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OAK PARK

TEAGASC

2007
Research Report

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Oak Park

Research Report 2007

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Crop production systems: a study of key factors in their performance; long-term effects of rotation and input level; and effective validation and dissemination

Forristal, P.D., Burke, B., Dunne B., ***RMIS No. 5616***

The overall objectives of this project are:

- To determine the interaction between seed rate, applied nitrogen rate and fungicide level in winter wheat.
- To continue studies on the effect of system including input level and rotation type on crop yields and production margin on high and moderate disease pressure sites.
- To develop simple rule based fungicide application systems for use in spring barley.
- To compare the effects of 10+ years of monoculture and rotation and input level on soil characteristics, weed flora and soil fauna.
- To investigate/develop on-farm research / demonstration methods to effectively validate and disseminate the techniques developed in this and similar research areas.

In 2007, the primary focus was on the first two objectives.

Methods

The trial is now carried out at three locations: Oak Park and Knockbeg near Carlow and Kildalton in south Kilkenny. Rotations and input levels are being evaluated at Knockbeg; input levels are being assessed at Kildalton, while the interaction of levels of inputs is being studied at Oak Park. The development and cropping history of the trial sites was outlined in the 2004 research report. The cereal crops at Knockbeg and Kildalton are subjected to combinations of six different input treatment strategies:

- ***High:*** Commercial levels of all fertiliser, herbicide, fungicide and other inputs. This is a high-yield, low-risk strategy which is easily managed but tends towards high production costs.
- ***Low:*** Nitrogen levels reduced to approximately 80% of the 'High' strategy with all other chemical inputs reduced to 50% of the 'High' rate. This is a reduced yield, moderate risk, but easily managed strategy with lower input costs.
- ***Decision-based (DB) High:*** Input levels are in-part determined by a decision making process aimed at optimising response to the input. This is a high-yield, moderate risk strategy requiring greater management levels than the fixed input levels outlined above. (winter wheat and spring barley only)
- ***Decision-based (DB) Low:*** Low levels of inputs which are in-part determined by a decision making process aimed at minimising costs while maintaining adequate yield. This is a reduced yield, high-risk strategy. (winter wheat and spring barley only)
- ***High-Nitrogen Low-Fungicide:*** A treatment coupling the nitrogen levels of the 'High' strategy with the fungicide levels of the 'Low' strategy (S.Barley, Kildalton)
- ***Low-Nitrogen High-Fungicide:*** A treatment coupling the nitrogen levels of the 'Low' strategy with the fungicide levels of the 'High' strategy (S.Barley, Kildalton)

Two rotations: a five course break-crop rotation incorporating a legume and oilseed crop with three cereals; and a three course all-cereal rotation with oats preceding wheat, are grown in comparison with continuous winter wheat and spring barley crops at the Knockbeg site. The basic plot (12.5m x 30m) constitutes an individual crop grown with either high or low levels of inputs with decision-based inputs used on one half of these plots in a split-plot design.

Each individual treatment is replicated four times. Decision based strategies are based on a combination of advisory decisions using crop and weather knowledge and computer-based decision support systems (DSS). The DSS systems, which were only used for winter wheat and spring barley (Knockbeg) disease control, were the Danish ‘Pro-plant’ system for the ‘DB-High’ strategy on both cereals and the ‘DB-Low’ strategy on spring barley. The less complex ‘Septoria Timer’ system was used for the wheat ‘DB-Low’ approach. The Kildalton spring barley crop was used to complete the determination of the source of the yield response as in the two previous seasons. A low herbicide and fungicide treatment coupled with high nitrogen rates (HNLF), and a high fungicide and herbicide treatment in combination with low nitrogen application rates (LNHF) were used in conjunction with the standard ‘Low’ and ‘High’ treatments.

Results

A combination of weather events during the growing season impacted negatively on winter wheat yields in particular. A wet autumn/winter coupled with near drought conditions in late spring/early summer followed by another very wet June/July period produced unfavourable conditions and high levels of take-all.

High vs. Low input levels*:* Unusually winter wheat receiving the ‘Low’ level of inputs yielded better than the high input levels at both sites (Table 1and 2). The earlier sown ‘High’ wheats were most affected by take-all. The ‘Low’ input strategies would therefore be far more profitable in this season. With winter barley, yields were good and the yield difference was small at about 0.3 t/ha between ‘High’ and ‘Low’ input levels. The winter oat crop responded well to the application of higher levels of inputs with the ‘High’ treatment yield exceeding that of the ‘Low’ strategy by 1.1 t/ha. Spring barley yields followed the trend of previous years with the ‘High’ input approach adding about 18% to the recorded yield at Knockbeg. At Kildalton the yield difference was just 8% between these treatments.

Rotation effect*:* The effect of rotation on wheat crop yields was very significant in 2007, probably due to the higher levels of take-all present, with wheats grown in both rotations yielding approximately 1.7 t/ha more than wheat grown in monoculture and the cereal rotation proving more beneficial to the following wheat (Table 3). Similarly winter barley benefited when it was grown in a beneficial part of a break crop rotation (following oilseed rape) compared to following a wheat crop in a cereal rotation.

Decision- based strategies in winter wheat and spring barley*:* The Danish decision based strategy used to generate the fungicide programme for the ‘DB-high’ wheat was not successful in 2007 with a substantial yield reduction recorded (Table 1 and 2). Conversely the ‘septoria timer’ DSS system worked well. The Danish system did not work well with spring barley. While its use resulted in fungicide savings, a substantial yield reduction was recorded.

Fertiliser and fungicide response in spring barley: The response to the four input strategies used on spring barley: High, HNLF, Low, LNHF at Kildalton is summarised in Table 2. While both nitrogen level and fungicide level contributed to yield, there was no response to using higher fungicide levels at lower nitrogen rates, confirming the general trend of previous years.

Table 1: Effect of input strategy on grain yield, Knockbeg 2007

Cereal crop	Input strategy	Yield (t/ha)
Winter wheat	High	9.91
	DB-High	8.99
	Low	10.31
	DB-Low	10.30
Winter barley	High	8.67
	DB-High	8.50
	Low	8.15
	DB-Low	8.43
Winter oats	High	8.45
	DB-High	8.48
	Low	7.38
	DB-Low	7.42
Spring barley	High N, High Fungicide	8.35
	High N, Low Fungicide	7.01
	Low N, Low Fungicide	6.72
	Low N, High Fungicide	5.98

Table 2: Effect of input strategy on grain yield: Kildalton 2007

Cereal crop	Input strategy	Yield (t/ha)
Winter wheat	High	9.16
	DB-High	8.51
	Low	9.67
	DB-Low	9.72
Spring barley	High N, High Fungicide	9.00
	High N, Low Fungicide	8.48
	Low N, Low Fungicide	8.32
	Low N, High Fungicide	8.19

Table 3: The effect of rotation on winter wheat and winter barley yields and production margins: Knockbeg 2007

Rotation	Wheat Yield (t/ha)	W.Barley Yield (t/ha)
Break Crop	9.87	8.60
Cereal Rotation	10.83	8.28
Monoculture	8.69	

Interaction of seed, nitrogen and fungicide rates in winter wheat
The aim of the two seasons work reported here was to assess the effect of seed rate, fungicide rate and nitrogen rate on wheat yield and disease levels and to assess the effect of their interaction on crop response.

Field trials were carried out in 2006 (Knockbeg) and 2007(Oak Park). Three seed rates (S), three (2007, four) nitrogen rates (N) and three fungicide (F) treatments were applied using the input levels outlined below.

		2006	2007
Seed Rate	S1 (seeds/m2)	150	150
	S2 (seeds/m2)	250	250
	S3 (seeds/m2)	350	350
Nitrogen	N1 (kg/ha)	-	120
	N2 (kg/ha)	165	165
	N3 (kg/ha)	210	210
	N4 (kg/ha)	255	255
Fungicide	F1 (% rate)	0	0
	F2 (% rate)	50	50
	F3 (% rate)	100	100

The full-rate fungicide application programme (F3) was a three spray programme applied at growth stages (GS) 31, 37 and 51. The half-rate (F2) used half of the active ingredient rates applied at the same timings. Each nitrogen rate was applied over three splits: 25% at GS 24; 50% at GS 30 and 25% at GS 37. The treatments were applied in a 3 x 3 x 3 (3 x 4 x 3 in 2007) factorial arrangement in a randomised block design with 5 replications. The 20m x 2m plots were sown on Oct 6th and Oct 12th respectively prior to the 2006 and 2007 harvest years, using the moderately disease susceptible variety, Richmond. Plant and head counts, disease and harvest parameters were assessed. Data from each year was analysed as a factorial arrangement of treatments using the GLM procedure of SAS, Version 9.1.

The level of significance for the main effects and interactions were assessed. There was no three-way interaction evident. While there was no significant two-way interaction recorded in 2007, in 2006, the use of lower seed rates resulted in a reduced response to fungicide use. Similarly there was a lesser response to fungicide use at lower nitrogen rates. The grain yield and disease levels on the flag leaf highlight the main effects of the treatments (Table 4). While the nitrogen and fungicide response are typical, the effect of reducing seed rate on the incidence of disease was marked in 2006. Plant counts, tiller numbers and head numbers were all significantly (P<0.01) influenced by seed rate with lower seeding rates giving lower plant numbers which were compensated for by a greater degree of tillering and more grains in the cereal heads.

Table 4: Input interaction trial: Disease level on flag leaf and grain yield

	2006		2007	
	Disease flag (%)	**Yield (t/ha)**	**Disease flag (%)**	**Yield (t/ha)**
S1	12.7a	10.32^{a}	7.81^{a}	10.76^{a}
S2	18.8b	10.73^{b}	9.31^{a}	11.11^{ab}
S3	22.7c	10.58^{b}	10.48^{a}	11.35^{b}
N1	-	-	9.30^{a}	10.04^{a}
N2	17.8a	10.15^{a}	9.98^{a}	10.85^{b}
N3	18.6a	10.63^{b}	9.13^{a}	11.60^{c}
N4	17.8a	10.85^{b}	8.40^{a}	11.81^{c}
F1	50.4a	8.57^{a}	23.15^{a}	9.64^{a}
F2	3.0b	11.26^{b}	1.89^{b}	11.61^{b}
F3	0.8b	11.80^{c}	2.57^{b}	11.98^{b}

[abc] within column, means with different superscripts differ (P<0.05)

The effect of minimum tillage on the production of spring barley and oilseed rape and an assessment of its impact on soil characteristics and soil fauna.

Forristal, P.D., Kennedy, T., Dunne, B., Murphy, K. and Connery, J. ***RMIS No. 5615***

This new project which commenced in 2007 has the following key objectives

1. To determine the effects of minimum tillage on components of yield, grain yield, grain quality and the profitability of spring barley and winter wheat production.
2. To assess the effects of cultivation system on crop development and seed yield in oilseed rape production systems.
3. To study the stratification of nutrients and soil organic matter in soils subjected to alternative cultivation strategies for more than 6 years.
4. To study the interaction between cultivation system and Nitrogen response in a spring barley crop.
5. To complete the investigations of the effect of cultivation system type on aphids and virus infection of winter cereals.
6. To determine the risk of plant density reduction due to slug damage on min-tilled wheat and to assess the effect of tillage system on aphid numbers in wheat ears.
7. To assess the effects of cultivation system on: a) earthworm populations and species composition; and b) on the species diversity and abundance of the pest-predator family of ground beetles.

Winter wheat

The experimental design for 2007 wheat trial was similar to that used in the previous project (RMIS 5242) The Knockbeg site has now been subjected to similar cultivation treatments for 6 years prior to the reported season. The experiment is laid down as a randomised block with 4 replications. The treatments are:

Conventional plough-based system with straw baled and removed.
Conventional plough-based system with straw chopped and incorporated.
Reduced cultivation with straw baled and removed.
Reduced cultivation with straw chopped and incorporated.

The conventional cultivation (PL) consisted of ploughing to 200-250 mm, followed by a single pass of a rotary power harrow to 100-120 mm. Reduced cultivation (MT) consisted of one pass in August/September with a 3-metre wide tine cultivator (Horsch), working about 70-80 mm deep, followed immediately by a consolidating run with a roller. This was followed by an interval of about 3 weeks to allow weeds and volunteer cereals to become established, prior to herbicide application. All crops were sown with a cultivator drill (Vaderstad Rapid).

The 2006/2007 crop was sown on October 16th in good conditions. Plant establishment varied depending on the cultivation system with the plough based system returning higher plant counts (Table 1). This may be a feature of the somewhat later than planned sowing date which may favour the plough based system when sowing conditions are less than perfect. Weeds were effectively controlled with a conventional autumn programme using pendimethalin and isoproturon for grass and broad leaved weeds, followed by a spring application of sulfosulfuron to control sterile brome. A conventional three spray fungicide programme was used for disease control and all treatments received 225 kg of N per hectare. Yields were very poor on this site in 2007. There was also a substantial difference in yield and harvest parameters between the different cultivation treatments (table 1). The plough based system treatments resulted in better establishment, higher yields and improved grain quality. Grain fill was poor in both treatments as evidenced by the low grain specific weights; however the minimum tillage treatment resulted in particularly low hectolitre weights. The cause of this poor grain fill is not fully ascertained although take-all was certainly a contributory factor. Over all the years of the trial, however, the minimum tillage establishment system has matched that of the plough-based system.

Table 1: Plant counts, grain yield and quality, winter wheat, Knockbeg, 2006-2007

Treatment	Plant count (n)	Yield @ 85% DM (t/ha)	Hectolitre weight (kg/hl)	Screenings < 2 mm (%)
PL - straw	302^{b}	8.76^{b}	67.9^{b}	2.2
PL + straw	305^{b}	8.44^{b}	68.9^{b}	1.9
RC - straw	269^{a}	7.54^{a}	65.2^{a}	2.2
RC+ straw	267^{a}	7.19^{a}	64.7^{a}	2.0
Sig	*	**	*	*ns*

Note: means within columns with different subscripts are significantly different (Tukey)

Winter barley

The performance of winter barley under PL and RC cultivation systems is assessed in a non-replicated observation trial. The systems are evaluated in a 4-hectare field, half of which is ploughed and half established with reduced cultivation. The site is on a free draining gravely sandy loam soil at Oak Park. In this experiment the straw was baled and removed from both treatments. The crop was sown in good soil conditions on 26/09/06. Establishment levels were similar across both treatments. Yields were satisfactory with no difference between establishment systems recorded (Table 2). Grain quality parameters were similar with both systems.

Table 2: Plant establishment and grain yield and quality, winter barley, Oak Park (House Field), 2006-07

Treatment	Plant establishment (plants/m²)	Yield @ 85% d.m. (t/ha)	Hectolitre weight (kg/ha)	1000-grain weight (g)	Screenings < 2.2 mm (%)
PL-straw	223	7.84	59.6	55.3	0.4
RC-straw	218	7.78	59.7	54.3	0.6

The previously reported problem of sterile brome was tackled by creating three successive stale seedbeds between the harvest of the 2005 crop and the sowing of the 2006 crop in an attempt to exhaust the seed reserve. In autumn 2006, two successive stale seedbeds were put in place. While the three stale seedbed approach was successful, sterile brome levels increased in the 2006/2007 season.

Spring barley – Oak Park
This non-replicated experiment compares PL and RC cultivation systems for spring barley. The treatments are as follows.

1. PL - straw incorporation
2. PL + straw incorporation
3. RC - straw incorporation
4. RC + straw incorporation

This was the seventh year of the trial and the field had been in continuous spring barley for at least 30 years before this work commenced. The 2-hectare site was divided into two large plots, PL and RC. These areas were further sub-divided into two 0.5-hectare areas on which the straw was baled and removed or chopped and incorporated. Cultivation treatments were similar to the previous year. Soil conditions were good at sowing.

Yields were very high despite low specific weights with little difference between the two establishment systems (Table 3).

Table 3: Grain yield and quality, spring barley, Oak Park (Clonaherk) 2007

Treatment	Yield @ 85% d.m. (t/ha)	Moisture content (%)	Hectolitre weight (kg/hl)	Screenings < 2.2 mm (%)
PL-straw	8.22	18.7	60.7	1.8
PL+straw	8.30	19.0	59.6	2.0
RC- straw	8.16	19.7	60.3	2.1
RC+ straw	8.61	19.6	60.8	1.9

Spring Barley - Knockbeg
A replicated field trial evaluating cultivation systems, applied Nitrogen fertiliser rates, and seed rates was set-up in 2007. The trial site is on a medium to heavy textured soil located at Knockbeg, which presents a greater challenge to the cultivation systems than the more easily worked soils at Oak Park where the previous spring barley observations were located. The main cultivation treatments are:

A *Conventional establishment:* Ploughing followed by secondary cultivation with a power harrow prior to sowing.
B *Min-till Autumn:* Stubble cultivation in the autumn followed by sowing in the spring
C *Min-till Autumn and Spring:* Stubble cultivation in the autumn followed by a second similar cultivation in spring prior to sowing.
D *Min-till Spring:* Stubble cultivation in the spring only followed by sowing

Within each of these plots, two seed rates (300 and 350 seeds/m^2) and five Nitrogen rates (0, 75, 105, 135, 165 kg/ha) were applied in a 5 x 2 factorial arrangement. For the 2007 harvest season, autumn cultivation took place later than planned due to weather conditions, on 16th October 2006. The conventional plots were ploughed on 14th March. Min-till spring cultivation was on 26th March 2007. All plots were sown with a modified Vaderstad drill on March 27th with the variety Wicket. The Nitrogen was applied on two occasions and all plots received a conventional herbicide and fungicide programme. Measurements included: plant establishment; components of yield and grain yield and quality.

The plough based system gave better establishment than the min-till cultivated plots with an average of 11% more plants than the mean of the three min-till treatments. The two seed rates used allowed min-till plots with greater plant numbers than the plough based system to be established. All cultivation treatments had sufficient numbers of plants established to optimise yield with little difference in head numbers prior to harvest. Nitrogen rates impacted on the components of yield with the lower two rates resulting in lower head numbers and less grain per head. The effect of cultivation system and Nitrogen rate on crop yield is summarised in Figs.1.and Fig.2.

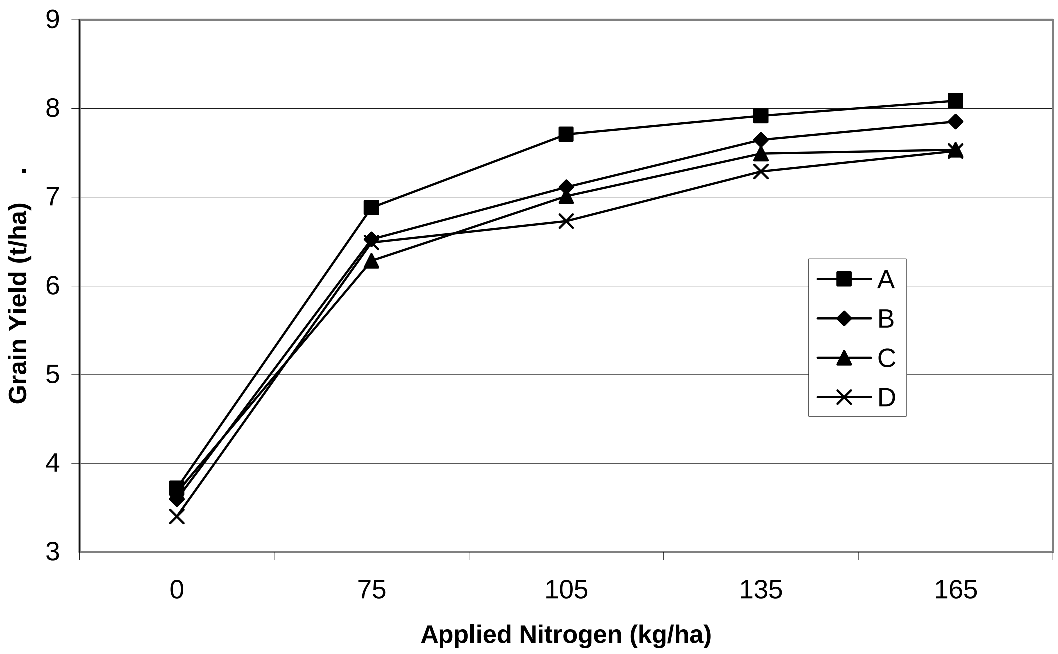

Fig. 1. The effect of cultivation system and N rate on spring barley yield (300seed/m2) 2007

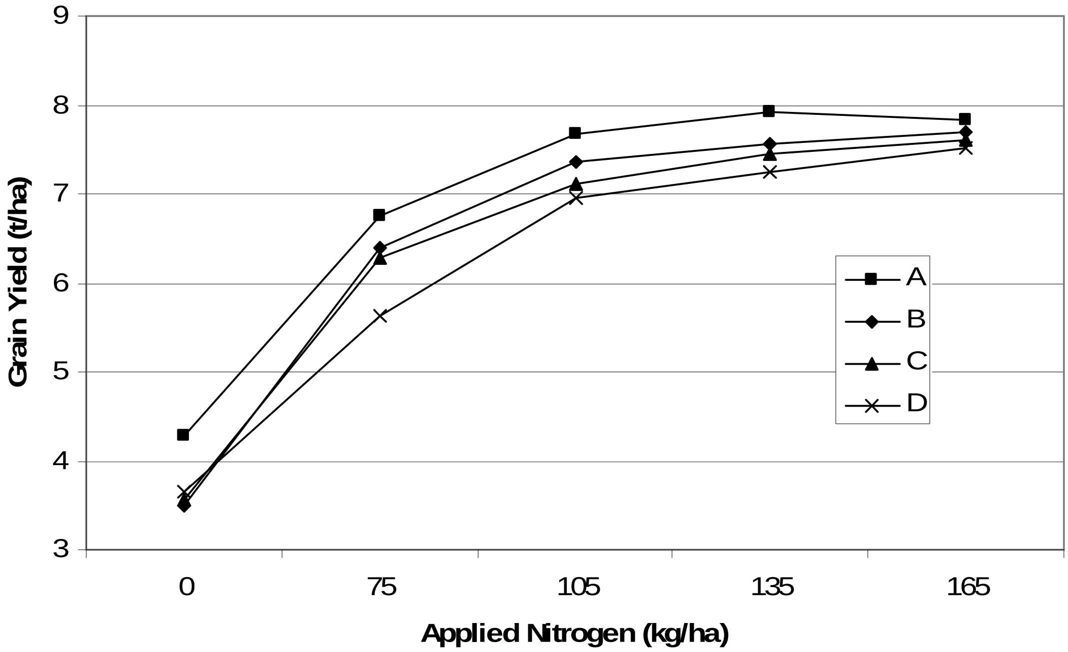

Fig. 2. The effect of cultivation system and N rate on spring barley yield (350seed/m2) 2008

Overall, the yield from the plough established spring barley tended to be greater than any of the min-till treatments at all applied nitrogen levels. Compared to the average of all the min-till treatments, the plough based system yielded about 0.5t/ha extra. The autumn cultivated min-till treatment tended to yield more than the spring cultivated system. There was no evidence of different N response characteristics between the cultivation systems in 2007.

Establishment systems for Winter Oilseed Rape

A trial evaluating alternative crop establishment systems was established in the 2006/2007 season. The objective was to determine the impact of crop cultivation system, specifically minimum tillage systems on crop yield and components of yield. The cultivation and establishment treatments used were:

A. Plough, press/roll, power harrow/drill, roll
B. Plough, press/roll, vaderstad drill, roll
C. Min-till 75-100mm 1 run, roll, broadcast sow, roll
D. Min-till 75 – 100mm 1 run, roll, vaderstad drill, roll
E. Mintill 75 – 100mm 2 runs, roll, vaderstad drill, roll
F. Min-till 75- 100mm 2 runs, roll, broadcast sow, roll
G. Min-till 150 – 200mm 2 runs, vaderstad drill, roll
H. Broadcast sow, roll

The plots were sown in good conditions on 29th August 2006 with rain immediately after sowing favouring good establishment. Each cultivation plot was split with a conventional variety of winter rape (Castille) sown on one part and a hybrid variety (Excalibur) on the other side. The cultivation plots were 6m wide x 30m long with 5 replications in a randomised block design. Crop establishment was good for all treatments except B, where excessive sowing depth reduced establishment. Treatment H had a lower percentage of plants establishing, but as this was anticipated from the outset, a higher seed rate (+30%) had been used resulting in a similar plant stand to the other treatments. The yields at harvest indicated that mostly there was little difference between cultivation treatments (Table 4). Treatment H, where the seed was broadcast on stubble, had a tendency towards lower yields. The hybrid variety yielded about 10% more than the conventional variety in this trial but there was no interaction between variety type and cultivation system.

Table 4: The effect of cultivation system on winter oilseed rape yields. 2007

Treatment	Yield (t/ha at 9% mc)
A	5.29
B	5.24
C	5.51
D	5.28
E	5.51
F	5.40
G	5.47
H	5.03
Sig	NS

Soil invertebrate studies at Road Field site

Aphid and soil invertebrate studies on minimum- and conventional-till winter wheat plots continued for a third season in 2007. The aphid infestation of wheat during early November 2006 was extremely low with fewer than 5 aphids/m2 recorded. As expected, the subsequent aphid-transmitted virus infection (BYDV) of plants was also low with less than one percent of tillers having disease symptoms. Nevertheless, as with earlier results, aphid infestation and virus infection were substantially lower for wheat grown on minimum-tilled plots when compared with conventionally-tilled plots. The aphid infestation of wheat heads in early July was again considerably lower (2.7-fold) for minimum-till wheat plots relative to wheat grown on conventional-till plots. The number of aphids on wheat heads were significantly fewer (adjusted p value = 0.006) for plots of each cultivation method to which chopped-straw was incorporated prior to sowing when compared with plots not receiving straw.

The slug density per ‘refuge trap’ in wheat plots in the period 26 October to 4 December 2006 comprised only 25% that for the preceding season. The dominant slug, Deroceras reticulatum, did not significantly differ in abundance between minimum- and conventional-till plots. Wheat plots of each method of cultivation in which straw was incorporated prior to sowing had significantly ($p = 0.041$) fewer Deroceras reticulatum when compared with plots that did not receive straw. Arion hortensis, the second most plentiful slug, did not differ significantly in abundance either between method of cultivation or straw and ‘no-straw’ plots. Slug occurrence as measured by means of ‘slug mats’ were broadly similar to that recorded using ‘refuge traps’. Slug damage to wheat leaves was low (< 5%) and while more damage was recorded for minimum-till plots than for conventional-till plots, differences were not significant. The examination of wheat seed for evidence of slug feeding on either germ or endosperm and the examination of seedlings for beneath the soil surface damage revealed an absence of damage.

Earthworm numbers and biomass were greater in minimum-till relative to conventional-till wheat plots by factors of 2.2 and 4.7, respectively. Worm abundance was significantly greater in minimum-till plots when compared with those conventionally-tilled. Additionally, plots of each method of cultivation in which straw was incorporated had significantly more worms than plots not receiving straw. As expected, worm biomass was broadly similar to worm abundance, however, while the difference between method of cultivation was significant that for straw and no-straw was not significant. Allolobophora chlorotica was the most common worm comprising 23% of species. Lumbricus terrestris represented only 5.2% of worms of which most (90%) were found in minimum-till plots. Immature worms of the genus Lumbricus were predominantly (93%) found in minimum-till plots.

The numbers of ground beetles (Family: Carabidae) were rather similar in plots of each method of cultivation but with greater numbers occurring in straw treated plots. The larger species, most notably Pterostichus melanarius, were more numerous in minimum-till plots relative to those tilled conventionally; the converse was true of smaller species such as Bembidion.

Soil invertebrate studies at Knockbeg

Sampling of minimum- and conventional-till wheat plots on 22 November 2006 revealed an absence of aphids. The subsequent recording of plants, in June 2007, showed less than 1.5% of tillers had symptoms of aphid transmitted virus (BYDV). The aphid infestation of wheat heads during summer 2007 was also low with a maximum of 0.3 aphids/head recorded at plant growth stage 79-80. Consequently, no effect of either method of cultivation or pre-sowing incorporation of straw on aphid infestation and virus incidence was recorded.

The number of slugs captured in the period 26 October to 5 December 2006 comprised fewer than one third that for the same period in 2005. Slug numbers were significantly greater for minimum-till plots ($p = 0.009$) when compared with those for conventional-till plots. In contrast with 2005, Arion hortensis was the dominant slug comprising 67%, Deroceras reticulatum 29% and most of the remainder were Milax species. The percent plants having slug damaged leaves was 6.6% for conventional-till plots and 13.1% for minimum-till plots. However, the latter differences were not significant. The incorporation of straw into plots of either method of cultivation did not affect slug abundance or the extent of slug damage by these pests. Feeding by slugs on wheat seed was extremely low (0.125%) and no severing of seedlings either at or beneath the soil surface by slugs was found.

Earthworm density and biomass did not differ between conventional- and minimum-till plots. In the case of minimum-till plots, the incorporation of straw resulted in a substantial though non significant increase in worm population and biomass. The species composition was rather similar to that for the preceding season and comprised Allolobophora chlorotica 28.4%, Aporrectodea caliginosa 2.8%, A. rosea 3.7%, Lumbricus castaneus 5.5%, L. terrestris 0.4%, L. rubellus 0.2%, L. festivus 0.2% and Satchellius mammalis 0.2%. The remainder comprised mostly immatures of which 56% were epilobic species and 2.3% tanylobic species.

Evaluation of the agronomic potential of oilseed rape in Ireland

Hackett, R. **RMIS No.5542**

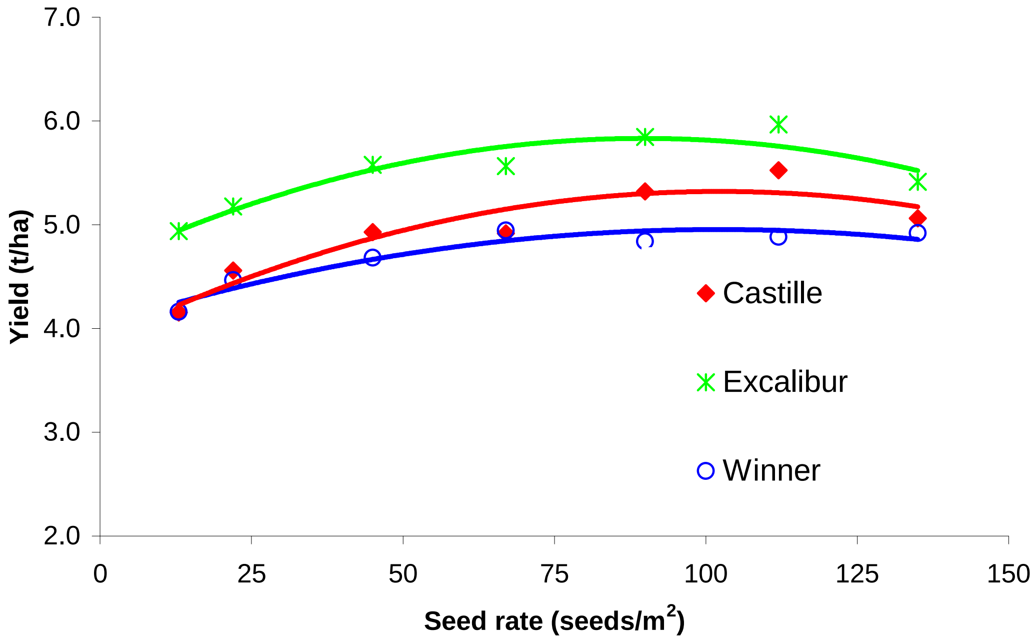

Fig. 1. Effect of seed rate and cultivar on yield of oilseed rape at Oak Park in 2007.

The effect of seeding rate on yield and quality of oilseed rape was studied in 2006/07 at a site at Oak Park research centre. A two-factor factorial design was used with cultivar and seed rate as factors. Three cultivars were included in the experiment; Winner, a conventional cultivar, Excalibur, a hybrid cultivar, and Castille, a low biomass conventional cultivar. Each cultivar was sown at seven seed rates; 13, 22, 45, 67, 90, 112 and 135 seeds/m^2.

There was a significant effect of both cultivar and seed rate (Fig 1). Yield of Excalibur, a hybrid cultivar, was significantly higher than either Winner, a conventional cultivar or Castille, a conventional low biomass cultivar, averaged over seed rates. Castille was significantly higher yielding than Winner. A significant interaction between cultivar and seed rate indicated that that the effect of seed rate was not consistent across cultivars. This significant interaction was largely due to a lower yield response by Winner to increasing seed rate than either of the other two cultivars which exhibited a similar response to increasing seed rate. In general the response to seed rates above approximately 75 seeds/m^2 was small.

Cultivar differences in terms of oil content, while statistically significant, were small (<1 %). There was a linear decrease in oil content as seed rate increased but the difference between the lowest and highest seed rate was small (0.45%). Due to the relatively small effects of cultivar and seed rate on oil content oil yield, the product of seed yield and oil content, exhibited similar trends to seed yield (Fig 2).

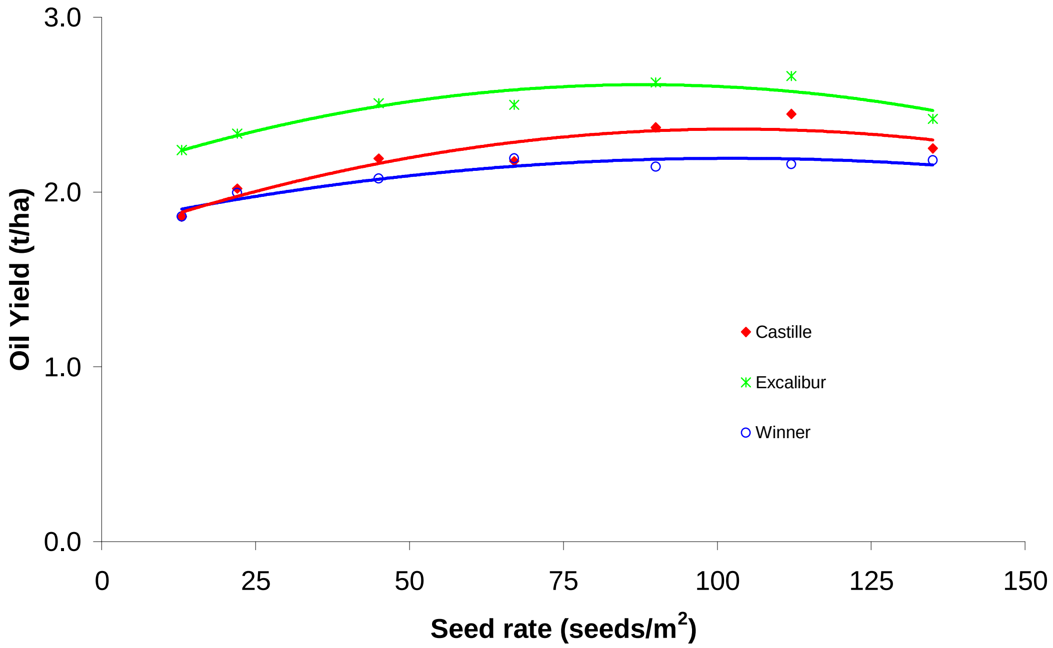

Fig. 2. Effect of seed rate and cultivar on oil yield of oilseed rape at Oak Park in 2007

A comparison of 30 cultivars of winter oilseed rape was carried out in 2006/07 at Oak Park (Table 1). Both conventional open pollinated and restored hybrid cultivars were included. A high oleic-low linolenic cultivar, V141OL, was also included.

The lowest yielding cultivar was Lorenz which had high levels of light leaf spot during the season. The three highest yielding cultivars were the hybrid cultivars Excalibur and DK Secure and the conventional cultivar Catana. The majority of cultivars yielded between 5 and 6 t/ha. The mean of the hybrid cultivars (5.7 t/ha) was significantly greater than the mean of the conventional cultivars (5.4 t/ha).

There were significant differences in oil content of the cultivars. Catana had the highest oil content while ES Astrid had the lowest oil content. The mean oil content of the conventional cultivars was significantly higher than that of the hybrid cultivars. Differences in relative oil yield, the product of seed yield and oil content, generally closely reflected differences in yield.

Table 1: Agronomic characteristics of oilseed rape cultivars evaluated at Oak Park in 2007

Variety	Cultivar type	Yield (t/ha @ 91% DM)	Oil content (% @ 91% DM)	Relative[a] yield	Relative[a] oil yield	Height (cm)
Adriana	Conv.	5.6	45.7	103	105	136
Agapan	Conv.	6.0	44.7	110	110	131
Astrale	Conv.	5.3	44.2	97	96	144
Barrel	Conv.	5.4	45.4	98	99	149
Canberra	Conv.	5.1	44.9	93	93	134
Castille	Conv.	5.4	44.3	99	98	123
Catana	Conv.	6.1	45.9	111	114	142
Celebration	Conv.	5.3	45.1	97	97	133
DK Secure	Hybrid	6.1	44.1	111	110	136
Epure	Conv.	5.8	45.3	106	107	142
ES Antonio	Conv.	5.4	44.8	99	99	139
ES Astrid	Conv.	5.5	43.7	100	97	132
ES Betty	Hybrid	5.2	44.2	95	94	148
Excalibur	Hybrid	6.3	45.3	115	116	149
Grizzly	Conv.	5.1	45.0	94	94	124
Hycolor	Hybrid	5.8	44.5	106	106	141
Kalif	Conv.	5.3	44.6	97	96	130
Komando	Conv.	5.2	45.3	94	95	114
Lioness	Conv.	5.7	45.3	104	105	136
Lorenz	Conv.	4.4	45.2	80	81	140
Monarch	Conv.	5.4	44.3	98	97	130
NK Bravour	Conv.	5.9	45.3	107	108	138
NK Grace	Conv.	5.2	44.9	94	94	130
NK Karibik	Hybrid	5.5	44.4	100	99	147
NK Victory	Conv.	5.3	44.6	96	96	144
PR45D01	Hybrid	5.5	44.2	101	100	99
Taurus	Hybrid	5.5	45.0	100	100	144
Tuscan	Hybrid	5.7	45.5	104	106	142
V141OL	Conv.	5.0	45.4	91	92	147
Winner	Conv.	5.5	44.5	100	99	135
LSD (5%)		**0.50**	0.46	-	-	**14.5**

[a] yield or oil content of the variety relative to the average of 30 varieties included in the trial

Investigations into aspects of the agronomy of triticale under Irish conditions

Hackett, R. ***RMIS No. 5376***

Table 1: Grain yield and quality of triticale cultivars at Oak Park in 2007

Cultivar	Grain yield (t/ha @ 85% DM	Hectolitre weight (kg/hl)	Screenings (%)	1000 grain weight (g)	Lodging score
Amarillo	9.60	65.2	0.6	52.4	6.1
Benetto	10.28	62.2	0.8	48.6	8.1
Bienvenu	8.20	60.2	0.8	50.2	7.5
Ego	8.77	66.0	0.9	50.6	6.2
Fidelio	8.97	61.2	0.5	47.9	7.5
Fleurus	9.95	63.8	1.1	43.2	8.3
Grandval	10.88	66.5	0.9	48.6	8.3
Grenado	9.87	64.0	1.3	43.4	9.0
Heti 505	8.98	63.6	0.6	49.3	9.0
Lamberto	8.22	59.7	0.5	49.1	5.2
Puerto	8.17	56.4	1.5	45.5	8.7
SW Fargo	9.10	61.9	0.6	49.6	8.1
SW Valentino	10.48	65.1	1.4	48.0	8.8
Tricolor	8.05	60.8	0.8	48.0	7.6
Triskell	8.77	64.8	0.8	52.4	6.2
Versus	9.17	58.7	0.7	48.7	7.7
Wilifred	8.13	60.2	0.8	47.3	9.0
LSD (5%)	0.64	1.31	0.28	2.95	1.2

Seventeen cultivars of autumn sown triticale were compared in terms of grain yield, grain quality and agronomic characteristics in 2007. Results are presented in Table 1.

Yields ranged between 8.1 t/ha and 10.9 t/ha. The highest yielding cultivar was Grandval, which was significantly higher yielding than all other cultivars except Bennetto and SW Valentino. Wilifred and Bienvenue were amongst the lowest yielding cultivars. However these are early maturing alternative type varieties that are more suited to late winter or early spring sowing and their yield may have been compromised by the October sowing date used.

Hectolitre weight was less than 70 kg/hl for all cultivars. Grandval also had the highest hectolitre weight of the cultivars compared.

Lodging was assessed towards the end of grain fill on a 1-9 scale with higher values indicating lower susceptibility to lodging. A number of the higher yielding cultivars (e.g. Grandval, Bennetto and SW Valentino) had good resistance to lodging. The cultivars Amarillo, Ego, Lamberto and Triskell exhibited significant levels of lodging.

Many of the cultivars exhibited visible sprouting prior to harvest. Subsequent determination of Hagberg Falling Number indicated high alpha amylase activity in all cultivars with no difference between cultivars (data not presented). This indicates that susceptibility to pre harvest sprouting is a problem with all the cultivars tested under Irish conditions.

Comparison of the response to fertiliser N of wheat and triticale

The response to fertiliser N of winter wheat (cv. Savannah) and winter triticale (cv. Fidelio) was determined using five fertiliser N levels (0, 100, 150, 200 and 250 kg N/ha) at Oak Park in 2007. The experimental design was 2-factor factorial design with variety and N rate as factors. There were 5 replications. Results are presented in Table 2.

Grain yield of Fidelio was significantly higher than Savannah but the difference was small (0.1 t/ha). Yield of both cultivars increased in response to incremental additions of fertiliser N but there was no significant interaction between cultivar and N rate indicating that the response to fertiliser N was similar for the wheat and the triticale. This suggests that the fertiliser N requirement of triticale, in terms of optimising yield, is similar to that of wheat. However, it must be borne in mind that triticale is more susceptible to lodging than wheat and therefore the amount of fertiliser N recommended for triticale is generally 20-30% less than that recommended for wheat in any given situation.

The hectolitre weight of Fidelio was significantly lower than that of Savannah. There was a significant effect of N rate on hectolitre weight but a significant cultivar x N rate interaction indicated that the effect of N rate on hectolitre weight varied depending on cultivar. For Savannah increasing N rate had a relatively small effect on hectolitre weight whereas for Fidelio increasing N rate gave a reduction in hectolitre weight.

N application had a relatively small effect on 1000 grain weight with Savannah whereas for Fidelio there was significant increase in 1000 grain weight where N was applied compared to where no N was applied. Screenings were low for all treatments. There was no significant effect of cultivar or N level on either 1000 grain weight or screenings.

Table 2: Effect of fertiliser N level on grain yield and grain quality of winter wheat (cv. Savannah) and winter triticale (cv. Fidelio)

Variety	N rate (kg N/ha)	Grain yield (t/ha)	Hectolitre weight (kg/hl)	1000 grain weight (g)	Screenings (%)
	0	3.3	68.3	53.2	0.3
	100	7.8	68.3	54.7	0.3
Savannah	150	8.4	70.7	54.6	0.3
	200	9.5	69.6	53.1	0.2
	250	9.5	69.7	52.9	0.3
mean		*7.7*	*69.3*	*53.7*	*0.3*
	0	3.6	65.1	50.9	0.6
	100	7.7	62.0	56.4	0.5
Fidelio	150	8.6	64.2	56.3	0.6
	200	9.6	62.9	53.6	0.6
	250	9.6	61.0	53.0	0.7
mean		*7.8*	*63.0*	*54.0*	*0.6*
5% LSD					
Variety (V)		0.09	2.17	ns	1.09
N rate (N)		0.44	1.64	1.40	ns
V x N		ns	1.90	1.98	ns

ns = non-significant

A comparison of the effect of cultivation system and winter cover on spring barley grain yield and nitrate concentrations in the soil solution over the winter period

Hackett, R. *RMIS No. 5179*

Studies on the effect of winter cover on grain yield of spring barley in a plough-based cultivation system and a reduced tillage system were continued at Oak Park in 2007. Three winter covers were compared, no vegetative cover, a mustard cover crop and natural regeneration consisting of volunteer barley and weeds. A factorial treatment structure was used with two tillage treatments and three over winter cover treatments arranged in a randomised complete block design with four replications. Plot size was 30m x 12m. Reduced tillage treatments were cultivated on August 31, 2006. Mustard was sown in both the reduced tillage and plough based systems on September 11. Natural regeneration treatments in the plough based system received no soil disturbance after harvest. Any vegetation on the no vegetative cover treatments was treated with glyphostae on September 25. The natural regeneration and mustard cover crop were sprayed with glyphosate February 14 and chopped in late March. Plough treatments were ploughed in early April before sowing. Reduced cultivation treatments were cultivated in autumn 2006 after harvest of the previous cereal and the only cultivation in spring 2007 was with discs of a Vaderstad drill during the sowing operation. All crops received standard pesticide and fertiliser N inputs with the exception of small areas (2m x 2m) within each plot which received no fertiliser N. These areas were used to determine the effects of the various treatments on growth and N uptake of spring barley in the absence of fertiliser N.

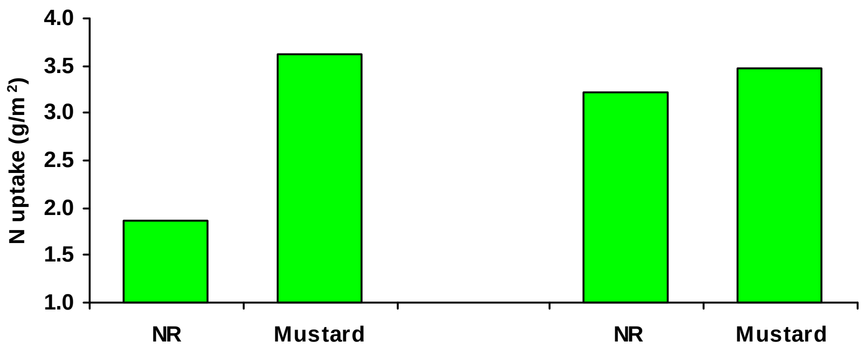

Fig.1. Nitrogen accumulation of natural regeneration and mustard winter covers in January 2007 at Oak Park.

Nitrogen accumulation by mustard in January 2007 was significantly higher than that of natural regeneration (Figure 1). However the interaction between tillage method and winter cover approached significance (p=0.07) reflecting a greater difference between mustard and natural regeneration in the plough based system than in the reduced cultivation system.

Table 1: Effect of cultivation method winter cover type on yield and quality of spring barley (cv. Wicket) at Oak Park in 2007

Cultivation method	Winter cover	Yield (t/ha)	Hectolitre weight (kg/hl)	1000 grain wgt (g)[a]	Protein content (%)[a]	Screenings (%)
Plough based	Natural regeneration	5.1	66.1	46.6	8.9	1.6
	Mustard	5.3	65.8	47.3	9.2	1.5
	No cover	5.3	65.8	47.8	8.8	1.4
Reduced cultivation	Natural regeneration	5.3	66.9	47.3	9.2	1.3
	Mustard	5.8	65.4	48.1	9.1	1.4
	No cover	5.5	65.4	47.1	8.8	1.5
Cultivation method (A)		0.21*	ns	ns	ns	ns
Winter cover (B)		ns	0.74*	ns	0.02	ns
A x B		ns	ns	ns	0.01	ns

[a] Data were log transformed for the purposes of analysis and back-transformed data are presented
* 5% LSD ns = non significant

There was no significant effect of winter cover on grain yield (Table 1). Grain yield was significantly increased by reduced cultivation but the difference between the two cultivation systems was small (0.3 t/ha). There was a significant effect of winter cover on hectolitre weight; the natural regeneration treatment had a significantly greater hectolitre weight than either the mustard or no cover treatments averaged over cultivation treatments but the difference was small (~ 1.2 kg/hl). There were no significant effects of either cultivation method or winter cover on screenings or 1000 grain weight. There was a significant effect of winter cover on grain protein content. The no cover treatment gave significantly lower protein content than either mustard or natural regeneration treatments. Grain protein did not differ significantly between the mustard and natural regeneration treatments. A significant interaction between tillage method and winter cover revealed that the grain protein content of the no cover treatment was only significantly lower than the natural regeneration treatment under reduced cultivation.

Table 2: Effect of cultivation method and winter cover type on harvest index and N accumulation parameters of spring barley (cv. Wicket) at Oak Park in 2007

Cultivation method	Winter cover	Harvest index	Crop N uptake ($g N/m^2$)	Straw N uptake ($g N/m^2$)	Grain N uptake ($g N/m^2$)	Nitrogen harvest index
Plough based	Natural regeneration	0.50	12.41	3.35	9.06	0.73
	Mustard	0.50	13.38	3.82	9.57	0.72
	No cover	0.51	12.68	3.29	9.39	0.74
Reduced cultivation	Natural regeneration	0.53	14.45	3.58	10.88	0.75
	Mustard	0.52	13.90	3.34	10.57	0.76
	No cover	0.51	13.82	3.62	10.21	0.74
Cultivation method (A)		0.019*	ns	ns	0.873*	ns
Winter cover (B)		ns	ns	ns	ns	ns
A x B		ns	ns	0.433*	ns	ns

* 5% LSD ns = non significant

Harvest index was significantly greater where reduced cultivation was used compared to where the plough based system was used (Table 2). The effect of cultivation method on nitrogen harvest index approached significance (p= 0.06) reflecting a higher NHI where reduced cultivation was used. There was no significant effect of winter cover on harvest index or nitrogen harvest index. Total crop N uptake was unaffected by tillage method or winter cover. A significant interaction between tillage method and winter cover on straw N uptake reflected a significantly higher straw N uptake when mustard was the winter cover compared to either bare soil or natural regeneration in the plough based system but not in the reduced cultivation system where there was no significant difference between winter covers. Grain N uptake was unaffected by winter cover but was significantly increased where reduced cultivation was used compared to where the plough based system was used.

Table 3: Effect of cultivation method and winter cover type on grain yield and components of grain yield of spring barley (cv. Wicket) in the absence of fertiliser N at Oak Park in 2007

Cultivation method	Winter cover	Ears/m^2	Grains/ear	1000 grain wgt (g)	Grain yield (g DM/m^2)
Plough based	Natural regeneration	394.55 (9.88x10^{-6})	9.11	45.74	139.50 (9.88)
	Mustard	490.68 (6.49x10^{-6})	10.51	46.68	207.30 (11.35)
	No cover	400.22 (9.61x10^{-6})	8.60	46.62	135.94 (9.79)
Reduced cultivation	Natural regeneration	430.07 (8.37x10^{-6})	9.46	48.20	169.32 (10.58)
	Mustard	501.57 (6.22x10^{-6})	10.48	48.87	220.42 (11.59)
	No cover	395.53 (9.83x10^{-6})	10.71	49.39	177.94 (10.76)
Cultivation method (A)		ns	ns	ns	ns
Winter cover (B)		1.824*	ns	ns	0.902*
A x B		ns	ns	ns	ns

[a] Data for ear density and grain yield were transformed for the purposes of analysis. Back-transformed data are presented with transformed data in parenthesis. LSD figures refer to transformed data.
* 5% LSD ns = non significant

In the absence of fertiliser N barley grain yield (hand harvested) was significantly increased where mustard was the winter cover when compared to natural regeneration or bare soil (Table 3). There was no effect of tillage on grain yield or no interaction between winter cover and tillage method. There was no significant effect of tillage method or winter cover on grains per ear or 1000 grain weight. Ear density was significantly increased by the mustard winter cover when compared to natural regeneration or bare soil.

Harvest index was significantly increased by reduced cultivation when compared to the plough based system in the absence of fertiliser N (Table 4). There was no significant effect of winter cover type on harvest index. Total crop N uptake, straw N uptake and grain N uptake were all significantly greater where the winter cover was mustard when compared to where the winter cover was either bare soil or natural regeneration. There was no significant difference between bare soil and natural regeneration in terms of total crop N uptake, straw N uptake or grain N uptake. Nitrogen harvest index was significantly increased by reduced cultivation when compared to the plough based system. Winter cover type had no significant effect on the nitrogen harvest index.

Table 4: Effect of cultivation method and winter cover type on harvest index and N uptake of spring barley (cv. Wicket) in the absence of fertiliser N at Oak Park in 2007

Cultivation method	Winter cover	Harvest index	Crop N uptake ($g N/m^2$)	Straw N uptake ($g N/m^2$)	Grain N uptake ($g N/m^2$)	Nitrogen harvest index
Plough based	Natural regeneration	0.41	2.95	1.07 (0.94)	1.85	0.61
	Mustard	0.43	4.22	1.48 (0.67)	2.71	0.63
	No cover	0.42	2.74	1.02 (0.98)	1.70	0.62
Reduced cultivation	Natural regeneration	0.46	3.20	1.02 (0.98)	2.14	0.67
	Mustard	0.47	4.14	1.24 (0.80)	2.89	0.70
	No cover	0.46	3.38	1.08 (0.92)	2.29	0.67
Cultivation method (A)		0.032*	ns	ns	ns	0.046*
Winter cover (B)		ns	0.670*	0.146*	0.620*	ns
A x B		ns	ns	ns	ns	ns

[a] Data for straw N uptake were transformed for the purposes of analysis. Back-transformed data are presented with transformed data in parenthesis. LSD figures refer to transformed data.
* 5% LSD ns = non significant

Organic rotation investigation

Kennedy T. and Mahon A. ***RMIS No. 5248***

The first cycle of an organic stockless 7-year rotation (winter wheat, potatoes, oats, legume, spring barley followed by 2-year grass/clover) was completed in 2007. Varieties of wheat and triticale were sown on 3 and 7 November 2006, respectively. Satisfactory establishment of wheat and triticale was obtained. Oat varieties were sown on 7 and 13 November. Establishment of oats was poor due to less than ideal soil conditions at sowing and the feeding on seed by crows. Consequently, some oat varieties were re-sown in spring 2007. Spring barley varieties were sown 4 April. Three potato varieties were planted 10 April. Copper sulphate (5 kg ha^{-1}) was applied to potatoes by spraying on 10 and 24 July and 1 August for the control of late-blight following 'blight outbreak warnings' by Met Éireann. Six varieties of lupins were sown 19 April of which five were of the branching type and one non-branching.

Grain and straw yields for winter wheat and spring oats are presented in Table 1. The best yielding wheat varieties were Timber, Claire and Lion producing 7.7, 7.5 and 7.0 t/ha, respectively. The wheat varieties having lowest yields were Alceste and Cordiale with respective yields of 3.5 and 3.4 t/ha. The highest yielding spring oat variety was Nord-05-123 producing 5.1 t/ha while the remaining four varieties investigated had rather similar yields in the range 4.4 to 4.7 t/ha. Twelve varieties of winter triticale were evaluated by the Department of Agriculture and Food at Oak Park in 2007. The mean yield for these varieties was 4.12 t/ha. The better yielding triticale varieties were Versus, Tremplin and Bienvenu. However, yields of the latter varieties were not significantly greater than the mean yield of the control varieties Bienvenu and Fidelio. One variety of triticale, Benetto, yielded significantly lower that the control varieties. Fifteen spring barley varieties were evaluated by the Department of Agriculture and Food for which the mean yield was 5.15 t/ha. Best yielding varieties, though not significantly greater than control varieties, were Cocktail, Sweeney, Publican and Frontier. The barley varieties with lowest yield were Spotlight, Centurion and Doyen.

Lupin plots had extensive weed infestations which delayed harvest date and was considered to have negatively impacted on yield. The mean yield for the five branching varieties was 2.1 t/ha (range 0.8 – 2.9 t/ha). The non-branching variety, Viol, yielded only 1.0 t/ha.

Weed control in potatoes, in the period between crop emergence and fifty percent leaf canopy, was achieved by means of cultivator following which drills were ‘moulded up’. Subsequently, weeds were not a major problem. Potatoes were harvested in the period 21 to 23 August. Data on tuber yield, amount of diseased tubers and dry matter content are given in Table 2. The variety Sante gave the best yield, 37.0 t/ha, and also provided the best yield in the commercially valuable 45-60 mm ‘ware’ fraction.

Table 1: Grain and straw yield, and quality parameters of wheat and oats, grown in 2007

Crop Cultivar	Grain Yield t ha $^{-1}$	hl wt	Screenings %	Straw Yield t ha $^{-1}$	Straw DM%
		Winter wheat			
Alchemy	6.7.	70.7	0.6	9.4	90.7
Claire	7.5	68.5	0.9	8.3	90.6
Timber	7.7	70.2	0.8	8.2	90.7
Lion	7.0	69.9	0.8	9.1	90.7
Solstice	6.2	68.1	0.9	6.7	90.4
Savannah	6.5	67.9	1.1	8.4	90.6
Glasgow	6.5	68.7	0.9	8.6	90.6
Robigus	5.0	68.8	0.8	7.6	91.1
Cordiale	3.4	71.5	1.1	5.6	90.7
Alceste	3.5	68.8	0.6	7.1	90.6
Cordiale + Alceste	4.9	69.5	0.7	6.9	90.8
Einstein	6.1	69.6	0.7	8.4	90.8
Gulliver	4.9	69.0	0.8	6.0	90.5
Hyperion	6.0	69.5	0.8	6.9	90.6
		Spring Oats			
Corrib	4.5	49.4	7.9	4.1	90.5
Evita	4.4	48.5	4.7	5.5	90.8
Freddy	4.5	50.4	4.1	4.5	90.4
Husky	4.7	49.7	3.9	4.9	90.9
Nord 05 - 123	5.1	50.5	3.4	4.0	90.6

Table 2: Potato yields, t ha^{-1}, for various grades of tuber size, diseased tubers, total yield and percent dry matter 2007

Cultivar	< 40 mm	40-45 mm	45-60 mm	60-80 mm	> 80 mm	Diseased*	t ha^{-1}	% Dry matter
Orla	0.6	5.5	21.1	0.8	0	1.6	29.6	18.6
Sante	0.7	5.8	27.2	2.1	0.1	1.1	37.0	20.8
Setanta	0.6	4.9	19.7	0.4	0	0.7	26.3	23.5

*Tuber blight and other diseases

Vegetation was cut and removed from the grass/clover plots on two occasions, 9 July and 4 October 2007. The grass/clover from each cutting was layered with barley straw from the preceding barley plots before being placed in a composting pit and covered with polythene. Five round-bales were layered on 9 July and 4 bales on 4 October. This compost will be applied to spring barley and potato plots, at 25 and 37 t/ha, respectively, in the 2008 season. Plots not having a crop over the winter period were sown with either black medic (*Medicago lupulina*) or mustard as cover crops for the purpose of preventing nitrate leaching.

An evaluation of the effects of applying 'biosolids' to arable land

Kennedy T., Artuso N., and Connery J. ***RMIS No. 5617***

Treated sewage sludge conforming to specific standards is termed 'biosolids'. Currently, the only means of disposing of this material is by applying to arable land. Application to land must comply with European and Irish law (ED 86/278/EEC; SI 183/1991; SI 267/2001) which sets standards to protect the environment/soil and food quality. In 2007, field and laboratory investigations commenced to determine if biosolids were detrimental to sensitive indicator invertebrate species including Collembola, Annelida and Coleoptera. Field trials investigated the biosolids "biofert" ≈ 95% DM and "Biocake" ≈ 26% DM while laboratory studies examined "biofert" obtained from the five Irish plants producing this material. Biofert rate-equivalents, used in the laboratory, ranged from 2 to 20 t ha-1. Preliminary results indicate no significant positive or negative effect of this material on either Collembola (springtails) or Annelida (earthworms) when applied to arable fields. Laboratory trials showed bioferts from two plants did not affect either worm mortality or well-being (weight gain). When applied at approximately 10-fold (20 t ha-1) the normal rate bioferts from three plants affected worm mortality.

Assessing populations of the major cereal pathogens for resistance or reduced sensitivity to fungicides

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Strobilurin resistance in Mycosphaerella graminicola

Studies on the resistance of *Mycosphaerella graminicola* populations in winter wheat crops to strobilurin (QoI) fungicides were continued in 2007. Leaf samples infected with *M. graminicola* were collected from 15 crops selected at random in the main winter wheat-growing regions of the country in March. In order to assess strobilurin resistance in samples a quantitative PCR assay using TaqMan minor groove binding DNA probes was used. Using this assay, the amount of *M. graminicola* DNA with the A143 mutation conferring strobilurin resistance and the amount of strobilurin sensitive DNA in the samples was quantified. High levels of strobilurin resistance were again detected in populations of *M. graminicola* in wheat crops. Resistance occurred in all crops with a mean of 94% for the 15 crops sampled. Following the emergence of resistance to strobilurins in 2002 resistant strains spread rapidly throughout pathogen populations. The use of strobilurin fungicides in wheat crops has decreased dramatically, thus reducing the selective pressure for resistance. The present results indicate that strobilurin resistance in *M. graminicola* is genetically stable, does not carry a fitness penalty and will continue to remain high, even when the selection pressure is reduced.

Sensitivity of M. graminicola to triazole fungicides

Populations of *M. graminicola* in 15 winter wheat crops were tested for sensitivity to four triazole fungicides, epoxiconazole (Opus), prothioconazole (Proline), tebuconazole (Folicur) and metconazole (Caramba). As in previous years samples of infected leaves were collected in March, to determine the levels of sensitivity at the beginning of the season, and again in July following completion of the fungicide control programmes. Isolates of *M. graminicola* were obtained from randomly-selected leaves and grown on potato dextrose agar (PDA) under NUV light for four days to induce production of conidia. Conidial suspensions of each isolate were added to potato dextrose broth (PDB) in microtitre plate wells in increasing concentrations (0, 0.04, 0.37, 0.12, 1.1, 3.3, 10 and 30 µg ml^{-1}) of technical grades of the appropriate fungicides. Growth was assessed as a measure of optical density at 405 nm using a Tecan Saffire II plate reader following 10 days incubation at 18^{0}C. EC50 values (concentrations at which growth was inhibited by 50% relative to untreated controls) for each fungicide were determined for all isolates.

All *M. graminicola* populations were sensitive to epoxiconazole, the majority of isolates having EC50 values not greater than 0.37 µg ml^{-1} in both March and July (Table 1). These levels of sensitivity are similar to those detected in populations of *M. graminicola* in previous years, including 2003 when testing for sensitivity to this fungicide began at Oak Park. This shows that there has been no shift in the sensitivity of populations of this pathogen to epoxiconazole in recent years despite the more intensive use of triazole fungicides that followed the development of resistance to the strobilurins in 2003.

M. graminicola populations had the same levels of sensitivity to prothioconazole as to epoxiconazole, with the majority of isolates having a similar range of EC50 values (Table 1). These levels of sensitivity are similar to those detected when populations of *M. graminicola* were first tested for sensitivity to prothioconazole in 2004. Epoxiconazole and prothioconazole are the fungicides most commonly used for disease control in wheat and most crops would have received products containing either or both of these as components of the various spray programmes. However, as in previous years, the majority isolates from samples collected in July fell into the same EC50 range as those sampled in March. There were slight shifts towards the insensitive end of the range for both products in July but these were unlikely to affect the efficacy of either fungicide.

Table 1: Sensitivity of *M. graminicola* isolates to epoxiconazole, prothioconazole and tebuconazole 2007 (% of isolates in each EC50 category)

	EC50 (µg ml^{-1})					
	<0.04	0.05-0.12	0.13-0.37	0.38-1.1	1.2-3.3	3.4-10.0
			Epoxiconazole			
March	1.9	56.8	35.8	5.6	0	0
July	0.5	43.5	48.3	7.6	0	0
			Prothioconazole			
March	3.2	54.8	37.4	4.5	0	0
July	1.0	33.0	50.7	14.7	0.5	0
			Tebuconazole			
March	11.7	51.2	8.0	7.4	16.0	5.5
July	6.7	38.0	11.1	9.6	25.5	9.1

Populations of *M. graminicola* were more sensitive to tebuconazole than to either epoxiconazole or prothioconazole when they were first tested for sensitivity to this fungicide at Oak Park in 2004. However, a shift in sensitivity to tebuconazole occurred from 2004 to 2005 when some isolates were less sensitive than any detected in 2004. *M. graminicola* populations tested in 2007 had similar levels of sensitivity to those sampled in 2005 and 2006 with EC50 values ranging from 0.04 – 10 µg ml^{-1} tebuconazole. There has been no shift towards greater insensitivity since 2005 i. e. isolates have not been found with EC50 values greater than 10 µg ml^{-1}. There was also a shift in sensitivity towards metconazole between 2004 and 2005 but no further increases in insensitivity since then. *M. graminicola* isolates that were less sensitive to tebuconazole were also less sensitive to metconazole indicating cross-sensitivity between both of these triazoles. There was little change in the proportions of *M. graminicola* strains with reduced sensitivity to tebuconazole between March and July in crops where this fungicide was not used as a component of spray programmes. However, in crops where tebuconazole (Folicur) was used selection for insensitivity occurred and the proportions of insensitive isolates increased markedly between March and July. There was also selection for insensitivity to metconazole in crops where tebuconazole was used.

Mutations in the CYP51 gene of M. graminicola

A fragment of the gene encoding the target site of the triazoles (CYP51) in *M. graminicola* was sequenced to identify possible mutations or alterations that may be involved in reduced sensitivity to triazoles. A number of mutations (V136A, A379G, I381V, Y459C, Y459S, Y461S, Y461H and V490L) and a deletion (Δ459/460) were identified. Allele specific PCR and PCR-RFLP assays were designed to screen *M. graminicola* isolates for these mutations. The mutation V490L, which has not been previously reported, was found in a small section of isolates with the mutation Y461S. Reduced sensitivity to tebuconazole was associated with the mutation I381V. This mutation was found in 25% of over 400 isolates tested. Isolates with the mutation Y461S continued to be the most dominant genotype among Irish populations. This may however change with continued selection by tebuconazole of isolates with I381V. No correlations were found between mating type and CYP51 genotype, with all mutations occurring in both mating types. An insert, approximately 800 bp in size was found in the promoter region of 5% of the isolates assessed. All isolates with this insert also had the mutation I381V.

Fungicide sensitivity in R. secalis

One hundred and five isolates of *R. secalis* collected from barley crops in 2007, were tested for sensitivity to fungicides. The fungicides epoxiconazole, prothioconazole, flusilazole, benomyl and azoxystrobin were selected as representing the major fungicide groups used to control foliar diseases of barley. *R. secalis* was isolated from infected fresh leaf material during the summer. Plugs of agar cultures were maintained in sterile distilled water, in bijou bottles, in a fridge, until required for testing. They were then cultured on Lima Bean Agar and incubated until sporulation occurred. Conidial suspensions from isolates were grown in microtitre plate wells in increasing concentrations (0, 0.04, 0.12, 0.37, 1.1, 3.3, 10 and 30 µg ml^{-1}) of the appropriate fungicides as described already for *M. graminicola*. Plates were read after 14 days incubation at 20^0C. Of the triazole fungicides, *R. secalis* populations were most sensitive to prothioconazole where all of the isolates tested had EC50 values not greater than 0.37 µg ml^{-1}. Populations were more sensitive to epoxiconazole than to flusilazole (Table 2) *R. secalis* populations were also sensitive to azoxystrobin where

Table 2: Sensitivity of *Rhynchosporium secalis* to fungicides (% of isolates in each EC50 category)

	EC50 (µg ml^{-1})				
	<0.04	0.04-0.12	0.13-0.37	0.38-1.1	1.2-3.3
Azoxystrobin	5.1	63.6	31.3	0	0
Prothioconazole	15.1	53.5	31.3	0	0
Epoxiconazole	0	2.0	50.5	43.4	4.0
Flusilazole	0	0	2.0	67.7	30.3

EC50 values for all isolates tested were less than 0.37 µg ml^{-1} of this fungicide. Populations of *R. secalis* in barley crops in Ireland have been showing similar sensitivity to triazole and strobilurin fungicides in different years in which they have been tested since 2003. Some 15% of isolates tested were resistant to MBC generating fungicides (benomyl). Sensitive isolates grew at concentrations up to 0.12 µg ml^{-1} of benomyl but resistant isolates grew at concentrations up to and including 30 µg ml^{-1} which is the highest concentration of this fungicide used in the microtitre tests.

Eyespot (Oculimacula yallundae and O. acuformis)

Populations of eyespot fungi obtained from15 winter wheat crops sampled in July 2006 were tested for sensitivity to fungicides. Infected wheat stems were allowed to dry in a glasshouse and stored until required. Eyespot fungi (*Oculimacula yallundae* or *O. acuformis*) were isolated from approximately ten infected stems from each crop, one isolate per stem. The species were separated based on morphological characteristics on potato dextrose agar (PDA). Testing of these isolates for sensitivity to some of the different classes of fungicides used to control eyespot: prothioconazole and prochloraz (azoles), cyprodinil (anilinopyrimidine), boscalid (anilide) and benomyl (MBC) was completed in 2007. Previously isolates of *Oculimacula* spp had been tested for sensitivity by growing them on PDA amended with different concentrations of fungicide and measuring mycelial growth after two weeks incubation. However, relatively high concentrations of either of the more recently-introduced fungicides prothioconazole or boscalid had little inhibitory effect on mycelial growth on PDA. The microtitre plate method was therefore used to test the sensitivity of isolates in 2007.

The isolates were grown on water agar under NUV light at 15^0C for two to three weeks to induce sporulation. Spore suspensions were grown in PDB in microtitre plate wells using the fungicide concentrations described above. Plates were read after 5 days incubation at 20^0C and EC50 values determined.

Table 3: Sensitivity of *Oculimacula* spp to fungicides (% of isolates in each EC50 category)

	EC50 (µg ml^{-1})				
	<0.04	0.04-0.12	0.13-0.37	0.38-1.1	1.2-3.3
Prothioconazole	14.2	25.4	35.1	23.1	2.2
Prochloraz	51.1	19.3	25.9	3.7	0
Cyprodinil	65.3	17.7	8.1	8.9	0
Boscalid	2.9	57.4	32.4	2.9	4.4

In the 1980s *O. acuformis* replaced the previously dominant *O. yallundae* as the most common species causing eyespot in cereals in Ireland and populations of both species became predominantly resistant to MBC fungicides. Studies of 147 isolates obtained from 15 winter wheat crops in 2006 showed that *O. acuformis* is still the dominant species comprising 74% of isolates, with *O. yallundae* accounting for 26%. Of the 147 isolates 92% were resistant to MBC. All isolates were either sensitive or completely resistant to MBC. Growth of sensitive isolates was completely inhibited at concentrations greater than 0.12 µg ml^{-1} while resistant isolates grew at concentrations up to and including 30 µg ml^{-1} of benomyl.

There was a wide range of sensitivity to prothioconazole and boscalid among isolates of Oculimacula spp under the conditions of these tests, though there were no isolates that would be considered resistant. EC50 values ranging from less than 0.04 to 3.3 µg ml-1 were recorded for both fungicides (Table 3). However, the proportions of isolates with EC50 values at the upper end of the scale were low for both fungicides. EC50 values for cyprodinil and prochloraz ranged from less than 0.04 µg ml-1 to 1.1 µg ml-1 of either fungicide. These results reflect the current sensitivity status of populations of Oculimacula spp in wheat crops in Ireland to these fungicides. They will be used as baseline against which the results of future sensitivity tests are measured. In this way any future shifts in sensitivity to fungicides in Oculimacula spp should be detected.

Eddy Covariance CO_2 fluxes in Miscanthus

Carroll F. Jones B M.., Burke J.I. ***RMIS No. 5675***

The net ecosystem exchange (NEE) of carbon over a mature *Miscanthus* stand was measured directly using an eddy covariance (EC) system. The EC system measures fluxes within a variable area called a flux footprint which can be defined by: wind speed and direction, vegetation aerodynamics and roughness, and equipment height. The footprint is site specific and constantly changing; the maximum fetch of the flux footprint in the *Miscanthus* plot is 200m under average wind direction and speed. The carbon fluxes are registered at twenty hertz and averaged over thirty-minute intervals. Daytime data are gap-filled using the Michaelis-Menten equation, based on light response curves during the growing season. When the crop senesces this technique is no longer appropriate and the mean diurnal variation technique (MDV) is employed. EC fluxes were downloaded and analysed on a weekly basis. Summing together the CO_2 fluxes demonstrates whether the *Miscanthus* crop was acting as a net sink or source of carbon. Average diurnals were calculated and a steady decrease in net ecosystem photosynthesis was found to occur from September through to November as the *Miscanthus* senesces and PAR levels decrease. From November until March net ecosystem respiration dominates as the above ground biomass is dead and leaf litter is decomposing; from March the *Miscanthus* crop begins to re establish and the net photosynthesis fluxes are resumed.

The sink-source nature of the *Miscanthus* stand was studied and the total carbon flux for each week of the growing season was calculated. The result illustrated in Fig. 1 demonstrates how the stand converted from a net carbon sink to a carbon source in October. This work will be continued in 2008 and will include life cycle analysis of miscanthus.

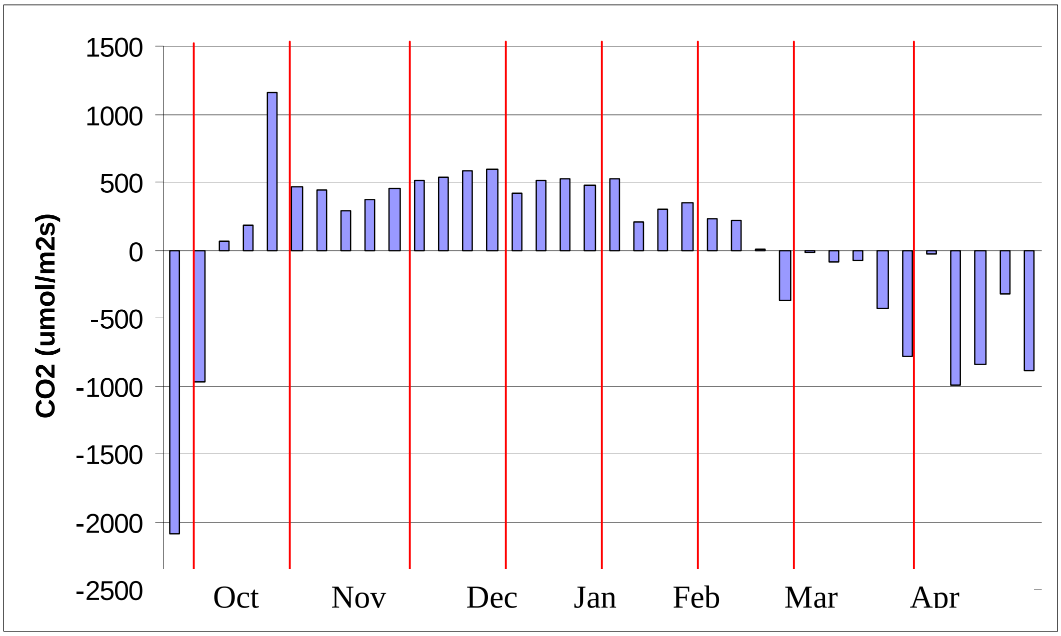

Fig. 1. Total weekly carbon fluxes ($\mu molm^{-2}s^{-1}$) from a *Miscanthus* stand located in Oak Park Crop Research Centre, Co. Carlow

Quantifying the environmental response of a tillage production system

Ryan D. ***RMIS No. 5693***

Introduction
This was the final year in a seven year programme with the object to determine the export of nitrogen (N) and phosphorus (P) from two tillage systems: (a) a tillage rotation including sugar beet and (b) continuous wheat and barley. Only P losses from (a) above were recorded in 2007.

Materials and method
Soil was tested on 19/2/07 for N, P and K. N and K were applied according to recommendations. Soil Test P for plot 3 was low as in previous years so fertilizer P was applied at a relatively high level (70 kg/ha) in an ongoing effort to establish P-index values of 2, 3 and 4 in plots 1, 2 and 3 respectively. Soil Test P was measured again in February of the following year but the data are not available yet. Spring Barley was sown in these plots on 24/3/07 and harvested in mid-August.

Overland flow measurements, flow proportional samples, and samples of macro-pore flow were collected throughout 2007 using the same methods as were used during the previous 2 years.

Results and discussion
The attempt to establish P-index values of 2, 3 and 4 on the three sites was only partly successful. Soil test P (STP) values in Table 1 indicate that plot 1 and 2 reached the target values. Plots 3 remained at P-index 3 instead of the target value P-index 4. The persistent failure to achieve P-index 4 was unexpected as high applications of P fertilizer were made to this plot over several years. A heavy infestation of weeds was associated with a low yield of grain in this plot (5.1 t/ha for plot 1 compared with 6.9 and 7.1 t/ha for plots 2 and 3 respectively) and high yield of straw and weeds (4.1 t/ha for plot 1 with 2.6 and 2.4 t/ha for plots 2 and 3 respectively).

Table 1: Losses of P and sediment in overland flow

Year	Plot	STP (mg/l) (P index)	Overland Flow (mm)	P conc. in water* (mg/l)	P Export (kg/ha)	Sediment loss (kg/ha)
2007	1	5.7 (2)	25	0.52	0.130	173
	2	7.8 (3)	10	0.82	0.082	65
	3	7.8 (3)	20	1.12	0.225	88

*Notes: * Average Concentration for sample dates 1/1/07 to 6/12/07*

Rainfall at Oak Park in 2007 was 843mm or 8% lower than the previous year. Conversely the quantity of overland flow in 2007 was 7% higher than the total flow in the previous year (Fig. 1). This increase may not be significant but the trend for the past three years has been for increasing overland flow over the period in line with expectation under climate change.

A greater percentage of flow occurred in summer 2007 than in previous years. The increase averaged 30% across the three plots and posed a greater threat than usual to water quality at a time when water levels in rivers are generally low.

The influence of STP on P concentration in water is evident in Table 1. While plot 3 did not have the highest STP at the beginning of the year it did receive more P fertilizer. This probably accounts for the greater P concentration in water from this plot and the greater export of the nutrient to the drainage system and to the River Barrow. Research on P loss from grassland at Johnstown Castle indicates a positive curvilinear relationship between STP and P concentration in overland flow. The relativity is maintained in P export values here but the effect of higher flows on plot 1 may also have increased P export for that plot. Sediment loss was low on all three plots.

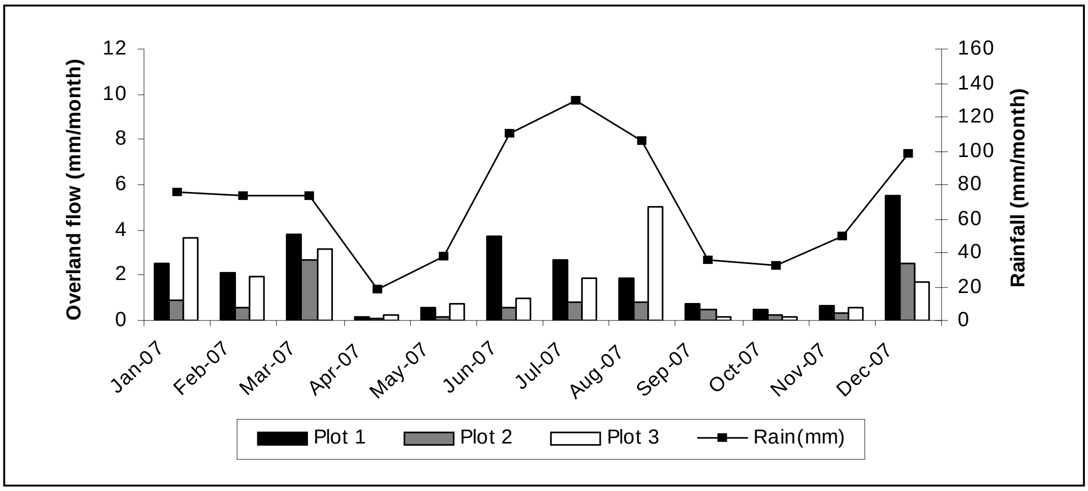

Fig.1. Overland flow and rainfall at the tillage site at the Big Bull Park, Oak Park, 2007

Phosphorus concentration in macro-pore samples in 2007 was 3.5, 4.4 and 7.9 mg/l. for plots 1, 2 and 3, respectively. This, as in previous years, was substantially higher than concentration of P in overland flow. Macro pore flow is overland flow that has passed through large pores in the soil. It may represent initial overland flow which tends to have higher concentration than overland flow occurring later in a storm. The number of samples collected in 2007 was less than that collected in each of the previous years. Summer 2007was wet and reduced numbers of macro pore samples probably reflects reduced cracking of the upper soil layers.

It is possible that aspects of overland flow or macro pore flow could be estimated from a more readily available parameter. Therefore overland flow was regressed against soil moisture deficit (SMD), a meteorological parameter calculated relatively easily. The best fit was obtained with combined data from three plots giving R2 values of approximately 0.46 for 2005 and 2006. In a separate analysis macro pore flow concentration was regressed on corresponding values for overland flow (R2; 0.85). Therefore SMD appears to be only a moderate predictor for overland flow and where overland flow concentration data exist for a site it is possible to get a good estimate of macro pore flow concentrations for the same site.

Development of Metabolomics Based Methods to Benefit Marker Assisted Breeding in Perennial Ryegrass

Byrne S. and Barth S. ***RMIS No. 5622***

Metabolomics is the study of small molecules that are the end products of gene expression. The project is using metabolomic tools to understand a plants response to various abiotic and biotic stress. Unlike animals, plants do not have the luxury of moving to more favorable environmental conditions when things get tough and depend on internal alterations to help them tolerate stressful conditions. Looking at the metabolome and transcriptome will help us understand what biochemical changes the plant is undergoing when subjected to stress. The target stresses include; drought stress, disease, low phosphorous and low nitrogen.

Early work has focused on drought stress and a number of metabolites and genes regulated by drought have been identified in a plant displaying superior drought tolerance. These may represent targets for improving the ability of perennial ryegrass to survive periods of water shortage, which are predicted as a result of global warming.

The project also aims to map the ryegrass metabolome in an F_2 population. The mapping of metabolite Quantitative Trait Loci (mQTL) will allow us to compare the position of mQTL to various traits QTL. This may lead to the detection of biochemical pathways affecting ryegrass traits of agronomic importance. One such trait that has been looked at as part of this project is crown rust resistance. A QTL has been identified on chromosome 2 of perennial ryegrass and this represents a region of the genome harboring gene(s) involved in crown rust resistance. The correlation of this region on chromosome 2 and a metabolite QTL may point toward metabolic pathways involved in resisting a crown rust challenge.

The Organelle Genomes of Perennial Ryegrass: Sequence Discovery and Genomics for Basic and Applied Agricultural Research

Barth S. ***RMIS No. 5532***

Plant cells have three organelle genomes which contain DNA: the nuclear genome, mitochondria and chloroplasts. In 2007 we extracted the *Lolium perenne* L. chloroplast DNA (cpDNA) and sequenced it to obtain the complete chloroplast genome sequence. The results can be used for phylogenetic comparisons to other grass species, marker development for plant breeding purposes and for the construction of plastid transformation vectors.
The annotation of the genome was done using online programs (DOGMA (http://bugmaster.jgi-psf.org/dogma/) /tRNAscan SE (http://lowelab.ucsc.edu/tRNAscan-SE/) and the complete chloroplast genome sequence was submitted to EMBL (European Molecular Biology Laboratory, http://www.ebi.ac.uk/embl/) a public database for sequencing results.The results can be accessed with the Accession number 777385.
The chloroplast genome of perennial ryegrass has a typical quadripartite structure of two inverted repeats separating a large and a small single copy region from each other. The total size is 135,282 bp which encode for 130 genes; 19 of them are duplicated in the inverted repeat region.

The project exploits the *in vitro* and molecular biological approaches of mutagenesis and transformation to examine plastid gene function and work towards the generation of cultivars improved with traits.
In order to establish a working protocol for plastid transformation in the species *Lolium perenne L* a couple of aspects have to be investigated to increase chances of success
es: (1) A study was undertaken to determine which tissues would be most suitable for plastid transformation, (2) attempts were made towards an efficient regeneration protocol for different possible target tissues, (3) a test series was done to study which antibiotics and in which concentration these can be used for the selection of transformants, and (4) suitable transformation vectors were created.

Generation of Mapping Tools, Construction of Suitable Plant Material and Isolation of Agronomic Traits in *Lolium perenne* L.

Barth S. ***RMIS No. 5244***

Development of Recombinant Inbred lines (RILs) as mapping tools and the description of their parental lines using molecular markers and cytology
RILs are still a novelty for the outbreeding plant species *Lolium perenne*. They are highly valuable tools for the dissection of complex traits and the fine mapping and cloning of genes of particular interest. In 2004 the initial cross between two highly inbred *Lolium perenne* parental lines was done, in 2005 individual F1 plants were selfed and two independent F2 populations were raised from the selfed F1 seed. In 2006 414 independent F2 lines originating from one of the F1 plants were selfed with the objective to generate RILs by decreasing the heterozygosity degree within a couple of selfing generations. Loss of heterozygosity from the F2 to the F3 generations was estimated with simple sequence repeat (SSR) markers. In 2007 the F4 generation of the RIL’s was generated.

Developing mapped and highly genetically informative molecular markers for Lolium perenne L.: taking part in an international EST-SSR consortium
In 2007 mapping of EST-SSRs from the EST-SSR initiative organised by DJF in Denmark continued. We mapped a list of further EST-SSRs on the Oak Park ‘Biomass’mapping population consisting of 360 individuals. Map positions of all EST-SSR markers mapped by consortium partners will be available.

Isolation of genomic fragments contributing to self-compatibility genes in Lolium perenne L.
Building on the results of the SSH SI library study, the identified candidate genes, which showed tissue specific expression pattern on pollinated stigma material, were further analyzed by real-time PCR on a self-pollination time series of 0 min, 2 min, 5 min, 10min, 20 min and 30 min after in-vitro pollination. The candidate genes showed a similar expression pattern of a rapid increase within 2 min after pollen-stigma contact and reach the maximum expression level between 2-10 min. The real-time PCR results confirmed the specific expression pattern of the candidate genes and revealed their involvement in the incompatibility response of Lolium. Full length sequences were obtained for six candidate genes. Two of them have a protein kinase domain and a calcium related domain. Their functions in the SI response were investigated by inhibitor studies. Calcium antagonists were shown to delay or inhibit the SI response of Lolium. Efforts have been made to map the candidates on the Lolium fine mapping populations. The fine mapping populations were developed to obtain a single

heterozogous genotype for S locus or Z locus. A total number of about 1500 plants were generated for each fine mapping population.

Management of Imported Bumblebees in Horticultural Production

Horgan G. F. and. Murray E. T ***RMIS No. 5633***

The use of commercial bumblebees (*Bombus terrestris* ssp. *dalmatinus* or *terrestris*) in the horticultural industry has increased steadily over the past 20 years. Bumblebees, of mainly southern European origin, are reared in Holland and Belgium and purchased through agricultural suppliers or directly from the producer. Their efficient pollination of plants leads to increased yields and better quality fruit for the grower. However, importation is currently unregulated, despite the fact that the imported bumblebees are not native to Ireland. In a project, funded by the Research Stimulus Program of the Department of Agriculture, we are investigating the benefits and risk involved in importing bumblebees.

During 2007, we conducted a comprehensive survey of fruit growers to determine the extent of the bumblebee trade, the crops and cropping systems that use bees, and the understanding among growers of associated benefits and risks. Based on survey results, we estimate that ca. 1300 colonies enter Ireland each year, these are mainly used in the pollination of strawberry (53%); raspberry (17%); apple (14%); cherry (5%), and plums (5%). Over 40% of growers place their hives in enclosed cultivation systems, such as greenhouses and walk-in-tunnels. Other systems (ca. 40% of hives), such as French and Spanish tunnels are prone to bee escape, and ca. 20% of growers use bumblebees for outdoor pollination. Most growers do not adequately dispose of hives, increasing the risks of hybridization and competition between Irish and imported bees. There was no association between the manner by which growers dispose of their hives and why they chose that method of disposal. Most growers, irrespective of how they disposed of their hive, generally used that method because they think it’s the easiest/best method, and not necessarily the safest.

As part of a phylogenetic study, bumblebee samples were collected throughout Ireland and Europe by Teagasc staff, collaborators at Carlow Institute of Technology and international colleagues. Samples are mainly of North European populations including Latvia, Poland, Denmark, Britain, France and Ireland. Southern European populations include Croatia, Greece and Portugal. Samples have also been acquired from New Zealand (where they are an exotic invader) and from Koppert and Syngenta. Phylogenetic analyses will continue in 2008.
Responses of bumblebees to forage, and efficiency of pollination were examined in 2007 using clover as a model plant. In a manipulative experiment, three cultivars of a common fodder legume, *Trifolium repens*, were assessed as sources of forage for the bumblebee, (*B. terrestris terrestris*), by monitoring colony development on monocultures in plastic tunnels. Colony response to absolute flower density was not as predicted. The cultivar with fewest flowers (40% fewer flowers the other varieties), had similar or greater worker thorax size, egg number, larvae and live pupal cells when compared to the other two cultivars. No seed was produced from either control (no bees) or artificial self-pollinated flowers. Bumblebee pollinated plants produced more seeds per flower than hand-cross pollinated flowers. The quality of the seed, measured as the proportions of soft, hard, total germinated or non-viable seed, were similar across cultivars. There was one significant interaction between pollination treatment and cultivar, whereby one cultivar produced a higher proportion of hard seed under the artificial cross-pollination treatment than either of the other two.

Statutory Testing for Plant Pathogenic Nematodes

Horgan G. F and Crombie K ***RMIS No. 5380***

Statutory testing of soil samples for the presence/absence of potato cyst nematodes (PCN) (Globodera spp.) is carried out at the Nematology Section (NS) in Oak Park. During 2007, a new directive was adopted by the EU commission [EC Council Directive 2007/33/EC] on sampling and testing for PCN. The new directive set out new sample sizes (ranging from 400 to 1500ml/ha) for 'official investigations' whereby potato fields destined for seed potato production are screened for presence of the pathogen. The directive also calls on member states to conduct 'official surveys' on 0.5% of ware potato acreage to monitor the incidence of PCN (sample sizes of 200 to 400ml/ha). In each case, testing of the entire sample is to be carried out. The NS evaluated current testing protocols and found that cyst extraction using the Schuiling centrifuge is more efficient than the Fenwick can method across a range of soil types and sample sizes, with cyst recovery from sandy soils at >80%. Recovery from clays and peat was relatively low using both methods (ca. 40 and ca. 30% respectively). The NS conducted tests of 2889 soil samples for potato production. The number of ware crop samples was reduced in 2007 because of other priorities of the Department of Agriculture. As part of a service to the Horticultural Section of the Department, the NS conduced 309 PCN-tests of soils for daffodil/tulip production. Furthermore, 103 samples of potato tubers were tested for root knot nematodes (Meloidogyne spp.) and 243 miscellaneous samples (peat, bulbs, imported plants and soils) were tested for parasitic non-cyst and cyst nematodes. Of these 138 were tests for Ditylenchus dipsici. Using newly installed mist chambers, extraction times for D. dipsici were reduced by ca. 10 fold and cleaner samples were achieved. Ditylendhuc dipsici is a minor problem in daffodil farms, but, in 2007 the pathogen had spread to previously (stem) nematode-free farms (possibly through soil contamination). During 2007, the NS conducted a number of tests for Teagasc advisors. Two unusual infestations were detected: Meloidogyne nassi occurred in wheat in Cork, Tipperary, Carlow and Kildare causing minor yield loss and Meloidogyne minor occurred in potatoes at a field in Tralee.

Sequencing Potato Chromosome IV

Milbourne D., & Destefanis M., ***RMIS No. 5545***

Potato (Solanum tuberosum L.) is the world's most important solanaceous food crop. An international consortium, the Potato Genome Sequencing Consortium (PGSC), has been initiated to sequence the entire genome of potato comprising 12 chromosomes, with a genome size of ~ 840 Mb. Under the PGSC initiative, Teagasc is sequencing a portion of chromosome 4 with a particular emphasis on a region surrounding a Quantitative Trait Locus (QTL) called Gpa4. The Gpa4 region confers resistance to Globodera pallida Pa2/3, a soil borne nematode that attacks potato roots causing severe yield losses. We have already developed diagnostic markers for the Gpa4 locus for use in breeding. Currently we are focusing on trying to identify and isolate the gene underlying the QTL.

The potato genome exhibits extensive co-linearity to the genome of tomato, which is currently at a more advanced stage in terms of genome sequencing. At present we are attempting to exploit the similarity between potato and tomato genomes to completely sequence the region between markers C237 and STM3016 as a first step to identifying the gene/s underlying Gpa4. The PGSC initiative is based on a bacterial artificial chromosome (BAC) library produced in a diploid potato line called RH. The library has an average insert size of 140kb, and at approximately 75,000 clones, corresponds to approximately eleven genome equivalents of potato **.**BACs from the Gpa4 region were isolated from this library using two genetic markers STM3016 and C237, which have been previously mapped to this region in two separate tetraploid mapping populations. The genetic distance between these markers is approximately 2cM. Using the markers STM3016 and C237, we identified a total of eight potato BACs, four associated with each marker. The two clusters of BACs did not overlap, and the physical distance between them is currently unknown. The selected BAC clones were sequenced to six-fold coverage using Sanger-based shotgun sequencing, and subsequently assembled to derive contiguous sequences (contigs) that reflect the original DNA segment. Initially, using BLASTn analysis against the currently available tomato genome sequence, we identified a region (containing 7 completely sequenced tomato BACs) which is orthologous to Gpa4 in potato. Subsequently, we used the programme PipMaker to align sequence contigs from the 8 potato BACs to this genomic interval in tomato**.** The genetic distance of 2cM between the markers in potato corresponds to a region spanning approximately 1Mb in tomato, suggesting a similar distance in potato. It will now be possible to use sequence information from this region in tomato to isolate further BACs in potato and span the gap between the two current clusters of BACs. All potato BACs were also searched for sequences homologous to known plant resistance genes using BLASTn analysis, and good matches were found on both of the potato BAC contigs. Resistance genes in plants occur in characteristic tandemly arrayed clusters. Examination of the data reveals blocks of duplicated genes, corresponding to the R-genes in both the potato and tomato sequences. These R-gene clusters are excellent candidates for the location of the gene or genes underlying Gpa4 in potato.

Development of a Framework for Marker Assisted Selection in the Breeding of the Novel Non-Food Crop *Adonis Palaestina*

Milbourne, D., & Bigio, G., ***RMIS No. 5544***

Adonis palaestina, a member of the Ranunclaceae (buttercup) family is an annual plant with red flowers which are a potentially rich source of the high-value red carotenoid pigment astaxanthin. Astaxanthin, a powerful antioxidant, has applications as a nutraceutical compound, and is added to the diet of farmed salmonid fish species to achieve the pink flesh coloration which, in the wild, is obtained through the fishes' diet of crustaceans which have, in turn, fed on astaxanthin rich algae. This project is part of a larger study in collaboration with the group of Professor Peter Jones of University College Cork and is funded under the Department of Agriculture and Food's Research Stimulus Fund. The goal of our component of the larger study is to develop molecular-genetics-based resources to assist in the rapid domestication of this wild species to a point where it exhibits agronomic characteristics that make it suitable for large scale cultivation in Ireland. The main foci of the project are to assess the genetic diversity in a germplasm set of a large-flowered variant of the species currently being used as the basis of the domestication programme, and to develop the molecular markers, and mapping families which will allow the genetic mapping of key agronomic traits (e.g. flower size and number, astaxanthin content) in *Adonis*.

In preliminary experiments on plants from the large-flowered *Adonis* germplasm collection, extremely high levels of genetic diversity were observed between individual plants when assayed with only three PstI/MseI-based fAFLP primer combinations, with an average of 40 polymorphisms per primer combination evident between any two lines assayed. This is a highly significant from a breeding perspective, since it indicates that the population from which future breeding material may be established is extremely genotypically diverse – a desirable scenario at the early stages of a breeding and domestication process for a species. In addition, it indicates that the generation of large quantities of polymorphic markers for mapping using this approach should be a relatively straightforward process.

We have also initiated microsatellite marker development for *A. palaestina*. A microsatellite-enriched genomic DNA library was developed, and screened using a variety of dinucleotide, trinucleotide and tetranucleotide motifs. Approximately 300 genomic clones, each potentially containing a microsatellite sequence were identified during the screening process. To date 200 of these clones have been subjected to DNA sequencing and approximately 60% of them have been found to contain microsatellite sequences. We have designed PCR primer sets to amplify the microsatellite repeat in 45 of these clones, and tested these for their ability to amplify a product in *A. palaestina* genomic DNA. Approximately 30 of these primer sets have successfully amplified a single-copy product of the expected size in *A. palaestina* to date. These are currently being tested for their ability to reveal polymorphism on the large-flowered *Adonis* germplasm set.

For genetic mapping experiments, a controlled, multi-direction crossing programme between over 20 parents has been established to generate multiple F_1 families. This is the first of two rounds of crossing that will be required for the development of a set of F_2 families which will later be used for all of the linkage and QTL analysis studies to be carried out later in the project. In order to maximise the probability of developing a successful mapping population, it is our intention to carry forward multiple F1 (full-sib) families, in order to develop multiple F2 families, one or more of which will be chosen for linkage studies. During the summer of 2007, 24 different plants were used in a pairwise intercrossing programme that resulted in a total of 34 successful intercrosses, yielding between 12 and 25 seeds in individual crosses. In addition, phenotypic data (flower diameter, eye diameter, bud number and number of petals on the primary flower) were collected for all of the parental plants involved in the crossing programme, and variation was observed for all of these traits. In the future, one or more of these populations will be used to develop the first genetic linkage map of this species, which will form the basis of future marker-assisted selection strategies.

Predicting the Impact of Genetically Modified (GM) Cropping on Irish Biodiversity

Mullins E. ***RMIS No: 5621***

Funded through the ERTDI programme of the EPA.

To help understand the impact of novel crops (such as GM) and counteract future agronomic challenges to farmland biodiversity, it is essential to first know how present farming practices have impacted biodiversity on Irish farms. An extensive literature review clearly indicates that peer-reviewed publications on research conducted in Ireland on this topic are quite scarce: just 21 papers investigating the impact of conventional crop cultivation on Irish biodiversity have been published within the past 30 years. Principally, these studies have concluded that conventional crop cultivation has had an adverse impact on biodiversity on Irish farms, with 15 of the 21 studies demonstrating negative trends for the taxa investigated. Compared to other EU states, the relative dearth of baseline data and absence of monitoring programmes designed to assess the specific impacts of crop cultivation on Irish biodiversity highlights the need to develop long-term research studies.

Following on from this, a list was compiled of GM traits which would be most suited to Irish crop management systems over the next 20 years in light of the challenges facing the Irish tillage sector, and hence have the highest probability of adoption by Irish farmers/growers. Clearly the crops with the most significant potential for genetic modification are those that are grown widely; barley, wheat and maize and/or currently receive high applications of pesticides and fertilisers (e.g. potato). GM traits with significant agronomic potential include late blight resistant potato, *Fusarium* head blight resistant wheat and *Septoria* resistant wheat and herbicide tolerant winter oilseed rape and maize. Following on from these, crops with enhanced nitrogen use efficiency could provide significant input to the tillage sector in light of EU-based restrictions on nitrogen usage, crops with elevated protein content could offset the costs of imported animal feed and crops with modified oil content/lignocellulose composition could assist in biodiesel/bioenergy production at a regional level. This work is ongoing, with the third and final phase focussed on actually providing clear information on the potential risks/benefits of each of the GM crops listed above.

In parallel, a project-specific website has been developed. Termed gmoInfo (see; http://www.gmoInfo.ie), the goal of this resource is to support public understanding of the issues associated with GM crop cultivation. As such, gmoInfo will be regularly updated with National and International research findings of most relevance to Ireland. The website is designed in an impartial, non-scientific manner and details ongoing research both at a national and international level, provide a question and answer format and present the issues central to the coexistence of GM and non-GM crops in Ireland.

Modelling the Effects of Different Crop Management Regimes on the Levels of Gene Flow from GM herbicide Tolerant Oilseed Rape

Mullins E ***RMIS No. 5629***

Funded through the DAFF Research Stimulus Fund

The potential introduction of GM oilseed rape (OSR) into Ireland raises public and sector concern over how the sustainability of a non-GM oilseed rape crop can be preserved in compliance with the EU labelling threshold of 0.9% (i.e. co-existence). Using a computer modelling system (‘GeneSys’), the potential of crop practises to minimise the spread of material (i.e. pollen / seed) from GM herbicide tolerant (GMHT) oilseed rape cultivated fields was investigated, with the goal of developing a coexistence strategy for the cultivation of GM herbicide tolerant oilseed rape in Ireland.

In the absence of a specific coexistence strategy, the adoption of GMHT oilseed rape into a standard 4 year rotation of oilseed rape followed by winter wheat (WW) over 3 years would have a substantial impact on the regional harvest impurities in non-GM OSR crops. At a 5% adoption rate, the regional harvest impurity rate could exceed 0.15% after a single rotation and possibly exceed the 0.9% threshold after 10 years. At a 15% adoption rate, the 0.9% threshold for food production could be exceeded within 5 years. At the field level, this result was reflected in the % of non-GM OSR fields found to exceed the 0.9% impurity threshold. For at the end of the first 4 year rotation (year 5), over 18% of fields could exceed 0.9% at the 5% GM adoption rate, increasing to 42.7% for 15% GM adoption.

However, modifying the standard crop regime had a significant impact. For example, substituting two spring barley crops for the latter two winter wheat crops had a significant impact on the degree of gene flow from GMHT oilseed rape cultivated fields. Specifically, the regional harvest impurity of non-GM OSR crops would not exceed the 0.9% threshold for the 5 or 15% rate of GM adoption. Similarly after simulating 12 years of cultivation, the percentage of fields exceeding the 0.9% threshold could equate to 1.7% and 6.5% for the 5% and 15% GM adoption rates respectively. Significantly, on examining volunteer emergence at a field level, the impact of introducing spring barley crops into the rotation could reduce the degree of GM volunteers in GM OSR sown fields up to 10-fold in the last year (year 4) of the rotation, from approximately 2/m^2 to 0.2/m^2.

Based on the date presented here, a continuation of the most commonly practiced rotation of OSR/WW/WW/WW, following the adoption of a GM OSR variety in Ireland would present a significant challenge to facilitating coexistence at the landscape level. However, the inclusion of two spring crops in year 3 and year 4 of this rotation could significantly reduce the degree of pollen and seed spread from a GMHT oilseed rape crop. This alteration to the rotation would not present a logistical challenge to tillage farmers as spring barley is widely grown in Ireland.

Investigating the Impact of Growing Herbicide Tolerant (HT) Oilseed Rape in Ireland

Mullins E. ***RMIS No. 5531***

The occurrence of volunteer oilseed rape as an impurity in a rotation is one of the major issues that require attention prior to the introduction of an HT oilseed rape crop system in Ireland. To quantify the potential for volunteer emergence in a rotation, the first task was to assess the average rate of seed loss at harvest in 11 fields across 7 separate farms in the Carlow area. Losses varied across sites, from a minimum of 1194 seeds/m^2 (~ 0.06 tonne/ha) up to 12944 seeds/m^2 (~ 0.53 tonne/ha). This equates to 1.9% to 17.76% respectively of potential yield, which not only presents a significant economic loss but also presents a challenge to farmers in regard to controlling emerging volunteers through the rotation.

Utilising an HT oilseed rape variety (603CL), two field trials were established to examine the efficacy of several post-harvest tillage operations with the goal of establishing a defined management practise to negate the potential for harvested seed to enter secondary dormancy and return as volunteers through the rotation. The completion of both trials confirmed that the most efficient regime to cull volunteers involved leaving the field undisturbed for a minimum of 4-5 weeks, after which the first flush of volunteers should be burnt off with a broad spectrum herbicide. Critically, a second flush of volunteers is then likely to occur and again this should be burnt off with an additional herbicide application 8-10 weeks after harvesting the original main crop. The introduction of a tillage treatment to disturb the soil was counter productive as it only served to induce secondary dormancy in those seeds that were yet to germinate. In turn this generated a seed-bank reservoir which facilitated the emergence of HT volunteers in the subsequent cereal crop.

To quantify the potential for and consequence of gene flow from an HT oilseed rape crop into populations of inter-related wild relatives (e.g. *Brassica rapa*), populations of 603CL and B. rapa individuals were grown adjacent to each other to mimic a field scenario. The calculated rate of hybridisation was 6.7% and analysis of the hybrids through microsatellite analysis confirmed the introgression of the genetic polymorphism that confers the herbicide tolerant trait. The ability of these B. rapa – 603CL hybrids to express tolerance to the herbicide is currently being assessed.

Once a novel HT trait has been commercialised, it is critical that the efficacy of the herbicide against inter-related weedy species is maintained, irrespective of whether the HT trait is GM (e.g. glyphosate) or non-GM (e.g. imidazolinone). Experiments on the potential of weedy *Brassica* species to develop spontaneous herbicide (e.g. imidazolinone) resistance as a result of spray drift noted that *B. rapa* individuals that receive ~ 6.3 % of the applied rate will exhibit typical herbicide-treated symptoms with severe leaf chlorosis but over 70% of individuals in this class will survive to set seed. This seed is currently being assessed for its tolerance/susceptibility to the imidazolinone herbicide.

Assessing Alternative Mechanisms to Control Septoria Tritici

Mullins E ***RMIS No:5536***

Project goal is two-fold; investigate the process behind resistance and susceptibility to *Septoria tritici* in what by identifying key genes that could facilitate the generation of wheat cultivars with improved disease resistance and assess the efficacy of a bacterial-based biocontrol agent in controlling S. tritici in the field.

Microarray analysis of a susceptible wheat cultivar following S. tritici inoculation identified a total of 64 genes which were up regulated and classified in 10 functional classes with 5 genes related to defence mechanisms. The individual activity of these genes is currently being assessed using a semi-quantitative RT PCR assay. In parallel, a comparative analysis was completed using microarray to study the response of a resistant cultivar following exposure to S. tritici. From the microarray, 366 genes were up regulated and classified in 14 categories where 49 genes were related to plant defence mechanisms. Out of the 366 genes, 156 were fungus sensitive genes represented in 11 categories with 23 genes related to plant defence. From the fungal specific genes, two genes per functional class were picked up, with the exception of the defence related genes where 8 genes were selected, and currently we are confirming the microarray results with semi quantitative RT PCR assay.

To study the potential of developing a biological control agent as an alternative to control Septoria, a field trial was conducted using two possible agents; *P. fluorescens* strain MKB91 and *B. megaterium* strain. Plants were either sprayed with bacterium through a 4 spray regime or with standard fungicides with a typical 3 spray regime or were untreated. Some reduction of disease leaf area on the flags was detected at certain time points but this was not significant. In order to improve the control efficiency, two combinations of three different biocontrol agents were tested on wheat seedlings under glasshouse condition. Wheat seedlings were pre-treated with the bacteria alone or in combination and 2 days later they were treated with *S. tritici*. Out of the 2 combinations tested, the one composed of two *P. fluorescens* strain MKB100 (control of Net blotch disease) and strain MKB249 (control of *fusarium* sp.) and the *B. megaterium* MKB135 was able to reduce disease symptoms. However the reduction was not significantly different to the *bacillus* alone.

To better understand the modes of action of *P. fluorescens* (MKB91) and *B. megaterium* (MKB135), we tested if the bacteria were able to reduce disease symptoms by inducing a local response and/or a systemic response and thus when the bacteria was applied at different time-points (pre- and post-fungal infection). It was observed that *P. fluorescens* (MKB91) was able to significantly reduce disease symptoms when applied locally (same leaves) 4 days prior to infection and it was relatively stable up to 2 days post infection (dpi). *Bacillus megaterium* (MKB135) was also able to reduce disease symptoms when applied locally 4 days prior to infection and it was also stable up to 2dpi. When the bacteria and the pathogen were applied to separate leaves a comparable response was recorded, illustrating that both biocontrol agents induce a systemic response which is able to control S. tritici infection under controlled conditions.

Developing Alternative Methods to Transfer Genes into Major Crop Species

Mullins E. ***RMIS No: 5630***

At present, *Agrobacterium tumefaciens* mediated transformation (ATMT) and direct particle bombardment (biolistics) are the two primary systems for the delivery of a transgene into a plant cell line. While both techniques are utilised at Oak Park to generate transgenic material that is employed in the current risk assessment programme of research, they are comprehensively covered by intellectual property rights. This research proposes to screen novel bacterial strains isolated from the rhizosphere for their ability to deliver genes of interest into both potato and oilseed rape.

Bacteria were collected from five *Brassica napus* individuals taken from a research plot in Oak Park and from four *S. tuberosum* varieties (Desiree, Maris Peer, Rooster, Kerr’s Pink). All bacteria strains were tested for their natural resistance towards the antibiotics spectinomycin and kanamycin. 55% of the strains had no natural resistance towards either of the antibiotics, whereas 22% were resistant towards spectinomycin and 7% resistant towards kanamycin. 16% of the library possessed resistance to both antibiotics. Over 50% of the remaining strains lost viability after three months and were discarded.

Of the 320 remaining samples with suitable antibiotic resistance 44 bacterial genotypes that successfully took up the pCAMBIA5105 plasmid were sent for sequencing to identify their species. Three strains are currently being tested for their ability to transform potato (cv. Desiree) and Arabidopsis (model plant related to oilseed rape).

Separately, four different *S. tuberosum* varieties (Desiree, Maris Peer, Rooster, Kerr’s Pink) were treated with three Rhizobia bacteria strains and compared to the standard *A. tumefaciens* as a control. Preliminary results indicate that the provision of antibiotic selection during the shoot inducing stage is crucial in order to get successfully transformed shoots. Tissue treated with the Rhizobia strains as well as the Agrobacterium control show amplification for both transgenes employed, indicating that the transgenes were indeed delivered into the target cells and that the non-Agrobacterium transformation of potato is possible. Further assessment is required to ensure that the individuals from all four treatments have experienced a stable integration event.

Strategies for the Control of Potato Late Blight

Dowley, L.J., Griffin, D. and Mullins, E. ***RMIS No. 5373***

The overall objective is to provide accurate up-to-date pathogen/fungicide information on which to base future disease control programmes. During 2007, we concentrated on the collecting isolates of *Phytophthora infestans* (Mont.) de Bary, determining the level of phenylamide resistance, establishing the physiological race structure and confirming the presence or absence of the A2 mating type. All isolates are maintained in pure culture for DNA finger printing within the new Stimulus project on late blight. Evaluation of fungicide programmes for the control of late blight and rhizoctonia were also carried out.

Collection of Phytophthora infestans isolates

The objective of this task was to generate a collection of *Phytophthora infestans* isolates for use in future genetic studies of the pathogen. Infected leaf and tuber tissue was collected by potato inspectors of the Department of Agriculture, Food and Rural Development, Teagasc potato specialists and Teagasc personnel and forwarded to Oak Park for isolation. Infected tissue was placed under 5 mm tuber slices of the cultivar Kerr’s Pink and incubated in moist Petri-dishes in the dark at 18^{o}C. Mycelium of *Phytophora infestans* was transferred from the upper surface of the tuber slices to Pea agar amended with rafinomycin to prevent bacterial contamination. Pure cultures of *Phytophthora infestans* were finally transferred to Rye agar and stored at 6^{o}C in the dark for use as required.

While 2007 was a very suitable year for the spread of late blight, the level of disease control in commercial crops was excellent. As a result only 13 samples of *Phytophthora infestans* were isolated into pure culture and added to the culture collection. The culture collection now stands at 173 isolates which will be added to during 2008.

Phenylamide resistance survey

The main objective of this survey was to determine the distribution of phenylamide resistant strains of Phytophthora infestans in Ireland during 2007 and to make comparisons with previous years.

During 2007, a total of 13 samples of late blight infected plant material were received from diseased crops around the country. Viable sporangial suspensions of P. infestans were prepared from all samples and these were tested for metalaxyl resistance. Only one (7.7%) of the samples tested were found to have phenylamide resistance present. The distribution of resistance (Fig. 1) has now remained very low for three consecutive years which would suggest that good blight control can be achieved from the use of a phenyalamide based fungicide.

Physiological race specialisation

During 2007, the physiological race structure of 13 different isolates of *Phytophthora infestans* were identified by inoculating spore suspensions onto detached leaflets of all 12 different indicator plants. As in previous years the most common races were able to overcome the resistance conferred by the genes R1, R3, R4, R7, R10 and R11. The frequency of the different races can be seen from Table 1. The race with the highest frequency in the population was race 1,3,4,7,10,11.

Table 1: The % frequency distribution of physiological races of *Phytophthora infestans* isolated in 2007.

Race	f
1,3,4,7,10,11	46.2
1,3,4,5,7,10,11	30.8
1,3,4,7,9,10	7.7
1,3,7,8,10,11	7.7
1,3,4,5,7,8,10,11	7.7

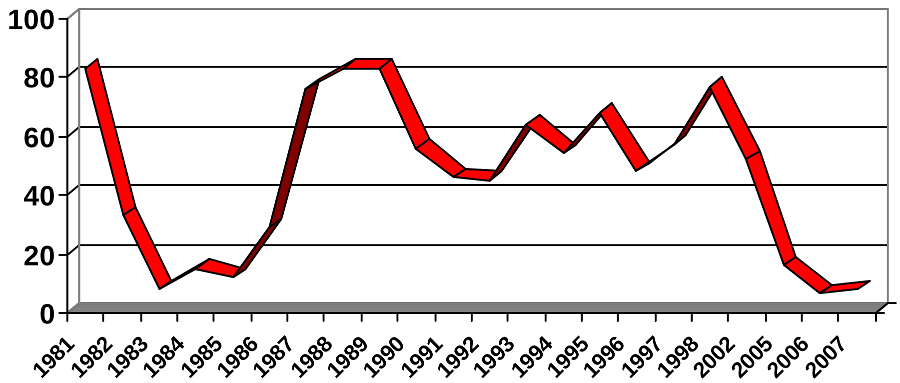

Fig. 1: % distribution of phenylamide resistance (1981-2007)

Spore Length

The mean spore length of 91 Irish isolates of *Phytophthora infestans* examined in 2007 was 36.6µ (Fig. 2). This is much larger than the 22-32µ reported in 1955 by Butler & Jones. Most isolates are now in the range of 30-40µ, with a range of 26 to 60µ.

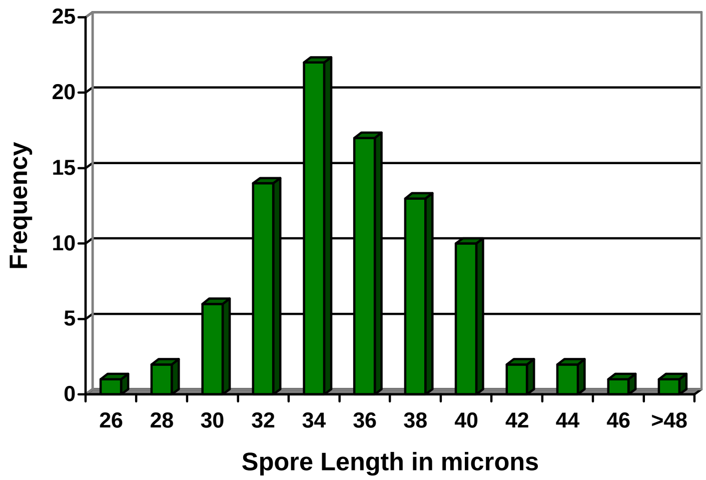

Fig 2: Variation in spore length of 91 isolates of *Phytophthora infestans*

Mating Type

The first record of the A_2 mating type was confirmed in field populations of *P. infestans* from Ireland in 1991. The distribution of the A_2 mating type was subsequently monitored and its frequency has been observed to fall from an initial high of 25% to 3% in 1994 and 0% in 2006 and 2007 (Fig. 3). This would suggest that the threat from oospores and sexual recombination has receded, at least for the present.

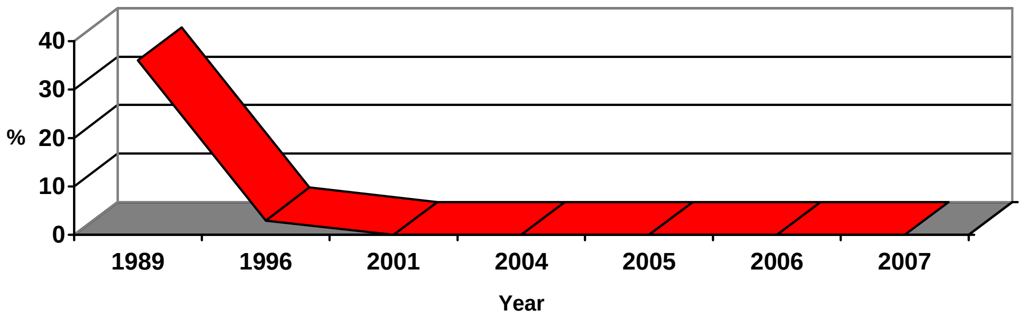

Fig. 3: Level of A2 Mating Type

Fungicide efficacy evaluation

a) Control of *Phytophthora infestans*

The objective of this sub-project was to determine the relative efficacy of 15 different fungicide programmes for the control of potato late blight caused by *Phytophthora infestans* (Mont.) de Bary compared with an untreated control. The fungicides were used as protectants and applied post emergence to a field-grown crop of the potato cv. Rooster. The experimental protocol was based on the EPPO guidelines for fungicide efficacy evaluation. The design was a randomised complete block (RCB) with 4 replications per treatment. Each plot was made up of 6 drills (84.66 cm) 7.39 m long. The total plot size was 37.5 m^2, from which 12.5 m^2 were harvested across the centre 2 drills. A 3 m divider strip was left between each plot to optimise the accuracy of the sprayer speed and to facilitate mechanical harvesting.

Cool, wet conditions persisted for much of the growing season and conditions were very favourable for blight. As a result, late blight was first recorded in the National Blight Trial at Oak Park on July 9th. Following the initial outbreak, the disease spread rapidly during July and reached 100% defoliation in the unsprayed control by the beginning of August. The crop was desiccated with full rate diquat on August 23rd.

All fungicide treatments significantly delayed the date of disease onset compared with the untreated control. Within the sprayed treatments the shortest delay in disease onset (10 days) was recorded for the two DSS programmes, NegFry and Proplant Expert and these were significantly shorter than all other sprayed treatments with the exception of Dithane at 10 day intervals and the Dithane/Shirlan mixture. The longest delay in disease outbreak (18.75 days) was recorded following the Shirlan fb Revus (all season) treatment and this was significantly better than treatments B, C, D, E, K, N, O and P (Table 2). There were no significant differences between the remaining sprayed treatments.

Despite the early development of the epidemic, all fungicide treatments (except Dithane at 10 days and the NegFry DSS) significantly reduced the incidence of late blight at all assessment dates up to August 23rd compared with the unsprayed control (Table 2). At the end of the growing season the lowest level of foliage blight was recorded for treatment J (Ridomil Gold fb Revus alternating with Shirlan) and this was significantly better than treatments B, C, D, F, L and all the DSS programmes. Due to the high disease pressure all the DSS programmes gave poor results in 2007. The best control was achieved with the Proplant Expert and this was better than the routine applications of Dithane (at 7 and 10-day intervals) and the routine application of Shirlan at 10-day intervals.

The area under the disease progress curve (AUDPC) allows more meaningful comparisons to be made between treatments over the whole course of the epidemic (Table 2). This method of comparison again confirmed that all fungicide treatments resulted in significantly lower AUDPC's than the unsprayed control. Within the fungicide treatments, the highest AUDPC was again recorded following the NegFry DSS treatment (N) and this was significantly higher than all other sprayed treatments. The lowest AUDPC was recorded following treatment J (Ridomil Gold fb Revus alternating with Shirlan) and this was significantly better than treatments B, C, D, F, L, N, O and P (Table 2). Within the DSS programmes the best results were achieved following the Proplant Expert programme (9 sprays) and this was significantly better than the NegFry DSS (5 sprays).

All sprayed treatments resulted in higher marketable yields compared with the untreated control and these differences were significant for all treatments with the exception of the NegFry DSS. Within the sprayed treatments, the highest marketable yield was achieved following the Ridomil Gold fb Curzate M alternating with Shirlan treatment and this was significantly higher than the NegFry and the control treatments. There was no significant difference between the remaining sprayed treatments in terms of marketable yield. Within the decision support systems, the highest marketable yield was achieved following the Opticrop DSS treatment and this was significantly higher than the NegFry DSS treatment but not significantly different from the Proplant Expert DSS treatment.

Levels of tuber blight were much higher than in previous years, despite the relatively high resistance of Rooster to tuber infection. Within the sprayed treatments, the lowest level of tuber blight was recorded for the Shirlan fb Revus treatment and this was significantly lower than treatments P, B, O, L and F (Table 2). The remaining Revus treatment also showed low levels of tuber blight indicating that mandipropanid gives very good control of tuber blight.

TABLE 2: Effect of fungicide programme on the delay in disease onset, % foliage blight at the end of the season, AUDPC and yield of cv. Rooster (Oak Park Research Centre, 2007)

Fungicide Programme [a.i. & rate of product ha-1] (No. of sprays)	Delay in Disease onset (in days)	% Foliage Blight on Aug. 23	AUDPC	Yield of blighted tubers (t ha-1)	Marketable Yield (t ha-1)
A. Unsprayed	0.00	100.00	3073	0.20	25.84
B. Dithane @ 10 day intervals [Mancozeb, 2.25 kg] (7)	11.75	78.75	817	0.60	46.38
C. Dithane @ 7 day intervals *[Mancozeb, 2.25 kg] (11)*	15.25	62.50	352	0.40	51.00
D. Shirlan @ 10 day intervals [Fluazinam, 0.40 l] (7)	15.25	62.50	600	0.20	46.40
E. Shirlan @ 7 day intervals *[Fluazinam, 0.40 l] (11)*	17.00	20.00	215	0.46	46.48
F. Half-rate Dithane + half-rate Shirlan @ 7 day intervals *[Mancozeb+Fluazinam, 1.12 kg + 0.20 l] (11)*	11.75	53.25	318	0.74	47.06
G. Ridomil Gold @ 10 day intervals [Metalaxyl M + Mancozeb, 2.50 kg] (2) fb Curzate M [Cymoxanil + Mancozeb, 2.50 kg] (4) alternating with Shirlan [Fluazinam, 0.4 l] (4) @ 7 day intervals	17.00	25.00	168	0.28	51.24
H. Ridomil Gold @ 10 day intervals [Metalaxyl M + Mancozeb, 2.50 kg] (2) fb Shirlan @ 7 day intervals [Fluazinam, 0.40 l] (8)	17.00	25.25	143	0.20	45.90
J. Ridomil Gold @ 10 day intervals [Metalaxyl M + Mancozeb, 2.50 kg] (2) fb Revus [Mandipropanid , 0.60 l] (4) alternating with Shirlan [Fluazinam, 0.40 l] (4) @ 7 day intervals	17.00	5.00	43	0.24	50.60
K. Ridomil Gold @ 10 day intervals [Metalaxyl M + Mancozeb, 2.50 kg] (2) fb Infinito [Propamocarb + Flupicolide , 1.6 l] (4) alternating with Shirlan [Fluazinam, 0.40 l] (4) @ 7 day intervals	13.50	9.00	86	0.52	44.08
L. Ridomil Gold @ 10 day intervals [Metalaxyl M + Mancozeb, 2.50 kg] (3) fb [Mancozeb, 2.25 kg] (7) @ 7 day intervals	17.00	43.75	292	0.68	46.82
M. Ridomil Gold @ 10 day intervals [Metalaxyl M + Mancozeb, 2.50 kg] (3) fb [Mancozeb, 2.25 kg] (7) @ 7 day intervals	17.00	15.00	90	0.42	51.18
N. NegFry DSS [Fluazinam, 0.40 l] (5) as per NegFry DSS	10.00	98.75	2028	0.30	39.32
O. Opticrop DSS [Fluazinam, 0.40 l] (10) as per Opticrop DSS	15.25	61.25	638	0.62	50.02
P. Proplant Expert DSS [Fluazinam, 0.40 l] (9) as per Proplant Expert DSS	10.00	55.00	436	0.58	46.20
R. Shirlan @ 10 day intervals [Fluazinam, 0.40 l] (3) fb Revus @ 7 day intervals [Mandipropanid , 0.60 l] (7)	18.75	14.00	71	0.12	45.62
LSD (5%)	n/a	22.21	241	0.44	8.14
LDS (excl. untreated control)	3.22	23.02	244		

b) Control of Rhizoctonia solani

The objective of this trial was to determine the efficacy of Amistar on the control of potato black scurf and stem canker caused by Rhizoctonia solani (Kuhn). Amistar was applied at planting to the seed tubers of the black scurf susceptible variety, Rooster.

Plant numbers emerged were assessed on three dates up to full emergence (June 22). Amistar resulted in a slight increase in plant numbers compared with the untreated control (Table 3) but this difference was not significant. No significant difference in stem numbers was recorded.

Amistar resulted in higher yields for the larger grades and this was significant for the yield over 85 mm. This would reflect the slight increase in plant numbers and decrease in stem numbers in the Amistar treatment. There were no significant differences in marketable yields (Table 3).

In general the incidence of black scurf was low compared with 2006. This was despite allowing a long interval between desiccation and harvesting. The incidence of black scurf was measured by the black scurf index (SI) and the relative black scurf incidence (RSI). Both methods of assessment confirmed that the use of Amistar resulted in a reduction in the incidence of black scurf on the progeny tubers. However, the reduction in the incidence of black scurf was not significant in 2007 (Table 3).

TABLE 3: The effect of Amistar application on emergence, yield and black scurf

Treatment	**No. of plants emerged plot^{-1}**	**Marketable yield t ha^{-1}**	**Black scurf index**	**Relative black scurf index**
Untreated	368.6	48.17	434.83	1.66
Amistar (3l/ha)	413.2	47.85	323.83	1.27
L.S.D. (5%)	92.7	7.76	201.26	0.72

Breeding and Evaluation of Improved Potato Varieties for the Domestic and Seed Export Markets

Griffin, D. and Dowley, L.J. ***RMIS No. 5612***

Objectives

The objectives for the breeding program in 2007 were to produce varieties with the following attributes

- Early maturity and high yield potential
- Excellent processing and quality traits
- Smooth bright skin finish
- Resistance to Late blight and potato cyst Eelworm

Seedling evaluation in Ireland

The size of the program remained similar to previous years. The number of seedlings tested at each generation in Ireland and the trial sites used are outlined below.

Table 1: Number of seedlings under field evaluation in Ireland 2007

Year of generation	Type of trial and location	No. seedlings under evaluation
Year 3	Singles in Wicklow mountains	59745
Year 4	Ten tuber lots in Wicklow Mountains	3100
Year 5	Replicated plots (3 replicates each of 30 plants) [Carlow]	196
Year 6		37
	Replicated trials	
	Maincrop: Carlow Early: Wexford	10
Years 7-11	Replicated trials:	
	Maincrop: 2-4 sites (Carlow, Wicklow, Louth and Meath)	40
	Early: Wexford	10
National List Trials (Dept. of Agriculture, and Food)	Maincrop: 3 sites (Cork, Meath, and Kildare)	2

Seedling evaluation abroad

Seedling evaluation also took place for advanced seedlings in years 7-11 at a number of foreign trial sites in conjunction with Irish Potato marketing and foreign partners.

Table 2: Number of seedlings under field evaluation abroad 2007

Country	Partner	No of trials	Type of trial	Location	No of seedlings
United Kingdom	NIAB, Cambridge	1	Clonal	Lincolnshire	30
Canary Islands	PEP Ltd	1	Clonal	Moya, Las Palmas	34
Morocco	Marosem SA	2	Clonal	Soalem Ziane	32 68
Spain	PEP Ltd	1	Clonal	Seville	29
	PEP Ltd	1	Clonal	Valladolid	67
United Kingdom	NIAB, Cambridge	1	Breeders observation plots	Cambridge	5

Trial analysis

The Irish and foreign trials were treated as distinct experiments for analysis purposes. Although different seedlings were included in each experiment a core group of seedling that a were either in national list trials or under consideration for entry to NL trials were included at all sites so a balanced data set could be achieved for the purposes of cross trials analysis. This Group varied slightly between Irish and Foreign evaluation trials. The common seedlings to both experiments were as follows.

Mediterranean trials: Cara, Desiree, Spunta, Orla, Lady, Rosetta, T3039/38, T3302/3, T2208a31, T3401/18, T3536/2, T3537/2, T3588/17, T, 3637/2, T3747/10, T3747/13, T2345/1, T2516/15, T3634/37, T3653/9, T3731A5.

Irish trials:
Cara, Desiree, Lady, Claire, Maris, Piper, Orla, Rooster, T, 2208a31, T, 3039/38, T3302/3, T, 3401/18, T, 3537/2, T2345/1, T2350/64, T2516/15, T2592b22, T3588/17, T3634/37, T3650/34, T3653/9, T3747/10, T3747/13, T3854/20, T3854/3, T3868/12, T3868/21, T3961/64, T4069/22

Mediterranean Trial Results:

Table 3: Marketable yield results for twenty selected seedlings at five Mediterranean trial sites 2007

	Yield T ha^{-1}				
Variety	Seville	Soalem	Valladolid	Ziane	Canaries
Cara	24.4	73.6	38.9	43.8	145.8
Desiree	27.8	73	42.2	46.9	92.2
Spunta	37.7	88.6	42.2	57.1	96.4
Orla	10	77.4	44.4	32.7	69
Lady Rosetta	25.5	70.4	35.5	33.3	56.5
T 3039/38	5	69.2	52.7	51.8	81
T 3302/3	31.6	60.1	41.1	29.6	64.9
T 2208a31	40	81.1	40	37.6	77.3
T 3401/18	26.6	51.3	42.8	40.3	78
T 3536/2	18.3	73.2	53.3	53	84.5
T 3537/2	35.5	73.1	35	41	86.3
T3588/17	33.3	56.8	32.2	41.8	73.8
T 3637/2	41.1	74.4	35	44.3	87.5
T3747/10	31.6	76.6	47.7	38.9	97.6
T3747/13	31.6	82.2	47.7	44.9	86.3
T2345/1	30	69.2	35	42.4	60.7
T2516/15	29.4	69.5	32.2	37.4	102.4
T3634/37	41.6	69.1	43.3	32.1	75.6
T3653/9	33.9	75.4	38.9	39.9	105.9
T3731A5	46.1	84.7	48.3	58.9	89.3
LSD	19.15116	10.11995	13.21061	12.23846	23.19883

The yield data was subjected to analysis across sites using the additive main effects and multiplicative interaction (AMMI) model for a 2-way genotype by environment balanced set of data as outlined by Zobel, Wright, and Gauch (1988). The AMMI ANOVA indicated highly significant differences ($P<.001$) for genotypes, environments and genotype x environment interaction.

In the Ammi model Principal components analysis is conducted on the covariance matrix. In this case the model calculated four principal component axes of which only the first two were significant. The first PCA axes explained 61% of the variation and the first two cumulatively explained 84% of the variation. A plot of adjusted average yield of the sites and genotypes across the five sites against the first PCA axes scores are shown in Fig 1. The X axis represents the main effects of Yield for Genotypes and environment while multiplicative interactions are represented by the Y axis. In interpreting this graph, if a variety is very close to zero on the Y axis then it has small interaction effects. When a genotype and an environment have the same sign on the PCA axis the interaction is positive; if different the interaction is negative.

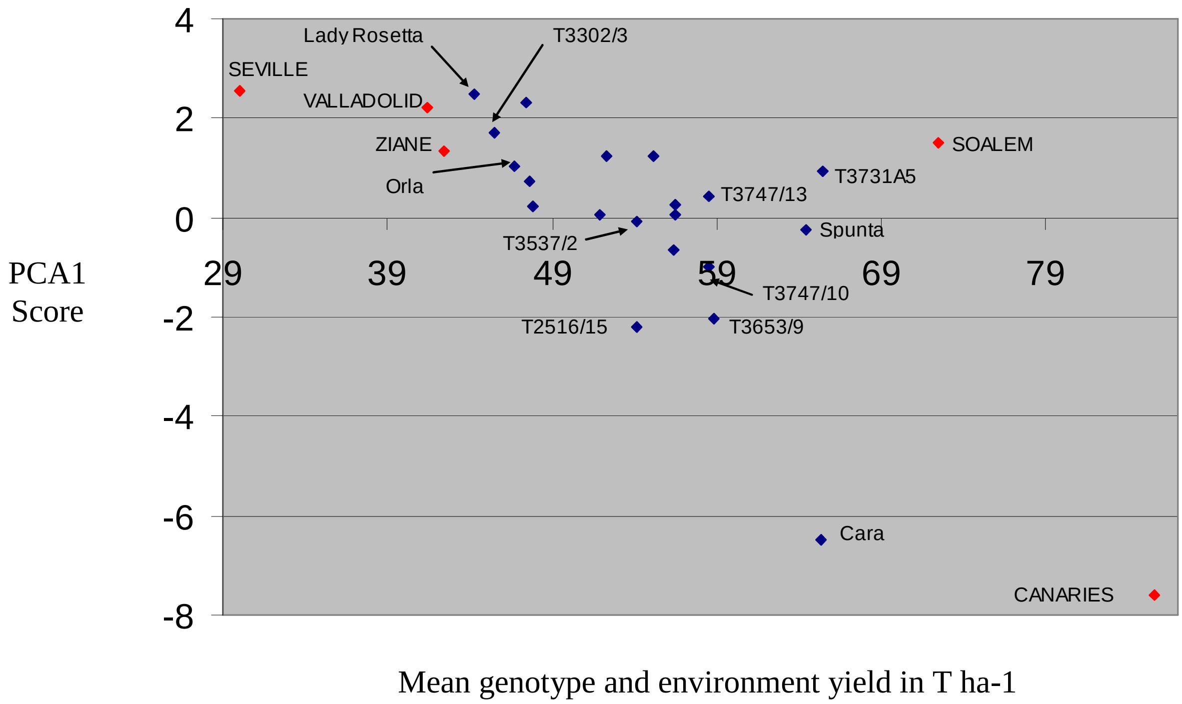

Fig.1. Bi-plot with X axis plotting trial and genotype mean yields (t/ha) and Y axis plotting PCA 1 scores. Trial means are shown in red and genotype means in blue. Selected controls and advanced seedlings are labelled.

The highest Yielding Seedlings in this trial series were Cara, T3731a5 and Spunta. Cara however was extremely variable across the sites showing a very large positive interaction with the Canaries site. This effect is noticed almost every year. Cara is the most extensively cultivated variety in the Canary Islands and is well adapted to local conditions there. Cara showed a large negative interaction with the three low yielding sites Seville,Valladolid and Ziane. T3731A5 and Spunta while also high yielding were much less affected by site and exhibited excellent yield stability. Seedling T3747/13 and T3537/2 which are both red seedlings currently in national list trials performed well with moderate yields but excellent yield stability across all sites.T3747/13 exhibited similar yield stability in 2006 trials. T3302/3 which is a high drymatter potato suitable for processing was generally low yielding, however this seedling is best compared to the control Lady Rosetta which was slightly less stable and also lower yielding.

Irish and UK yield trial results:

Four trials were conducted at sites in Louth Meath Carlow and Cork. One trial was also conducted in Lincolnshire in the UK. Marketable yield and % drymatter results for each of the seedlings are shown in Table 4 and 5.

Table 4: Marketable (45-85mm) yield results for selected seedlings at four Irish and one UK trial sites 2007

Variety	Cork	Louth	Meath	Oak Park	Lincolnshire
			Yield T ha^{-1}		
Cara	73.4	35.7	59	51.2	60.5
Desiree	64.8	37.9	48.7	40	43.5
Lady Claire	68.2	25.8	40.2	29.3	31.8
Maris Piper	70.2	50.9	67.2	56.4	42
Orla	84.6	40.1	59.9	48.1	43.5
Rooster	71	36.2	55.4	48.2	47.2
T2208a31	77.9	33.6	63.9	42.3	36.6
T3039/38	34.3	35.5	38.7	51.7	31.4
T3302/3	61.1	37.6	63.1	33.5	44.1
T3401/18	70.3	35.9	49	55	36.1
T3537/2	72.1	41.7	64.1	54	49.5
T2345/1	71.2	34.9	57.3	41.6	47.3
T2350/64	70.2	37.8	42.9	38.1	24.1
T2516/15	67.9	37.5	46.3	36.3	34.4
T2592b22	81.7	39.6	72.7	59.7	45.3
T3588/17	60.4	24.3	38.4	41.9	39.8
T3634/37	88	39.2	57.7	58.8	47.8
T3650/34	41.1	15.7	31.1	27.2	21.1
T3653/9	74.5	26.1	38.2	57.1	38.9
T3747/10	82.7	45.6	71.8	54.7	40.6
T3747/13	66.4	48.1	60.5	35.5	44.7
T3854/20	53.5	24.4	48.9	40.6	33.4
T3854/3	51.6	34.6	53.9	31.7	30.3
T3868/12	46.8	27.4	40.9	45.9	35.6
T3868/21	75.7	31.3	55.3	42.4	36.8
T3961/64	79.5	19	52	31.8	39.3
T4069/22	58.7	31.3	55.9	39.3	47.6
LSD	22.82	8.42	22.34	10.29	9.15

Table 5: Drymatter results for selected seedlings at four Irish and one UK trial sites 2007

Variety	Cork	Louth	Meath	Oak Park	Lincolnshire
			% Drymatter		
Cara	22.17	23.83	18.77	20.47	24.8
Desiree	21.1	26.07	20.1	21.27	23.45
Lady Claire	22.47	28.67	21.3	22.07	24.55
Maris Piper	26.03	27.77	19.73	23.3	26.25
Orla	19.37	22.43	16.93	18.33	21.6
Rooster	25.43	27.63	23.63	24.47	27.4
T 2208a31	19.2	21.87	18.3	21.17	20.8
T 3039/38	19.17	22.17	16.37	18.07	21.15
T 3302/3	26.23	30.13	24.7	26.4	27.55
T 3401/18	18.63	22.73	17.9	20.37	21.1
T 3537/2	21.33	23.13	18.47	20.53	22.25
T2345/1	21.3	24.47	18.73	22.13	22.95
T2350/64	20.83	25.37	19.1	19.83	26.2
T2516/15	23.9	27.53	20	22.97	27.75
T2592b22	24.4	25.93	20.63	23.33	25.3
T3588/17	18.7	24.3	19.27	22.4	24.25
T3634/37	16.2	21.9	16.17	17.13	21.3
T3650/34	20.53	24.43	20.03	21.43	23.7
T3653/9	20.33	23.07	19.33	19.77	22.15
T3747/10	20.23	24.83	18.83	20.63	24.3
T3747/13	19.77	23.53	18.87	19.13	20.75
T3854/20	17.47	21.77	17.23	17.77	21.05
T3854/3	18.33	23.53	18.1	19.87	22.6
T3868/12	17.8	23	17.93	19.63	21
T3868/21	19.43	24.43	19.37	20.73	22.2
T3961/64	19.77	22.53	16.5	18.6	20.1
T4069/22	19.97	25.93	19.13	20.53	24
LSD	1.90077	1.0493	1.8012	1.68163	1.9398

Again the data was subjected to analysis using the 2 way AMMI Model. Biplots of Yield and Drymatter are shown in Figure 2 and 3.

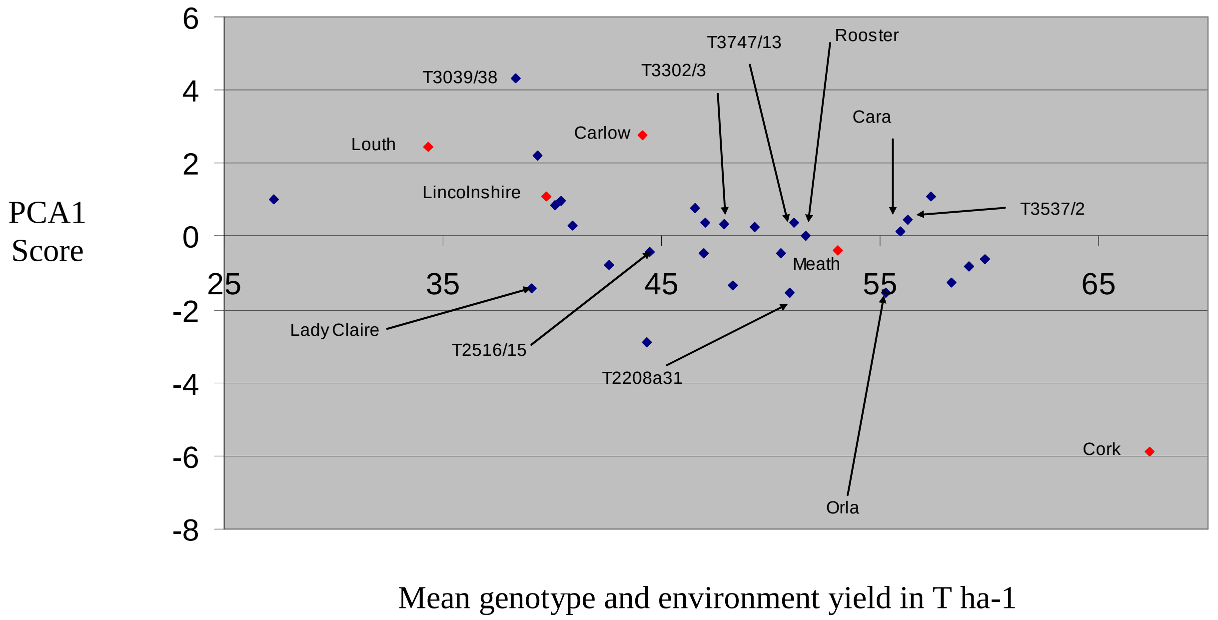

Fig.2. Bi-plot with X axis plotting adjusted trial and genotype mean yields (Marketable yield in T/ha) and y axis plotting PCA 1 score from AMMI analysis for four Irish sites and one UK site in 2007. Trial means are shown in red and genotype means in blue. Selected controls and advanced seedlings are identified.

The AMMI analysis indicated highly significant differences (P<.001) for genotypes, environments and genotype x environment interaction (GEI) The first principle component derived from the AMMI model explained 43.32% of the variation and the second PCA score explained a further 29%. Yield results were most variable at the Cork site where mean yields were also highest. The Meath site was the second highest yielding. Yields were quite low at the Louth site due to a heavy infection with powdery scab which allowed a good assessment for disease resistance to be made. Most advanced seedlings exhibited good yields but more importantly all exhibited excellent yield stability. Seedling T3039/38 was the most variable seedling in trials having been very stable in 2006. This was due to extreme susceptibility to rhizoctonia which manifested in this seedling at all sites. T3039/38 was subsequently withdrawn from national list trials. While Rooster was not one of the highest yielding seedlings due to its high drymatter content, it was extremely yield stable across the sites with almost zero interaction. This is a good example of a locally adapted variety being suitable to all regions in Ireland. Seedling T3537/2 was one of the highest yielding seedlings, and was also extremely stable across sites. Seedling T3302/3 which is under consideration for crisping was much higher yielding than the most comparable control Lady Claire.

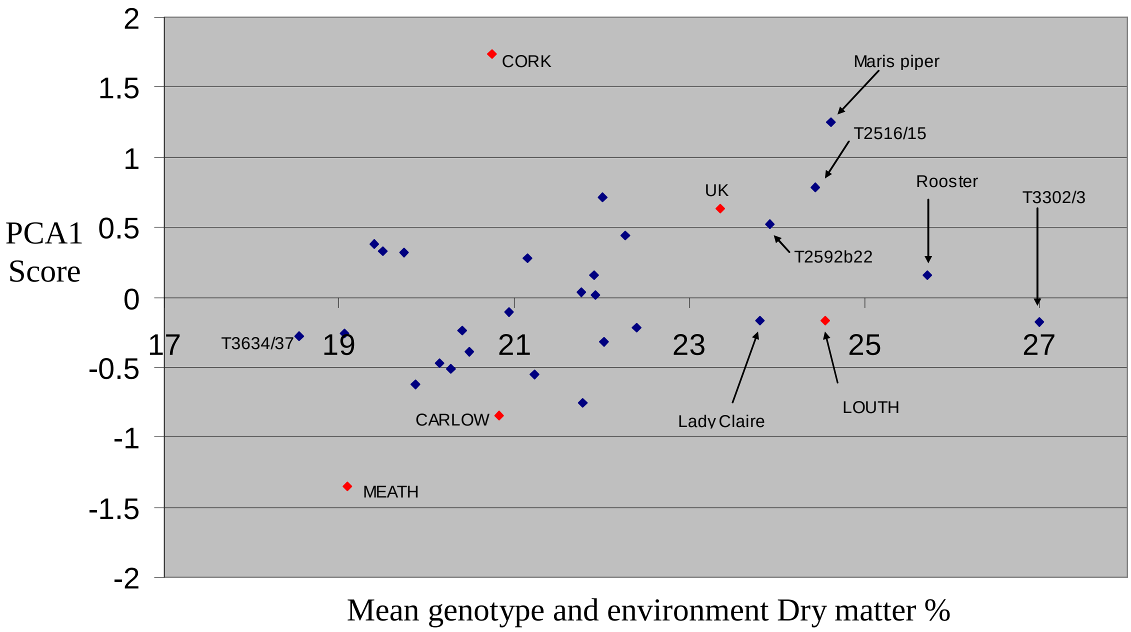

Fig. 3. Bi-plot with X axis plotting trial and genotype mean Drymatter and Y axis plotting PCA 1 scores for 27 potato varieties/seedlings at four Irish and one UK trial sites in 2007. Trial means are shown in red and genotype means in blue. Selected controls and advanced seedlings are identified.

The AMMI ANOVA for dry matter indicated highly significant differences (P<.001) for environment, genotype and genotype by environment interaction. Variance components (%) of the sum of squares were 44% for genotypes 40% for environment but only 7 % for Genotype by environment interaction (GEI). This indicates that an individual genotypes dry matter rank within a trial is highly heritable and largely independent of environment. 40% of the variation was accounted for by the first principal component and a further 34% by the second component. Highest drymatter was achieved at the Louth and UK sites where yield was lowest while drymatter was low at the Meath site where yield was very high. Seedling T3302/3 had the highest drymatter in the trials and was very stable across sites. Lady Claire which is the commercial standard for crisping had considerably lower drymatter results, both seedlings were site stable. T3302/3 is under consideration for crisping and the stable high drymatter would be of great benefit in this sector. Lady Claire had slightly better fry colours (results not shown). Rooster and Maris Piper ranked next with Rooster being most stable. Seedling T2516/15 had quite high drymatter also and was similar to Maris piper. This seedling may be suitable for general ware and French fry production with high dry matter being of benefit in this sector. T3634/37 was the lowest drymatter in the trials at approximately 18.5%.

National List and DUS Trials

Seedling T3302/3 completed national list trials in 2007 and will be added to the Irish national list in 2008. T3747/13 was entered for NL2 trials in 2008 after performing well in NL1 trials 2007. Three new seedlings were proposed for NL1 trials in 2008. These were T3537/2, T2516/15 and T2208a31 (early Trials). These advanced seedlings are described below.

T3302/3 Is an early maincrop deep red variety. Flesh colour is light yellow. The variety is low to moderate yielding but has extremely high dry matter and good fry colours. The variety should be suitable for the production of crisps and was consistently higher yielding than the control Lady Claire which is the commercial standard. The variety gives similar fry colours.

T 3747/13 is a high yielding early maincrop variety. Skin finish is excellent and the variety has a very deep red skin with white flesh. The seedling is suitable for prepacking for fresh consumption.

T2516/15 is a maincrop variety with white skin. Skin finish is excellent and tuber shape is long oval. The variety has moderate tuber size but has high dry matter and excellent eating quality. It may be suitable for French fry production.

T3537/2 is a deep red skinned round variety with maincrop maturity. Skin finish is excellent. The variety has moderate dry mater levels and a deep yellow flesh. Yield is excellent and the variety is highly resistant to a range of diseases including Late Blight.

T2208a31 is a white skinned white fleshed first early variety. It is very high yielding and has the potential to be grown as an early maincrop. Tuber shape and uniformity are excellent.

Grants of Plant Breeders rights

Seedlings T2704/1 and T2637/12 received their Irish Grant of plant breeders' rights and were named Electra and Romeo respectively. Both seedlings should receive a grant of European plant breeders' rights in 2008.

The production of virus tested seed stocks of new potato seedlings

The objective of this programme is to ensure that an adequate quantity of virus tested seed is available for multiplication under the Seed Certification Scheme when a new potato variety is recommended for release. It is also designed to produce high quality seed for the commercial evaluation of seedlings at home and abroad.

The production of virus-tested stocks of new potato seedlings was continued at the isolation centre in Co. Wicklow during 2007. This covered an area of approximately 10 ha and was made up of plots varying in size from single-plant plots to 1,500-plant plots. Virus testing and seed distribution was similar to previous years.

During the winter, samples of all clones are tested for virus infection using the ELISA technique. All infected clones were discarded. All advanced clones are also tested for the presence of potato spindle tuber viroid (PSTV) using the nucleic spot hybridisation test and for ring-rot and brown rot using the immuno-flourescent technique.

During the growing season a total of 91,945 plants were sampled from 3,117 clones representing 3,032 seedlings. This material was subjected to 30,075 serological tests using the ELISA technique. Visual examinations were also carried out at weekly intervals. A total of 655 clones were infected with PVY, 1 clone infected with PVS and 8 clones infected with PVX. The presence of PVA, PVM or PLRV was not detected in any of the clones tested. This represents a significant increase in infection with the aphid transmitted virus PVY compared with previous years despite a more remote isolation centre and more stringent entry standards. All infected clones were discarded from the propagation programme.

The produce of selected seedlings were sent for trial to 8 countries while the remainder were used for further propagation, disease resistance screening and demonstration.

Meristem-tip culture and micro-propagation

During 2007 meristem-tip cultures of 4 advanced seedlings (T3537/2, T3588/17, T3637/2 and T2345/1) was handed over to the Department of Agriculture and Food for micro-propagation under the Irish Seed Potato Certification Scheme. Following confirmation of the health status, this material is also forwarded to Scotland for multiplication under the Scottish Seed Certification Scheme.

Disease resistance in new potato varieties

Disease resistance is an important objective of the potato-breeding programme and all advanced seedlings are tested for resistance to a wide range of commonly occurring diseases. Using standard laboratory and field techniques, testing commences when seedlings have completed their seventh year of propagation, and continues until a seedling is discarded or released as a new variety. During 2007 seedlings were tested for resistance to wart disease (Synchytrium endobioticum), foliage and tuber blight (Phytophthora infestans), common scab (Streptomyces scabies), dry-rot (Fusarium caeruleum and F. sulphureum), gangrene (Phoma exigua var. foveata), Rhizoctonia (Rhizoctonia solani), potato virus X (PVX) and potato virus Y (PVY). Many of the new seedlings were found to possess high levels of disease resistance and could make a significant contribution to reducing disease losses and decreasing pesticide use in potato production.

During 2007, 29 seedlings were tested for field resistance to wart disease (S. endobioticum) and only 5 were found to be susceptible. Seven advanced seedlings were also subjected to laboratory tests for resistance to wart disease. Of these, 1 exhibited the RG1 reaction and 2 exhibited the RG2 reaction while 4 seedling was considered susceptible.

Testing for resistance to foliage blight (Phytophthora infestans) confirmed that the most resistant seedling was T3537/2 (6), however, all seedlings tested were more susceptible than European standard resistant cultivars, Cara and Robijn. Nine of the advanced seedlings (T3653/9, T2592b22, T3717/28, T3954/51, T3961/64,T3983/1, T3634/37 and T4062/22) showed very high levels of resistance to tuber blight.

The seedlings T3302/3, T3537/2, T3747/13, T3634/37, T3854/20, T3868/21, T3954/51, and T3983/1 were highly resistant to dry rot (F. caeruleum and sulphureum) but the remaining seedlings were all susceptible to highly susceptible. Only one seedling (T2516/15) showed good resistance to gangrene (P. foveata), while most seedlings showed moderate to high levels of resistance to common scab (*S. scabies*). All seedlings tested were highly susceptible to infection with PVY.

It can be concluded from these results, that with the possible exception of gangrene and PVY, all advanced seedlings show moderate to high levels of disease resistance and this should give these seedlings a distinct commercial advantage.

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Feasibility of Production and Combustion of Pellets from Straw and Energy Crops

Finnan, J., Carroll, J., Frohlich, A. and Brett, P. ***RMIS No. 5613***

Funded by the Department of Agriculture Stimulus fund

The use of pellets from sawdust for home heating in Ireland is expanding rapidly. Sawdust has many advantages for pellet production, but its supply is limited and other feedstocks will soon be needed. Short-rotation willow, miscanthus, rape straw and cereal straws are all alternatives of interest to Irish farmers. Pelleting these materials, increases bulk density, which should make them suitable for use in a wide range of biomass boilers and stoves.

In this project begun in Oct 2006, pellets are currently being made from a range of energy crops, cereal and rape straws. The pelletability of these materials and the suitability of the pellets as boiler and stove fuels is being examined. To date research has focussed mainly on the energy crop, miscanthus. Pellets have been produced under varying conditions of moisture content, feed rate, oil addition, and water addition and the samples produced have been tested and compared to the standard wood pellets. The results are shown in Table 1.

Table 1: Pellet Characteristics

		Miscanthus	Wood	Significant
Moisture Content (%)	Mean	11.39	8.13	*
	s.d	1.74	2.21	
Density (kg/m^3)	Mean	695	770	N.S.
	s.d	95	45	
Calorific Value (MJ/kg)	Mean	20.34	20.29	N.S
	s.d	0.45	0.18	
Durability (%)	Mean	95.54	98.06	N.S.
	s.d.	2.06	0.82	
Chlorine Content (%)	Mean	0.101	0.036	*
	s.d.	0.011	0.004	
Ash Content (%)	Mean	2.112	0.716	
	s.d	0.171	0.168	

These results indicate that miscanthus can be used successfully as a feedstock for pellet production. The bulk density and calorific value of miscanthus pellets compared very favourably with those of wood pellets. The increased moisture contents in miscanthus pellets necessitate alternative handling and storage methods. The occurrence of higher ash contents in miscanthus pellets requires automatic ash scraping and removal systems. The presence of high corrosive chlorine contents in miscanthus necessitates further developments in boiler and flue manufacture. Pelleting and testing of rape and cereal straws is ongoing and further testing, along with combustion trials will commence shortly.

Energy Crops and Bio-Remediation

Finnan, J., Rice, B., Ryan, D., Frohlich, A. and Galbally, P. ***RMIS No. 5543***

This project is funded by the Department of Agriculture Research Stimulus Fund. The project was initiated in 2006; there are a number of sub-projects.

Use of Energy Crops for Effluent Disposal
Restrictions on spreading industrial and municipal waste on food crops presents an opportunity to energy crop growers who can attract additional income by offering their non-food crops for such uses. However, waste application introduces additional risk of nutrient loss and heavy metal contamination. The objective of this sub-project is to monitor nutrient losses and soil and water contamination after waste application to energy crops.

Two Miscanthus sites, each with three plots (42*28m) were used for disposal of waste materials during 2007. Biosolids were applied to one site using a modified disc spreader at rates of 0, 10 and 18 t/ha on control, medium and high application treatments respectively. An irrigation system was established at the second site, the system was used to apply silage effluent to the Miscanthus. Boreholes in the centre of each plot and nylon pipes were installed to give access to the underlying groundwater for sampling. Overland flow was monitored using collection channels, excavated by plough around the boundary of each site, and electronic monitors which recorded the time and duration of flow.

Willow Chip Drying
Willows at harvest contain in excess of 50% moisture. Consequently, willow chips need to be dried to ensure safe storage and to render the chips suitable for combustion in a range of boilers. Purpose built drying systems are expensive both in terms of capital and operating cost and are unavailable to most farmers. Consequently, work on a low cost willow chip drying system began in 2006. Two willow chip ventilation trials were carried out in 2007, at Oak Park and at a farm near Grangecon, Co. Wicklow. The storage pile at Oak Park was constructed from ordinary wooden pallets and measured 5.5m wide, 7m in length and 2m in height (Fig 1).

The pile was ventilated using a 375mm axial fan blowing through a similar sized perforated tube on the floor of the storage pile. The pile at Grangecon was larger in dimension (7.5m wide, 12m long and 3m high) and was constructed using large square bales. Two fans and ducts of the same size as used in the Oak Park trial were used for ventilation. 25 tonnes of willow chips were loaded into the Oak Park pile on April 10 while 80 tonnes of chips were loaded into the Grangecon trial on April 4th. Both piles had an initial moisture content of 53% and were covered with polythene. The piles were ventilated for 12 hours a day between 8.00 am and 8.00 pm. The Oak Park trial was ventilated until August 23rd while ventilation in the Grangecon trial continued until August 28th. The results of both trials are presented in Table 1.

Table 1: Drying Trial Results

	Oak Park	Grangecon
Initial Moisture Content (%)	53	53
Final Moisture Content (%)	16	20.4
Dry Matter Loss (% DM)	4.6	11.7
Power Consumed (KWh per tonne DM)	124	104
Ventilation rate (m^3/hr per tonne DM)	307	182

The trial results have demonstrated that it is possible to construct a simple, low-cost drying system for willow chips capable of drying chips to a moisture content <20% over a four-five month period. The chips can then be sold off the farm to supply the winter heat market. The trial results are suggesting that ventilation rates close to those in the Oak Park trials need to be provided to achieve complete drying of the stack with low dry matter loss.

Miscanthus Boiler

Two boilers capable of burning Miscanthus were commissioned at Oak Park during 2007. Initial trial results have shown that Miscanthus for combustion should have high bulk density (>100kg/m3). Miscanthus with lower bulk densities (lighter biomass) does not tend to burn very well on the grate, the lighter material being pushed up the flue by the airflow leading to higher particulate emissions. Additionally Miscanthus with lower bulk densities tends to bridge over the feed auger restricting supply to the combustion chamber.

The Use of Arable Energy Crops and Straw as Heating Fuels

Finnan, J., Rice, B, Keppel, A and Brett, P ***RMIS No. 5377***

The purpose of this work is to evaluate a number of crops as heating fuels for biomass boilers. Work concentrated on the measurement of fuel properties of a range of biomass materials, combustion trials were also conducted.

Work continued during 2007, the principal focus was a further examination of the combustion properties of cereal grains and straws. The research also focused on an examination of the combustion characteristics of pelleted fuels in comparison with their parent material. Parameters investigated included heat release, activation energy, peak temperature, char burn-out temperature in addition to the effect of porosity on combustion. Thermogravimetric and differential thermal analysis techniques were used to replicate the combustion process. Mercury prosimetry was used to determine the porosity of samples.

Initial findings have demonstrated reductions in heat release from pelleted materials compared to their, un-pelleted, parent material (Figure 1).

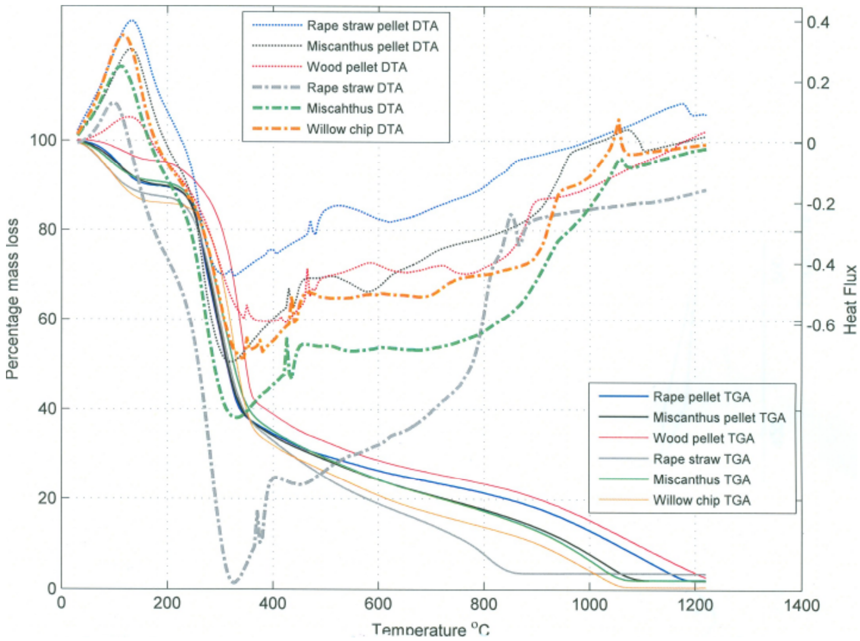

Fig .1. Mass loss and heat flux during biomass combustion.

Breeding Improved Varieties of Perennial Ryegrass

Conaghan P ***RMIS No. 4758***

Grassland is the primary resource for almost all our agricultural output. About 90% of the farmed land in the country is devoted to grassland. The competitiveness of Irish agriculture is based on grassland providing a cheap and high quality feed source. While sward composition, especially for old pastures, is often complex, perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens*) are the key components of the most productive pastures. Genetic improvement of these species by breeding cultivars with superior yields of quality forage over a long grazing season provides a cost effective mechanism to increase the profitability and reduce the environmental cost of animal production from grassland.

The principal objectives of the grass breeding programme are to breed superior diploid and tetraploid perennial ryegrass cultivars with:

- Greater forage yield in spring and autumn
- Increased total annual forage yield
- Greater persistency
- Improved sward density
- Reduced stem in the aftermath regrowth
- Higher quality
- Better disease resistance

The selection procedure is based on full-sib progeny tests under sward conditions and is designed to bring the families under selection to the field plot stage as early as possible. Full-sib families derived from pair-crosses do not give enough seed for sowing plots. Each family is multiplied in isolation to give enough seed for such field trials. Field evaluation requires a minimum of 3 years, sowing year plus two harvest years. Selection is based on two cutting management regimes: frequent (8 harvests/year) and infrequent (4 harvests/year) cutting. Rust resistance is assessed in France. The superior families are used to form new cultivars (synthetics). The newly created cultivars are evaluated at Oak Park and at several sites throughout Europe. Cultivars which show excellent performance are submitted to National List Trials in the appropriate countries.

In 2007, one new cultivar was awarded Recommended Listing and another two cultivars were awarded National Listing:

JANUARY (Breeder's reference R960342ED) – Early diploid *Lolium perenne* L. cultivar. *Recommended List Award.* England and Wales (NIAB) Recommended List 2007/08.

GIANT (Breeder's reference R970349) – Early tetraploid *Lolium perenne* L. cultivar. *National List Award.* Germany, 31 May 2007.

KINTYRE (Breeder's reference R970354LT) – Late tetraploid *Lolium perenne* L. cultivar. *National List Award.* United Kingdom, 19 March 2007.

In addition, seven grants of Plant Breeders' Rights were awarded to the following new cultivars:

JANUARY (Breeder's reference R960342ED) – Early diploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders' Rights.* United Kingdom, Grant no. 7927, 1 December 2007.

KINTYRE (Breeder’s reference R970354LT) – Late tetraploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders’ Rights.* United Kingdom, Grant no. 7928, 1 December 2007.

GALTEE (Breeder’s reference R970343ED) – Early diploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders’ Rights.* United Kingdom, Grant no. 7920, 19 October 2007.

GLENCAR (Breeder’s reference RCOF54/82) – Late tetraploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders’ Rights.* Ireland, Grant no. 396, 15 March 2007.

SHANDON (Breeder’s reference R88/40374) – Intermediate diploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders’ Rights.* Ireland, Grant no. 397, 15 March 2007.

BARROW (Breeder’s reference R950359LT) – Late tetraploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders’ Rights.* United Kingdom, Grant no. 7893, 19 January 2007.

BRANDON (Breeder’s reference R950371LD) – Late diploid *Lolium perenne* L. cultivar. *Grant of Plant Breeders’ Rights.* United Kingdom, Grant no. 7892, 19 January 2007.

To date the Teagasc grass breeding programme has bred, commercialised and released 13 new perennial ryegrass cultivars. Summary details are as follows:

Cultivar	Ploidy	Maturity group
CASHEL	Diploid	Intermediate
GIANT	Tetraploid	Intermediate
GLENCAR	Tetraploid	Late
GLENSTAL	Tetraploid	Intermediate
GREENGOLD	Tetraploid	Intermediate
GREENISLE	Tetraploid	Early
JANUARY	Diploid	Early
MAGICIAN	Tetraploid	Intermediate
MILLENNIUM	Tetraploid	Late
OAKPARK	Diploid	Early
SARSFIELD	Tetraploid	Late
SHANDON	Diploid	Intermediate
ULYSSES	Tetraploid	Late

An additional 17 cultivars are currently under test by governmental agencies such as the Department of Agriculture, Fisheries and Food in Ireland.

Breeding Improved Varieties of White clover

Conaghan P. ***RMIS No. 4755***

White clover (*Trifolium repens*) benefits grassland agriculture through its ability to fix nitrogen, its high nutritive value, its seasonal complementarity with grass, and its ability to improve animal feed intake and utilisation rates. Therefore, including white clover in the sward tends to build and maintain soil fertility, improve individual animal performance and reduce production costs. Cultivars that are persistent, high yielding and adapted to a range of managements are required to underpin the exploitation of good grass/clover production systems.

The principal objectives of the white clover breeding programme are to breed superior varieties of small, medium and large leaf size with:

- Greater persistency
- Increased total annual yield
- Improved seasonal yield in spring and autumn
- Higher stolon density
- Better disease/pest resistance
- Good seed production

The selection procedure is based on full-sib progeny tests in mixed grass/clover swards. The system is designed to bring the families under selection to the field plot stage as early as possible in the selection programme.

The families are evaluated under three managements:

1. Yield assessment in competition with grass,
2. Persistence measurement in competition with grass,
3. Seed yield potential in clover plots only.

Separate trials must be established for each management. The superior families are used to form new cultivars (synthetics). The superior families are used to form new cultivars (synthetics). The newly created cultivars are evaluated at Oak Park and at several sites throughout Europe. Cultivars which show excellent performance are submitted to National List Trials in the appropriate countries.

In 2007, one new cultivar was granted Plant Breeders' Rights:

CHIEFTAIN (Breeder's reference H27/006) – Medium leaf *Trifolium repens* cultivar. *Grant of Plant Breeders' Rights.* Ireland, Grant no. 398, 15 March 2007.

To date the Teagasc clover breeding programme has bred, commercialised and released 8 new white cultivars. Summary details are as follows:

Cultivar	Leaf size
ARAN	Very large
AVOCA	Medium
CHIEFTAIN	Medium
GALWAY	Small
PIROUETTE	Small
SUSI	Medium
TARA	Small
ARAN	Large

An additional six cultivars are currently under test by governmental agencies such as the Department of Agriculture, Fisheries and Food in Ireland.

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