

Research Stimulus Fund

Final Report

Cereal Improvement through Variety choice and understanding Yield Limitations (CIVYL)

DAFM Project Reference No: 11/S/121

Start date: 01/12/11

End Date: 31/08/17

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Collaborating Research Institutions and Researchers:

UCD - Fiona Doohan

AFBI - Ethel White & Lisa Black

Teagasc - Ewen Mullins & Joseph Lynch

Please place one "x" below in the appropriate area on the research continuum where you feel this project fits

Basic/Fundamental		→	Applied		→	Pre Commercial	
1	2	3	4	5	6 X	7	

Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	Sustainable Food Production and Processing
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Key words: (max 4)

Wheat, Barley, Yield, Septoria

1. Rationale for Undertaking the Research

This section should outline the rationale for carrying out the research and identify the need / problem to be addressed

It has been suggested that Ireland has a climate that bestows a very high yield potential for cereal crops (e.g. Sylvester- Bradley et al. 2005) and achieves the highest average wheat yields in the world at 8.80 t/ha over the period 1998-2007 (Spink, 2010). Using the same approach as Sylvester-Bradley et al. (2005) the potential wheat grain yield in South east Ireland is estimated to be 21 tdm/ha or a green yield of 25.2 t/ha, nearly 3 times the yield currently being achieved, although this accounts only for solar radiation, not soil type and precipitation.

The structure of the farming industry and climate gives Ireland a high cost of production of cereals, exploitation of the high yield potential to minimise the cost/t is critical to remain competitive. A detailed knowledge of crop growth and development in any given environment is the first step to understanding yield formation and how yield is being restricted.

Winter wheat and spring barley are the 2 most important tillage crops in Ireland, yet there has been no domestic breeding of varieties of either for some decades. Tillage farmers are reliant on the import and testing of varieties from overseas breeding programmes primarily the UK but also other north western European countries. The primary test for a variety's suitability is yield and a variety can be added to the recommended list after 3 years of testing. Climatic conditions in Ireland differ considerably from the East of England and Europe where the breeding programmes are based, thus the relative importance of agronomic characteristics differs significantly from the areas where initial selections are based. A knowledge of the economic importance of varietal characteristics could be utilised to select varieties or lines earlier in the breeding cycle that are likely to be well suited to Ireland.

Septoria tritici blotch (STB) resistance is known to be a key trait for wheat grown in Ireland due to the high disease pressure. However, it is also known that the severity of foliar symptoms is a poor indicator of the likely yield loss due to disease. For example, in work by Parker et al (2004) the yield loss due to disease was demonstrated by taking the average yield loss in t/ha over 5 experiments of 4 example varieties and compared to *Septoria* resistance ratings (in brackets); Avalon (4) 1.04, Norman (4) 1.90, Flame (7) 1.11 and Hunter (7) 1.60. Similar inconsistencies between disease ratings and yield response to fungicides have also been observed in barley. A primary goal of this project is therefore to test if there are better ways of assessing the susceptibility of wheat and barley varieties to yield loss due to disease and feed the information back into the evaluation system as well as to breeders with a view to producing varieties better suited to Ireland.

2. Research Approach

Specify the research methodologies employed, emphasising novel techniques and also outline any modifications from the original approved project proposal

Understanding crop growth and yield formation in Irish conditions was approached by developing models of crop growth and development for spring barley and winter wheat. In the case of spring barley, it was developed using data from detailed monitoring funded by Teagasc in a separate project and in the case of wheat the data was generated within this project. These models were used to identify periods of crop growth most limiting to yield and run using spatial weather data to understand variation in yield potential across the country.

Understanding variation in variety performance was first approached by developing a data base of variety trials across the UK and Ireland utilising AHDB, DAFM, AFBI and commercial variety trial results

from 2007 to 2015. The format of the data depended on the data source with significant variation between the organisations contributing to the database in the characteristics assessed, their definitions and the units etc. used in assessment. There were also considerable differences between organisations in the design of the field trials (eg size of plots, numbers of replicates, timing of assessments, statistical design) and in the specific characteristics and range of diseases recorded. A large degree of data scrutiny was required to maximise the alignment and resolution of the component databases, with changes over time in each component database also adding complication. A number of statistical techniques for working with multi-variate data were considered and investigated. Finally, the use of the 'yield penalty' was adopted allowing the value of individual characteristics to be determined. Grower surveys were conducted at Crop/Tillage conferences to ascertain the importance growers attached to the information on variety characteristics. The value of some individual agronomic traits was estimated in variety by input interaction experiments measuring the differential response of varieties with a range of agronomic characteristics such as disease resistance.

Dissection of *septoria* resistance to better understand resistance mechanisms started with screening a wide range of varieties for resistance in the glasshouse, a selection of these varieties were then screened using natural *septoria* epidemics in the field at 3 sites ranging from high to low *septoria* pressure; Waterford, Carlow and Norwich, UK respectively.

Identification of genes important in determining *septoria* resistance was initially investigated using microarray analysis during *septoria* infection. The expression of these genes was subsequently validated by qPCR and Virus Induced Gene Silencing (VIGS).

3. Research Achievements/Results

Outline main results achieved

Analysis of yield development of winter wheat indicated that variation in yield correlated more with grains/m² than the size of the individual grains. However, as no relationship was observed between maximum shoots/m² and final shoots/m², it can be concluded that high rates of tillering are not as beneficial to the yield of winter wheat in Ireland as they are in spring barley.

A validated model was developed for winter wheat which calculated that water-limited yield potential, using currently available varieties, ranged between 15.6 and 17.9 t/ha based on 30 year average weather data. This confirms that the majority of sites have the potential to grow high yields of cereals provided adequate soil conditions and topography are available.

The variety database indicated that: *Septoria* was the most serious disease of winter wheat on the island of Ireland whilst yellow rust was most prevalent in Great Britain. *Rhynchosporium* was the most serious disease on spring barley across the UK and Ireland with net blotch being prevalent in DAFM but less so in AFBI trials. Calculating resistance ratings for the winter wheat varieties for all three trial series (Ireland, NI and GB) enabled the yield penalty to be converted to a financial penalty. At a grain price of £ / € 150 per tonne varieties with a rating of 8 had a potential financial penalty of between £ / € 200-300 /ha across all three trial series. However, varieties with a resistance rating of 4 had a potential financial penalty of around £ / € 500 /ha in the Ireland and NI trial series compared to c. £ / € 350/ha in the GB trial series.

With the exception of Ramularia in the Irish trial series, disease incidence and severity was very weakly associated with yield penalty in spring barley varieties in all three trial series.

To further investigate the value of variety traits, trials evaluated the response of winter wheat and spring barley varieties differing in rankings to characteristics of interest (i.e. disease and lodging resistance) to related crop inputs. For *Septoria* tritici blotch, the findings indicated that varieties ranked

higher for *Septoria* resistance (within the commercially available range) didn't always confer a lower proportionate loss of yield when fungicides were applied, and no currently available varieties conferred a level of resistance that allowed for a reduced intensity in fungicide program. Spring barley varieties that differed in *Rhynchosporium* resistance generally had similar responses to fungicide application rates, with a high level of plant protection achieved at rates <60% in most cases. For spring barley, higher yield losses were observed in seasons with high lodging pressure for varieties that had a medium-low rating. This highlighted the potential benefit to final yield and crop quality in selecting more resistant varieties for high risk sites and emphasises the high importance of the recommended list trails and publications. *Rhynchosporium*

The *septoria* latent period (LP) is the length of time it takes from exposure of the leaf surface to *septoria* spores and the appearance of visible lesions (*Septoria tritici* blotch (STB)). Using a set number of STB isolates, the diversity in LP was recorded between a collection of winter wheat varieties. Based on glasshouse studies, delayed LPs significantly decreased the rate of disease progression, with a synthetic hexaploid wheat variety supporting an LP of up to 35 days, compared to ~20 days for the more susceptible varieties. The findings were further validated at three separate locations; Co. Waterford, Co. Carlow, and Norwich UK. These represent areas of high, medium and low STB disease pressure. Completed over two seasons (2013–2015) with commercially grown cultivars, the potential of the LP in stalling STB epidemics was significant as identified with cv. Stigg, whose high level of partial resistance was characterized by a lengthened LP (c. 36 days) at all three locations but in particular under the high disease pressure environment of Waterford. To conclude, this work highlighted the agronomic significance of the LP in supporting strong partial resistance against STB.

The genetic response of wheat cultivars during the *M. graminicola* latent period was investigated using Microarray analysis and complimentary RNAseq studies to identify genes associated with both the susceptible and resistant wheat response to STB disease. The results were validated for specific genes of interest using gene-specific quantitative expression studies. Thereafter, gene silencing studies were conducted and validated that specific genes enhanced wheat resistance to STB disease. Overall this work identified the pathways involved in both the resistant and susceptible wheat response to STB disease and identified novel disease resistance genes of interest to breeders.

4. Impact of the Research

4(a) Summary of Research Outcomes

(i) Collaborative links developed during this research

An industry and research network named the Irish Cereals Improvement Network (ICIN) was successfully developed during the course of this project. This network has involved in excess of 50 members to date and has included representatives from seed merchants, plant breeders, researchers, plant protection product merchants, farm advisors/consultants, farm organisations and regulatory bodies. The network has met on an annual basis since 2014 and has continued beyond the lifetime of this project. At these meetings results from trials are disseminated rapidly and discussed with the members to understand fully the value and potential impact of the findings. In addition, meeting discussion allows for a more targeted research strategy for future work, both from national research bodies and the industry.

The AFBI Crossnacreevy cereal variety team strengthened their collaborative links with the DAFM cereal variety evaluation team at Backweston during the course of the project.

(ii) Outcomes where new products, technologies and processes were developed and/or adopted

The development of models that allow for the estimation of yield potential of spring barley and winter wheat in different growing seasons may allow for increased availability of information to growers on the potential to improve yield further based on the weather data for their region. Growers that are operating close to their maximum yield potential are more likely to gain increased profitability from reducing inefficient input costs than investing further in additional inputs.

The genetic studies identified target pathways and genes of interest to breeders as markers for breeding wheat with enhanced disease resistance. The studies on the LP, have highlighted processes in phenotyping that could lead to the identification of sources of strong partial resistance to STB in the field.

(iii) Outcomes with economic potential

'Yield penalty', the difference between yields of varieties in 'treated' and untreated' trial series is confirmed as a very important indicator of the sum total of the relative benefits delivered by the agronomic characteristics of varieties. Providing information on yield penalty would enable growers to assess the likely financial benefit from applying fungicides and plant growth regulators. Conversely, yield penalty also indicates the risk of financial loss where varieties are more susceptible to diseases and lodging if control is not appropriate and timely.

(iv) Outcomes with national/ policy/social/environmental potential

The observation of that varieties ranked higher for *Septoria* resistance do not always confer a lower proportionate loss of yield when fungicides are applied at sub-optimum rates highlights that untreated yields would be a valuable addition to the current data presented to farmers and industry in the recommended variety lists.

The observation that varieties that are ranked higher for lodging resistance incur lower yield loss in seasons of high lodging pressure emphasise the importance of growers using the valuable recommended list data that is currently available to them to minimise risk.

The introduction of a 'yield penalty' characteristic to variety information provided in the DAFM Recommended List would help growers to manage cereal crops more sustainably by using fungicides and plant growth regulators more sustainably. With varieties with a smaller yield penalty, i.e. with a lower risk of yield and financial loss, fungicides could be judiciously used, so reducing costs. Ideally this would be combined with tools either predicting and/or monitoring real-time within-crop disease development so that the actual disease risks are known.

The identification of the genetic determinants of STB resistance will assist breeders in developing disease resistant wheat varieties and thus contribute to low input agriculture.

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.

JOSEPH P. LYNCH DEIRDRE DOYLE SHAUNA MCAULEY FIONA MCHARDY QUENTIN DANNEELS LISA C. BLACK ETHEL M. WHITE & JOHN SPINK (2017) The impact of variation in grain number and individual grain weight on winter wheat yield in the high yield potential environment of Ireland. *European Journal of Agronomy* 87, 40-49.

LYNCH, JP; GLYNN, E; KILDEA, S AND SPINK, J (2017) Yield and optimum fungicide dose rates for winter wheat (*Triticum aestivum* L.) varieties with contrasting ratings for resistance to *septoria* tritici blotch. *FIELD CROPS RESEARCH*. 204, 89-100.

J.P. LYNCH, R. FEALY, D. DOYLE, L. BLACK & J. SPINK (2017) Assessment of water-limited winter wheat yield potential at spatially contrasting sites in Ireland using a simple growth and development model. *Irish Journal of Agriculture and Food Research* DOI: <https://doi.org/10.1515/ijafr-2017-0007>

JAMES GERARD HEHIR, CLIONA CONNOLLY, AOIFE O'DRISCOLL, JOSEPH P. LYNCH, JOHN SPINK, JAMES K.M. BROWN, FIONA DOOHAN AND EWEN MULLINS. (2017) Temporal and spatial field evaluations highlight the importance of the pre-symptomatic phase in supporting strong partial resistance in *Triticum aestivum* against *Zymoseptoria tritici*. *Plant pathology*, DOI: 10.1111/ppa.12780

BRENNAN, CIARAN J., BENBOW, HARRIET R., Mullins, EWEN AND DOOHAN, FIONA M. (2019) A review of the known unknowns in the early stages of *septoria* tritici blotch disease of wheat. *Plant pathology* <https://doi.org/10.1111/ppa.13077>

(ii) Popular non-scientific publications and abstracts including those presented at conferences

JOSEPH LYNCH, ELIZABETH GLYNN, STEVEN KILDEA and JOHN SPINK (2016) Yield and optimum fungicide dose rates of winter wheat varieties with contrasting resistance to *Septoria* tritici blotch – European Society of Agronomy, 5-8 September, Edinburgh, UK.

JOSEPH LYNCH, JOHN SPINK, AND DEIRDRE DOYLE (2016) Wheat growth and development. – National Tillage Conference, 28 January, Kilkenny, Ireland, p25-38.

JOSEPH LYNCH, REAMONN M FEALY, TIM O'DONOVAN AND JOHN SPINK (2016) The Estimation of the Yield Gap Between Achieved and Potential Winter Wheat Yield Across Ireland Using a Parsimonious Model. Tri-Societies Conference, Phoenix Arizona, 55-6

JOSEPH LYNCH, SHARON SPRATT, DEIRDRE DOYLE, LISA BLACK, ETHEL WHITE AND JOHN SPINK, (2016). The Response of Spring Barley Varieties Contrasting in Lodging Resistance Scores to N Application and Plant Growth Regulator Program. Tri-Societies Conference, Phoenix Arizona, 218-5

JOSEPH LYNCH, DEIRDRE DOYLE, JOHN SPINK, ETHEL WHITE, LISA BLACK, and SHARON SPRATT (2017) The value of variety choice in cereals – National Tillage Conference, 28 January, Kilkenny, Ireland.

JOSEPH LYNCH, REAMONN FEALY, AND JOHN SPINK (2017) Assessment of winter wheat yield potential at spatially contrasting sites in Ireland using daily temperature, radiation and rainfall data. EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017, 4–8 September 2017, Dublin, Ireland

BRENNAN, CIARAN J., RANSBOTYN, VANESSA, AND DOOHAN, FIONA M. (2013) Title: Investigating the mechanisms underpinning resistance to the fungus *Mycosphaerella graminicola* (*Septoria tritici*) in wheat. Irish Plant Scientists' Association Meeting (IPSAM) 2013 conference, National University of Ireland Galway, 16/05/2013-17/05/2013, Page 32.

BRENNAN, CIARAN J., RANSBOTYN, VANESSA, AND DOOHAN, FIONA M. (2013) Title: Investigating the mechanisms underpinning resistance to the fungus *Mycosphaerella graminicola* (*Septoria tritici*) in wheat. Society of Irish Plant Pathologists (SIPP) 2013 conference, Derry City, 02/09/13-2013/09/2013.

BRENNAN, CIARAN J., RANSBOTYN, VANESSA, MULLINS, EWEN AND DOOHAN, FIONA M. (2014) Investigating early response genes of wheat during infection by the pathogenic fungus *Zymoseptoria tritici*. Science and Solutions for a Sustainable Environment (SSSE) Conference, University College Dublin, 11/12/2014-12/12/2014.

BRENNAN, CIARAN J., O'DRISCOLL, AOIFE, BENBOW, HARRIET R., MULLINS, EWEN AND DOOHAN, FIONA M. (2019) Mining for orphan genes of wheat during infection by the pathogenic fungus *Zymoseptoria tritici*. IPSAM 2016 conference, Trinity College Dublin. 27/04/2016-28/04/2016, Page 42.

BRENNAN, CIARAN J., O'DRISCOLL, AOIFE, BENBOW, HARRIET R., MULLINS, EWEN AND DOOHAN, FIONA M. (2013) Mining for orphan genes of wheat during infection by the pathogenic fungus *Zymoseptoria tritici*. European conference of fungal genetics 2013 (ECFG13), Société d'Horticulture de Paris, 06/04/2016-10/04/2016, Page 113.

BRENNAN, CIARAN J., ZHOU, BINBIN, BENBOW, HARRIET R., AJAZ, SOBIA, JUNG KARKI, SUJIT, HEHIR, GERARD, FEECHAN, ANGELA, MULLINS, EWEN AND DOOHAN, FIONA M. (2019) Investigating the role of taxonomically restricted genes and their potentially antagonistic role in combatting secreted fungal effectors. International Symposium on Cereal Leaf Blights 2019 (ISCLB), University College Dublin. <https://www.isclb2019.com/portal/public/abstracts/ABS61361/>

Mullins E. et al. (2018) Intensive field phenotyping to support breeding initiatives against *septoria tritici* blotch (STB) disease of wheat. EUCARPIA Cereal Breeding Conference, Clermont Ferrand, March 19th – 21st

Black, L.C. (2017). Cereal variety evaluation in the UK – current status and future challenges. Society of Irish Plant Pathologists, University College Dublin, Ireland, 5 December 2017

White, E.M., Black, L.C., Milligan, A., Weir, D. (2017). CIVYL database - value of *Septoria* resistance. Teagasc *Septoria* Conference 2017, Dunboyne Castle Hotel Co Meath, 22 March 2017

White, E.M., Black, L.C., Easson, L. (2018). Vital information on *Septoria* resistance in Wheat. Crop Advisors Conference, The Elvetham, Hook, Hampshire, 6 February 2018

Spratt, S.E., White, E.M., Black, L.C. (2015). CIVYL research project - using old and new data to sustainably produce winter wheat and spring barley in Ireland. Poster Presentation at Agronomy and Business Management Conference for Cereal Growers, CAFRE Greenmount Campus, Antrim, 13 January 2015

Black, L.C., White, E.M., Garrett, J.C., Weir, D., Spratt, S., Allen, M.M., Lynch, J., Doyle, D., Spink, J. (2017). CIVYL: Cereal Improvement through Variety choice and understanding Yield Limitations. Poster Presentation at Adapting to Change - Agronomy and business Management Conference for Arable Growers, CAFRE Greenmount, 10 January 2017

Black, L.C., White, E.M., Garrett, J.C., Spratt, S., Weir, D., Allen, M.M., Lynch, J., Doyle, D., Spink, J. (2017). CIVYL: Cereal Improvement through Variety Choice and Understanding Yield Limitations. Poster at the Teagasc National Tillage Conference, Kilkenny, 26 January 2017.

Black, L.C., White, E.M., Garrett, J.C., Weir, D., Spratt, S., Allen, M.M., Lynch, J., Doyle, D., Spink, J. (2018). CIVYL: Cereal Improvement through Variety choice and understanding Yield Limitation. Poster Presentation at CAFRE/UAS/UFU 6th Annual Arable Conference, CAFRE Greenmount, 11 January 2018

Black, L.C., White, E.M., Easson, L. (2018). CIVYL database – a wealth of variety information. Poster Presentation at Teagasc National Tillage Conference, Carlow, Ireland, 31 January 2018

White, E.M., Black, L.C., Easson, L. (2018). CIVYL database – *Septoria* in winter wheat varieties. Poster Presentation at Teagasc National Tillage Conference, Carlow, Ireland, 31 January 2018

(ii) National Report

SPINK, J., HENNESSY, M., LYNCH, J., O'DONOVAN, T., FORRISTAL, D., HACKETT, R., KILDEA, S., GLYNN, L., HICKEY, K., KENNEDY, S., PLUNKETT, M., WALL, D., & BRYAN, T. (2015), The Spring barley guide, Teagasc

LYNCH, J., SPINK, J., DOYLE, D., HACKETT, R., PHELAN, S., FORRISTAL, D., KILDEA, S., GLYNN, L., PLUNKETT, M., WALL, D., HUTTON, F., HENNESSY, M. & WHITE, E. (2016) The winter wheat guide, Teagasc.

(iii) Workshops/seminars at which results were presented

Irish Cereals Improvement Network – Oak Park, Co. Carlow June 2014

Irish Cereals Improvement Network – CAFRE Greenmount, Jan 2015

Irish Cereals Improvement Network – Oak Park, Co. Carlow Feb 2016

Irish Cereals Improvement Network – Ashtown Dublin, July 2017

Irish Cereals Improvement Network – Ashtown Dublin, March 2018

Syngenta Technical Meeting, 7 March 2017

CAFRE BDG meeting, 7 March 2017

Teagasc *Septoria* Conference, 22 March 2017

Society of Irish Plant Pathologists, 5 December 2017

BSPB Crop Group, Ely, Cambs., 9 January 2018

Crop Advisors Conference, Hampshire, 6 February 2018

(iv) Intellectual Property applications/licences/patents

One invention of disclosure submitted to UCD on STB resistance genes (2019)

(vi) Other

LYNCH J.P. and SPINK J. (2015) Variety Choice – An underused tool? Irish Farmers Journal- “Crops” pullout. 18 June. pp3

Spratt, S.E., White, E.M., Black, L.C. (2015). CIVYL - addressing industry feedback. Irish Cereals Improvement Network (ICIN) meeting, CAFRE Greenmount Campus, 14 January 2015

Black, L.C., Brennan, J. (2015). Cereal variety testing - UK and Ireland. Irish Cereal Information Network (ICIN) meeting, 14th January 2015

Black, L.C. (2017). Cereal varieties for 2017 and AFBI arable research. CAFRE BDG meeting, Ballydugan House, Downpatrick, 7 March 2017

Black, L.C. (2017). Syngenta Technical Meeting - Update of AFBI cereal research. Crossnacreevy, 7 March 2017

Brennan, J., Black, L.C. (2017). How growers choose varieties: survey findings. Irish Cereal Information Network (ICIN) meeting, Teagasc Ashtown, Dublin, 19 July 2017

White, E.M., Black, L.C., Easson, L. (2018). 'CIVYL Database - Value of *Septoria* resistance' BSPB Crop Group, Ely, Cambs., 9 January 2018

White, E.M., Black, L.C., Easson, L. (2018). CIVYL Project database - value of *Septoria* resistance. IBERS & Teagasc Oat Agronomy meeting, Northumberland, 29 March 2018.

LYNCH, J.P and SPINK J. (2017) Spring barley nitrogen and lodging. Irish Farmers Journal - 11 May.

LYNCH, J.P. (2017) The place for variety in protecting our fungicides. Irish Farmers Journal - Crop protection magazine - April 2017.

5. Scientists trained by Project

Total Number of PhD theses: 1

Please include authors, institutions and titles of theses and submission dates. If not submitted please give the anticipated submission date

Brennan C. University College Dublin. Exploring the genetic responses during the latent phase of *Septoria tritici blotch* disease of wheat. 2019.

Total Number of Masters theses: 2

Please include authors, institutions and titles of theses and submission dates. If not submitted please give the anticipated submission date

Deirdre Doyle. University of Aberdeen. Evaluating the role of fungicides and host resistance in spring barley under temperate environmental field conditions. July 2017

Cliona Connolly. University of East Anglia. Investigating the rate of fungal growth during the latent period of *Zymoseptoria tritici* in winter wheat cultivars. December 2017

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (person years)
AFBI	7	0.97
Teagasc	3	0.82
UCD	1	0.5
Total	11	2.29

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates/Contract Researchers	1 (AFBI) 1 (Teagasc) 1 (UCD)	2.27 3.54 0.25
PhD students	1 (UCD)	3.92
Masters students		
Temporary researchers	7 (AFBI)	3.86
Contract technicians	2 (Teagasc)	7.27
Total	13	21.11

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended

9. Project Expenditure

Total expenditure of the project: € 1,227,375

Total Award by DAFM: € 1,227,375

Other sources of funding including benefit in kind and/or cash contribution (specify): None

Breakdown of Total Expenditure

Category	Teagasc	AFBI	UCD	Name Institution 4	Total
Contract staff	294,040	270,726	7,198		571,964
Temporary staff					0
Post doctorates	164,033				164,033
Post graduates			87,800		87,800
Consumables	63,691	371	16,691		80,753
Travel and subsistence	21,254	2,228.62	7,510		30,993
Sub total					0
Durable equipment	603		467		1070
Other	10,100				10,100
Overheads	162,905	81,998	35,760		280,663
Total	716,023	355,323	155,426		1,227,375

10. Leveraging

Summarise any additional resources'/funding leveraged by this award from other sources e.g. Additional Staff, National/EU funding secured, EI Commercialisation Fund, etc.

CIVYL was instrumental in leveraging

- EU funding through the Marie Curie ETN programme CEREALPATH (2015-2019; 4 million-euro total, UCD lead), the H2020 project INNOVAR (€8.0M total; UCD Scientific lead),
- National state funding through SFI (Wheat security; UCD and Teagasc, €1.5M), Industrial funding through an Origin-SFI partnership grant (€10.0M)
- Follow on EU funding of a Marie Curie funded International Fellow at Oak Park, to work on deploying Genetic Strategies against *Septoria* (€175,866)
- EU funding through the H2020 project INVITE (€7.99M total). Teagasc are partners (€198,000) in INVITE tasked with completing wheat – STB research

11. Future Strategies

Outline development plans for the results of the research.

The results of the variety performance and selection part of the project should be included in any future review of the RL testing and recommendation system.

The models developed, could in, conjunction with Met Eireann be linked to interpolated weather data to provide real time crop yield forecasts.

The genetic results arising from this project feed into the H2020 project INNOVAR and the SFI project Wheatsecurity. Their applied potential will also be investigated in future research (e.g. as proposed in current DAFM grants under review).

The fundamental work completed in CIVYL around the potential importance of the LP in the wheat-STB interaction have formed the foundation for the current work planned through the H2020 project INVITE

References

Sylvester-Bradley, R., Foulkes, J. & Reynolds, M. (2005) Future wheat yields: Evidence, theory and conjecture. In: *Yields of Farmed Species: Constraints and opportunities in the 21st century*. Eds R. Sylvester-Bradley and J. Wiseman

SPINK, J. (2010). Winter wheat yields in Europe and at a global scale. In: Plantekongres, Herning Denmark, 12-Jan-2010

Parker SR, Welham S, Paveley ND, Foulkes MJ & Scott RK (2004). Evidence for tolerance to *Septoria* leaf blotch in winter wheat. *Plant Pathology* 53, 1-10.