Breeding Ash for tolerance to dieback disease

Dheeraj Singh Rathore

FGRT Scientific Meeting

Monday, 27th June, 2022

Teagasc
Agriculture and Food Development Authority

Ash breeding programme

Developing ash tree genetic resources with tolerance to ash dieback and breeding for suitability under Irish climatic conditions

Ash

- Ash is ecologically, economically and culturally one of our most important native trees
- Common native broadleaf trees in Irish hedgerows and a traditional woodland species
- Timber is prominently used for making Hurls

Problem

- Survival of Ash is increasingly threatened by ash dieback disease causing severe damage
- Caused by the fungal pathogen *Hymenoscyphus fraxineus*
- First detected in 1992 in Poland (first in Europe) and in Ireland in 2012

Research

In Teagasc, Ash breeding programme to develop disease tolerance started in 2015
Field trial consisting of 1000 Irish genotypes was established in Lithuania
Established gene-banks of around 200 ash genotypes collected from European countries

Ash breeding programme

Gene bank establishment

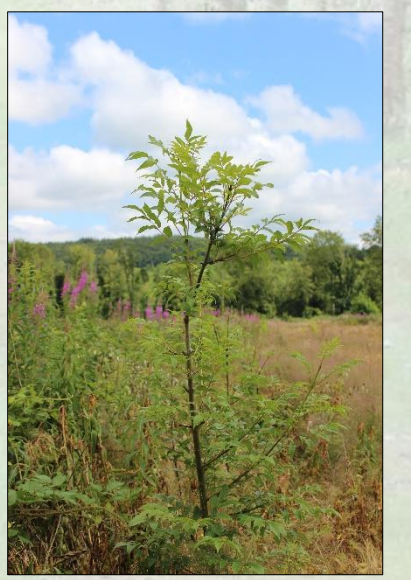
Propagate the selected 208 genotypes by grafting
Establish three gene-banks (in 2019, 2021, and 2022)

Monitor performance

Growth
Disease occurrence

Tree breeding

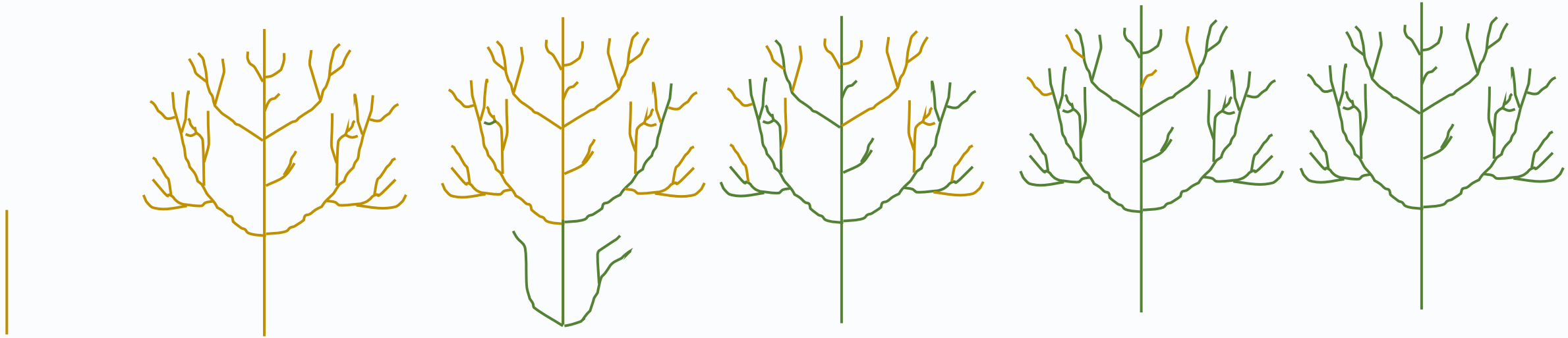
Tolerant/resilient genotypes
Increase genetic diversity



Tolerant genotype

Susceptible genotype

Scoring strategy of ash dieback on selected genotypes



(1) The tree has died during the first year after planting, dead tops and no sign of former re-sprouting

(**2**) Dead tree: The main stem and all emerged sprouts are dead

(**3**) Severely damaged tree: main stem or most of the shoots are dead. Tree is re-sprouting from root collar

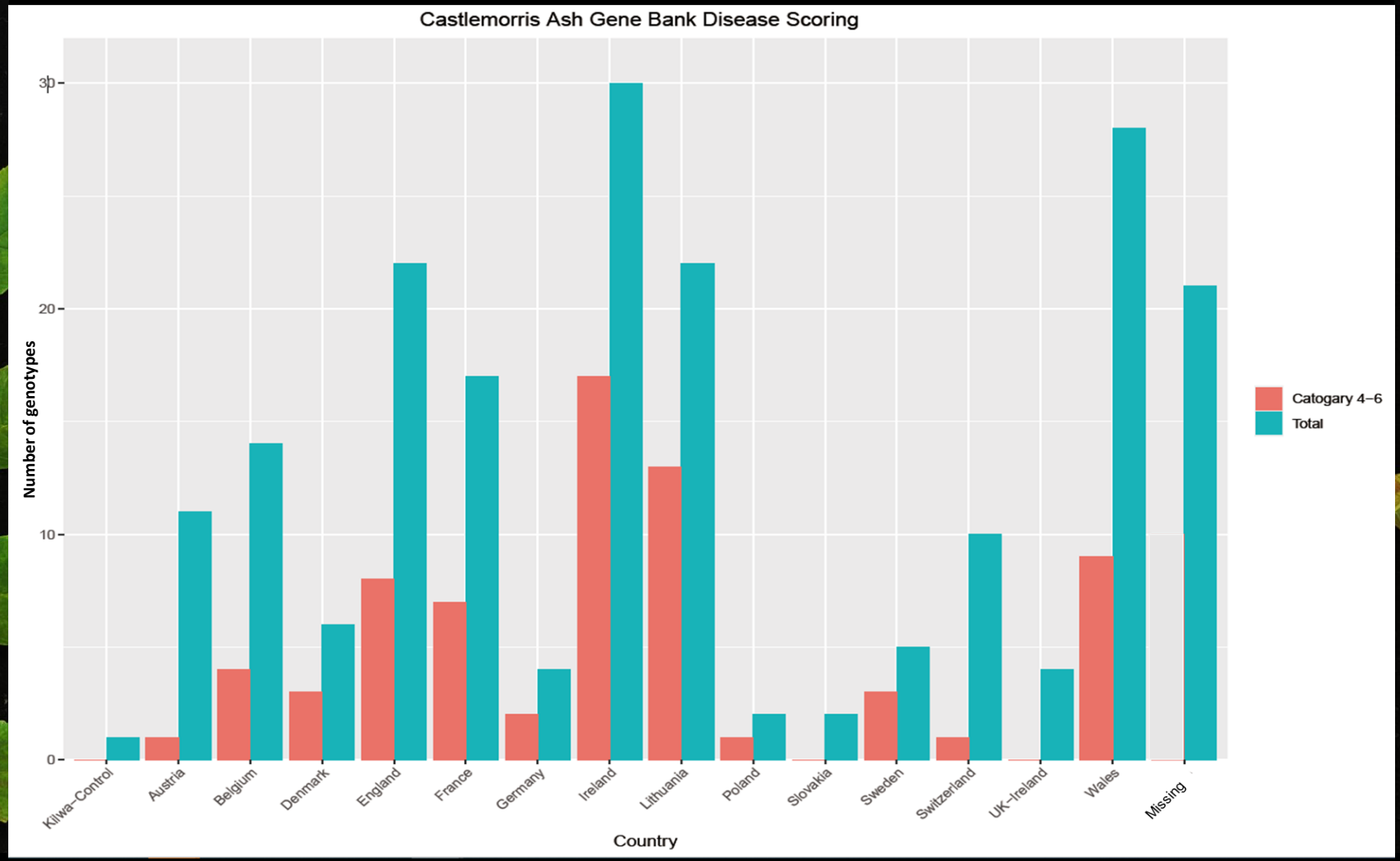
(**4**) Moderately damaged tree: dieback of two-three shoots, some necrotic lesions on the side branches, advanced necrosis, no lesions on main stem

(**5**) Slightly damaged tree: sporadic disease symptoms on separate shoots, single necrotic lesions on shoots or stem

(**6**) Visually healthy tree: no visible damages

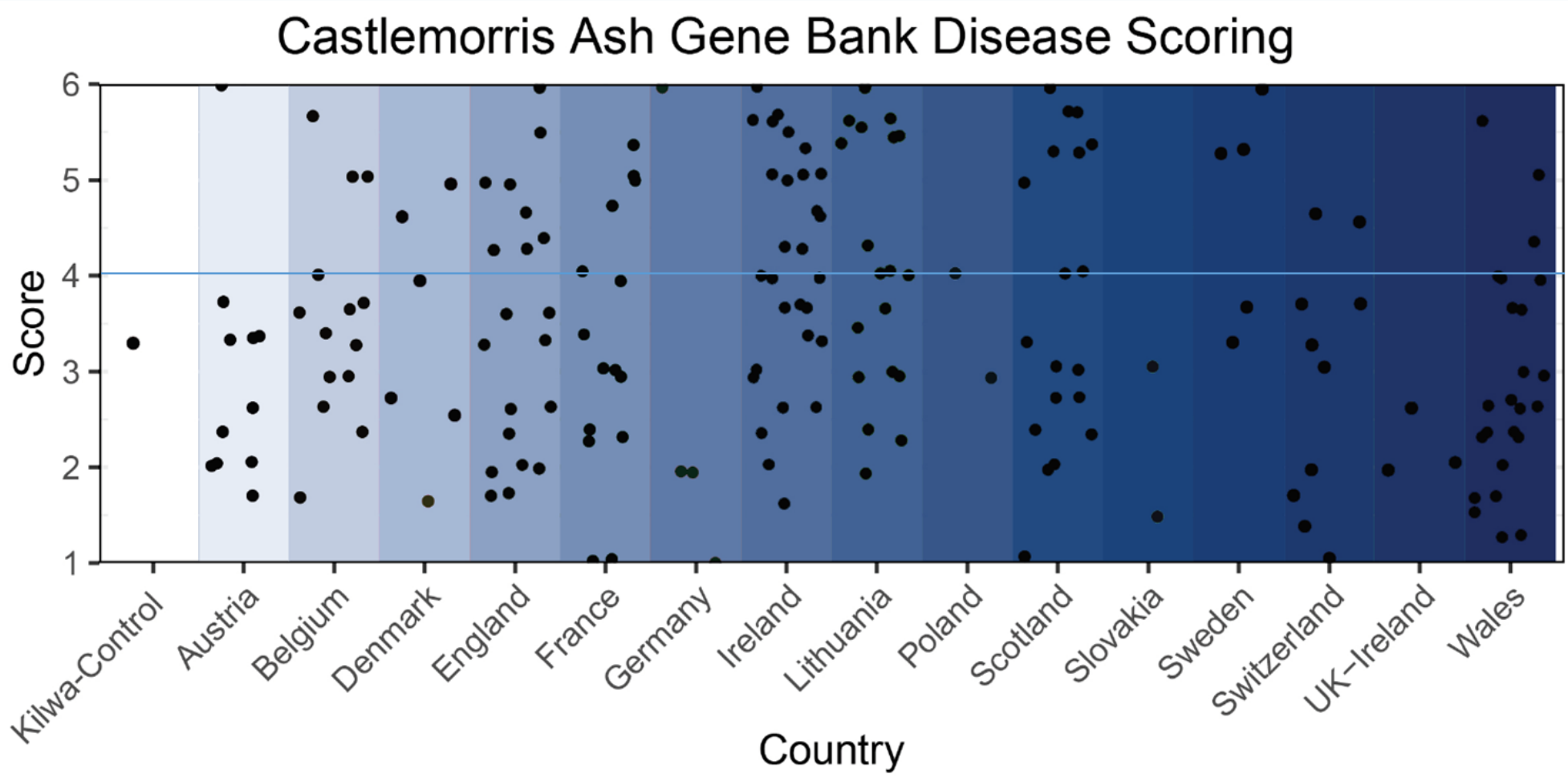
Pliura *et al*, 2011, Bakys *et al,* 2009

Ash die back – breeding for disease tolerance



- Based on preliminary data collected over the last two years, around 6.73% of the trees are category 6, 16.8% are category 5-5.9 and 14.4% are category 4-4.9.
- Current research is focused on exploiting the vegetative micropropagation techniques to rapidly multiply these genotypes for further testing

Disease tolerance of genotypes in the ash gene-bank



Bud burst of genotypes in the ash gene-bank

Category 1: bud at rest, black, fully dormant winter state

Category 2: buds swollen but still closed, green-black in colour

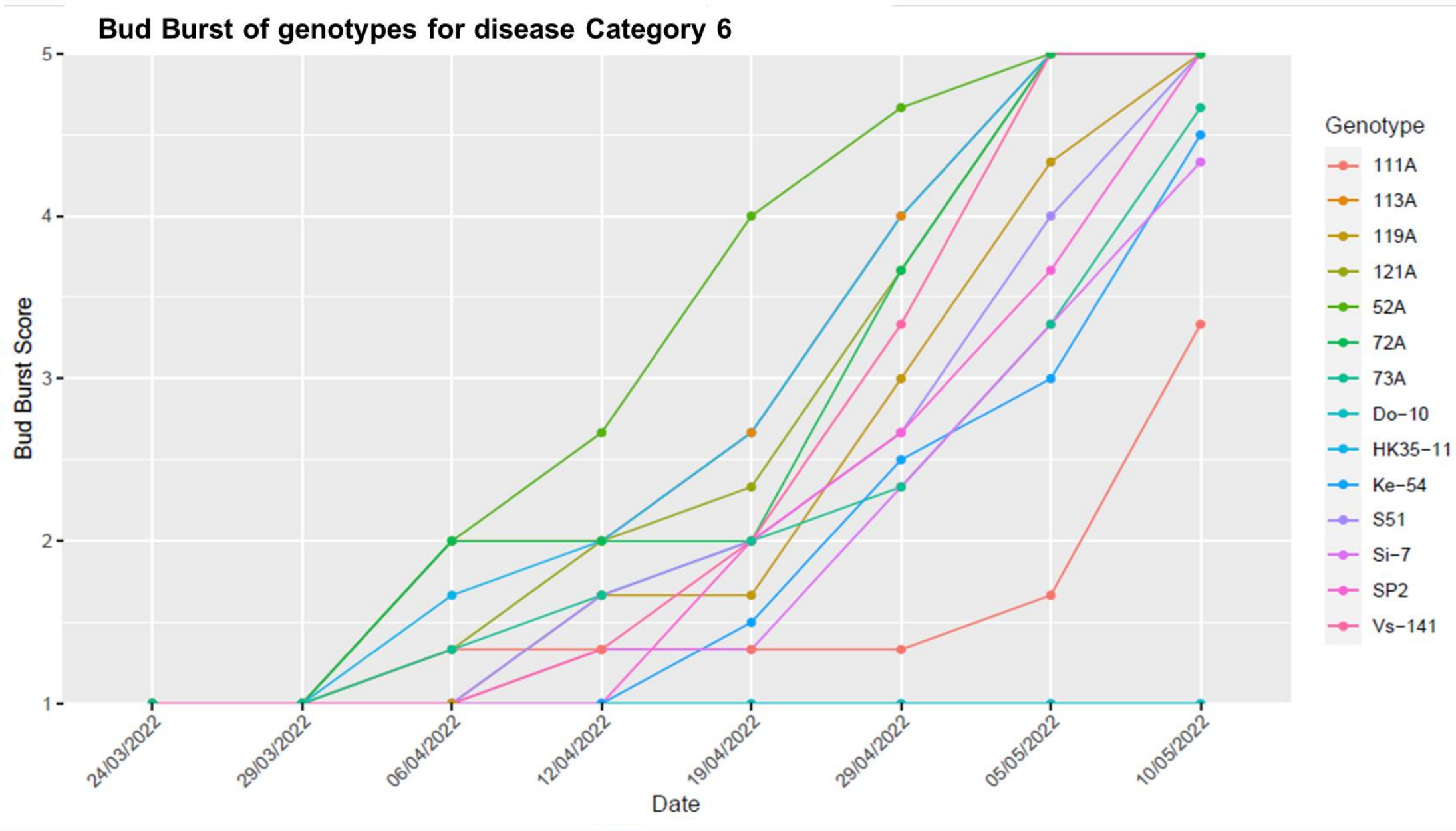
Category 3: 1st leaves visible but not yet protruding

Category 4: 1st leaves protruding but not yet unfolding

Category 5: 1st leaves unfolding

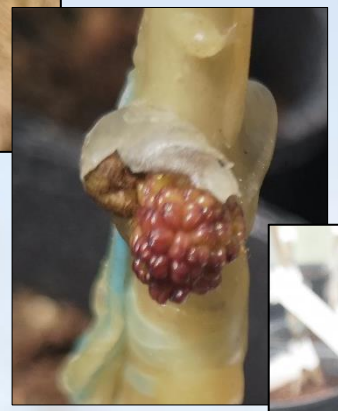
Vander Mijnsbrgge *et al*., 2015; Leslie *et al.*, 2017

Bud burst of genotypes in the ash gene-bank



Flowering time of genotypes in the ash gene-bank

Category 1: first date of flowering, bud open, flower visible



Category 2: bud open, flowers coming out

Category 2.5: pollen starts to be released/stigma are receptive

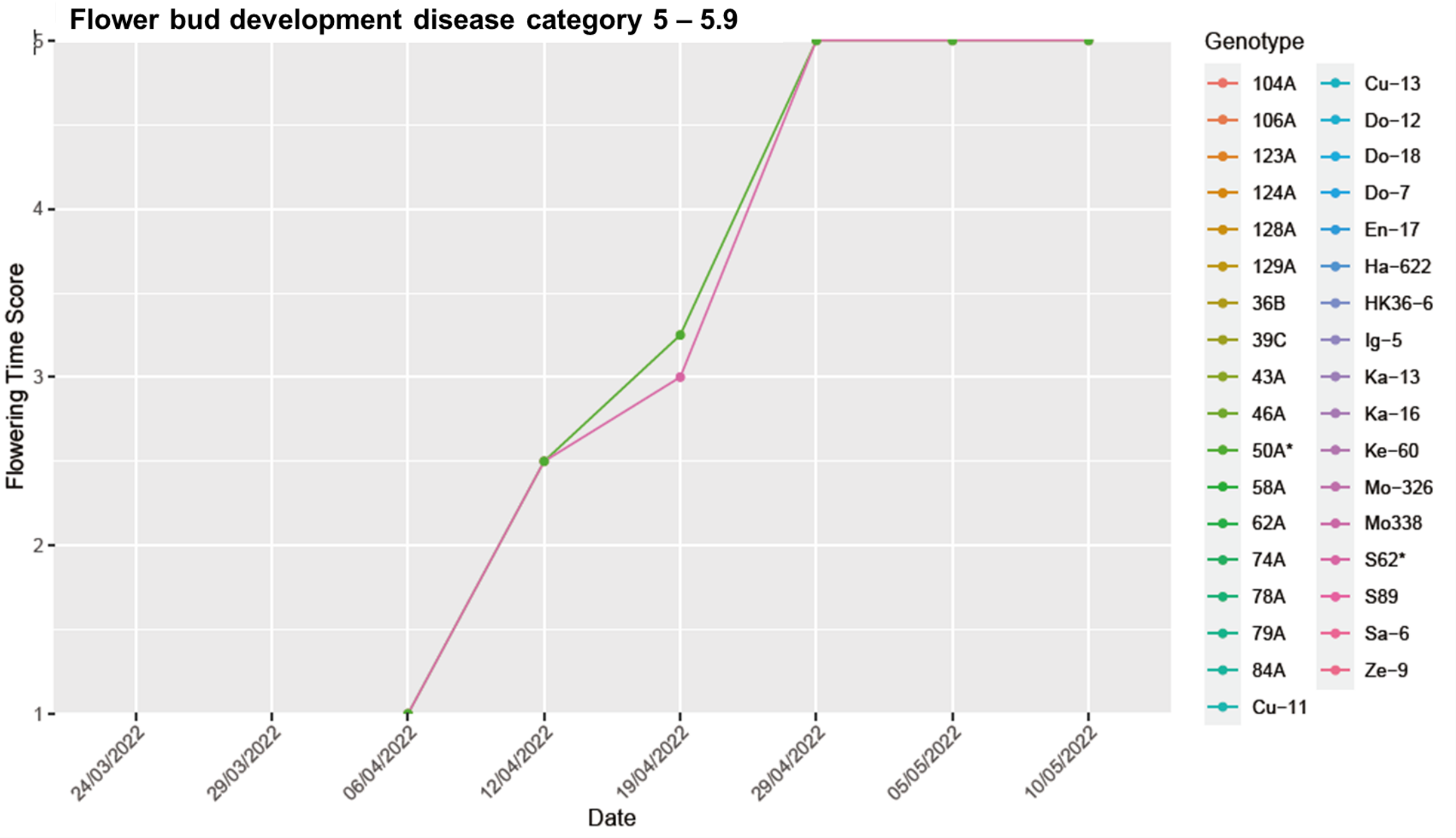
Category 3: pollen getting visibly less/stigma receipted pollen

Category 4: flower starts to wilt

Category 5: flower wilt

Douglas & Thomasset 2013

Flowering time of genotypes in the ash gene-bank



Indoor seed orchard

Genotypes in polytunnel (OP)	
1006_9	45A
116A	S89
125A	S57
39A	Mo337
39D	Do-20
39E	91A
405-14	64A
HK30	53A
HK36C	51A
HK43B	49A
HK45C	49B
HK48A	49D
HK49C	48B
HK50A	45C

Research Project 2: Exploitation of plant and rhizosphere microbiome of Alder (*Alnus glutinosa*) trees to isolate potential bio-agents for improved disease tolerance against Alder dieback caused by *Phytophthora alni* (ExAl)

Objective 1	Investigate the microbiome of susceptible versus tolerant alder genotypes
Objective 2	Isolate culturable microbes to test for antagonistic activity against pathogen
Objective 3	Exploit potential bioagents to enhance disease tolerance in susceptible genotypes

Teagasc
Agriculture and Food Development Authority
IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn
SETU
Ollscoil Teicneolaíochta an Oirdheiscirt
South East Technological University

Research Project 3: Investigating rapid multiplication techniques and microbiome of Ash (*Fraxinus excelsior*) and genetic conservation of Wych elm (*Ulmus glabra*) to breed disease-resistant genotypes (ElmAsh)

Objective 1

Examine and develop rapid multiplication methods to accelerate breeding for disease-tolerant Ash genotypes.

Objective 2

Investigate the endophytic microbiome of Ash trees from gene-banks, which are showing a varying level of tolerance to the natural infestation of Ash dieback disease.

Objective 3

Collect and propagate healthy Wych elms plant material to establish a germplasm collection for Dutch elm disease screening.

Conclusions and Future plans

Ash breeding programme

- Preliminary results from the ongoing breeding programme to improve disease tolerance are promising
- continue to monitor and assess surviving healthy ash trees in Ireland and to include them in the disease screening programme
- establish field trials of trees selected from the gene bank that show higher levels of tolerance to the ash dieback disease
- followed by seed-producing orchards for the deployment of the tolerant material
- Forward selection – screening of seedlings for early disease tolerance
- Progeny trials will be conducted in different locations for adaptability, phenology, and productivity, once the seed production commences from tolerant genotypes

Screening for a/biotic stresses

- Developing resilience to diseases/pests and changing climate (flood/drought/frost)

Other areas of interest

- Developing novel breeding tools to accelerate Tree breeding (Omics assisted breeding)
- Broadleaf tree species: Downy & Silver Birch, Alder, Sycamore, Elm…

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Forestry Research

Dr. Niall Farrelly

FitForest Project

- To assess the ability of key forest tree species in Ireland to adapt to climate change
- Key forest species will be assessed, such as Sitka spruce, Norway spruce, Douglas fir, Oak, Beech, Cherry and Sycamore
- Species and provenance trials will be assessed and the data will be analysed to determine if certain provenances are more suited in altered climatic conditions
- A series of new trials will be established to assess the adaptability of the current range of provenances used in Ireland and their suitability for warmer climates

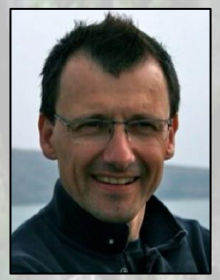
AdaptForRes Project

- To provide critical information to assist and increase the resilience of forest ecosystems in Ireland
- Three pathways will be studied aimed at increasing resilience in forests; forest genetic options, forest management practices and forest protection measures
- Assess the performance of conifer and broadleaved forest reproductive material from research trials consisting of basic and improved forest reproductive material currently in use in Ireland
- Assessment of growth phenology and adaptive traits of commercially available seed origins of important tree species
- Research to develop breeding tools for early selection of improved families and the potential to utilise genomic data to build upon existing genomic selection work in Sitka spruce

Acknowledgements

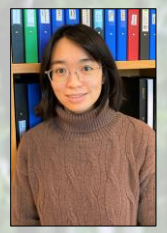
Agriculture and Food Development Authority

WALSH SCHOLARSHIPS PROGRAMME

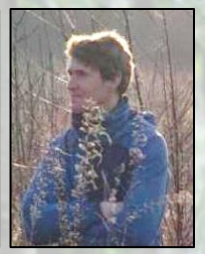


Prof. Trevor Hodkinson

Trinity College Dublin
The University of Dublin



Ms Jie Huang
Teagasc Walsh scholar



Dr. Richard O'Hanlan
Dr. Brian Clifford

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Dr. Susanne Barth
Dr. Stephen Byrne

Ms Emma Fuller
IRC funded PhD scholar

Mr. Mick Power

COILLTE
GROW · TRANSFORM · SUSTAIN

NONE-SO-HARDY (FORESTRY) LTD.

Dr. Kieran Germaine

SETU
Ollscoil Teicneolaíochta an Oirdheiscirt
South East Technological University

Mr. John Kavanagh

Dr. Colin Kelleher

national botanic gardens

Dr. Gerry Douglas
Dr. Eugene Hendrick

FGRC

Mr. Oliver Sheridan
Mr. Derek Gibson
Dr. Ian Short

Prof. Oliver Gailing
HOD Forestry dept.

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

UCD DUBLIN

Dr Akshit Puri
Asst. Lecturer

Dr Anna Tilley

afbi AGRI-FOOD & BIOSCIENCES INSTITUTE

Mr. Michael C. Doyle
Placement student

Waterford Institute of Technology
INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn