings could not be completely explained by variation in the percentage of basal grain and grain weight.

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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 ($P<.05$)

Performance Of Arable Organic Farming : a UK Experience

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INTRODUCTION

The concept of organic farming has been with us for about half a century, although clearly before the development of inorganic fertilisers and chemical pesticides crops were inadvertently grown organically, even if the term to describe the style of cultivation had not been penned.

The growth of organic production over this period has been slow. Priorities for agricultural production in the post war period in Europe were focused on increasing production to reduce the reliance on imports, and to improving food security.

Developments in plant breeding, crop protection and crop nutrition, as well as advances in cultivating and harvesting machinery, has seen year-on-year yield increases until the 1970's when the UK began, for the first time, to generate exportable surpluses of cereals. The past 20 years have been a period of food surpluses with the cost of food relative to average incomes reducing.

In recent years issues of food security and cost have become less and less important to consumers who have largely never experienced shortage. Indeed, the development of global trading in food has meant choice is now greater than at any other time in history. In such a climate other considerations have begun to become more important to consumers. Such considerations include the methods used to grow the crop, the conditions in which livestock are reared, and the effect of the process on the environment.

Following a series of high profile food scares in the UK which included Salmonella in eggs, lysteria in cheese, E-Coli and BSE in beef, along with ongoing concerns surrounding pesticide residues, consumers began to seek out organic food which they perceived to be free from these threats.

In response retailers began to stock a greater range and farmers began to switch land into organic production. In 1990 the land area in the UK devoted to organics was less than 0.3%, but the increase in consumer demand, met largely through imports, led the principle licencing body in the UK, The Soil Association, to call for a target of 20% of UK land to be farmed organically by 2000.

Despite this and strong consumer demand, the level of conversion remained low principally because of the financial penalties incurred by farmers during the two year conversion period. To overcome this the UK Government introduced a subsidy scheme, known as the Organic Aid Scheme (OAS) in 1993.

Whilst this undoubtedly stimulated additional farmers to convert, it coincided with a general downturn in the economy which depressed demand and saw a number of high profile retailers withdraw from the sector. Subsequently demand has more than recovered and the introduction of The Organic Farming Scheme (OFS) in 1998, which increased the conversion subsidies has facilitated a substantial switch, with the area of land farmed organically now around 3%.

ORGANIC FARMING SYSTEMS

Mixed Organic Farming

Organic agriculture is typically based around ley/arable rotations which include a livestock enterprise. During the ley (or restorative period) grass clover swards increase soil organic matter and improve soil structure, whilst building fertility and breaking the build-up of pest, diseases and weeds which thrive in the arable part of the rotation.

The presence of stock is required to derive income from the ley period, and these contribute to the system through the production of manure which allows nutrients to be applied at later stages of the arable phase of the rotation. Leys normally exist for 2-3 years before being ploughed out to sustain arable cropping. The length of the arable phase is very much dependant on soil type, with more fertile soils able to sustain longer rotations.

All-Arable Organic Farming

The assumed requirement that organic systems include both a livestock and arable enterprise has meant that farmers, who currently practice arable agriculture only, have considered conversion as unfeasible. Were an all-arable conventional farmer to consider switching to mixed organic farming the overhead costs of installing buildings, fencing, quota and obtaining the necessary expertise would undoubtedly make the proposal unviable.

However, the purpose of the grass/clover ley period in mixed organic farming is principally to increase nitrogen levels in the system, and stock simply provide a means of managing these leys and contributing to the economic performance. If the objective is to fix atmospheric N and then make it available to subsequent crops, there is no reason why a method known as green manuring, which involves cutting and composting a fertility building crop on the soil surface, cannot be considered. Indeed it might be argued that in terms of efficiency of N transfer, stockless systems might have the edge on mixed systems, since leaching and volatilisation losses occur in the handling of livestock manures and when animals are at pasture.

The advent of set-aside has also been advantageous to all-arable systems. Prior to set-aside the farmer would have to accept zero income from any fields in the green-manure, fertility building phase of the rotation. Lampkin (1990) suggests that in stockless systems around 30% of the land is likely to be out of production in any one year, with serious implication for cash flow and profitability. By putting land into fertility building during the set-aside period the farmer can at least draw some income to support the overall rotation.

Stockless Trials in the UK

There is some disagreement amongst members of the organic movement as to the desirability of stockless systems. The purists view is that systems without stock are a corruption of the balance which can be achieved through mixed farming, brought about by the intensification of agriculture and associated with chemical usage and European Union subsidies.

Others argue that any type of organic agriculture is preferable to its conventional cousin and therefore even stockless organic systems are preferable.

A consequence of this disagreement has been that only limited research has been carried out. Over the past decade there have been four studies looking at stockless systems in the UK. The scope of these has varied from small plot trials to whole farm assessments.

The trials are as follows:

1. Elm Farm Research Centre (EFRC) stockless experiment, Berkshire.

   Three four-year rotations in three fully randomised blocks using plots 20m x 12m.

2. Luddesdown Organic Farm/EFRC farm trial, Kent.

   Five different rotations on 10 acre blocks (50 acres).

3. ADAS Terrington Organic Project, Norfolk (30 acres).

   Five plots of around six acres with a single rotation which is subjected to modification.

4. CWS Farms Group organic farming experiment, Leicestershire (270 acres total, 61 acres stockless).

   In this instance a mixed organic farm is compared with three 20-acre stockless fields. There is a single rotation which is subjected to modification.

Each of the systems used crops in the rotation which fitted with the cropping of the farm generally, whilst the sequences used were designed to examine how organically derived nutrients could be cycled through the system and to examine weed pressure.

Elm Farm Research Centre

The rotations examined in this trial were extremely short, reflecting the low level of fertility at this site, which is on grade 4 land.

Table 1: Rotations in the EFRC Stockless Experiment

Rotation	Course			
	1	**2**	**3**	**4**
A	Red Clover	Winter Wheat	Winter Wheat	Spring Oats
B	Red Clover	Potatoes	Winter Wheat	Winter Oats
C	Red Clover	Winter Wheat	Winter Beans	Winter Wheat

Table 2: Dry Matter (t/ha $^{-1}$) and nitrogen accumulated above ground (kg/ha $^{-1}$) as affected by rotation, mean of values 1988-1995

	Rotation					
	A	**B**	**C**	**SE**	**df**	
DM t/ha^{-1}	10.9	11.8	10.3	0.254	46	***
N kg/ha^{-1}	278	292	250	7.34	46	***

Rotation B achieved significantly higher DM and N accumulation than C only. This is interesting since rotation C has two fertility building phases compared with rotation B which has only one, and therefore we might expect to see higher gross accumulation in this rotation. This suggests that crop sequencing has a significant effect on the efficiency of N recovery.

Likewise, while all first wheats which followed the fertility build achieved similar yields (A2 and C2), wheat following wheat (A2 to A3) yielded much lower than wheat following potatoes (B2 to B3) – (Table 3).

Table 3: Wheat yield (t/ha @ 15% moisture) means, 1988-1995

	Winter Wheat				
	A2	**A3**	**B3**	**C2**	**C4**
Yield	4.21	2.67	4.34	3.77	4.05

The respectable yield achieved by C4 is also notable since it indicates the grain legumes, which when harvested do export much of the N they have fixed, still can leave sufficient reserves to advantage the next cereal crop.

Table 4: Gross margins (GM) of green manures and cash crops

Rotation A	GM £/ha	Rotation B	GM £/ha	Rotation C	GM £/ha
Red Clover	288	Red Clover	288	Red Clover	288
Winter Wheat	1021	Potatoes	1427	Winter Wheat	932
Winter Wheat	712	Winter Wheat	1137	Winter Beans	737
Spring Oats	381	Winter Oats	725	Winter Wheat	988
Mean	600	Mean	894	Mean	736

Conclusions EFRC Experiment

This experiment clearly demonstrates the importance of crop sequencing. A crop rotation of Red Clover, winter wheat, winter wheat and spring oats has shown that second wheats are not a good option, and that spring-sown cereals at this site are probably inappropriate.

A crop rotation using Red Clover, potatoes, winter wheat and winter oats uses the fertility from the Red Clover to grow a high value cash crop. The level of soil disturbance in growing potatoes mineralises nitrogen to the benefit of the next crop. The subsequent winter oat crop is nearly twice as profitable as the corresponding spring crop.

A rotation using Red Clover, winter wheat, winter beans and finally winter wheat demonstrates how grain legumes can contribute both fertility and gross margin.

Luddesdown Organic Farm, Kent

Rotations are also short at this location since much of the farm is located on a light soil type. This lends itself to more spring cropping, as sowing can take place in early spring while moisture is still available, but the soil is workable and machines can travel.

Table 5: Luddesdown Organic Farm – Rotational Comparison

Year	Rotation				
	A	B	C	D	E
1	Red Clover/ Ryegrass (mulched)	Mixed Legume (mulched)	Winter Wheat Red Clover	Spring Oats Mustard	Spring Beans
2	Winter Wheat	Winter Wheat Mustard	Red Clover	Spring Beans	Winter Wheat undersown
3	Winter Oats undersown	Spring Oats	Winter Wheat Mustard	Winter Wheat undersown	Red Clover
4	Spring Wheat Red Clover/ Ryegrass	Winter Wheat Mixed Legume (undersown)	Spring Beans	-	Spring Wheat
5	-	-	-	-	Winter Oats Mustard

By using undersowing and cover cropping, the system is constantly building and holding fertility. On light soils such as this, N is easily lost, so a policy of 'little and often' and loss reduction through uptake is a sound policy.

Unfortunately no economic data has yet been reported for each rotation, although yield averages and gross margins are shown in Table 6.

Table 6: Yields and gross margins at Luddesdown Farm

Crop	Yield (t/ha)	Gross Margin (£/ha)
Winter Wheat	4.9	1254
Winter Oats	4.3	1059
Winter Beans	3.7	1008

ADAS Terrington Organic Project

The Terrington site is unique in terms of stockless organic trials being located on grade 1 land, a stoneless silty clay loam. This soil is retentive of both water and nutrients, and has been in an arable rotation for around fifty years although cultivated conventionally for nearly all of this period.

The blueprint rotation is as follows:

Year						
1	**2**	**3**	**4**	**5**	**6**	**7**
Clover	Clover	Potatoes	Wheat	Beans	Wheat	Clover

Clover was used to build fertility during the conversion phase and subsequently only a single year of clover was grown. This means that this soil type is able to sustain four cash crops for each year of fertility building. In the two conversion years mulched Red Clover achieved an average addition of 682 kg/ha N.

The rotation adopted is a combination of Rotations B + C in the EFRC study. It uses potatoes to maximise the returns following the fertility build, and then follows this with wheat and a grain legume. The effect of this sequencing and the fertility of the soil is spectacular yield and gross margins.

Table 7: Average yields, prices and gross margins, ADAS Terrington

	Yield (t/ha)	**Price (£/t)**	**Gross Margin (£/ha)**
Potatoes	28	227	6370
Winter Wheat	7.6	192	1457
Spring Beans	3.4	175	595
Spring Wheat	4.3	200	1100
Clover	-	-	-

The fertility of this site means that longer rotations should be feasible before returning to the fertility building phase, but that would extend the interval to the next potato crop, and given the economic importance to the rotation of this crop that would be undesirable.

CWS Farms Group, Organic Farming Experiment

The soils at the Stoughton site fall between the extremes of Terrington and Elm Farm, so although they are moderately retentive of nutrients and moisture and can therefore support extended rotations, the yields are lower.

The blueprint rotation is given in Table 8.

Year						
1	**2**	**3**	**4**	**5**	**6**	**7**
Red Clover	Red Clover	Winter Wheat	Winter Oats	Winter Beans	Winter Wheat	Winter Oats

A number of variations have been incorporated including substituting the first wheat by potatoes, and winter beans by lupins.

This stockless trial is twinned with a mixed organic farming trial immediately adjacent, which has allowed yield comparisons to be made. This is revealing, as Table 8 indicates.

Table 8: CWS Farms, organic wheat yields (t/ha)

Year	Mixed Farming	All-Arable
1	2.96	-
2	4.69	4.69
3	4.07	5.43
4	2.84	4.94
5	5.23	4.79
6	-	4.03
7	5.20	7.96
Average	**4.2**	**5.3**

This shows that stockless organic farming can be more productive than its mixed counterpart, supporting the theory that N transfer is more efficient.

ADDITIONAL ASPECTS

Weed Control

The lack of extended ley period does mean that pressure from weeds, particularly those with short viability, are likely to build up. This means that more spring cropping may be necessary and mechanical control is more frequently employed.

Several of the trials report a build up of perennial weeds – docks at Elm Farm and CWS; couch grass at CWS; and creeping thistle at Terrington. A number of measures have been employed to control the problems but all with limited success. These include damaging the crowns through rotavating; ploughing up the roots and raking together with a mechanical weeder (docks); hand rogueing (thistles); and summer fallows (couch).

Soil Organic Matter (SOM)

Researchers at EFRC reported SOM declined from 3.0 to 2.5% over the rotation. Likewise at the Terrington experiment, SOM initially rose under the fertility build but declined from a peak of 4.5% back to around normal levels of 2.5% under arable cultivation.

This concurs with Drinkwaters research in the United States, where the benefits of manure to soil structure and biology were noted. Organic carbon in manure tends to provide a more persistent carbon source than that from green manures, since the more labile compounds are selectively removed during digestion.

Mycorrhizal Activity

Measurements at CWS site between the two organic systems indicate that mycorrhizal activity was much higher in manured plots. The stockless system appears to depress numbers and activity, similar to levels seen in conventionally fertilised soils. This is interesting since the low levels of mycorrhizal activity found in coventionally farmed soils has often been attributed to the use of readily soluble fertilisers, particularly phosphates, when compared with organically farmed soils. However since almost all organic farms in the UK are mixed, the comparison may have been invalid since it may be the use of manure that is supporting the activity.

CONCLUSION

All arable organic farming is economically viable and technically feasible. As prices for organic arable crops decline, soil types less able to support long rotations will become unviable. However the short-term prospects look bright; of the land converting to organic status in the UK only 18% is registered for the production of arable crops. This suggests that the majority of conversions taking place are livestock based with a high percentage of permanent pasture. This means that there will probably be a shortage of organic concentrate for inclusion in dairy, pig and poultry rations and for finishing beef animals. This is likely to keep prices firm provided that imports do not increase significantly.

Those soils that can grow good yields and support extended rotations will sustain profitable organic production, despite any future downturn. Correct sequencing of crops to maximise returns is a fundamental requirement.

Maize and Other Forage Crops as Cash Crops for the Tillage Farmer

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ABSTRACT

The expanding demand for maize silage offers the tillage farmer the opportunity to include a new break crop in the rotation. Maize grown on contract for a neighbouring animal production unit offers better returns than any other break crop at present. Done well, maize growing can compete economically with the best of the cereal crops, with returns in the order of £625/ha (£250/ac). As a relatively easy crop to produce, maize offers the opportunity of easing the workload at peak times and contracting out the sowing and harvesting operations. While whole-crop cereals and peas are very useful alternatives to grass silage they are of limited value to the tillage farmer. Expanding protein grain production should be encouraged. The lack of improved varieties and the existing Agricultural Support Policies militate against expanded production of protein crops.

INTRODUCTION

Research and practical experience have established that, when a high proportion (50-75%) of grass silage is replaced by an alternative high dry matter forage like maize or whole-crop cereals there invariably follows an increase in DM intake. Whether or not this is converted into increased output, beef/milk, depends largely on the quality of the alternative feed offered; quality being measured in terms of dry matter content (>25%) and grain content (>35%) and digestibility (>65%).

The range of possible alternatives has increased in recent years with the successful introduction of forage maize and, more recently, the developments in fermented whole-crop cereals and whole-crop peas. Fodder beet, the traditional and highly successful alternative forage, has declined due to the high labour and production costs.

The increased use of maize with its low protein content, <10%, is creating an increased demand for bought-in protein supplements. A combination of events, the withdrawal of meat and bone meal, the increase in soya bean meal prices, consumer worries about GM crops and strong consumer demands for traceability, have all combined to highlight the shortfall in home-grown animal feed protein.

MAIZE

A number of attempts to introduce maize growing to Ireland have taken place over the past forty years. Trials in 1956 in Wexford produced a yield of 8.6 t/ha (3.4 t/ac) dry matter. Maize was evaluated again in Oak Park in 1961. Commercial maize production began in 1970. The maize acreage fluctuated over the next 25 years or so, reaching a peak of approximately 2,400 ha (6,000 ac) in the mid-seventies and tailing off to less than 80 ha (200 ac) by 1989. Starting from that base the maize area in Ireland has increased to 16,000 ha (40,000 ac) in 2000 and is expected to increase again in 2001 (Fig. 1).

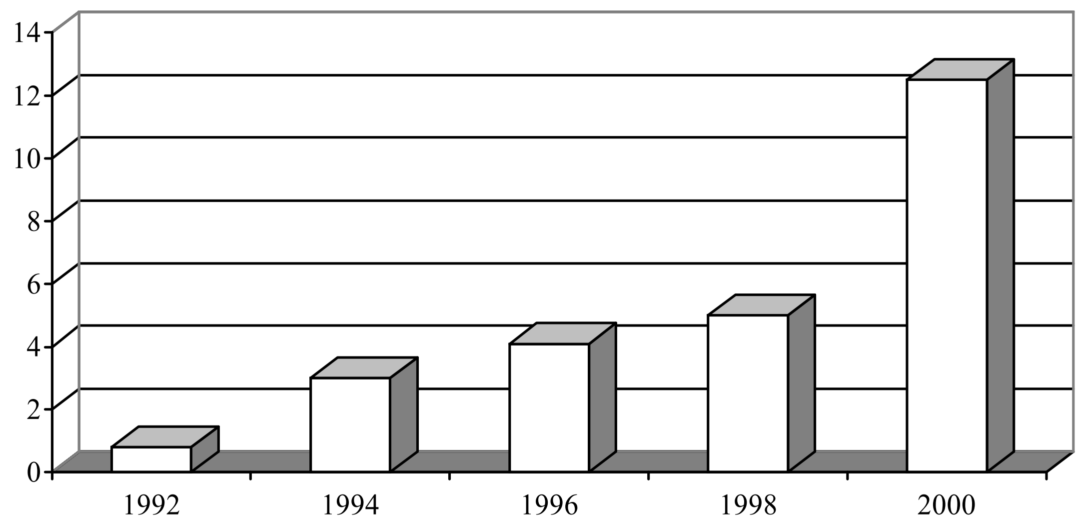

Fig. 1: Increase in the maize Area Aid applications ('000 ha) 1992-2000

This level of expansion has a number of underlying factors, not least of which was the introduction of Area Aid in 1993. The payment for 2001 is £295 or £118/ac.

One of the main factors for the increasing area of maize, apart from its undoubted value as a forage, is the improvement in varieties. Table 1 shows how early-maturing maize varieties have developed over the years.

Table 1: Developments in maize varieties

Variety	Yield DM t/ha	Maturity DM%	Years tested
Dekalb	10.85	25.0	1970-'73
LG11	11.54	28.7	1978-'80
LG20.80	11.29	31.0	1984-'88
Botanis	12.08	36.4	1986-'90
Melody	13.86	38.6	1990-'94
Hudson	14.50	39.1	1991-'95

Dry matter yields have increased by over 1.5% per year over the period. More importantly, from an Irish perspective, the level of maturity attained has increased by over 40% in the same period. In other words, the risks involved in growing maize have been significantly reduced. Growers to-day, using the best early varieties, can expect with confidence, a high yield of high quality forage in all, but exceptionally, poor years. The same rapid changes can be expected over the next 10 years. The emphasis, however, will be on improving the digestibility of the leaf and stem portion of the plant rather than on yield and grain content.

The increasing confidence in the ability of maize to produce high yields (12.5 to 15 t/ha) of high quality (25% starch) silage is fuelling increased demand for the product.

Market Opportunities

To-date most of the maize crop is grown and utilised on animal production units. However, there is a growing demand from milk and beef producers who, for various reasons, i.e. land availability, eligibility etc., cannot produce their own maize. This is creating an opportunity for neighbouring tillage farmers to grow maize as a cash crop. This trend is likely to grow as the satisfaction and economic advantage gained by those using maize becomes more widely appreciated.

From the tillage farmer's perspective, growing maize can be attractive for the following reasons:

- It is a relatively easy, low labour input crop
- It offers the opportunity to introduce an effective break crop
- It spreads and reduces the work-load in spring and autumn
- It can be grown anywhere in the rotation

- Economic returns are higher than any other break crops and compete very favourably with the returns on cereals
- Area Aid of £295/ha (£118/ac) is available

Already there have been a number of instances where tillage farmers have agreed to produce and deliver maize to livestock farmers at an agreed price.

To ensure that the grower is guaranteed a reasonable margin and the user receives a quality product, an agreed and, hopefully, a uniform payment system must be devised to satisfy both parties. Any system should be based on both returns to the grower and value for money to the buyer. In this respect, the quality of the maize delivered, i.e. the DM % and the grain/ starch content, should have an influence on the price per tonne charge.

The charging system for contract growing of maize must, therefore, take into account the cost of production, transport costs, quality and growers margin.

Production Costs

The product costs (Table 2) are based on the Teagasc Crop Cost and Returns 2001 and are compiled on the basis of full contractor prices. Some of the figures have been adjusted to the circumstances encountered on a tillage farm as against those on an all-grass or mixed farm. The high cost, £150/ha (£60/ac), for fertiliser is based on all artificial fertiliser use. Where slurry is available significant savings can be made. Herbicide/spraying costs have been reduced on the assumption that perennial weeds will not be present and that the more expensive contact herbicides will not be required for maize grown as part of a rotation.

Table 2: Maize production costs £/ha (£/ac)

Item	£/ha	(£/ac)
Seed	150.0	60
Fertiliser	150.0	60
Herbicides	15.0	6
Sowing etc.	157.5	63
Harvesting and ensiling	237.5	95
Total variable	710	284
Area Aid	295.0	118
Net cost	415.0	166

*Teagasc Crop Costs and Returns – J. O'Mahony; adapted to growing maize in a rotation

The net cost per tonne of DM works out at £33.2 based on a DM yield of 12.5 t/ha (5 t/ac). This is in line with commercial yields over the last five years. Well-managed crops of maize on suitable sites have a potential yield of 15 t/ha (6 t/ac). Achieving these yields would significantly reduce the cost per tonne DM. Allowing a reasonable return for the grower of, say, £550/ha (£220/ac), would suggest a selling price of around £77 per tonne of DM.

A trading price of £77 per tonne DM is very similar to the production cost on a dairy/beef farm where Area Aid is not available and where a £20-£25/t DM land charge is added. Recognising that every 20 tonnes of maize DM bought-in is equivalent and additional to 1.6 ha available for grazing.

Transport Cost

Where maize is produced on one farm and transported to another, the distances travelled will be longer than normal and should be accounted for in any charging system. The standard silage operation; harvesting an 18 tonne crop of maize at 28% DM, requiring one high output harvester and three 5.5 m trailers and harvesting 4-5 acres per hour, is taken as the basis for the calculations shown in Table 3. The figures were supplied by D. Forristal, Oak Park.

Table 3: Trailer requirements and cost for extra transport distances

		Distance travelled in kilometres, one way				
	Speed kph	0	1	5	10	20
No. of trailers required for 90 t/hr	20	2.7	3.5	6.8	10.9	19.0
	30	2.7	3.3	5.4	8.1	13.6
	40	2.7	3.1	4.7	6.8	10.9
Extra cost per tonne DM	20	0	£0.42	£3.03	£6.28	£12.80
	30	0	£0.21	£1.94	£4.11	£8.45
	40	0	£0.10	£1.40	£3.03	£6.28

It is worth noting that even a draw of up to 10 kilometres does not add too much extra cost, but the logistics of organising the number of trailers required may be the more limiting factor. Based on the data (Table 3) it appears that a round trip of 10 kilometres from the field to the buyer's yard could be accommodated.

Charging System

Based on feeding trial results, maize silage has been valued at between £70 and £85/t DM and even higher in milk production units where quota is not a limiting factor. The range in values is largely dependent on quality, i.e. DM content and starch content. So whatever system is introduced should take into account the quality variations inherent in maize production. Any maize silage introduced into the diet will increase intake. Increased outputs, in terms of beef or milk are, however, largely dependent on two factors; DM content and grain content. Low DM (<25% DM), low starch (<10%) is only equivalent to good quality (70-75% DMD) grass silage. The aim should be to supply maize of 26-30% dry matter with a starch content of around 25%. Dry matter above 32% and starch levels over 30% will not always produce higher returns.

Ideally the selling price should be based on DM% and starch %. However, starch analysis is both slow and expensive. In addition the variations encountered in practice tend to be large; anything up to 10% from the same load. The problem relates more to sampling error than errors in the analysis. For this reason and the fact that the higher the DM% the higher the starch content, a simple DM determination is probably good enough to determine the quality of the maize especially if combined with a crop inspection. The above only applies to maize crops which mature naturally and are not desiccated by frost.

Already a number of *ad hoc* systems are operating. All the figures shown for each of the four systems are based on a yield of 12.5 t/DM/ha (5.0 t/ac) and a net production cost of £415/ha (£166/ac) (Table 2).

System 1: Standard charge of £22/tonne of harvested crop

The consequences for both buyer and seller are outlined below over the range of maize crops normally harvested.

Table 4: The economic effect of DM% of the harvested crop on the buyer and producer using a System 1 contract

Crop DM %	Cost to buyer £/t DM	Margin over costs to grower £/ha
22	100	1005
25	88	685
28	79	460
31	71	310

This system tends to favour the grower and acts as a disincentive to produce a quality product. In fact, from the buyer's perspective, the poorer the quality the higher the price. The price is also out of line with the suggested selling price of £77/t DM for the two wetter crops.

System 2: **A charge of £1 per 1% DM content of the crop i.e. £20/tonne for 20% DM; £28/tonne for 28% DM**

Consequences for both buyer and seller across a range DM% are set out in Table 5.

Table 5: The effect of crop DM% at harvest on the buyer and grower of using a System 2 contract

Crop DM%	Cost to buyer £/t DM	Margin over cost to grower £/ha
22	100	835
25	100	835
28	100	835
31	100	835

This system sets too high a cost on bought-in maize, and will stifle any developing trade for tillage farmers. It does, however, ensure that the grower does not lose by producing a high quality silage, as is the case under System 1. For the buyer, there is no account taken of the quality of the crop.

System 3: **A straight charge of £1000 to £1125 per hectare grown (£400-£450/ac)**

The consequences for both buyer and grower across a range of yields are set out in Table 6.

Table 6: The effect of the yield achieved by the grower on the cost of maize silage using a System 3 contract

Yield t/ha DM	Cost to buyer £/t DM	Margin over costs to grower £/ha
10.0	100-113	585-710
12.5	80-90	585-710
15.0	67-75	585-710

This system places the total cost consequence to both grower and buyer in the hands of the grower. It removes any incentive on the grower's part to produce a good crop of maize by guaranteeing a high return irrespective of crop performance and is unlikely to be acceptable to farmers in the market for maize. The buyer is severely penalised by the grower's failure to produce a high yielding crop.

System 4: An agreed charge per tonne DM delivered within the standard 1 km delivery distance

Consequences. In this case the cost to the buyer is known in advance and does not vary except with the distance travelled. The effects of yield variations on the grower's margins are presented below (Table 7). Allowances are made for the variation in maize quality by presenting a range of selling prices.

Table 7: The returns* (£/ha) to the producer as effected by yields attained and the agreed sale price

Yield (t/ha) DM	Sale price (£/t) DM			
	£70	£75	£80	£85
10.0	285	335	385	435
12.5	460	523	585	648
15.0	635	710	785	860

*Assumes a net production cost of £415/ha (Table 2)

Using this system provides a sound basis for developing a contract growing system for maize. The buyer is getting good value for money and there is a strong incentive on the grower to produce good crops. Any yield increase over the 12.5 t/ha (5 t/ac), which is very achievable in many places, will significantly increase the profitability of the enterprise without affecting the buyer. The value of the contract to the tillage farm is totally dependent on the yield achieved. Any significant drop below the 12.5 t/ha DM target will have serious consequences for the overall profitability of the enterprise.

This system can be relatively easily monitored by allowing the buyer to inspect the crop before harvesting begins and then agreeing the price depending on the quality of the crop. A simple field inspection of the crop should allow it to be classified as low, medium or high quality without too much disagreement. Counting the number of trailers delivered and weighing an agreed sample number will determine the quantities delivered. A crop sample taken by both grower and buyer will accurately determine the dry matter content and allow the calculation of the total dry matter weight delivered.

Area Aid Restrictions

The problem of the continued expansion of the maize area reducing Area Aid payments to tillage producers has been removed. Any reductions in Area Aid payments due to overshooting of the NBA area will be confined to maize. This, in itself, may worry tillage farmers planning contract maize crops. In fact, based on previous years claims for all crops, a doubling of the maize area to 25,000 ha, which is very unlikely to happen, would only reduce the Area Aid payment on maize by 20% or £60/ha (£24/ac). In the unlikely event of this happening it would not significantly affect the profitability of growing maize on contract, provided high yields are achieved.

Achieving High Yields

Originating in the semi-tropics maize requires a relatively high level of heat units to yield and mature. Most areas of Ireland below 120 metres (400 ft), given adequate shelter, can produce good maize in most years.

Maize is essentially an arable crop until ready for harvest. While the agronomy is relatively simple, good timing and agronomic practices are necessary to achieve high yields of quality forage, an essential ingredient for successful cash cropping maize. The most important features are as follows:-

Site selection
On tillage farms low pH (below 6.0), perennial weeds, compaction and soil pests are unlikely to be a problem. Any good arable soil site is suitable for maize provided it is reasonably sheltered and below 120 metres (400 ft.). Midland sites north of Dublin are likely to require the use of plastic to give a consistent high yield of high quality maize.

Variety
If sowing without plastic use only early-maturing varieties; those in the Department of Agriculture's list of Recommended Varieties. Going outside that list will increase the risk of producing low quality, i.e. low grain/starch maize.

Sowing
The optimum date for sowing maize is between 10 April and 30 April. Earlier or later sowings increase the risk of producing low yields. Try to complete sowing by 10 May. Maize is precision-sown so seed rates are given in numbers rather than weight. Sow 91-104,000 seeds/ha (38-42,000/ac). Higher seed-rate can increase total dry matter yield but will reduce DM% and starch content.

Rotation
Maize can be grown anywhere in the rotation, but it is prudent not to follow either potatoes or sugar beet to avoid (a) expensive measures to control groundkeepers and (b) the possibility of compaction following a root crop harvest. Early sowing or the use of plastic should allow for a September harvest, allowing adequate time to follow with winter wheat. Provided atrazine applications are kept to the recommended level of 3.75 l/ha, there will be no problems with the following cereal.

Fertiliser

A 15.0 t/ha crop of maize will require 180 kg N, 70 kg P and 250 kg K/ha to achieve its potential. Fertiliser inputs should be adjusted according to soil analysis and yield expectation. On grassland farms slurry normally supplies all the P and K requirements and some of the N requirement, but slurry is not essential for high yields.

Weed control

Maize grows very slowly during April, May and June and unlike most other tillage crops it is not able to compete with weeds until early to mid-July. For this reason early and good weed control is essential. On most tillage farms 3.75 l/ha of atrazine will give adequate weed control very cheaply. Atrazine can be applied pre-sowing, pre-emergence or post-emergence. Pre-sowing with some incorporation generally gives the best results.

Once the crop is well established and weed-free by the end of June no further action is required until the crop approaches maturity from late September to late October.

Use of Plastic

About 30% of the maize area is now grown under plastic. Two techniques are used commercially; a complete cover (CC) or X-tend system and a mulching or Punch Plastic (PP) system. Both systems give very similar results and cost approximately an extra £250/ha (£100/ac) over the conventional non-plastic system. The main benefits of the plastic systems are:-

1. An increase in total DM yield of 4 t/ha (1.6 t/ac), on average, ranging from 2.5 t/ha to 5 t/ha depending mainly on sowing date and also influenced by site. Early-sown crops on high potential (v. good) sites are likely to show responses in the lower half of the above range.

2. Harvest date is advanced by approximately two weeks by the PP system and three weeks by the CC or X-tend system.

3. For crops sown after the end of April an increase of up 10 percentage points in starch content can be expected.

4. The use of plastic could be regarded as a cost-effective insurance investment against low yields, due to seasonal effects or below average site conditions.

For tillage farmers the two to three weeks earlier harvest would be very important in guaranteeing adequate time to drill a winter wheat crop following the maize. The increased yield will, at a minimum, repay the extra cost of using plastic.

WHOLE-CROP CEREALS

Whole-crop cereals, like maize, offer the opportunity of improving the returns from milk and beef units. Their high DM and starch contents result in higher intakes than are achievable with even high quality grass silage.

Whole crop cereals, wheat, barley and triticale, can and have been ensiled for a number of years now. Like maize, the first attempts proved variable, with, in some cases, disappointing preservation, poor yields and in **some** cases poor animal performance. Many of the earlier problems have now been overcome and well-preserved whole-crop cereals will increase intake and yields in beef and dairy herds. Improved overall health and cleaner animals are an additional attraction. Whole-crop cereals attract an Area Aid of £310/ha or £124/ac.

There are two main approaches, urea treated or fermented with or without additives. Fermented whole-crop is probably now the most popular. The urea system, while technically the more efficient, is difficult to carry out properly in practice. Whole-crop cereals are an option for those who cannot grow maize, with the added attraction of flexibility and the security of forage supply. Where grass supply is short of demand, the cereal crop can be used to boost winter forage supplies.

For success the cereal crop must be grown as you would grow a grain crop. Cutting back on fertiliser, weed control, disease/pest control etc. is not cost effective. The most critical part of the operation is getting the harvest date right. There is, generally, about a two-week interval for harvesting a whole-crop depending on growing conditions. Harvest when the grain is at the ‘soft cheddar’ stage. Harvesting beyond this stage will result in poor utilisation by the animals of the starch present in the grain. Whole-crop wheat has the potential to produce over 12 t/ha DM at 35% DM and 20% starch, with barley and oats yielding 10 to 15% less.

The crop is best harvested by direct cutting using a Kemper header or a combine header fitted to the forage harvester. Aim for a chop length of 1.25 cm (0.5”). Additives are available which claim to improve the straw fraction digestibility as well as eliminating secondary fermenting when the clamp is open. As for any high DM forage, use a narrow pit if possible and consolidate very well by constant rolling. Ensile quickly, sheet and weigh down as soon as possible. Do not leave overnight. Allow at least six weeks before opening the clamp.

Whole-Crop Peas

Producing a home-grown high protein forage is now an option. Legume crops are generally difficult to conserve and success depends, to a large extent, on the availability of purposely-designed additives. These are just now coming on the market. This development could be of particular interest to organic producers, who are having difficulty sourcing a GMO–free traceable protein source. Production costs have been estimated at about £30/t DM, inclusive of an Area Aid payment of £357.5/ha or £143/ac.

A crop of protein peas is grown as for protein pea production but harvested when the peas are fully formed but still of a soft rubbery nature. There will still be a few flowers on top and the crop will be standing erect. The time span from sowing to harvest is around 16-20 weeks. Yield potential is approximately 7.0-8.0 t/ha DM.

The crop is mown leaving a stubble of 10/12.5 cm (45") and left to wilt for 3 to 4 days to reach a 35% DM. It is then picked up with a forage harvester and clamped. The crop is ensiled as for maize or whole-crop. Typical analysis show 35-40% DM, 18-20% C.P., 15-20% starch, D values of 66-72%. The crop can be fed in conjunction with grass, maize or whole-crop and will help reduce the reliance on bought-in protein concentrate.

While there is little doubt that whole-cropping can play a significant role on beef/milk farms and mixed farms, its role as a cash crop is less certain. Whole-crop cereals do not act as a break crop. The higher transport costs involved, combined with a lower sale price, make whole-crop, altogether, less attractive to tillage farmers. Whole-crop peas do not have a proven track record as yet, and the risks involved for the grower are high.

PROTEIN SOURCES

Since 1973 the demand within Europe for material rich in protein for animal feeds has almost tripled. To-day almost 70% of this demand is satisfied by imported soya bean meal. Against this background, Agenda 2000 is encouraging the production of cereals at the expense of oilseeds and protein crops by (a) paying the same support aid to all crops while cereals are the only product to benefit from a minimum support price and (b) the introduction and expansion of set-aside. Since set-aside is calculated on the basis of cereals plus oil and protein crop areas, and not cereals alone, this applies the same penalties to all crops, whatever the market demands. Cross-compliance, which would benefit protein oil crops, has not really been implemented across Europe.

The protein supply situation has become critical and very costly in recent times with the ban on meat and bone meal, the concern about and, in some cases, the non-acceptance of GM modified sources, the demand for a strict traceability and just now the increase in the price of soya. All these facts have created an increasing demand for home-grown protein.

While it is possible to increase protein output in Ireland it is not without its problems, at least in the short-term. The price on offer for peas, beans and lupins including the level of Area Aid payments is not sufficient to make growing these crops very attractive at present yield levels. High year-to-year yield variation, the relatively narrow window of opportunity for sowing and late maturity (late harvest) are deemed very important negative factors by many grain growers.

***Peas*:** Although peas for human consumption have been successfully grown in Ireland for many years, attempts to expand the crop into the animal protein sector in the 1980's failed. The risk of severe harvesting problems and crop losses are still a feature of pea production. The economics of pea production have not changed sufficiently to support the demand for expansion. The development of high yielding varieties capable of standing to harvest is still awaited, although some improvements have been achieved.

***Beans*:** Bean production peaked in Ireland in 1988 at 3,300 ha and has since declined. The main reasons have been a reduction in the profitability of beans relative to cereals combined with a higher year-to-year variability in yields. Market demand is high for beans, particularly for coarse rations. The estimated potential market is in the region of 31,000 hectares annually. Field beans offer an attractive break crop for many cereal growers, provided the guidelines for variety choice, date of sowing and, in particular, disease control measures are followed closely. The prospects for expansion are good in the short-term.

***Lupins*:** Lupins are a rich source of plant protein, second only to soya-beans in protein content. With protein content in the range 35-45% and a good balance of amino acids, lupins can be used as a direct replacement for soya in rations. Even a 50% replacement of soya would reduce soya imports by over 100,000 tonnes annually, requiring 20,000 ha in lupin production. Lupins, because of their size, handling characteristics and protein levels, should be very attractive to compounders.

However, the varieties available to-date will restrict lupin production to the lighter soils in the country. On heavier soils the harvest date can often extend into late September with the risk of poor harvesting conditions and high seed moisture content.

The expansion of protein crops, which is highly desirable, would be greatly helped by EU policy changes which would include upward adjustment of Area Aid and a greater recognition of the positive environmental aspects of protein crops in cross compliance awareness.

CONCLUSIONS

- Maize growing on contract offers the tillage farmer the opportunity to expand his crop mix.
- Having maize on the farm can increase the returns on the following cereal crop.
- High returns, in excess of cereal returns are achievable.
- To develop this opportunity, tillage growers must produce high yield >12t/ha DM of a high quality product.
- Whole-crop cereals, while not as tradeable or attractive as maize, can play a useful role on mixed farms.
- The production of protein crops should be increased. This could be helped greatly by EU and National policy adjustments.

A Fresh Look at the Preservation and Storage of Feed Grain

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ABSTRACT

There is now a wide range of options available for the preservation of feed grain, from conventional drying to high-moisture preservation. The up-coming grant scheme is providing a stimulus for new investment in drying and storage facilities. For many growers, the first big decision is whether to store or sell green. When all costs are included, the cost of on-farm drying, storage and later sale is likely to exceed £20/t on most farms, and is unlikely to be profitable on smaller farms. Acid treatment is an economic system for small growers feeding their own grain. It also has a role at merchant level, as an economic way of increasing intake capacity. Aerated stores should have a ventilation rate to match the maximum initial moisture content of the grain. This applies whether the air is delivered through horizontal ducts or pedestals. Systems of ensiling grain at up to 40% moisture offer interesting possibilities for the grower-feeder, especially in wetter areas. Where the major operations are contracted, these systems can be economic even for small lots.

INTRODUCTION

As a cereal crop approaches ripeness, grain yield peaks and moisture content begins to fall. By the time the moisture falls below 40%, yield has reached a maximum. From then on, the aim is to harvest and preserve the grain at low cost, with minimum loss of yield or quality, in a way that facilitates subsequent feeding to animals. While drying to a safe moisture is the standard approach, it is not always the cheapest or most suitable for feed grain; treatment with mould inhibitor, and ensiling in an airtight environment are worthy of consideration in some situations. Several recent developments justify a re-assessment of all options for the preservation and storage of feed grain:

1. The inclusion in the National Development Plan of a provision for grant aid for the upgrading of grain drying/storage facilities has stimulated much interest among grain growers and merchants. While the details of the scheme are not yet announced, grain quality assurance is likely to be a key theme. Proposals that can be seen to lead to an improvement in final grain quality will be the most likely to find favour. This could be

achieved by reducing bottlenecks of wet grain at harvest, by providing improved storage conditions for dried and wet grain, or by reducing contamination by birds, rodents and insects.

2. Ever-tightening crop margins make it necessary for the cereal grower to cut costs wherever possible. Cereal growers are getting fewer and bigger. In these changing circumstances, the relative merits of on-farm drying/storage and off-combine sale are worthy of consideration.

3. Reduced cereal prices should encourage dairymen and cattle feeders to include a higher proportion of cereals in animal diets.

4. There has been a steady growth in the proportion of grain being rolled for inclusion in coarse rations. Moist, preservative-treated grain is well suited to this use.

5. Higher fuel costs have increased the cost of drying. Long-term energy price trends must surely be upwards.

6. Wet harvests appear to be getting more frequent. Time will tell whether this trend is transitory or permanent.

7. Interesting developments are taking place in the harvesting and ensiling of very high-moisture grain.

This paper looks at the available preservation options under two headings:

- Low-moisture systems such as drying, ventilation and mould inhibitor treatment.

- High-moisture options such as alkali and ammoniation treatments, and combinations of acid treatment and crimping.

STORING AND FEEDING LOW-MOISTURE GRAIN

Safe Moistures and Temperatures

In most years, green grain from the combine has a short shelf life. If quality is to be maintained, the temperature and/or moisture need to be quickly reduced to levels that will slow the onset of mould growth and infestation by insects or mites. Fig. 1 gives a picture of the temperatures and grain moistures that need to be achieved. The three options for safe preservation of this grain are:

1. Dry immediately to a safe moisture, then keep cool
2. Ventilate to cool quickly; some drying may also be achieved
3. Treat with mould inhibitor and keep cool

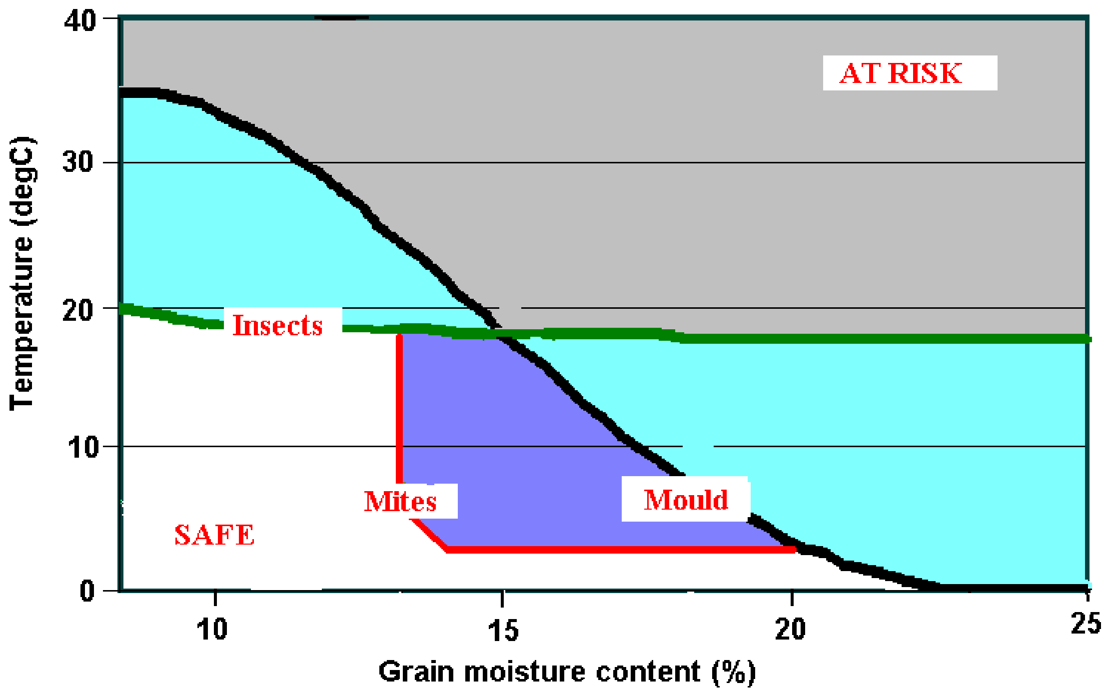

Fig. 1: Safe storage moisture contents and temperatures

Ventilation

Most proposals for grant aid will probably include a storage area for either:

- Dried grain
- Green grain with moisture up to 20%

Where large lots of dried grain are stored, it is prudent to provide some level of ventilation to ensure that the grain can be kept cool and insect attacks can be controlled. A ventilation rate of 5-10 cfm/t (cubic feet per minute per tonne of grain) is sufficient for this purpose. This would also be adequate for acid-treated grain. For green grain from 16 to 20% that is to be held into the new year, an air-flow of about 20 cfm/t should be provided. This will keep the grain cool, and achieve some drying in early autumn if the weather conditions are favourable. These guideline ventilation rates were established in the seventies, after experiences with lower rates were found to give occasional problems.

On-floor storage and drying of grain at higher moistures is possible, but increased ventilation rates and more powerful fans would also have to be provided, as well as closer lateral ducts. It is very important that one is clear from the start as to the maximum initial moisture content that the system is intended to handle, that adequate air is provided for that purpose and that the ducts are big enough and at the right spacing.

Pedestals

The only new development in ventilation equipment is a resurgence of interest in pedestals, i.e. movable vertical ducts through which air is sucked from the grain. Their big advantage is that they are very easy to install and remove, and no changes are needed in the building structure. For these reasons they are likely to be widely used in the future. However, anyone thinking of using pedestals should be clear about their limitations as well as their advantages:

1. When pedestals are used at the normally recommended spacings, the ventilation rate is likely to be in the region from 5 to 10 cfm/t, i.e. the band suitable for maintaining the temperature of dried grain. If they are to be used for moist grain, the spacing would need to be reduced to provide the higher air-flow required for this material.

2. Pedestals are frequently supplied with one fan-motor unit to be moved between a number of pedestals. This greatly diminishes the ability of the system to cope with wet grain. The moving of the fan units from one pedestal to the next at the correct time interval requires a regular time input and attention to detail. Many growers would need to think carefully whether they would be likely to provide this management input on a continuous basis.

3. Pedestal ventilation transfers heat and moisture from the heap to the overhead space in the store. Another ventilation system is required to move this warm, moist air out of the shed, otherwise it will be recirculated back through the grain. In small sheds a natural draught may be enough, but in big stores an air extraction system in the gable walls may be required.

Pedestals are convenient tools for providing a low level of ventilation for dry or near-dry grain. It would be a pity if their reputation were tarnished through being used in situations that were beyond their capacity.

Mould Inhibitors

Propionic acid treatment has been well established for many years as a method of preserving moist grain, and many farmers have used it successfully to preserve small lots for on-farm feeding.

However, when used at this level the technique suffered from several limitations:

1. Success requires that the acid be applied uniformly to the grain, at a rate matched to the grain moisture and storage period. It is difficult to apply the right rate uniformly to small lots with very low-cost equipment.

2. It is often used in emergency situations in very wet harvests. Where grain has a high and variable moisture content, it is very difficult to avoid patchy results with acid.

3. The grain has to be rolled before feeding, so labour at feeding is high.

4. The treated grain needs to be kept cool, otherwise insects may become a problem.

5. Acid application presents some health hazards to the operator, especially where simple hand equipment is used.

Acid treatment is an economic preservation system for small growers feeding their own grain. However, to get consistent results it is necessary to measure the moisture content accurately, to use application equipment that can apply the correct dose evenly, and to store the treated grain in shallow piles or in a store with some ventilation.

In recent years, preservative treatment of grain up to 20% moisture has moved to the other end of the scale, with several merchants installing a separate intake line for mould-inhibitor treatment. The treated grain has been subsequently rolled for inclusion in coarse rations for cattle. The additive used in this case, while still based primarily on propionic acid, is less corrosive and presents a reduced hazard to the operator. These enhancements lead to a slight increase in cost when compared with the traditional form of the acid.

The use of this treatment for grain in the 17-20% moisture range has two major advantages for the merchant:

1. It can provide a second intake stream and a greatly increased total intake capacity for a moderate investment. It can thus be a very economical way of reducing stockpiles of green, uncovered grain at merchant premises at peak intake periods.

2. The grain is stored at a moisture content that is ideal for rolling and inclusion in coarse rations.

3. At present, some of the grain required for coarse rations is dried, stored and then re-wet before rolling. Acid treatment of this grain would save energy and reduce costs.

The use of this treatment by compounders to increase their intake capacity could be expanded to meet their coarse ration requirement. Where it is not feasible for merchants to treat their own intake, bigger farmers could treat and store for them, to the point where the country's full coarse ration requirement (currently about 0.25Mt and growing) would be supplied in this way. At this level, the increase in national intake capacity would be significant, and this increase would be achieved at a cost far below the provision of additional drying capacity.

For farmers to become involved in this development, treated grain would have to become a tradeable commodity, with its own quality standards. Some method of assurance of the treatment would be required, and a degree of trust would have to be developed between grower and merchant.

Insects, Mites

Fig. 1 shows that mites will tolerate temperatures and moistures so low that they cannot be controlled completely by drying or ventilation. There is no substitute for good hygiene practices, especially cleaning and disinfestation of the store before filling. Any stores erected under the grant scheme should be built with a view to making this operation easy. Main ducts should be big enough to allow easy access so that they can be swept out, and all ducts should have smooth floors and walls. The rest of the building should be kept free of crevices, ledges and other dust traps.

Acid treatment is intended to control mould growth, but not insects or mites. While this is not usually a problem in small lots, large piles of treated grain would require a low level of ventilation to keep the temperature below insect-friendly levels.

Costs

Whatever type of investment in drying/storage systems is being considered, it is very important that the costs and returns be fully evaluated. The mere fact that a grant may be available does not necessarily mean that the returns will justify the investment.

As an example, in calculating the costs of drying a tonne of grain with a mobile dryer, one immediately thinks of three cost items:

- *Capital repayment and interest:* This is greatly influenced by the size of dryer purchased in relation to the amount of grain to be dried. If these are well matched, the cost should not be much above £5/tonne. If a 40% capital grant becomes available, this would reduce to about £3/tonne.

- *Weight loss as moisture:* If green grain is valued at £80/tonne and the moisture is reduced by 5% at drying, the cost of the weight loss is £4.71/tonne.

- *Fuel cost:* This includes both the tractor, the dryer burner and cooling fans. Fuel cost has increased sharply in recent times, and could be estimated at about £3/t for 5% moisture removal at present.

In most cases these three cost items will total about £10-13/t, and this may well be a good estimate of the immediate additional costs that are incurred on a farm by the purchase and operation of the dryer. However, if the aim is to compare the cost of on-farm drying (followed by storage and later sale) with immediate sale of green grain from the field, then there are other on-farm costs which have to be considered carefully. These would include:

- *Cost of tractor used to drive the dryer:* Even if this is already on the farm, some portion of its overhead cost should be set against grain drying.

- *Cost of labour:* Labour on farms is now very scarce, and even if no extra labour is recruited, the time spent on grain drying should be included in its cost.

- *Cost of dried grain storage:* If a building for dried grain storage already exists, could it be put to some other profitable use if it were not required for grain? If this building needs modification, or a new building is required, it will have a major impact on the total project cost.

- *Working capital cost due to delayed sale:* The money tied up in the grain has a cost. This could be either the bank interest paid or investment opportunities foregone during the storage period.

- *Invisible weight loss during drying/storage:* Some loss of dry weight during drying and storage must be expected. The size of this loss on farms is unknown, but merchants have estimated their loss at about 1.5-2% at 5% moisture removal.

- *Cost of handling equipment:* Additional handling equipment may be required in the transfer of the grain into the dryer, and then from the dryer to the store.

As an example, depending on how one decides to treat these additional costs, and what value one assigns to them, the total cost of drying a tonne of 20% m.c. grain valued at £80/t and storing it for sale six months later with a 20-t mobile dryer drying 1500 tonnes per year might look as in Table 1.

Table 1: An example of total costs of drying and storage for 6 months with mobile dryer drying from 20 to 15% moisture

	£/t
Annual cost of capital	4.13
Moisture loss	4.71
Invisible loss	1.44
Fuel	3.00
Tractor	0.50
Labour	0.50
Working capital	3.20
Dry grain storage	6.62
Dryer maintenance	0.21
Total cost (@ 15% moisture	**24.31**

Evaluating investment in a ventilated store is a simpler exercise. Servicing the capital cost of the building is the major cost item. If a new building is planned, the cost of site preparation and provision of electrical supply should be included. Also, it is still important to include additional labour requirements, working capital costs and invisible weight losses in calculating the full cost of drying and storing a tonne of grain. An approximate set of costs of a 1000-t store with adequate ventilation for grain up to 20% m.c. is shown on Table 2.

Table 2: Approximate costs of ventilated storage at 20% moisture (ventilation rate 20 cfm/t, grain dried to 17%, 6 months storage)

	£/t
Annual cost of building	8.66
Moisture loss	2.89
Invisible loss	0.86
Electricity	1.80
Equipment	0.93
Labour	0.40
Working capital	3.20
Total cost	**18.74**
Cost corrected to 15% m.c.	**20.62**

Acid treatment followed by storage with minimal ventilation is little cheaper than drying (Table 3). So its main attraction is the increased intake capacity that is provided for a low investment cost in application equipment, as well as the suitability of the product for rolling.

Table 3: Approximate cost of acid treatment and storage for 6 months of 1000t lot at 20% m.c.

	£/t
Annual cost of capital	0.40
Acid	5.64
Labour	0.30
Working capital	2.80
Cost of DM loss	0.50
Electricity	0.20
Treated grain storage	6.61
Equipment maintenance	0.08
Total cost	**16.53**
Cost corrected to 15% m.c.	**21.23**

The cost of providing a storage building for dried or moist grain is a major component of each system cost. This cost is very much affected by scale. It is very difficult to provide economic storage in a new building for lots of less than 500 t.

If a grant of 40% were available for all the equipment and building costs in these systems, the cost per tonne would be reduced by between £3 and £5 per tonne (Table 4). This is certainly a significant benefit, but in many cases it will still not be enough to make on-farm drying/storage more profitable than off-combine sale.

Table 4: Impact of 40% capital grant on grain drying/storage costs

System	Mobile	On-floor	Acid
Drying/storage cost	24.30	20.62	21.23
Less 40% capital grant	19.23	17.16	18.40

In summary, while costs will differ on every farm, the full cost of drying, storage and later sale is likely to be £20-25/t without grants, and not much less than £20/t with grants. The main factors dictating the cost are the scale of the project and the full utilisation of dryer capacity. Grants certainly reduce drying costs, but anyone thinking of changing from selling green grain to drying and storing needs to evaluate the decision carefully beforehand. In particular for smaller units, the economics may still be dubious.

STORING AND FEEDING HIGH-MOISTURE GRAIN

Treatment/Storage Systems

Where grain is destined to be fed on the farm, various methods of harvesting at moisture contents up to 40% and storing and feeding without drying have been tried by farmers in recent years. This has been stimulated mainly by lower cereal prices and consequent higher inclusion rates in ruminant rations.

The main challenge with the storage of high-moisture grain is the control of mould growth. In some treatments this is achieved by storage in air-free conditions, in others by treatment with chemicals such as organic acids or caustic soda. Some treatments also alter the physical characteristics and modify the nutritive value of the grain.

The most common high-moisture treatment/storage options being tried at present are the following:

- *Acid treatment/crimping/ensiling:* This involves harvesting grain at up to 40% moisture and storing it anaerobically until feeding time. Under these conditions it undergoes a lactic acid fermentation. The grains can be rolled at ensiling (i.e. crimped) or at feed-out.

The commercial exploitation of the system has been boosted by the development of high-throughput crimpers, which allow this operation to be performed at ensiling with minimum delay. Crucial to the success of this system is achieving and maintaining strictly air-free conditions throughout storage and minimising the duration of access to air during feed-out. The use of mould-inhibiting acids helps to preserve the grain prior to ensiling and during feed-out. The grain is normally ensiled beneath the type of plastic used for grass silage.

- *Alkali treatment:* Whole grain harvested at up to 30% moisture is soaked in or sprayed with sodium hydroxide solution. This grain is then stored aerobically.

- *Ammoniation:* Urea is the most common source of ammonia used to treat grain harvested at 30-35%, but anhydrous or aqueous ammonia could also be used. The grain is normally stored under sealed, air-free conditions (e.g. sealed beneath conventional silage plastic sheeting) to prevent ammonia loss. The ammonia prevents mould growth and when it binds with moisture in the seed-coat of the grain the resultant hydroxide effect is expected to replace the need to roll the grain.

Costs

High-moisture grain systems incur their own set of harvesting, treatment, preservation and storage costs. Typical quoted costs would be £10-16/t for the crimping/acid, urea or caustic soda treatments. If these costs are corrected to 15% moisture, and then a working capital cost and a small storage cost are included, the total cost of these systems is similar to that of dry-grain options.

The nutritive value of the treated grain is the subject of Grange research now under way. While we await the results of this work, it would appear that all the treatment options discussed here have the potential to preserve the grain effectively if carried out properly, and in that case the differences in feed value in cattle rations are likely to be small.

In that case, decisions to adopt the various treatments are likely to be based on convenience and practicability issues on individual farms. All the high-moisture systems have both advantages and disadvantages:

- On the credit side, they allow an earlier harvest and re-use of the cereal field. Harvest losses may be reduced, though in most years there will probably be little difference. They may allow a better utilisation of the combine harvester by extending the harvest period. On the other hand, they require timely co-ordination of a number of activities during the harvest-process period, which may clash with conventional harvesting of other crops.

Also, in some seasons the crops may dry very quickly through the optimum-moisture window.

- The under-ripe straw may have a higher feeding value, but it may also be more difficult to dry in the field.
- Feeding costs and labour input may be reduced by the elimination of rolling.
- Feeding value may be enhanced, for instance by ammoniation treatments that increase protein levels in the feed.
- To date, high-moisture grain has been grown, stored and fed on the same farm, and this is likely to remain the most common method of utilisation. However, short-distance of the harvested grain from the grower for ensiling by the feeder should be easy to organise. Ensiling in sealed, transportable bags is another possibility that would need some research. These approaches would open up some possibilities for non-feeding growers to become involved with high-moisture grain preservation systems.

If operations such as crimping can be contracted, high-moisture systems are likely to be more economical than drying/storage operations for the preservation of smaller lots of feed grain.

CONCLUSIONS

The up-coming grant scheme will provide a stimulus for cereal growers to consider whether to make any changes in their grain drying-storage systems. As lower grain prices offer the opportunity to increase the use of grain in animal rations, it is also a good time for those feeding grain to consider:

(i) Could more of this grain be stored on the farm?
(ii) Would a non-drying on-farm storage and feeding system fit in better?

While every farm needs to be studied individually, a few general rules are likely to apply in most cases:

1. For relatively small amounts of grain, say less than 500t, where there is no on-farm grain use, the most likely options are to sell from the combine or to join with neighbours to achieve a scale that would justify the cost of improved drying/storage facilities.

2. For small operations where grain is fed on the farm, the two most likely options are conventional harvesting at less than 20% followed by propionic acid treatment, or one of the high-moisture ensiling systems.

3. Many of the larger grain growers will be interested in availing of the grant scheme to augment existing drying and storage facilities. For a few, it may be worth considering the possibility of mould-inhibitor treatment, if a merchant can be interested in buying treated grain at up to 20% for inclusion in coarse rations.

4. For any proposal, it is essential to calculate all the extra costs of on-farm preservation and make sure that it makes economic sense compared with selling straight from the combine.