DIVERSIFOOD

Embedding crop diversity and networking for local high-quality food systems

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H2020 - Research and Innovation Action

D2.5

Searchable database on performance results of underutilised genetic resources

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Workpackage concerned: WP2

Concerned workpackage leader: Ambrogio Costanzo (ORC)

Lead Beneficiary: ORC

Dissemination level:

- **X PU:** Public (must be available on the website)
- ☐ **CO:** Confidential, only for members of the consortium (including the Commission Services)
- ☐ **CI:** Classified, as referred to in Commission Decision 2001/844/EC

Abstract

The DIVERSIFOOD database aims to provide an information basis on performances of genetic resources, as well as to stimulate participatory crop evaluation experiences. The primary target audience is existing or novel multi-actor networks/communities, involving farmers, breeders, researchers, processors and citizens, engaged, or willing to engage, with underutilised crop genetic resources.

The DIVERSIFOOD database enables an interactive, analytic exploration of genetic resources performances in different trials, each with its pedo-climatic and socio-economic context and its objectives and resources, as resulting from a participatory multi-actor approach. In this database it is possible to build and/or substantiate with evidence narratives about reintroduction and increase of crop genetic and species diversity, identify useful genetic resources, get in contact with teams having undertaken specific trials.

The database is currently a proof-of-concept including 16 integrated datasets from 55 individual experiments (one experiment = one location in one crop season) and conveys performance information on approximately 250 accessions, with more datasets currently in the pipeline that will be completed and integrated soon. As such, this tool is open to improvements and to host new datasets from past, current or future experiences. We hope to see it developing in a common resource to enable communities engaged in testing and using a diversity of plant genetic resources to collect, share, and base their decisional processes on, structured evidence.

The present document is divided in three sections: (i) an introductory chapter including the rationale and basic, logical features of the database, as well as an outline of trials results; (ii) a visual guide to use and navigate the database, which is downloadable as an excel file from the DIVERSIFOOD.eu website; (iii) a series of 19 factsheets about as many trials experiences on nine crop species, where more details about rationales, methods, participatory processes and results can be found.

Authors

This deliverable – the report and the database – has been assembled and coordinated by Ambrogio Costanzo, WP2 leader, with contribution from all partners involved in WP2 field trials. Each factsheet indicates authorship of individual trials. Data ownership lies with the relevant partner organisations indicated in the main spreadsheet of the database, with contact of the responsible person.

Contents

1. Introduction and outline of results

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The **DIVERSIFOOD database performance of underutilised genetic resources** is the collection of multi-actor experiences of testing these accessions in specific contexts. Whilst the primary goal is to share information about the genetic resources, there is a secondary, perhaps more important goal, i.e. to provide, alongside phenotyping information, a **proof-of-concept of participatory crop evaluation experiences** and thereby **stimulate the onset of novel experiences alike**, in a "distributed research" perspective. The target audience of this deliverable is wide and plural, as it may/should include farmers, breeders, researchers, processors, citizens. However, if the overall goal is to stimulate participatory crop evaluation experiences, we can also identify, as an overall target audience, ***existing or novel multi-actor networks/communities*** engaged, or willing to engage, with underutilised crop genetic resources.

Background

During the third DIVERSIFOOD Annual Meeting in March 2018, a workshop was held to brainstorm, openly discuss and explore the possible ways this deliverable could be prepared, based on the hypothesis that some creativity and awareness could make the difference between a "forgotten" project product and a tool to keep the project experience alive and ongoing.

A first outcome of the workshop was that, in the plethora of knowledge platforms and databases existing in Europe, all with a different approach, there seems to be a common missing point, which is overlooking the use of the shared information. It has been pointed out that existing PGR databases range between two extremes: on the one hand, centralised databases with 'passport information' (generic, standardised phenotypic descriptions of genetic resources) that lack any specification of the potential contexts of use and related performance and, on the other hand, locally maintained datasets that generally end up being "data graveyards". It is also true that there are many examples of existing databases, and before preparing an additional one, a reflection has been made not to repeat errors from the past, or even just not to overlap with existing resources. The key point to address was, therefore, **how to make the data and information useful and valuable**.

To make the data and information useful and valuable, there are several characteristics and topics to be aware of while building a database. The main constraint in the current panorama is the lack of a **planned and agreed data model** on PGR, which translates into a bottleneck to enable data distribution. This mainly calls for problems of **unification** and **interoperability** of different data sources. Another key feature to be aware of, and that might help respond to the problems of distribution, is the **transparency** of the database, which means a clear link between the available information and the way this information has been generated, and, ideally, enables the user to 'find what is needed without consulting with anyone else than the database itself'.

Attention has been raised on the issue of which data can be publicly shared and whether we must be aware of data protection needs towards biopiracy risks. While many participants agreed that, given the underutilised nature of the tested genetic resources, it is unlikely that attempts of appropriation might occur, the **risk and the necessary measures of protection** will be taken into due account.

Most of the discussion has dealt on 'what are the actual information that we want/need to share'. **Trials results** should be included, and this could also be done without effort in form of small reports. However, we all agreed that the focus is not necessarily on the 'numeric' results of the trials, but to the experimental process, "the **story of the trials**" as well. This is not detachable from the results, since the nature of WP2 trial is highly contextualised. The "story of the trial" is what depicts the **contexts** (pedo-climatic, as well as multi-actor, socio-economic) in which given results have been generated and are useful, and the **methods and tools** used to obtain them. It has as well been pointed out and agreed that the database should as well provide access to the **seeds** of the accession tested whenever possible.

Features and future of the database

1. A database of performance results

In DIVERSIFOOD, a series of parallel experiments with underutilised genetic resources has been carried out based on a common underlying hypothesis: that *reintroducing genetic resources with a status of underutilisation can trigger benefits in provisioning agroecosystem services and supporting local, high-quality value chain, in the overall vision of agroecological systems and circular economy*. As far as testing underutilised crops is concerned, the focus is therefore on **crop performance**, *i.e.* **the capacity and effectiveness to provide multiple *services***. Experiences on plant genetic resources either have a very specific focus (e.g. resistance to a specific disease) or assume that yield on its own is a proxy of overall performance. This is why the DIVERSIFOOD database is explicitly focusing on multiple aspects of performance rather than on generic crop descriptions.

It is important to conceptualise how to assess performance addressing multiple services, as multiple services at the same time are expected from a sustainable crop in a sustainable food system. We encouraged having a threefold focus and create information on (i) agroecosystem performance; (ii) productive performance, and (iii) quality performance. To improve the relevance and usefulness of the performance information, in order to enable predictions, it is essential to link the actual performance with its potential predictors: the crop phenotype, in terms of morphology and phenology, and the crop growing environment.

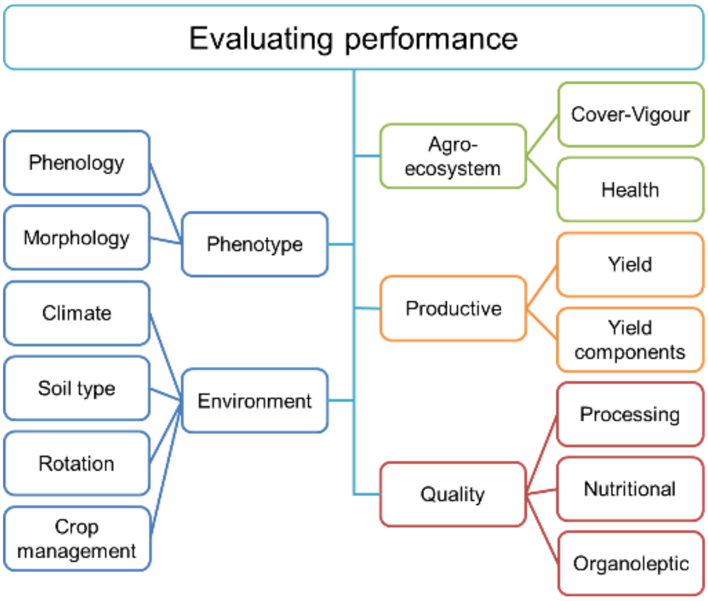

Fig. 1. The different aspects of crop performance evaluation (right-hand side) and examples of the key predictors of performance that is essential to record (left-hand side) (DIVERSIFOOD Booklet #2)[1]

2. Decentralised performance profiles

Multiple services, i.e. aspects of performance, are simultaneously expected from a crop. These aspects form altogether a 'performance profile'. The database accounts for two key aspects of performance profiles:

- **Performance profiles can change according to local conditions**, needs, and trials organisational aspects. Therefore, **every trial has built its own performance profile**. For example, rivet wheat has been tested on overall performance indicators, including organoleptic quality, in the UK, where full performance trials have been carried out on a relatively small number of accessions, whereas basic descriptors and performance indicators have been assessed in the French experiment, where a large collection of rivet wheat genetic resources has been screened. The factsheets attached to this document explain how the performance profiles were built.
- **Performance of a same accession can change** by year, location, crop management system. Therefore, rather than univocal descriptions of every accession's performance, in the database profiles are broken down by

[1] Costanzo A, Serpolay E (eds). 2019. A guide to participatory experiments with underutilised genetic resources. DIVERSIFOOD Booklet #2, Deloiverable D2.3.

year, location and crop management system whenever relevant and possible. For example, in the UK cereal trials, each einkorn accession can be visualised in different soil conditions and rotational positions.

3. Scoring/rating system

Numeric results do not often convey much information if taken out of a context. For example, a cereal yield of 3 t/ha can be very low in a fertile location but very good in a marginal location. The database does not visualise actual yield in t/ha, but a **rating from 0 to 9, based on a range between the minimum acceptable (0) and the maximum/best achievable (9)** value for each variable in each context, where context is given by the pedo-climatic conditions. These minimum and maximum values are based on local experience, for example knowing the average yield of organic wheat in organic farming in a specific region/year where einkorn has been tested, or based on literature to define ranges of e.g. concentration of nutritional active compounds in harvested grains. In fact, visualising a performance profile of an accession, the key information to convey is for which aspects of performance this accession can be qualified as “good” or “bad” in a specific context.

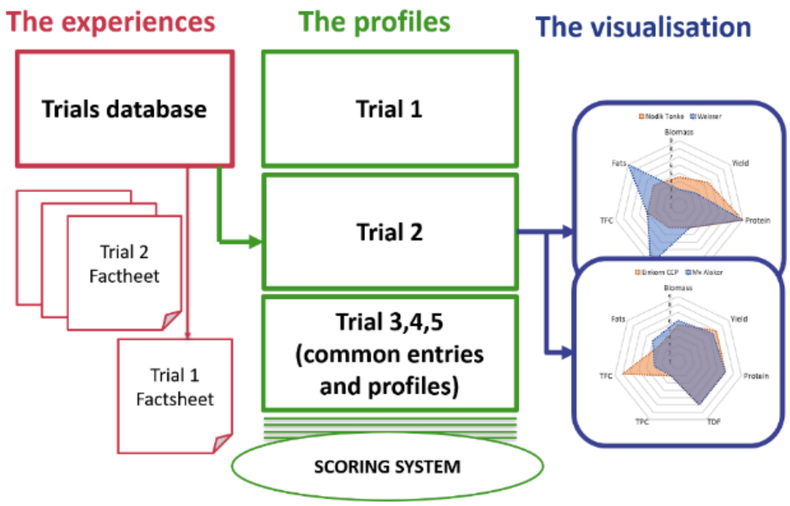

Fig. 2. Structure of the DIVERSIFOOD database

4. Prospects for use and development

The current version of the database is supposed to be a proof of concept of visualising decentralised and diversified performance results of participatory experiments, as a core database to be increased and improved in the future. The main development prospects are as follows:

- Strengthening and improving the scoring system, by:
  - refining the minimum-maximum ranges
  - proposing a normalised system on defining the performance range of each variable
  - once results from multiple years are available, account more explicitly for performance stability
- Including results from more trials from
  - DIVERSIFOOD WP2, where still in processing and not yet included,
  - DIVERSIFOOD WP3, therefore including data on newly developed populations
  - experiences held outside DIVERSIFOOD
- Upgrade to an interactive web page

Outline of results from the DIVERSIFOOD WP2 trials

DIVERSIFOOD WP2 trials have broken down crop "evaluation" into four main dimensions, strictly connected with one another, yet all with a value of their own: (i) crop descriptors, *i.e.* those phenotypic traits useful to identify a genetic resource; (ii) agroecosystem performance, as a driver of environmental fitness; (iii) productive performance, as a driver of the yield potential; (iv) quality performance, as a driver of success in local, high-quality value chain.

As far as crop descriptors are concerned, two main remarks emerged. First, certain traits reappear that, during modern breeding, were lost. The wide diversity also included undesirable traits, that have been bred against and might also have played a role in the abandonment of certain phenotypes. A typical example is the extreme straw height of certain winter cereals that generates problems of lodging. At the same time, cereals with similar straw height were found to differ significantly in terms of lodging susceptibility, suggesting that the existing wide genetic diversity also includes the resources to counteract the negative effects of certain characteristics. Second, single genetic resources show considerable within-crop phenotypic diversity, which can either be part of their genetic structure, being them landraces or OPVs or composite cross populations, or result from intentional or even accidental mixtures, as observed in certain entries of rivet wheat which included considerable amounts of bread wheat.

Agroecosystem performance was evaluated under different angles, mostly looking at weed competitiveness, pest and diseases resistance and abiotic stress tolerance. In some cases, the focus was really specific and set on *e.g.* resistance to a certain disease, whereas in others the focus was broader and set on the overall fitness in marginal conditions. The overall outcome is that agroecosystem performance of a same genetic resource can vary greatly depending on where it is grown and must therefore be looked at a very local scale. This reinforces the importance of deploying and testing genetic resources in multiple farms rather than in centralised research stations.

Productive performance highlighted a, perhaps expected, trend: yield of underutilised crops can be a serious limiting factor, as the tested material can be either low-yielding or difficult to harvest, but, in many cases, can be a relief for marginal conditions. Species as einkorn, emmer or rivet wheat can thrive where their commonly grown closest relatives (e.g. durum or bread wheat) are not a viable option. This is one of the key benefits expected from underutilised crops: that they can be a valuable option for areas that would perhaps be abandoned if only relying on widely available seeds.

Quality performance was as well evaluated under different angles, namely (i) processing quality, (ii) nutritional and nutraceutical quality, (iii) organoleptic quality and (iv) intangible value. Main highlights under these points are that a diversity of crops triggers a diversity of products that needs adaptation in both the processing and the methods and concepts to assess their quality. This in not to be seen as a limitation in itself. Grains from minor cereals are not necessarily suited to industrial milling but are an opportunity for e.g. artisanal millers and bakers, whose processing methods are more flexible, to add value to highly nutritious raw materials. Similarly, broccoli OPVs can show higher concentration of health-promoting compounds (as e.g. glucosynolates) than mainstream hybrid without necessarily lower yield. Their phenotypic diversity in shape and sometimes taste of the florets makes them more suited to alternative distribution as direct selling or "farmers' markets" than e.g. supermarkets, at least in the immediate future. Last but not least, the "intangible" value is something not measurable but, yet, not negligible in importance as it builds on the "cultural identity" of a product and can therefore support the development of production and supply chains with values other than yields and revenues.

2. The DIVERSIFOOD database on underutilised genetic resources performance - *A guide to navigate the results of participatory on-farm evaluation*

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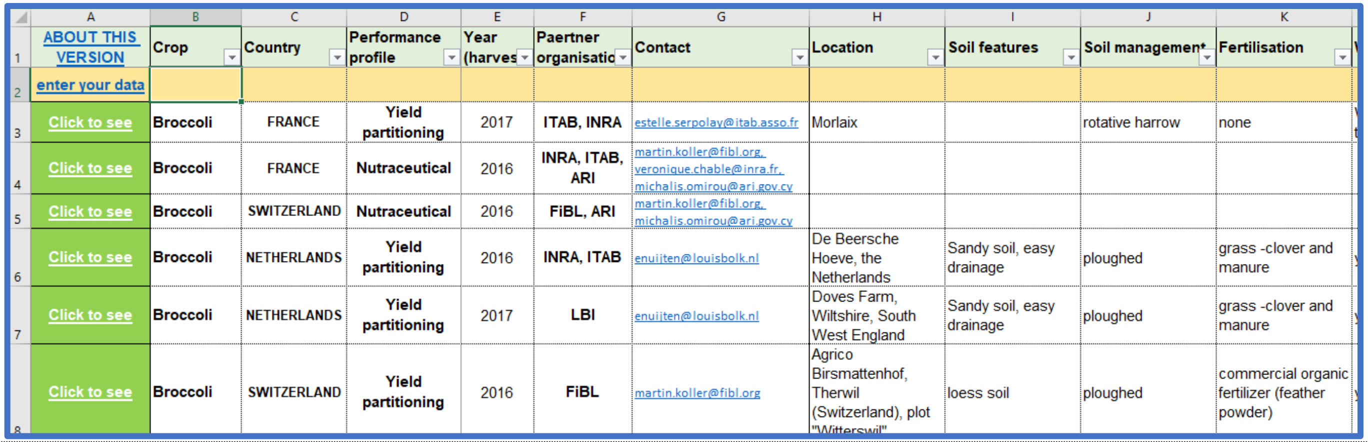
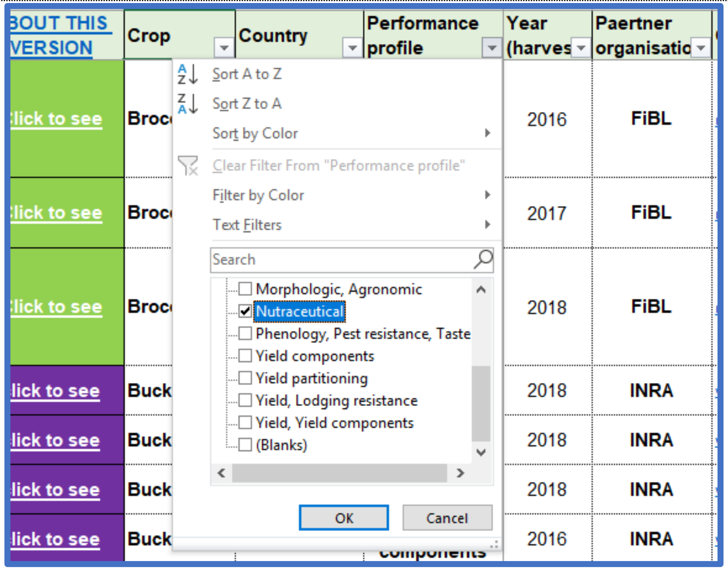
The main spreadsheet

The database is an **excel file** that can be navigated using links and the **“filter” function**. When opening the file, you are on a general sheet with all the trials represented. This sheet can be navigated and filtered by all its columns.



	A	B	C	D	E	F	G	H	I	J	K
1	ABOUT THIS VERSION	Crop	Country	Performance profile	Year (harves	Paertner organisatio	Contact	Location	Soil features	Soil management	Fertilisation
2	enter your data										
3	Click to see	Broccoli	FRANCE	Yield partitioning	2017	ITAB, INRA	estelle.serpolay@itab.asso.fr	Morlaix		rotative harrow	none
4	Click to see	Broccoli	FRANCE	Nutraceutical	2016	INRA, ITAB, ARI	martin.koller@fibl.org, veronique.chable@inra.fr, michalis.omirou@ari.gov.cy				
5	Click to see	Broccoli	SWITZERLAND	Nutraceutical	2016	FiBL, ARI	martin.koller@fibl.org, michalis.omirou@ari.gov.cy				
6	Click to see	Broccoli	NETHERLANDS	Yield partitioning	2016	INRA, ITAB	enuijten@louisbolk.nl	De Beersche Hoeve, the Netherlands	Sandy soil, easy drainage	ploughed	grass -clover and manure
7	Click to see	Broccoli	NETHERLANDS	Yield partitioning	2017	LBI	enuijten@louisbolk.nl	Doves Farm, Wiltshire, South West England	Sandy soil, easy drainage	ploughed	grass -clover and manure
8	Click to see	Broccoli	SWITZERLAND	Yield partitioning	2016	FiBL	martin.koller@fibl.org	Agrico Birsmattenhof, Therwil (Switzerland), plot "Witterswil"	loess soil	ploughed	commercial organic fertilizer (feather powder)

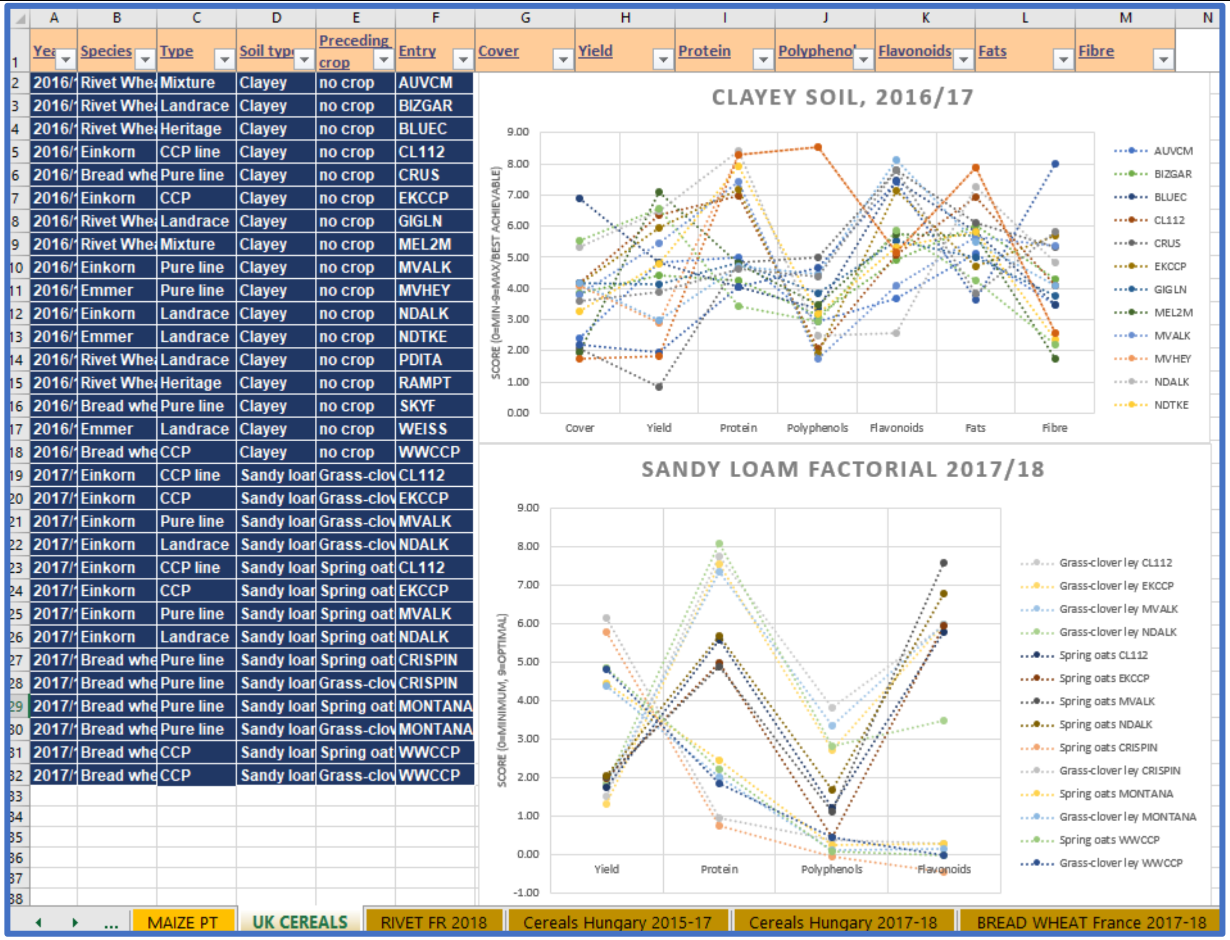
For example, you can filter by “performance profile”, where the performance variables shown are indicated, and decide you want to select trials who show a “nutraceutical” profile of the accessions tested. You then visualise the trials who cover this kind of profile and can further filter by “crop” or “country” for example. Once identified a trial of interest, **link on the first cell of the row (“click to see”)** leads you to the data spreadsheet.



The data spreadsheets

A data sheet opens. **Fixed variables** (in this case, Year, Species, Type, Soil type, Preceding crop, Entry) are on the left-hand side. **Performance variables** are inserted as **scores derived by relating actual values to a min-max range** derived from literature and/or from local conditions and knowledge.

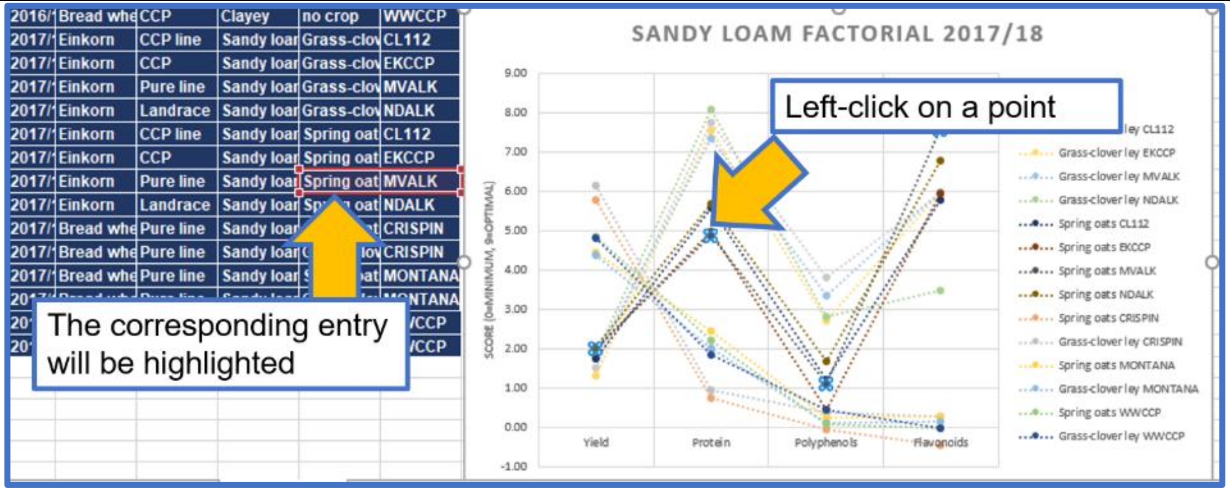
A scoring 0 to 9, '0' indicates the minimum acceptable value and '9' indicates the maximum or best achievable value. This way, the charts on the right-hand side will visualise the performances as positioned in a meaningful range: even visualising the profile of a single accession, you will be able to understand if its yield and quality are "low", "average" or "high".



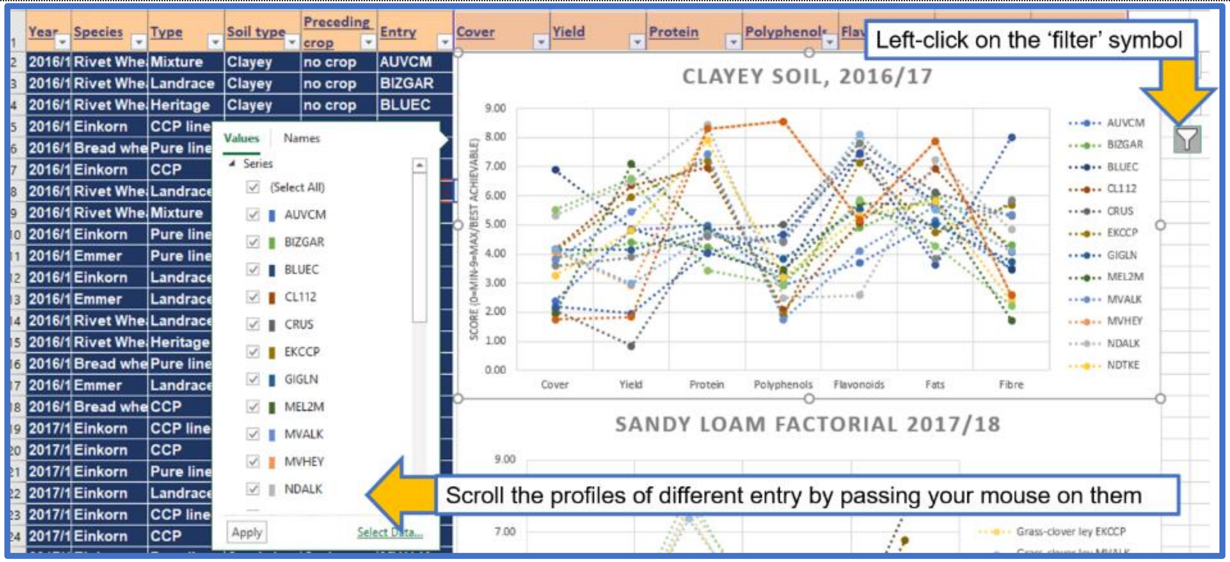
Yea	Species	Type	Soil typ	Preceding crop	Entry	Cover	Yield	Protein	Polypheno	Flavonoids	Fats	Fibre
2016/	Rivet Whe	Mixture	Clayey	no crop	AUVCM							
2016/	Rivet Whe	Landrace	Clayey	no crop	BIZGAR							
2016/	Rivet Whe	Heritage	Clayey	no crop	BLUEC							
2016/	Einkorn	CCP line	Clayey	no crop	CL112							
2016/	Bread whe	Pure line	Clayey	no crop	CRUS							
2016/	Einkorn	CCP	Clayey	no crop	EKCCP							
2016/	Rivet Whe	Landrace	Clayey	no crop	GIGLN							
2016/	Rivet Whe	Mixture	Clayey	no crop	MEL2M							
2016/	Einkorn	Pure line	Clayey	no crop	MVALK							
2016/	Emmer	Pure line	Clayey	no crop	MVHEY							
2016/	Einkorn	Landrace	Clayey	no crop	NDALK							
2016/	Emmer	Landrace	Clayey	no crop	NDTKE							
2016/	Rivet Whe	Landrace	Clayey	no crop	PDITA							
2016/	Rivet Whe	Heritage	Clayey	no crop	RAMPT							
2016/	Bread whe	Pure line	Clayey	no crop	SKYF							
2016/	Emmer	Landrace	Clayey	no crop	WEISS							
2016/	Bread whe	CCP	Clayey	no crop	WWCCP							
2017/	Einkorn	CCP line	Sandy loar	Grass-clov	CL112							
2017/	Einkorn	CCP	Sandy loar	Grass-clov	EKCCP							
2017/	Einkorn	Pure line	Sandy loar	Grass-clov	MVALK							
2017/	Einkorn	Landrace	Sandy loar	Grass-clov	NDALK							
2017/	Einkorn	CCP line	Sandy loar	Spring oat	CL112							
2017/	Einkorn	CCP	Sandy loar	Spring oat	EKCCP							
2017/	Einkorn	Pure line	Sandy loar	Spring oat	MVALK							
2017/	Einkorn	Landrace	Sandy loar	Spring oat	NDALK							
2017/	Bread whe	Pure line	Sandy loar	Spring oat	CRISPIN							
2017/	Bread whe	Pure line	Sandy loar	Grass-clov	CRISPIN							
2017/	Bread whe	Pure line	Sandy loar	Spring oat	MONTANA							
2017/	Bread whe	Pure line	Sandy loar	Grass-clov	MONTANA							
2017/	Bread whe	CCP	Sandy loar	Spring oat	WWCCP							
2017/	Bread whe	CCP	Sandy loar	Grass-clov	WWCCP							

Exploring the charts

These graphs can be navigated in different ways. First, you can explore by **left-clicking on specific points** or data series on the graph, and **the corresponding entry will be highlighted**

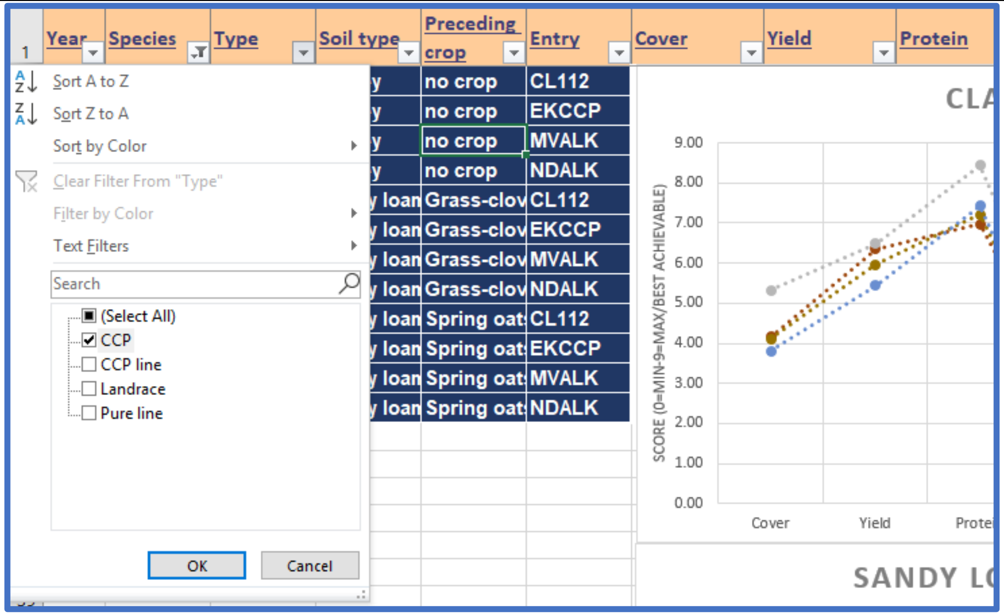


Alternatively, you can explore the different profiles using the **filter button appearing on the top-right side of the graph** when selected

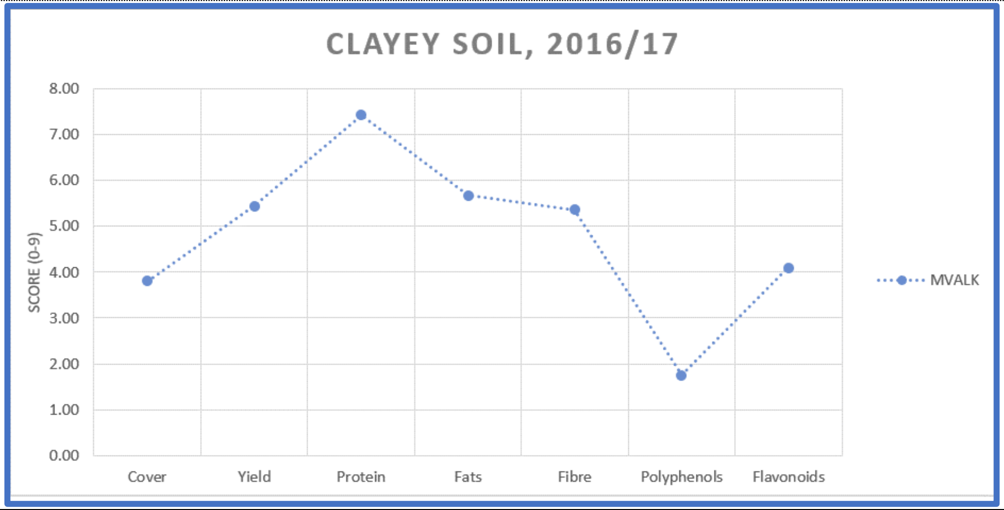


Navigation through filters

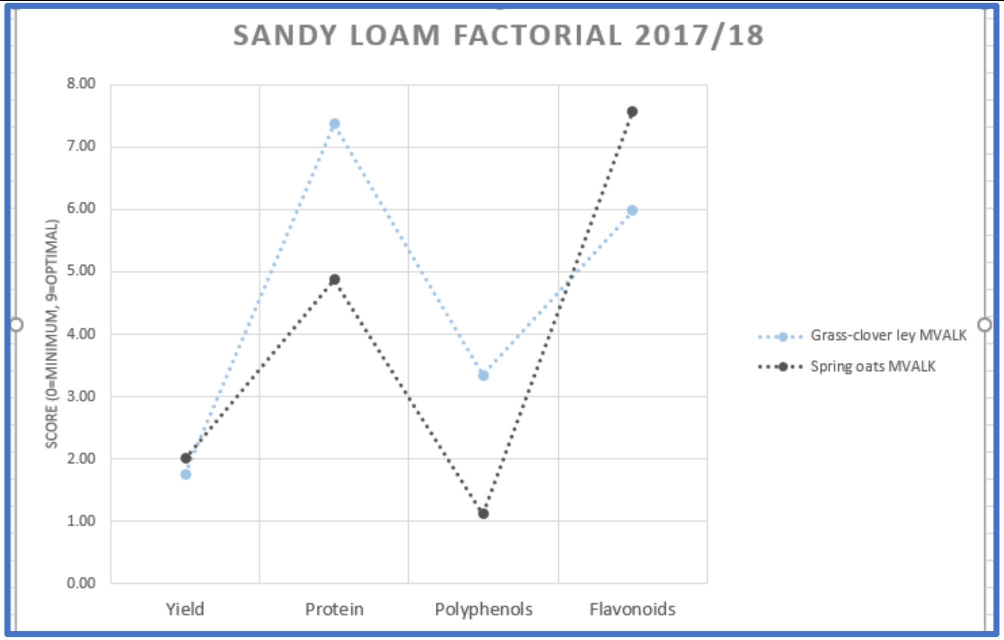
To analytically navigate the graphs is using the **filter function on the header row**.
In this case, for instance, you can filter by “species” and select one out of four different species tested.
Further filtering by “type” you can select within the genetic types available within the species filtered earlier on.



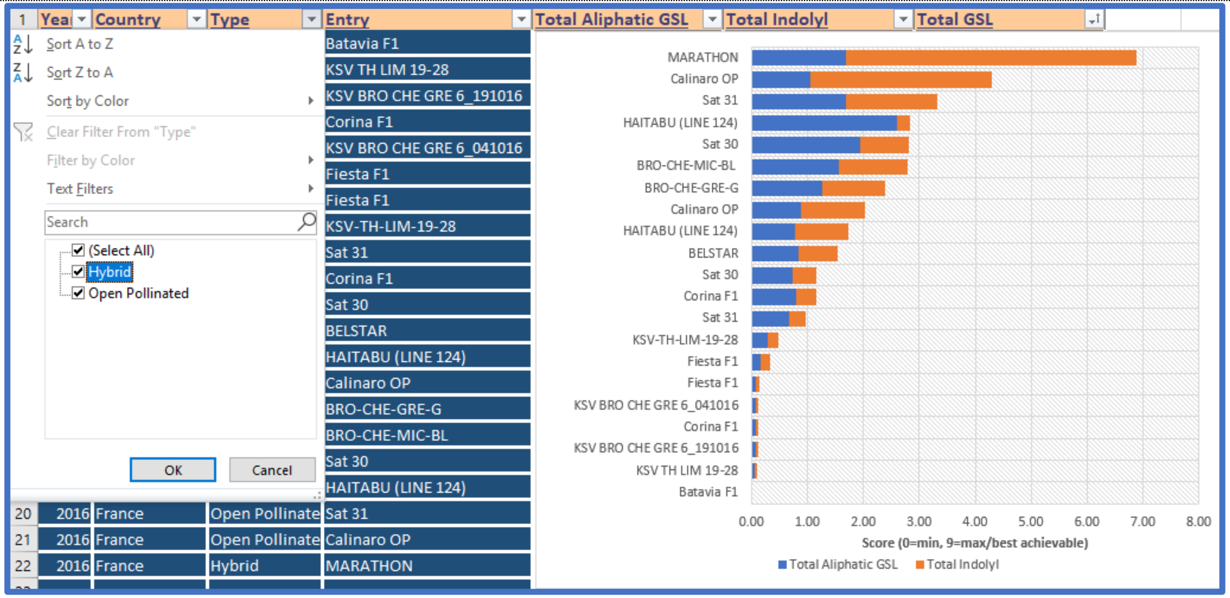
You can finally **identify a single accession**, whose **profile will appear on the graphs**.
In the first graph there is only one profile for this accession, as it has been tested in a single site in that year. You can observe its average cover, good yield, extremely good protein level, and low polyphenol content.



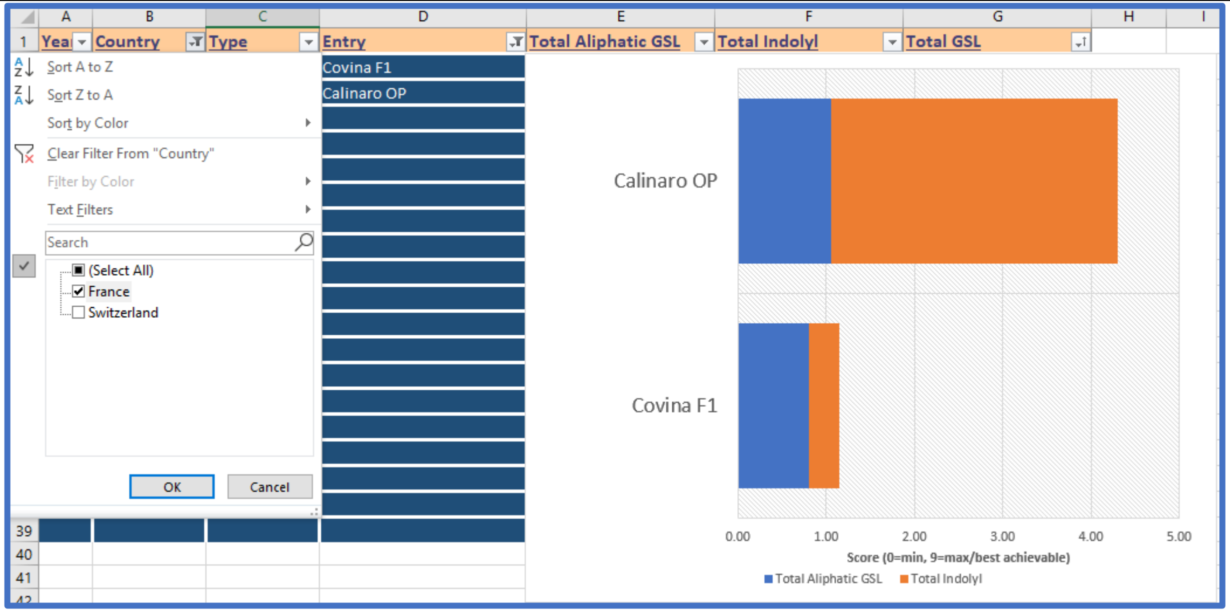
In the second graph of this sheet, you see two profiles instead, as the accession was **tested on two fields** in different rotational positions. Here you can appreciate that the yield is generally low, grain protein and polyphenols content are visibly higher the crop grown after a grass-clover ley (light blue line) than after spring oats (dark grey line).



Other data sheets have different graphs. Here for example the graph shows the content of the two main components of glucosinolates in broccoli. The entries represent open-pollinated (OP) and F1 hybrid varieties grown in Switzerland and France in 2016.

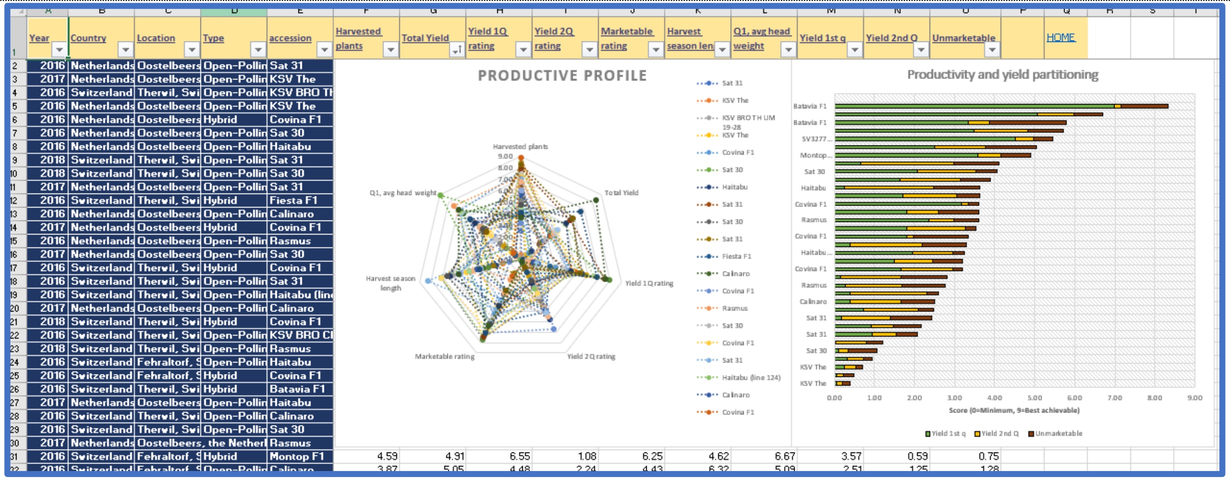


Selecting one open-pollinated and one hybrid that were grown in both sites, the graph shows that the GSL content was visibly higher in the OP than in the F1 hybrid in France, mainly due to higher indolyl (orange bars).

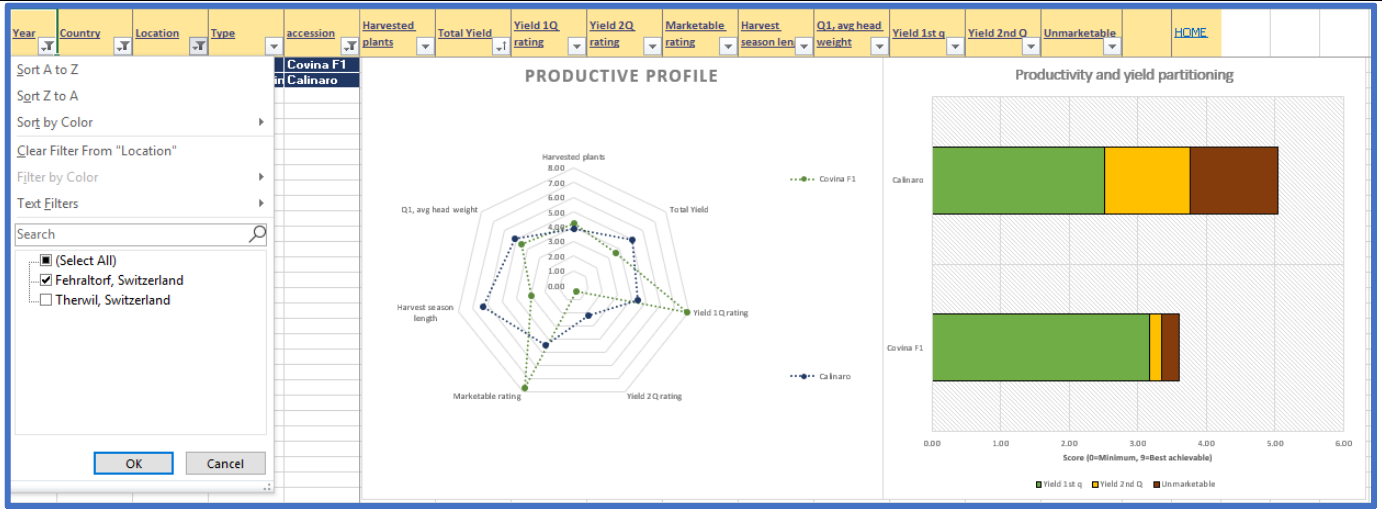


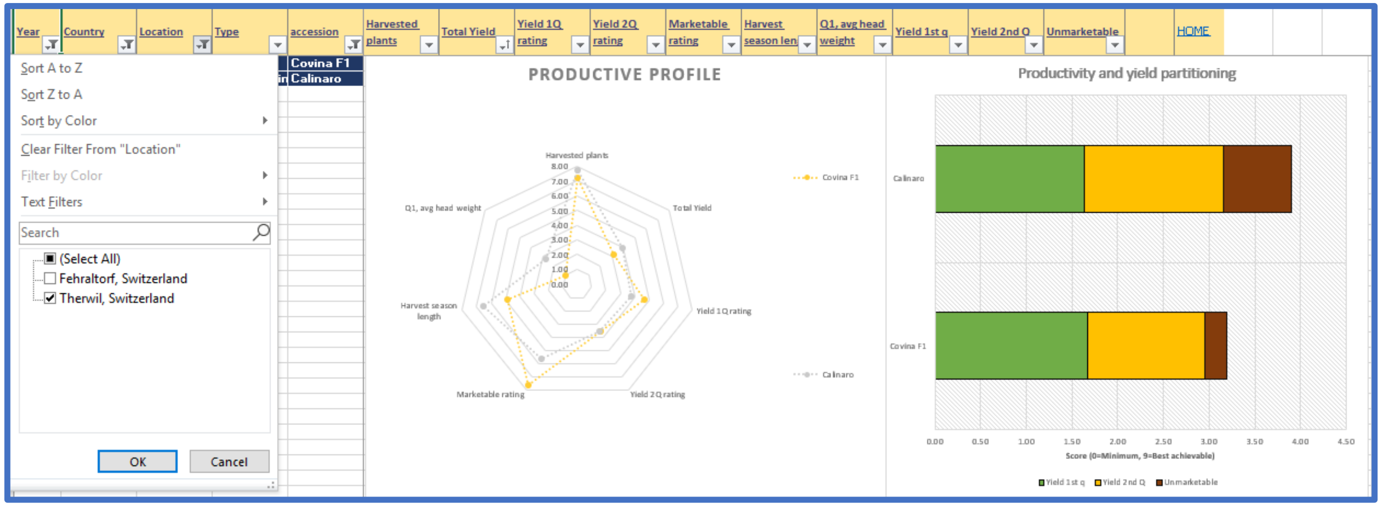
Results from multiple locations

Broccoli trials also have a comprehensive sheet with a **multi-year multi-location trials** (2016 to 2018 in Switzerland and the Netherlands) where the productive profile is visualised with a **radar chart** (left-hand) and the yield partitioning as a **stacked bar chart** (right-hand).



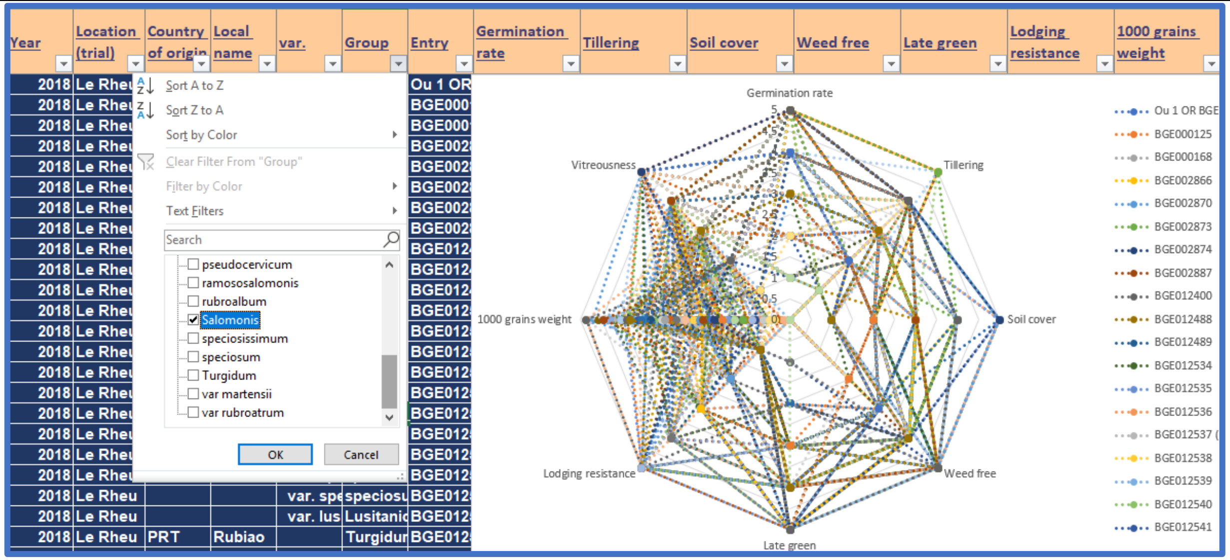
Entries are classed as Open-Pollinated and F1 Hybrid. An OP ("Calinaro") and a F1 hybrid ("Covina") can be compared in the two location where they have been tested in Switzerland, showing that the OP had higher total productivity than the F1, but higher rate of unmarketable (brown bar) yield.



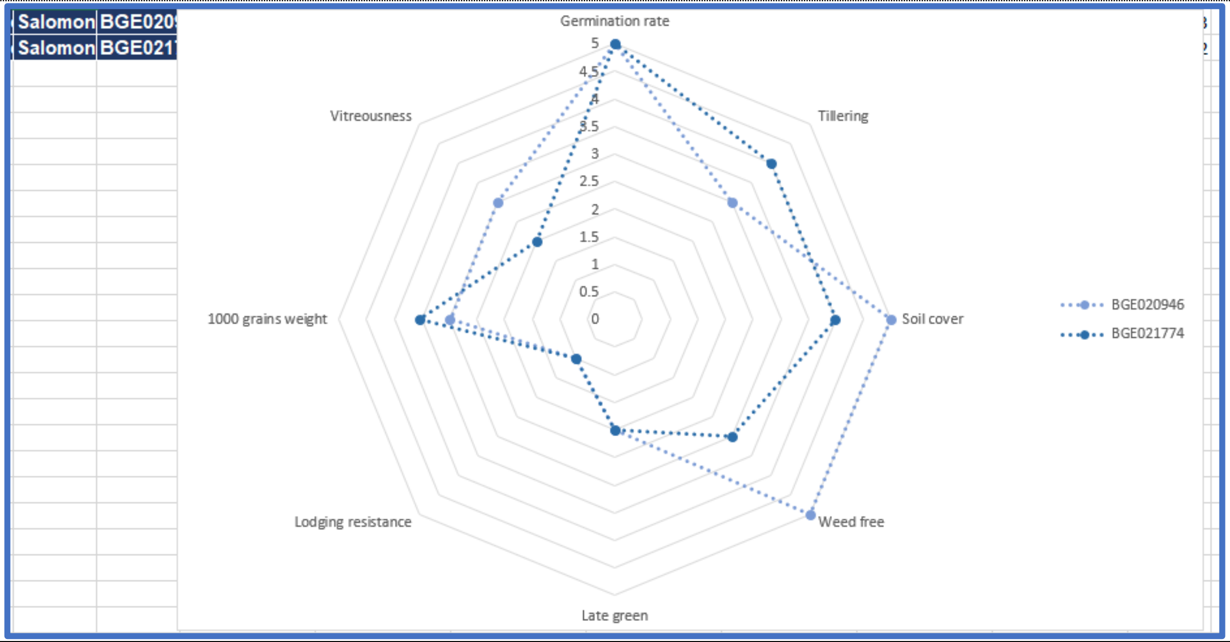


Screening a large collection

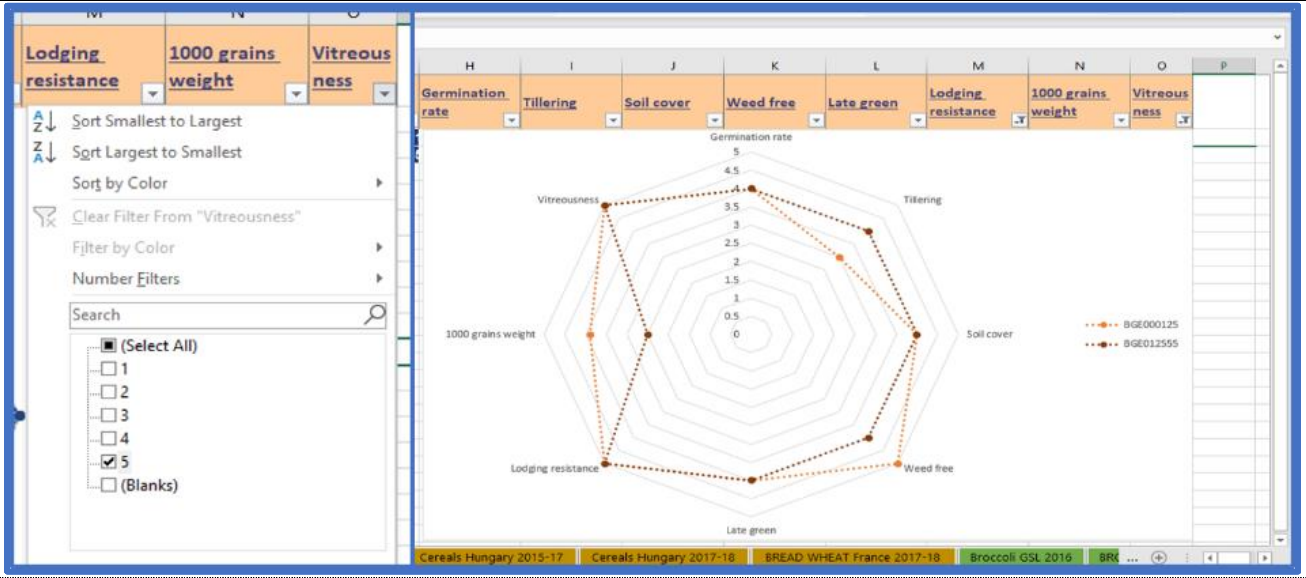
As a last example, there is a datasheet (RIVET FR) with more than 150 rows visualised by a radar graph, with an agronomic and grain features screening of rivet wheat accessions. This can be browsed by e.g. taxonomic group.



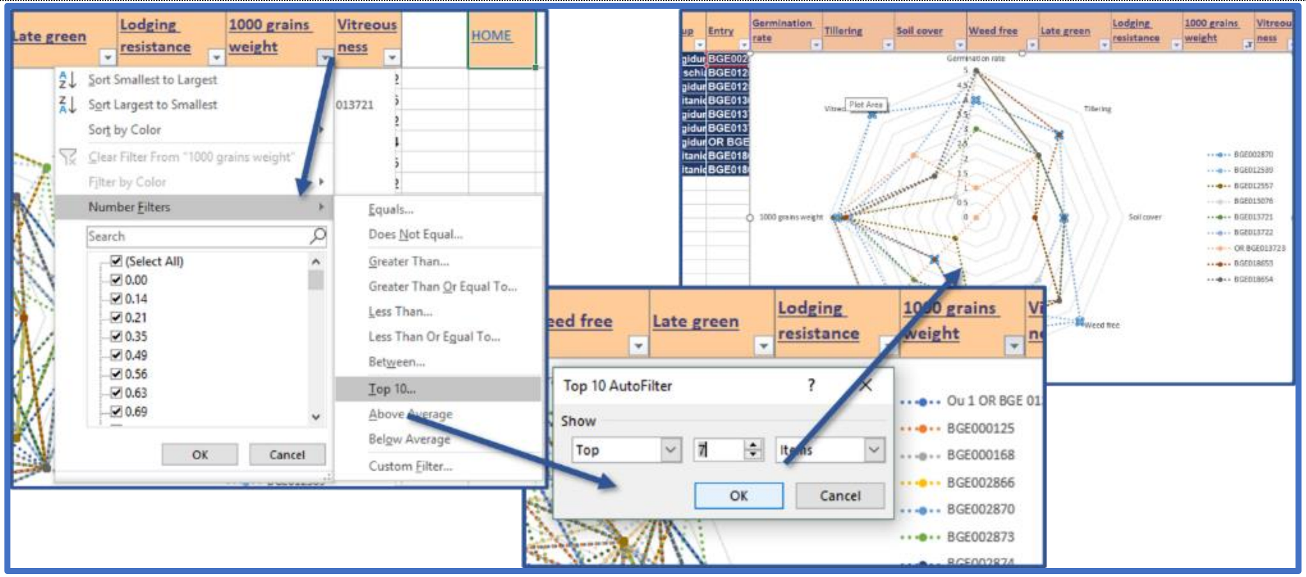
Here is for example the profile of the two entries of *Triticum Turgidum Salomonis*



In this case it may be good to directly **filter by performance variables**.
For instance, two key variables for rivet wheat are vitreousness, indicator of pasta-making quality, and lodging resistance, very important for a tall cereal. Both variables are a 1 to 5 score. Filtering by maximum value (“5”) for both you can identify accessions responding to your criteria.

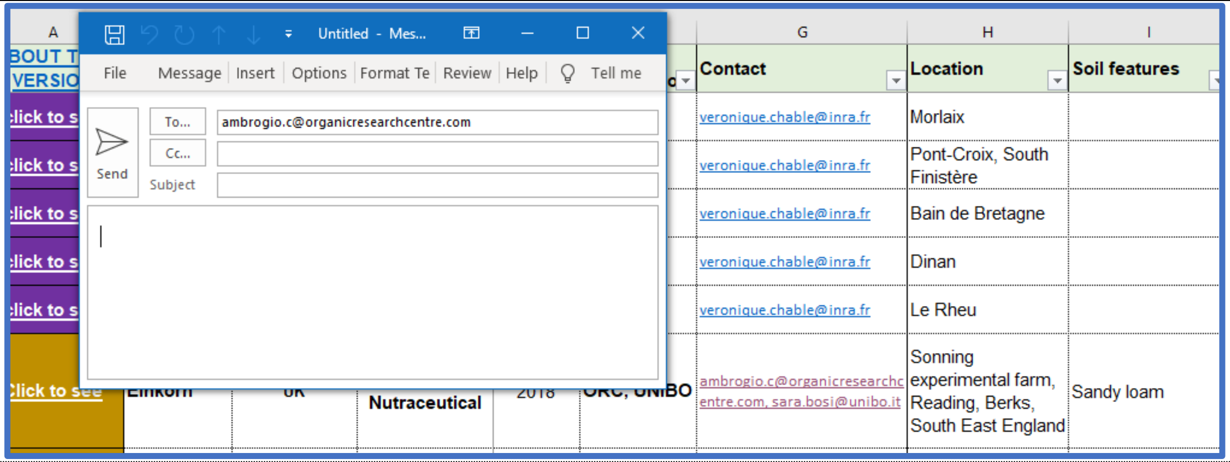


For continuous, numerical variables, a further option is to use the number filter functions, to select e.g. the top 7 values of grains average weight

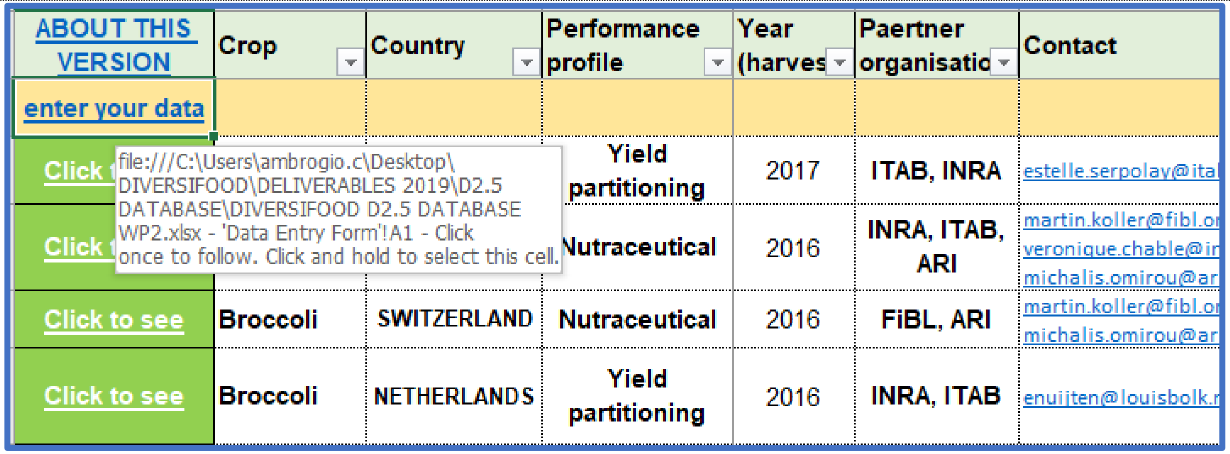


Get in touch

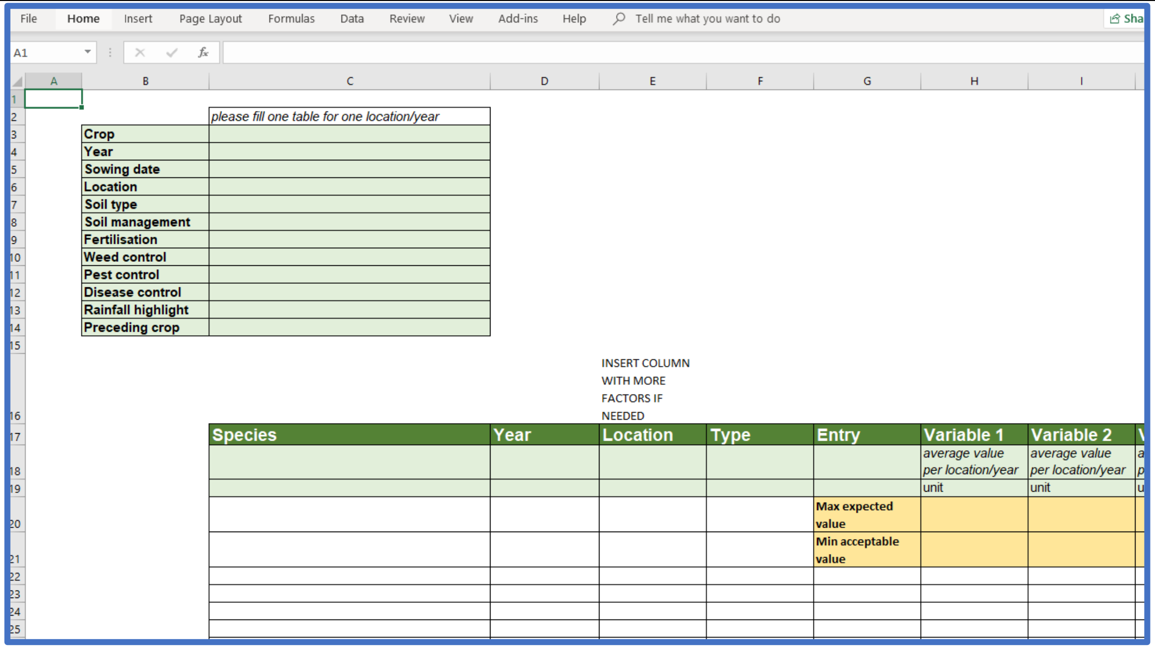
More information, including actual data, description of specific accessions and access to seeds if available, can be obtained directly from the trial's leaders, whose email contacts are indicated in the main spreadsheet.



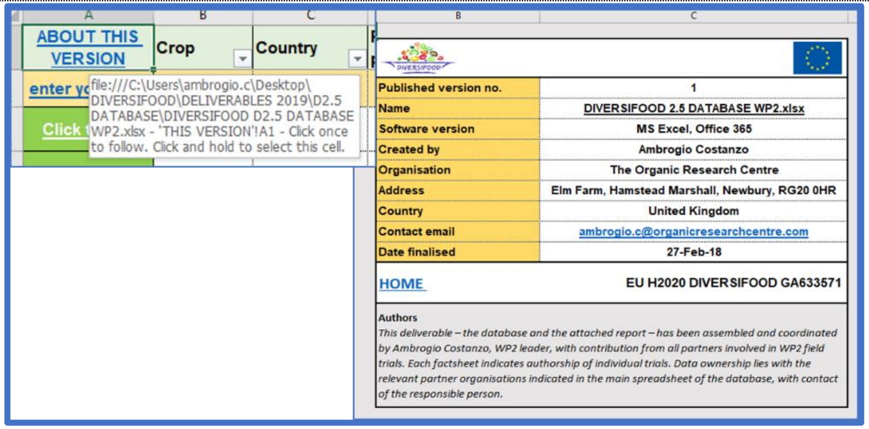
This Excel file is a proof of concept of a database to visualise performances of different accessions in different trials, each with its own conditions and performance profiles. The database will be **periodically updated and improved**, and this could be an opportunity to visualise and bring value to other data coming from other experiences. In the first sheet, there is a link to a "**data entry form**".



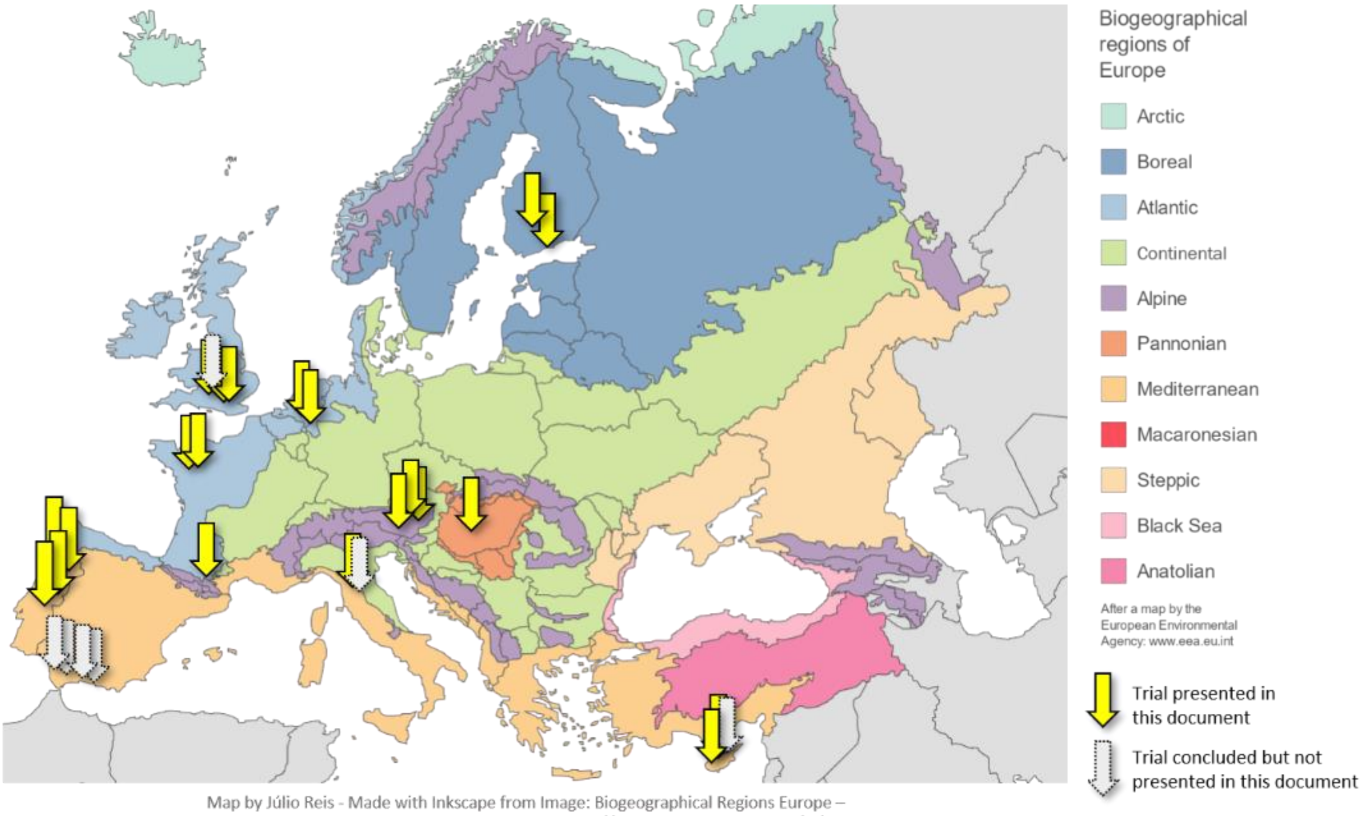
In this data entry form, there are **two tables that you can copy and fill with your data**. Filled entry forms can then be sent to the Organic Research Centre (email: Ambrogio.c@organicresearchcentre.com). **Do not forget to indicate, for each variable, what the best/maximum and the minimum acceptable value would be**. According to your indications, your data will be transformed in a 0-9 rating and visualised accordingly. When overlapping with existing trials exist (e.g. common accessions and/or variables), we will attempt to merge outcomes from your experiences with existing results.



You can always check which version you have downloaded by clicking on the top-left cell in the main sheet



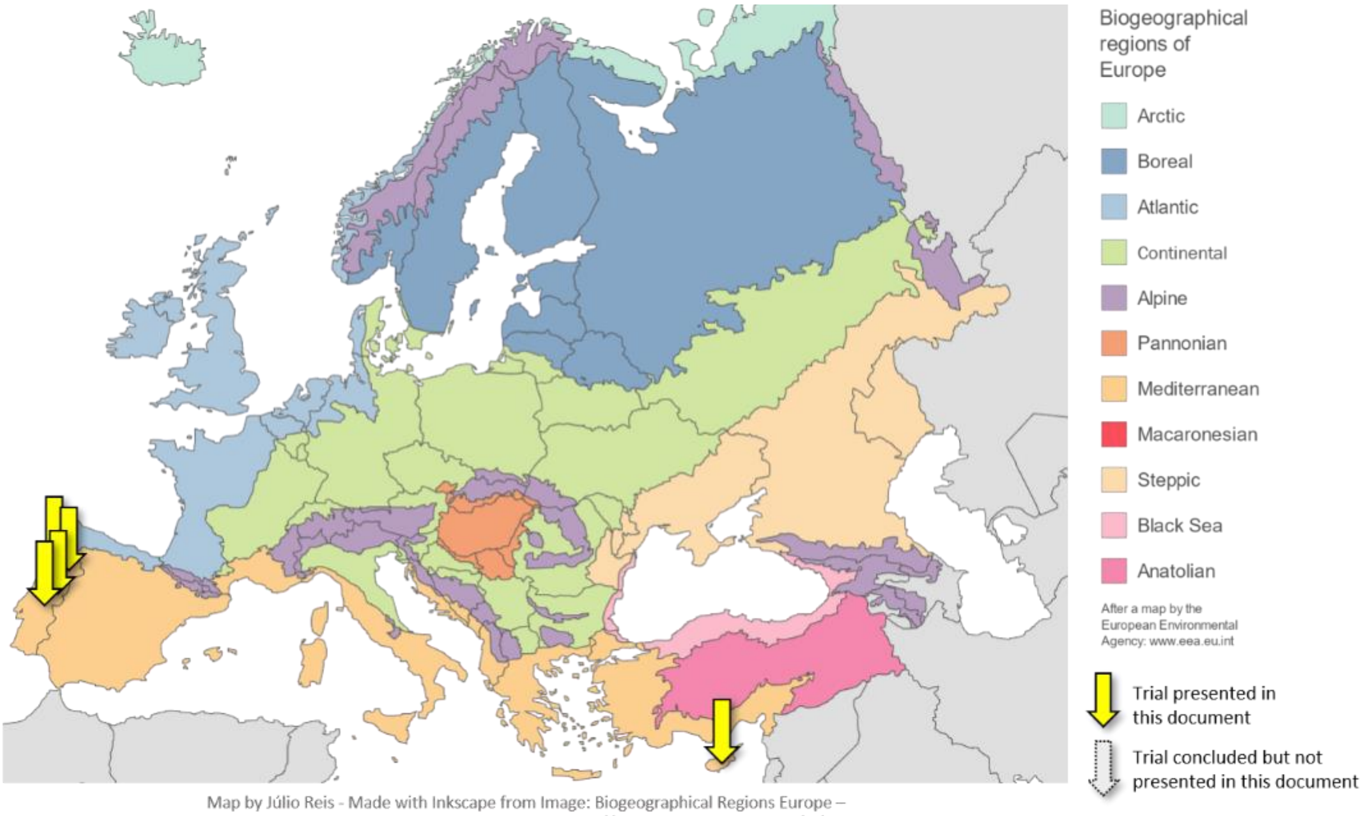
3. Annexes: Factsheets from DIVERSIFOOD WP2 trials



Map by Júlio Reis - Made with Inkscape from Image: Biogeographical Regions Europe – Map (intl).png by the European Environmental Agency, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=804348

Maize

Zea mays



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Assessing Maize suitability for organic and low-input condition and for 'broa' bread production in Portugal

ESAC – Portugal, Pedro Mendes Moreira and Emanuel Ferreira – pmm@esac.pt

Abstract

Trial in DIVERSIFOOD follow the Project VASO and other national projects were collection missions, selection and participatory plant breeding took place. In the year 2010 under SOLIBAM Project there was the evaluation of 51 accessions. From these accessions, the 9 most promised accessions were chosen for trials. Trials were done since 2015 to 2018 in one to three locations. The agronomic data obtained were associated to the information gathered by field trials, focus groups and interviews. Tasting information will also be collected

Rationale

The work carried out in DIVERSIFOOD for maize follow the continuation of the SOLIBAM FP7 Project and the VASO Program, as well as from other national projects. The objectives of this work were to obtain maize germplasm with good appetence for human consumption, preferably on the form of broa and that had a good productive performance in agriculture of low-input and Organic agriculture. This work has been carried on in transdisciplinarity and has a multiactor approach, which has been support the plant breeding goals.

List of accessions

The germplasm used were selected from previous projects and developed in DIVERSIFOOD, trials took place in three locations since 2015 to 2018.

- *Am(C3)97*
- *Amiúdo Tomar C0*
- *Broa70*
- *Fandango C0*
- *Pigarro C0*
- *SinPre C0*
- *VA C1S1*
- *Vermelhinho*

Location(s)

Alvarenga: soil is loam with high soil mass fraction, high organic matter content, contributing with mineralized N estimated amount about 182 kg/ha.year, pH is slightly acid, it has a low availability of phosphorus and it has a medium level of potassium.

Lousada: soil is loam with good soil mass fraction, good organic matter content, contributing with mineralized N estimated amount about 140 kg/ha.year, pH is quite low, the available phosphorus content is very high and potassium level is medium.

Vouzela: soil is loam, with high soil mass fraction, medium organic matter content, contributing with mineralized N amount estimated about 113 kg/ha.year, pH is slightly acid, the available phosphorus content is very high and potassium content is high.

Climate

Vouzela

The municipality of Vouzela is in a region of transition between the Mediterranean climate, and temperate climate of maritime influence. The Region's climate can be classified as transitional AxSA (AtlanticxSubatlantic), with

oro-atlantic influence due to its altitude and proximity of mountain areas. According to Thorntwaite, the climate of the area is moderately dry to humid, mesothermic, with a water deficit in summer.

Lousada/Alvarenga

The municipality is located in a region of Atlantic influence, the natural corridors of the Sousa and Mezio rivers also contribute for this humid maritime climate: Winters and summers with climatic variations of cool to mild climate, with average annual temperatures between 10-12.5ºC.

Trial design and management

Nine entries were used and tested during three years. In 2015 at Lousada, in 2015 to 18 at Alvarenga and Vouzela from 2015 to 16. These locations are in the North and Central Portugal.

For each location, a randomized complete block design, with two to three replications was used. Each plot consisted of two rows (6, 4 m long with 0, 75 m between rows). Each plot was overplanted by hand and thinned at seven leaf stage growth development stage.

ANOVA was done for the traits measured, considering the genotype and environments (location and year) and their interaction. Post-hoc comparisons did use the Sheffe test.

Main variables assessed

Crop characterization				
Traits	Codes	Scale	Type of data available	How it has been assessed / Description
Stand*		Plants ha-1		Thousands of plants per hectare;
Moisture	HR	%		The grain moisture was measured with the ISOELECTRIC GRAIN CHECK® moisture meter, using the grain of four random ears of the plot;
Cob and Ear ratio	CW/EW			Using four random ears of each plot to determine this indicator that would allow to calculate the kernel weight (KW)
Height	H	cm		Plant height, from the stalk basis to the last leaf insertion before the tassel
Height of the First Ear	H1E	cm		Ear height, from the stalk basis to the highest ear bearing node
U**niformity**	U	1 to 9	50% in the Plot	1-minimum uniformity and 9 – maximum; 1-4 to pure lines and 5-9 to populations.
Leaf ANgle	N	1 to 9	50% in the Plot	Angle of the adaxial side of the leaf above the ear with the stalk (5=45º, <5 =<45º and >5 = >45ºC)
T**assel Branching**	T	1 to 9	50% in the Plot	1- absent tassel (Inbreeds and hybrids) 9- a much branched tassel (frequent in populations with abnormal fasciated ears).
E**ar Placement**	E	1 to 9	50% in the Plot	5- indicates that the ear is located in the middle of the plant, if <5 bellow and if >5 above the middle of the plant.
R**oot Lodging***	R	%		Percentage of plants leaning more than 30º from vertical
S**talk Lodging***	S	%		Percentage of plants broken at or below the primary ear node, related with the quality of the stalk and the stalk damage caused by some insect attack.
Crop productive performance (yield, yield components)				

Trait	How it has been assessed	Type of data available
YieldProd/ha 15%HR	Yield to 15% of moisture, manual harvest. The harvested plot is multiplied by the ratio between (1-CW)/EW, that will indicate the kernel weight. Kernel weight is then converted to 15% moisture	Quantitative (Mg/ha)

Main results

ANOVA results indicated significant differences across genotypes for all the traits with exception for Leaf angle and root lodging. Significant differences were found across environments for all the measured traits. For the interaction between G x E significant differences were found for yield15%, number of ears per ha, plant height, stalk lodging, ear placement and stand.

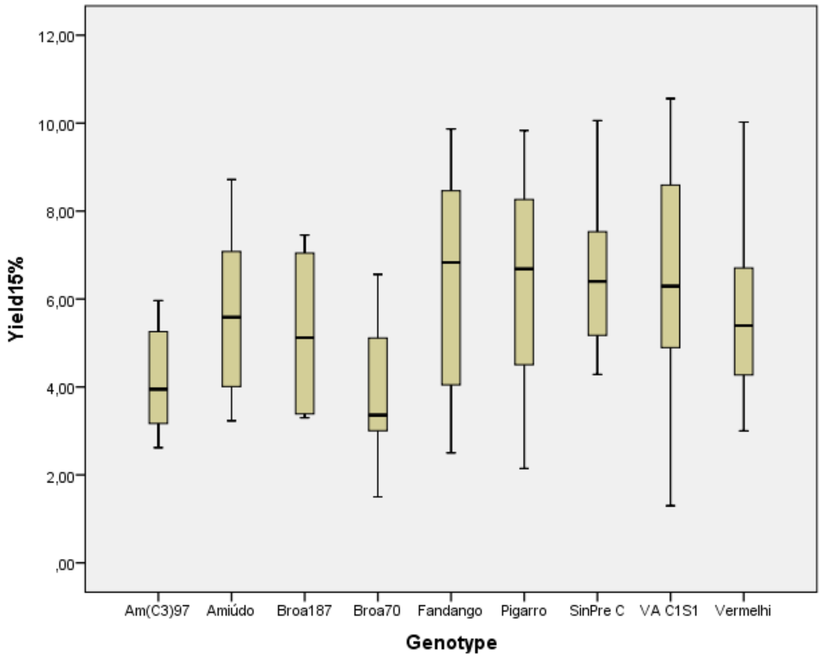

Fig. 1. Yield of the different Maize genotypes.

Significant differences were found between the Broa 70 and Am(C3)97 respectively with 3,78 Mg/ha and 4,11 Mg/ha and Pigarro C0 (6,34 Mg/ha), VA C1S1 (6,41 Mg/ha), Fandango C0 (6,45 Mg/ha) and SinPre C0 (6,55 Mg/ha).

The high yield location were represented by Vouzela 2016 that were significantly different from the other locations.

Broa 187 represented the lowest plant height and Fandango C0 the highest, significant differences were observed and four groups were identified.

Ear placement in Broa 187 was significantly lower than the other accessions. Significantly differences were also registered among three groups were Vouzela 2015 (4,5) had the significantly lower value compared with Alvarenga 2017 (6,96).

Root lodging was significantly different among Alvarenga 2016 (2,49%) versus Lousada (11,10%) and Vouzela in 2015 (13,71%).

Significantly differences were observed between Vermelhinho (2,75%) with Pigarro C0 (23,18%) for stalk lodging. Significantly differences were also observed for Alvarenga 2017 (1,51%) versus Lousada (26,21%) and Vouzela (25,54%) in 2015.

The prolificacy registered a significantly lower level for Fandango when compared with Broa 187, indicating that Fandango C0 needs to reduce their stand or increase adaptation for higher stand.

Three groups with significant differences in Moisture at harvest were observed, trait that are generally related with earliness (Vermelhinho, Broa 70, Am(C3)97) or lateness germplasm (Fandango). Among locations three groups were also identified being Alvarenga 2017 with less moisture versus Vouzela 2015.

The CW/EW ratio can be organized in three groups according Sheffe Am(C3)(19,11%, Vermelhinho (20,03%) and Broa 70 had a significantly lower value compared with Pigarro C0 (32,89%). CW/EW also changed significantly with the location where Alvarenga 2017 was lower (20, 75%) and Vouzela 2015 higher (30,23%).

Discussion and Conclusion

The data here presented provides the main differences among germplasm. Indicating their potential for breeding according the preferences for early or late germplasm (moisture percentage), reducing the CW/EW and search for a higher kernel dept. Ear placement are important to make easier for both hand harvest, and mechanical harvest. Stalk lodging measures the health of the plant.

We can also observe that traits such yield15%, number of ears per ha, plant height, stalk lodging, ear placement and stand that showed significant differences for the interaction genotype and environment.

The trials in which we obtain the data, were also used for farmers day selection and the harvested maize served for maize bread manufacturing and taste. Till the end of this month a SENSE-Bus test will be elaborated.

Field phenotyping of traditional maize landraces under water stress conditions

ITQB and ESAC – Portugal

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Abstract

The main objective of the trial was to evaluate the maize traditional landraces response to water stress, collected from different ecogeographical regions and different water availability conditions. Four Portuguese traditional landraces from different altitudes (Fandango, Pigarro, Caniceira and Bilhó) were grown in field conditions subjected to two different watering regimes (well-watered vs. imposed water stress by water withholding). Destructive and non-destructive biophysical and morpho-physiological parameters were assessed by using, whenever possible, rapid screening approaches throughout the water stress imposition cycle.

Clear differences were observed between the tested landraces in response to the two water regimes with the identification of the best performing ones, better adapted to marginal conditions. Ongoing field trials will enable to register final yield and biomass production for each treatment/landrace expected by the end of September beginning of October.

Location(s)

The trial is being carried out at the Caldeirão (IPC), Coimbra, Portugal.

List of accessions / Landraces

Four Portuguese maize landraces (Pigarro (300 m), Fandango (300 m), Caniceira (1000 m) e Bilhó (65 m)) were used.

List of traits assessed

Crop productive performance		
Plant growth	Field evaluation	Height of the plant
Plant biomass	Field evaluation	Number of leaves
Plant precocity	Field evaluation	Male and female flowering time
Plant yield	Field evaluation	Harvest seed weight
Plant overall aspect (vigour, green colour)	Field evaluation by RGB imaging	RGB images
Crop resistance performance		
Leaf water status	Relative water content (RWC) using leaf discs collected at field trial	RWC calculated in accordance to Catsky (1960), using 3 foliar discs per plant with 0.636 cm^2, RWC = [(FM-DM)/(TM-DM)] x100, where FM is the fresh mass of the leaf discs, TM is the mass after overnight rehydration of the discs in a humid chamber at room

		temperature, and DM is the dry mass after subjecting discs to 80 ºC for 24 h.
Leaf/canopy temperature	Field evaluation by Thermal imaging	Using a ThermaCAM (Flir B20, Flir Systems Inc., USA, 7-13 µm, 320x240 pixels)
Plant photosynthesis performance index/Chlorophyll fluorescence	Field evaluation by Photochemical capacity (Fv/Fm-OJIP test)	Using a chlorophyll a fluorometer (Hansatech Instruments, Kings Lynn, UK).
Individual leaf transpiration, stomatal conductance to water vapour and net photosynthesis under saturating light	Field evaluation by Leaf gas exchange	Using a LCpro+ (ADC BioScientific, UK) infra-red gas analyser (IRGA)
Soil water content		
Soil moisture content	Field evaluation of soil water content (SWC)	Using a TDR (time-domain reflectometer)

Trial background and evolution

The main objective of the trial was to comparatively evaluate four maize traditional landraces response to water stress, collected from different ecogeographical regions in order to assess if the premise of higher altitude origin, normally associated with lower water availability, has allowed development of landraces with higher resistance to drought. Additionally, the trial also served to test and validate some fast and less rapid screening approaches to select the most drought resistant genotypes to be incorporated in new populations more resistant to water deficit. Landraces were evaluated under two different watering regimes (well-watered vs. water deficit). The measurement of several biophysical and morpho-physiological parameters throughout the stress imposition cycle, will allow to identify potential sources of resistance to water stress and better understand the resistance mechanisms characteristic of traditional varieties.

Remote and contact screening approaches (Tleaf and the OJIP test) will be tested and validated for complementing the ongoing participatory selection on these landraces.

Trial design and management

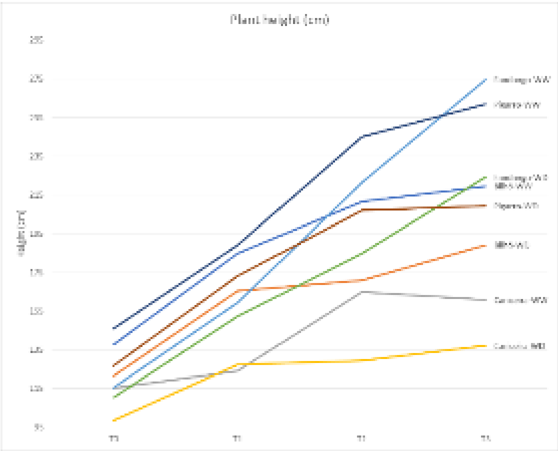
A completely randomized experimental design with two blocks (well-watered and water deficit) and three repetitions was applied. Each of the 24 plots had an area of 9,675 m2 and an average of 48 plants. The experiment was sown on the 16th June 2018. Statistical analysis will be carried out at the end of the trial.

All plants of the trial were kept under well-watered conditions (more or less at field capacity) until the 6th expanded leaf (T0 - 38 days after sowing). After that, the water deficit treatment was not watered anymore, reaching after one month about 20% soil water content. The control plants were kept well-watered to maintain a good water status (RWC above 90-95%). Measurements were taken every week during 5-6 weeks. Seed production, root and aerial biomass will be measured at the end of the season.

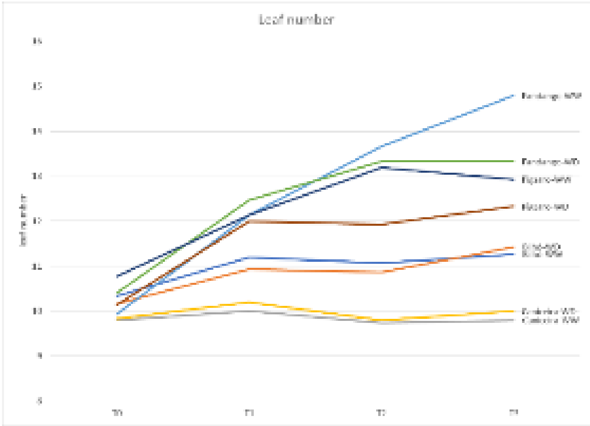
Main results

Clear morphological differences were observed between the landraces response to the two water regimes along the weekly measurements (T0-24.07.2018; T1-31.07.2018; T2-07.08.2018; T3-14.08.2018). Also clear differences were observed at the photosynthetic performance index (Fv/Fm - OJIP test) and at the intrinsic water use efficiency (WUEi = net photosynthesis/stomatal conductance) with the identification of some better performing landraces better adapted to more marginal conditions (Figure 1). Water stressed plants showed also higher leaf temperatures as compared to the well-watered plants (Figure 2). However maize architecture posed some limitations on thermal imaging measurements when comparing landraces at field conditions. Field trials are still on going to register the final production of each treatment expected for September-October. At the end of the season data will be statistically analysed to identify significant different responses to water stress among the tested landraces.

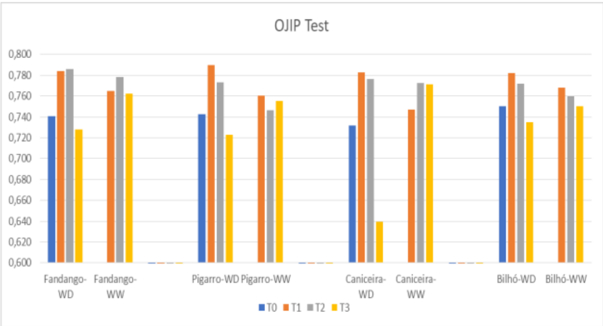
a)



b)



c)



d)

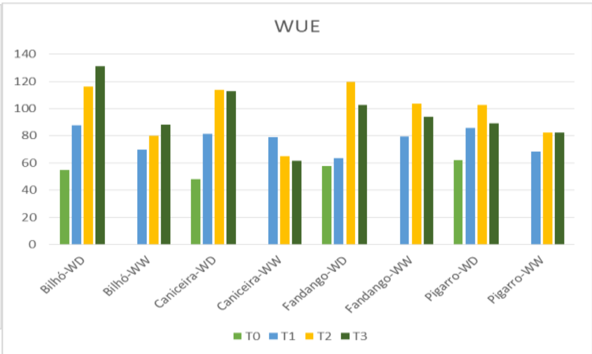


Figure 1. Evolution of plant height (a), leaf number (b), fv/fm (c) and Water Use efficiency (d) among four maize traditional landraces (Fandango, Pigarro, Caniceira, Bilhó) under two water regimes (WW: well-watered; WD: water deficit) from Time 0 (24.07.2018) to Time 3 (14.08.2018) weekly measurements.

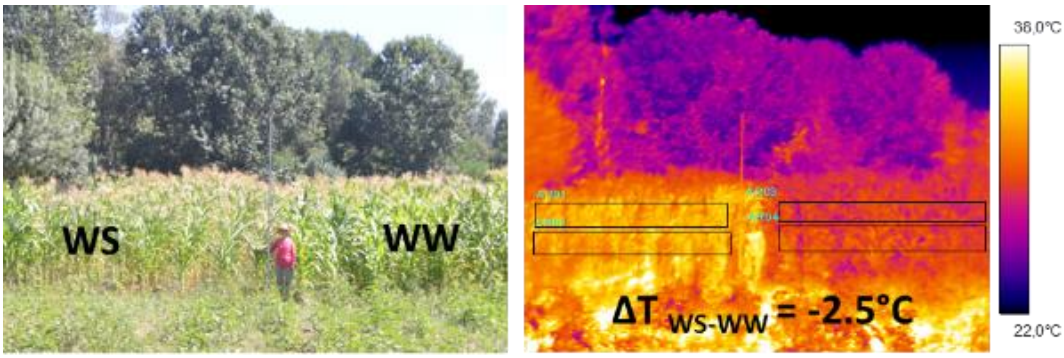


Figure 2. Example of RGB (left) and thermal imaging (right side) to assess water stress in maize plants growing at field conditions. WS – water stressed; WW - control, well-watered plants. Measurements done in the afternoon (14 August, 15.30h).

Discussion

Preliminary results showed that responses to the drought treatment were only started to be visible (leaf curling recorded with RGB) under a severe stress (20% SWC - T3) imposition. Leaf temperature was higher in water stressed plants due to stomatal closure. However the more sensible leaf gas exchange measurements detected these responses earlier during the stress imposition (40% SWC - T2). Differences were also clear between water regimes on the plant growth, clearly reduced in some of the genotypes under drought, with male flowering completed well before the starting of female flowering.

Conclusion and next steps

The field trials are still on going to register the final production (yield and biomass production per landrace) of each treatment expected for September-October, as the main trait measuring the behaviour under marginal water stress conditions. At that point all the collected data will be jointly analysed.

Selection from maize landraces under different nutrient managements in Cyprus

ARI – Cyprus

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M. Omirou – michalis.omirou@ari.gov.cy

Abstract

We evaluated 13 different genotypes under 3 different nutrient management schemes namely chemical fertilization, animal manure and compost. The objective was to further evolve the testing material according to traits like Harvest Index, biomass production, ear yields and kernel yields. We also evaluated the mycorrhizal colonization of these genotypes and assessed the importance of this rhizosphere related trait with yield and biomass productivity. Our findings clearly show a significant effect of the nutrient management scheme and genotype on maize productivity. These factors had a strong effect on AMF colonization. A differential relationship between genotype and AMF presence was recorded.

Location(s)

Zygi experimental station ARI, Cyprus

List of accessions

13 selections from seven French landraces: Abelando, Lavegue, Sical, SM Pigawo, Sponcio, Amido, Mateo

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Height	Field measurements	Quantitative (cm)

Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
Biomass production	Weight of above ground biomass measurement	Quantitative (g)
Ear yield	Number of ears per plant Weight of ears per plant	Quantitative (g)
Kernel yield	Weight of kernels per plant	Quantitative (g)
Microbiome performance (type of functional microbial guilds)		
Trait	**How it has been assessed**	**Type of data available**
AMF colonization	Light microscopy of stained maize root segments	Quantitative (%)
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	**How it has been assessed**	**Type of data available**

Trial background and evolution

The initiative was taken by ARI group and key decisions during the trials have been taken after data analysis and inspection by interested farmers who visited the trials. Farmers visit was organized by ARI in collaboration with the Ministry of Agriculture and particularly with the extension service of the Department of Agriculture. Quantitative data are available.

Trial design and management

The Honeycomb field selection design was implemented to evaluate individual plants for all the above traits and select the most promising genotypes. Statistical analysis was performed using the JMP software and in-house scripts and algorithms.

The relationship between microbiome related traits (AMF colonization) and plant performance was assessed using Pearson correlation matrices.

Main results

The main findings of this trial are the following:

- There is great variation within landraces for all traits examined
- Genotype and nutrient management scheme have a strong effect of AMF colonization
- AMF colonization is not always positively correlated with high yield

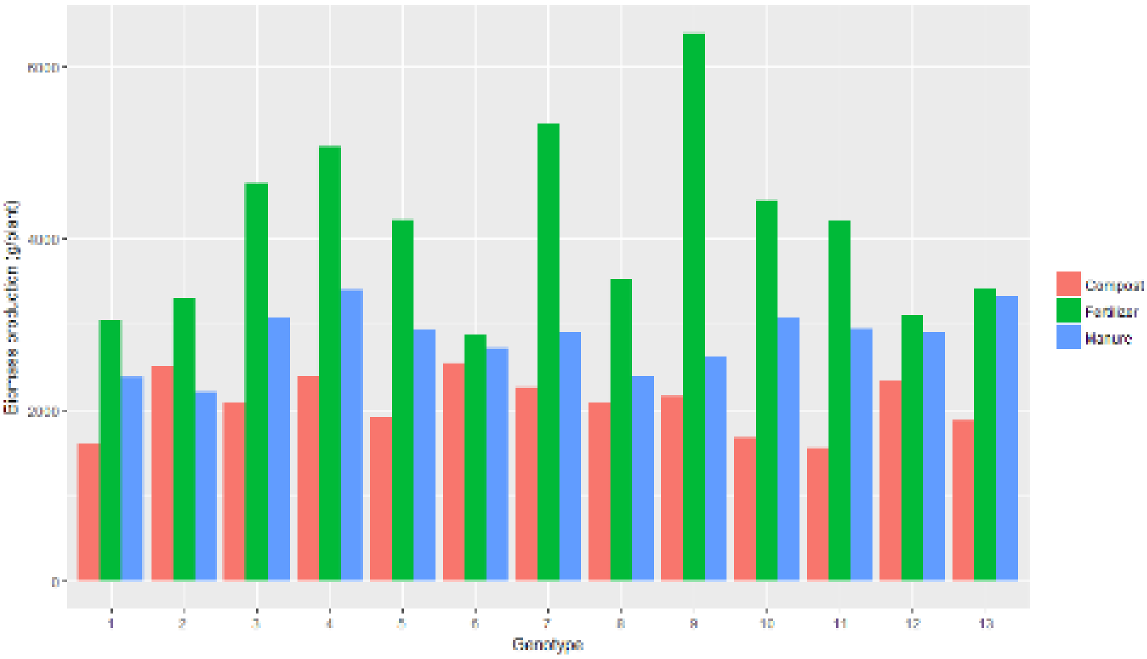


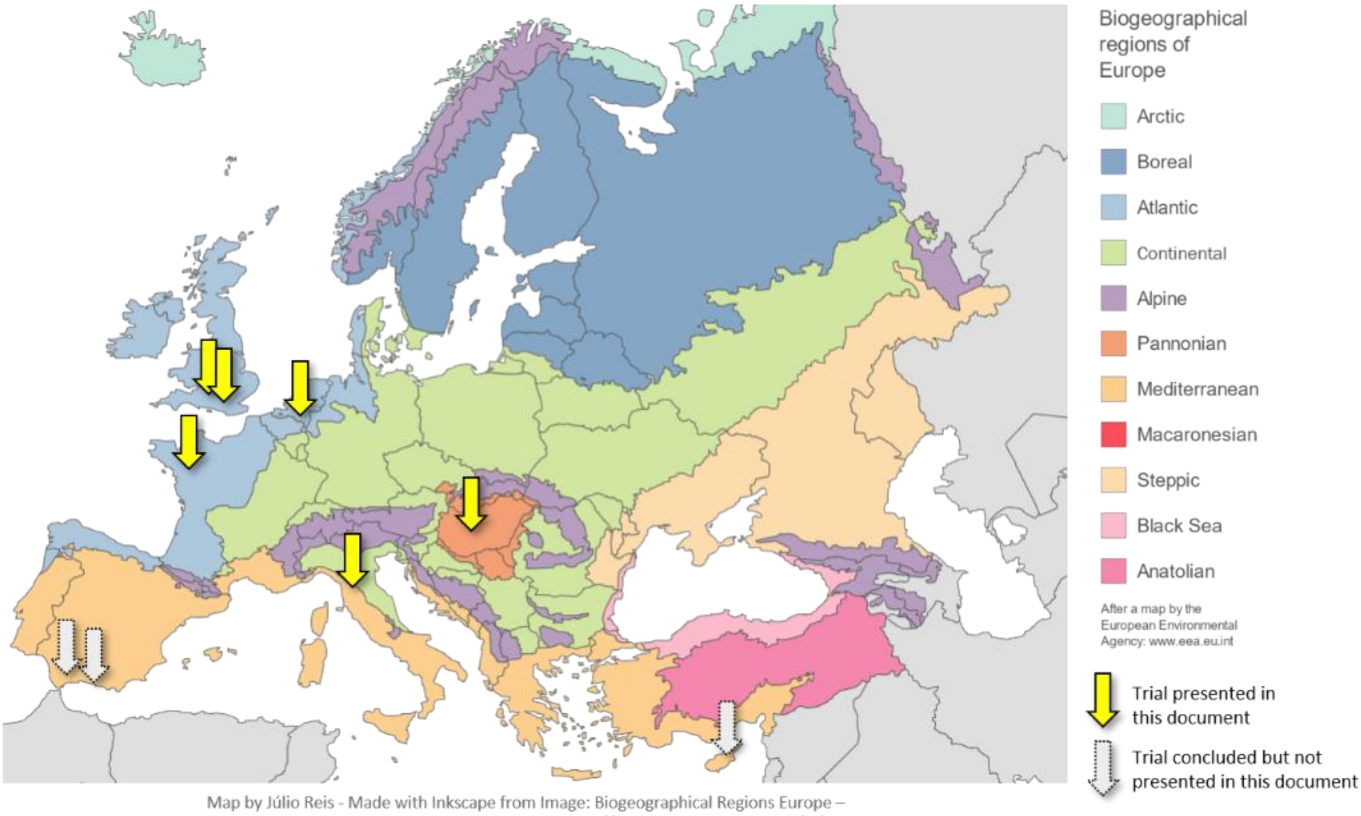
Figure 1. Biomass production (g/plant) of the different maize landraces under different nutrient management schemes. Code 1 and 2 belong to Abelando, Code 3,4 and 13 to Lavegue, Code 5 to 8 to Sical, Code 9 to SM Pigawo, Code 10 to Sponcio, Code 11 to Amido and Code 12 to Mateo

Discussion

Our findings clearly show that genotype as well as nutrient management scheme control maize yield under Cyprus conditions. Within the various landraces, there are genotypes that are more suited for low-input agricultural systems. Moreover, there are landraces that are more productivity under high soil nutrient availability. It is also evident that these factors are affecting AMF colonization. For example, within the same landrace (numbers 5, 6, 7 and 8 belong to Sical) the colonization differs substantially suggesting a highly specific genotypic control of AMF colonization.

Cereals

Triticum monococcum
Triticum dicoccon
Triticum durum subsp. turgidum
Triticum aestivum



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Mobilization of rivet wheat diversity in Brittany, France

ITAB, INRA – France

Estelle Serpolay – Estelle-serpolay-besson@itab.asso.fr

Abstract

About 200 accessions of rivet wheat from Spanish gene bank are multiplied and observed with the view to propose them to French farmers involved in participatory breeding with a minimum of interesting information. Some mixtures will be created on specific criteria in order to create diversified populations with one or more common traits of interest.

Location(s)

Brittany, around Rennes

List of accessions

The list is quite long and there is not or very few information about each accession (an extract below). Some accessions were grouped into sub-sub taxa in seed bank.

Accession Number	Genus	Species	SUBTAXA_AUTHORITY	Recodage var	SUBTAX AUTOR
BGE021829	Triticum	turgidum	subsp. turgidum convar. turgidum		L.
BGE021839	Triticum	turgidum	subsp. turgidum convar. turgidum		L.
BGE013093	Triticum	turgidum	subsp. turgidum convar. turgidum var. bucale	var. bucale	Al.
BGE013728	Triticum	turgidum	subsp. turgidum convar. turgidum var. bucale	var. bucale	Al.
BGE020952	Triticum	turgidum	subsp. turgidum convar. turgidum var. candiens	var. candiens	Flaksb
BGE002887	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE012561	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE012565	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE013708	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE013727	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE030923	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE030924	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE030925	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE030926	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE030927	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE030928	Triticum	turgidum	subsp. turgidum convar. turgidum var. dinurum	var. dinurum	Al.
BGE012400	Triticum	turgidum	subsp. turgidum convar. turgidum var. dreischianum	var. dreischianum	Korn.
BGE012539	Triticum	turgidum	subsp. turgidum convar. turgidum var. dreischianum	var. dreischianum	Korn.
BGE012554	Triticum	turgidum	subsp. turgidum convar. turgidum var. dreischianum	var. dreischianum	Korn.
BGE013717	Triticum	turgidum	subsp. turgidum convar. turgidum var. dreischianum	var. dreischianum	Korn.
BGE018621	Triticum	turgidum	subsp. turgidum convar. turgidum var. gentile	var. gentile	Korn.
BGE018622	Triticum	turgidum	subsp. turgidum convar. turgidum var. gentile	var. gentile	Korn.
BGE018625	Triticum	turgidum	subsp. turgidum convar. turgidum var. herrerae	var. herrerae	Korn.
BGE018656	Triticum	turgidum	subsp. turgidum convar. turgidum var. herrerae	var. herrerae	Korn.
BGE040242	Triticum	turgidum	subsp. turgidum convar. turgidum var. iodurum	var. iodurum	Korn.
….	….	….	….	….	….

List of traits assessed

We observed only phenotypical traits and not productive or quality traits because the cultivation condition didn't allow us to give reliable information (sowing at 31st of January 2017 because first sowing was eaten by birds, and 3 lines of 1 meter long per accession, sown by hand).

Crop development and agro-ecological performance (phenology, weeds, diseases, …)

Trait	How it has been assessed	Type of data available
Germination rate – winter	Note 0=0% 1=from 1 to 15% 2=about 25% 3=about 50% 4=about 75% 5= about 100%	Semi-quantitative data
Growth habit – winter	Note (1-not erected to 5-totally erected)	Semi-quantitative data
Tillering – at tillering	Note 1=weak 2=medium 3=strong	Semi-quantitative data
Precocity – at spike emergence	Note (relative among varieties) 1=very early 2=early 3=medium 4=late 5= very late	Semi-quantitative data
Diseases – at spike emergence	Note 1=weak 2=medium 3=strong	Semi-quantitative data
Top of plant curvature - maturity	Note 1=Strait 2=semi-curved 3=strongly curved	Semi-quantitative data
Glume Hairiness – maturity	Note 0=no hair 1=hair	Semi-quantitative data
Awns – maturity	Note 1=no awns 3=awns as long as spike 5=awns twice long as spike	Semi-quantitative data
Awns colour – maturity	Note = colour (6 colours) – to be re-defined	Qualitative
Spike ramification - maturity	Note 0=not ramified 1=ramified	Semi-quantitative data
Grain colour – after harvest	Note White – Cream – Brown – Red	Qualitative data

Black peak – after harvest	Note 0=no 1=yes	Semi-quantitative data
Grain shape – after harvest	Note Long – round – transitional	Qualitative data
vitreousness – after harvest	Note 1=all floury grains 2=really more floury grains 3=about 50% floury grains and 50% vitreous grains 4= really more vitreous grains 5= all vitreous grains	Semi-quantitative data

Crop productive performance (yield, yield components)

Trait	**How it has been assessed**	**Type of data available**
TKW	grams	quantitative

Trial background and evolution

In order to enlarge diversity that is already cultivated by French farmers, we (INRA-ITAB research team at Rennes) started the trial/collection on rivet wheat. After a work of bibliographical researches and interviews at farms, a list of accessions was asked in the Spanish gene bank (2016).

The researchers took the initiative. During the first year, no farmers came to see the trials. But during the third year of breeding in 2018, we asked farmers a personalized list of interesting agronomic criteria to be observed. Based on those criteria, farmers could build their own bulked populations, made of an average of 30 varieties per population in order to distribute the diversity within the French Farmers' seeds network. The data collected should contribute to fill in the data base Shinemas, but it still needs to be not done

Trial design and management

The trial was sown in a farmer's field, by hand, and managed all by hand. For example, the plots were hand-weeded, so the plots were not conducted under real cultivation conditions, because there were very few grains available per accession (about 100 seeds). The first year, there was only one line 80 cm long per accession (after re-sowing because of bird attack…). The data is still not completely treated (descriptive statistics).

Main results

Following the first year's harvest of breeding (2016-2017), we again sowed the rivet wheat collection for the 2017-2018' season in order to confirm the data already obtained and to continue the agronomic observations in field. The main results are presented in the graphs below (Fiure 1). In addition, the hierarchical classification carried out according to the criteria of agronomic interest observed in the trials, does not make it possible to refine and regroup the accessions belonging to the same sub-sub taxa identified by the seeds bank (see list of accessions - Figures 2 and 3).

Rather than distributing samples one by one (each of which is very close to pure lines because ex-situ conservation reduces diversity), we proposed to a group of farmers, to distribute to them diversified and customized populations to increase opportunities in diversity exploration. As diversity is a guarantee of adaptability, the idea is that each farmer starts to work with one or more populations diversified, but with one or more specific orientations. That means, a mixture of different populations that have in common one or more characters of interest (aesthetic, agronomic ...) among those we have observed. For example, several farmers have chosen the population that we have created with all the samples with branched ears ("miracle" type), another with mealy grains, another very covering, etc. We have also combined specific criteria. At the end, 44 populations diversified have been distributed to 23 farmers.

Discussion

This trial is important because the farmers want to deploy a large diversity in their fields, but they don't have means to multiply such a great quantity of accessions and to keep them « pure ». The research team is here a "connection" between the genetic resources and the farmers to start to cultivate a forgotten species, with a lot of diversity.

Conclusion and next steps

This methodology is an additional tool to spread and use the diversity for organic/living agriculture and high quality products. Once on farm, these diversified populations are supposed to have a great potential for adaptation. However, we are at the beginning of the methodology and its evaluation has to be thought. An important point is the follow up of the populations', that's why facilitators and animators are needed, to stay in contact with the farmers, and to maintain a collective dynamic among them, involving new ones, etc. Another point is the involvement of different types of actors to embed this methodology in the whole food system and make multi-actor research. Human diversity has to be mobilized!

Additional material

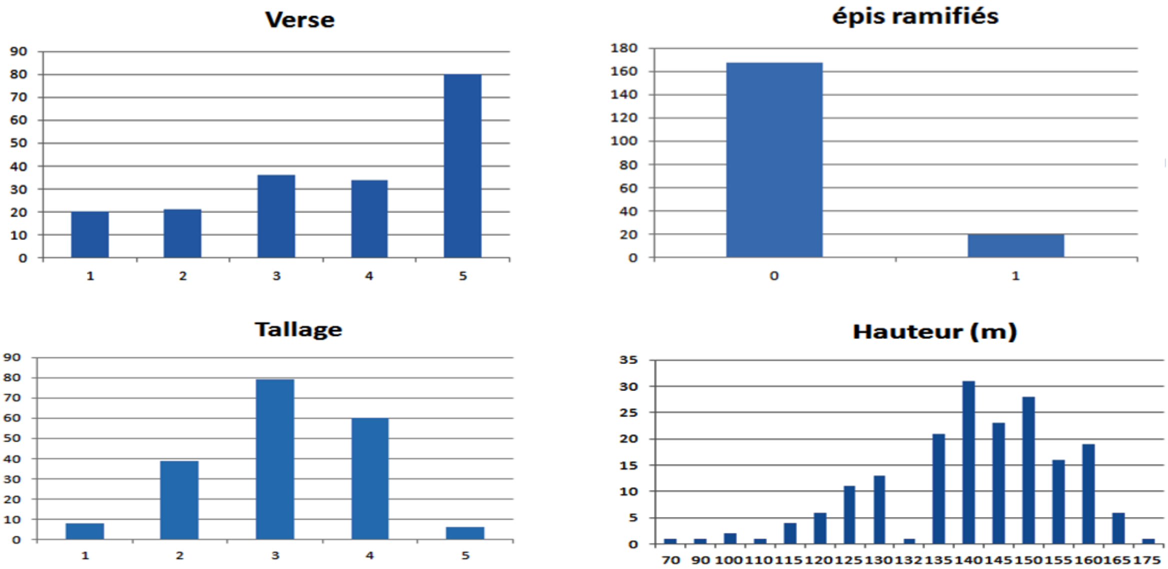

Figure 1: Varieties distribution according to four observed criteria: a) Lodging; b) Branched ears; c) Tillering; d) Height (m). For all the studied variables (54), there are no distinct groups of varieties among the collection. The distribution profiles are overlapping. This shows a high level of diversity among the collection.

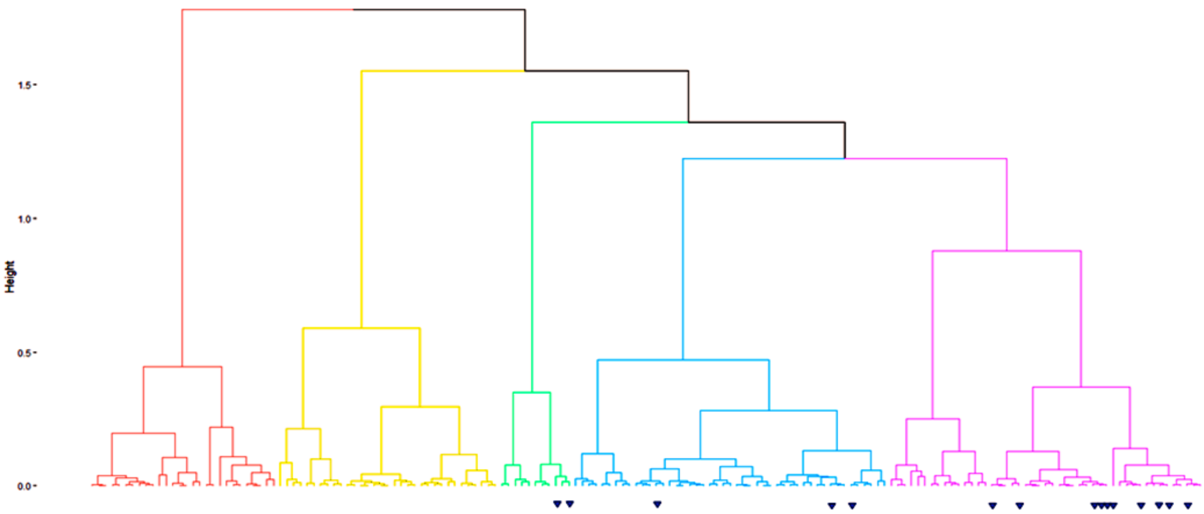

Figure 2: Hierarchical clustering of the rivet wheat accessions 2018 from the FAMD test results. Accessions that did not enter in any of the diversified populations are indicated with ▼

Three years of Emmer, Einkorn and Rivet wheat trials in UK organic farming

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Background

Einkorn (*Triticum monococcum*), Emmer (*T. dicoccon*) and Rivet wheat (*T. durum subsp. turgidum*) are underutilised cereals which may prove as a good alternative to winter wheat growing in the UK, especially in marginal arable lands and organic farming. In addition, these species may support novel, local value chains as e.g. pasta making from rivet. Here, we present temporary results of a three-years case study where, by testing 34 entries of these species, we tried to overcome the current lack of knowledge and of suitable genetic resources.

List of accessions

Einkorn Accession tested by ORC by harvest year

Name	Type	2016	2017	2018
Einkorn CCP	CCP	4 reps	3 reps	8 reps
NODIK Alakor	Landrace	4 reps	3 reps	8 reps
COL 122	Line	4 reps	3 reps	8 reps
GY-2139	Line	4 reps	3 reps	8 reps
Mv Alkor	Commercial	4 reps	3 reps	8 reps
Mv Menket	Commercial	4 reps	3 reps	8 reps
Tifi	Commercial	-	-	8 reps
ORC Wakelyns Population	Wheat CCP	-	3 reps	-
Skyfall	Milling wheat	-	3 reps	-

Emmer Accession tested by ORC by harvest year

Name	Code	2016	2017	2018
Blau-Emmer	GT-831	3 reps	-	-
Grauer	GT-1399	2 reps	3 reps	5 reps
Mv Hegyes	Mv Hegyes	4 reps	3 reps	8 reps
NODIK Tonke	NODIK landrace	3 reps	3 reps	11 reps
Schwarzbehaarter Winteremmer	GT-1400	3 reps	-	-
Schwarzer Samtemmer	GT-381	1 rep	-	-
Schwarzwerdende	GT-143	1 rep	-	-
Weisser	GT-1971	3 reps	3 reps	10 reps
Weisser behaarter Winteremmer	GT-1402	1 rep	-	-
Zublin	GT-2140	3 reps	-	-
Zweikorn	GT-196	1 rep	2 reps	6 reps
ORC Wakelyns Population	Wheat CCP	-	3 reps	-

Crusoe	Milling wheat	-	3 reps	-

Rivet Wheat Accession tested by ORC by harvest year

Name	Type	2016	2017	2018
Anvergur	Durum	4 reps	-	-
Asturias	Rivet	1 rep	-	-
Auvergne Capmartin	Rivet	1 rep	3 reps	8 reps
Bizargari	Rivet	1 rep	2 reps	8 reps
Geant De Sainte Helene	Rivet	1 rep	-	-
Gigante Lampino De Najera	Rivet	1 rep	2 reps	8 reps
Gros De Cerdena	Rivet	1 rep	-	-
Karur	Durum	4 reps	-	-
Melange 1 Aguillon	Rivet	1 rep	-	-
Melange 2 Marie	Rivet	1 rep	2 reps	8 reps
Milanais De Limagne	Rivet	1 rep	-	-
Miracle	Rivet	1 rep	1 rep	6 reps
Nonette De Lausanne	Rivet	1 rep	-	-
Percival's blue cone	Rivet	2 reps	3 reps	9 reps
Poulard D'Australie	Rivet	1 rep	-	-
Poulard De Italie	Rivet	1 rep	3 reps	8 reps
Rampton Rivet	Rivet	4 reps	3 reps	9 reps
Touzelle Blanche Barbue	Rivet	1 rep	-	-
Turgidum Di Maliani	Rivet	1 rep	-	-
ORC Wakelyns Population	Wheat CCP	-	3 reps	-
Crusoe	Milling wheat	-	3 reps	-

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	How it has been assessed	Type of data available
Ground Cover	Visual estimate at GS31 and GS65	Numeric, %
Height	At various GS	Numeric (cm)
Phenology	BBCH GS assessed in several dates across crop cycle	BBCH GS
Disease response / Health	Visual estimate of main diseases around BBCH GS65	Numeric %
'Weediness'	Visual scoring of weed abundance at BBCH GS 75	Score 1 to 5
Total Biomass	Sampling 0.25 m^2 before harvest	g/m^2
Lodging	Assessment of lodging severity at several dates from flowering to maturity. Severity is calculated as sum of different severity (angle from vertical) classes: $\frac{(\%\ 20° - 50°) + 2(\%\ 50° - 80°) + 3(\%\ flat)}{3}$	% severity

Crop productive performance (yield, yield components)		
Trait	How it has been assessed	Type of data available
Combine grain yield	Combine harvest	t/ha at 15% humidity
Ears density	Sampling 0.25 m^2 before harvest	n/m^2
Harvest Index	Sampling 0.25 m^2 before harvest	%
Average Grain Weight	On combined grains	g

Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Nutraceutical	Spectrophotometric analyses	Content of free, bound and total polyphenols (mg of polyphenols/g of flour)
Nutraceutical	Spectrophotometric analyses	Content of free, bound and total flavonoids (mg of flavonoids/g of flour)
Nutraceutical	Spectrophotometric analyses	Antioxidant activity (DPPH and FRAP test)

Methods and trial development in the first two years

Six entries of Einkorn, 11 of Emmer and 17 of Rivet wheat were tested in 2015/16 in an organic farm, on a clayey soil in south-west England, in three partially replicated block design trials, with the dual purpose of having a first morphological and field performance screening, and of multiplying the seeds. Crops were assessed for agro-ecological performance, including establishment, phenology, height, ground cover in different times, disease severity, weed abundance, yield and yield components. All einkorn entries, five out of 11 emmers and seven out of 17 rivets were brought forward in the following seasons. For each species a fully replicated block design with the selected entries from the first season was carried out in 2016/17 in the same location, with the addition of a winter wheat composite cross population (CCP) and two winter wheat varieties classified as milling wheat as a control.

2015/16 - 38 entries.

- Climate: extremely wet autumn-winter

2016/17 - selected 19 entries plus three bread wheats (Triticum aestivum)

- Climate: spring, wet summer.
- Location: Organic farm, “blue clay” (heavy, poorly drained soil) in the North Wessex Downs.

2017/18 - The same entries were then sown in a factorial experiment to test effect of Rotational position (High vs. Low Fertility) and Tillage (Ploughed vs. Non-Inversion).

- Climate: cold and long winter, dry and warm summer.
- Location: organically managed rotation, sandy loam, Sonning Experimental Farm (University of Reading, UK).

Results from the first two years of trial

Einkorn was well performing crop in terms of yield (3.2 ± 0.15 t ha-1 on average in the 2nd year) and agroecosystem performance, particularly thanks to its low disease severity and high competitiveness. In fact, it may reach extremely high biomass production and ears density. Whilst tall entries, including old varieties, landraces, a composite cross population and its derived lines, showed some susceptibility to lodging, they clearly outperformed a modern, dwarf variety in terms of yield and weed suppression. In emmer, yield was slightly lower than einkorn, with an average of 2.3 ± 0.19 t ha -1 in the 2nd year, and, alike einkorn, strictly associated with ears density. Yellow rust appears to be a main constraint for emmer, although entries with low susceptibility have been identified.

With an average yield of 2.98 ± 0.21 in the 2nd year, rivet also appears as a promising crop, thanks to its competitiveness and generally low susceptibility to diseases. This is counterbalanced by its straw height and heavy ears, which makes it prone to lodging. However, lodging was never extreme, and some entries seemed to be lodging resistant despite their straw length. All these species could be a relief for marginal arable lands, as showed in the 2nd year by the comparison with winter wheats. In fact, only the wheat CCP performed comparably, yet with lower yield (12% less than the average of the minor cereals), to all the three species, whereas the commercial milling varieties 47% less than the average of the minor cereals. Principal component analyses showing relations between relevant traits will be presented.

Feedback from farmers and other players, third year trial and quality analyses

Discussions about this trial, with farmers and other players of the organic arable sector, undertaken in different field days and other events, highlighted the potential of emmer, einkorn and rivet as low-input alternative to mainstream cereals. A priority question: whether these crops' ability to produce in limiting environments might be used to add value to low-fertility positions in rotations and to counterbalance potentially weed-favouring and yield-depressing effects of reduced tillage in organic conditions. As a result, in the current 2017/18 growing season, the emmer, einkorn and rivet entries already tested in the 2nd year are being tested in in a factorial design representing four different environments: two positions in rotation and, in each of these, a ploughed and a shallow non-inversion tillage system. Grain samples are currently being analysed for processing and nutritional quality indicators such as: protein content; soluble and insoluble dietary fibre; flavonoid and polyphenol content and antioxidant properties. Rivet wheat samples are currently being analysed for processing quality indicators (such as ash and colour of semolina) to assess its potential for pasta-making. By encompassing all aspects of performance for a range of genetic resources, this research, once concluded, will possibly lay the grounds for a diversification of local food systems, from field management to value chains.

Grain yield was 1.62 ± 0.05 t ha–1, and not affected by rotational position (p=.17), tillage (p=.62) or entry (p =.98), whereas height was lower in the low than in the high-fertility (p=.000***), and in the non-inversion than in the ploughed (p=.040*).

- Total fibre was 19.0 ± 0.4 % on average, affected by entry (p=.013*) and highest in the Composite Cross Population [CCP] (20.8 ± 0.5%).
- Fat content was 4.2 ± 0.1 % on average, significantly lower in the low than in the high-fertility (p=.01*).
- Total Flavonoids content was 1497 ± 52 mg/g on average, and significantly higher in the low than in the high-fertility (p=.045*).
- Total Polyphenols content was 1971 ± 53 mg/g on average, and unaffected by experimental factors.
- Antioxidant capacity (DPPH, 2.95 ±0.15 mmol trolox/g on average) and antioxidant power (FRAP, 7.1 ± 0.2 mmol Fe/g on average) were strongly affected by rotational position (p=.000***) and were, unexpectedly, inversely correlated (r= –.46, p=.008 **).

Conclusions

In UK organic farming, Emmer, Einkorn and Rivet wheat can offer an alternative to bread wheat, especially in marginal environments characterised by high weed pressure, low fertility and abiotic stresses.

The 2017/18 results suggest that they are well suited to low-fertility rotational positions and can withstand the stresses associated with less intensive tillage with no performance penalties.

Top performing entries of each species are now being multiplied to be tested on different farms at a commercial scale.

Figures

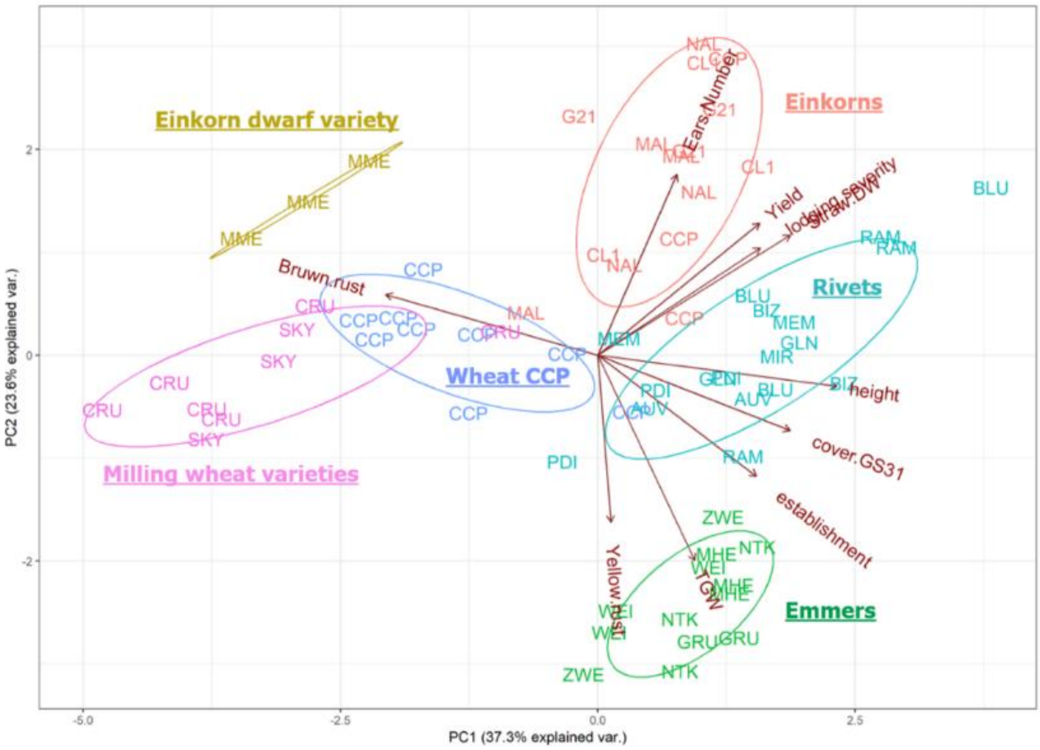

Fig. 1. Principal Component Analysis of 2017 trial results. Explanatory variables are yield, lodging severity, straw biomass (Straw.DW), height at maturity (height), cover in late winter (cover.GS31), establishment, average grain weight (TGW), yellow rust severity, brown rust severity, ears density (Ears.Number).

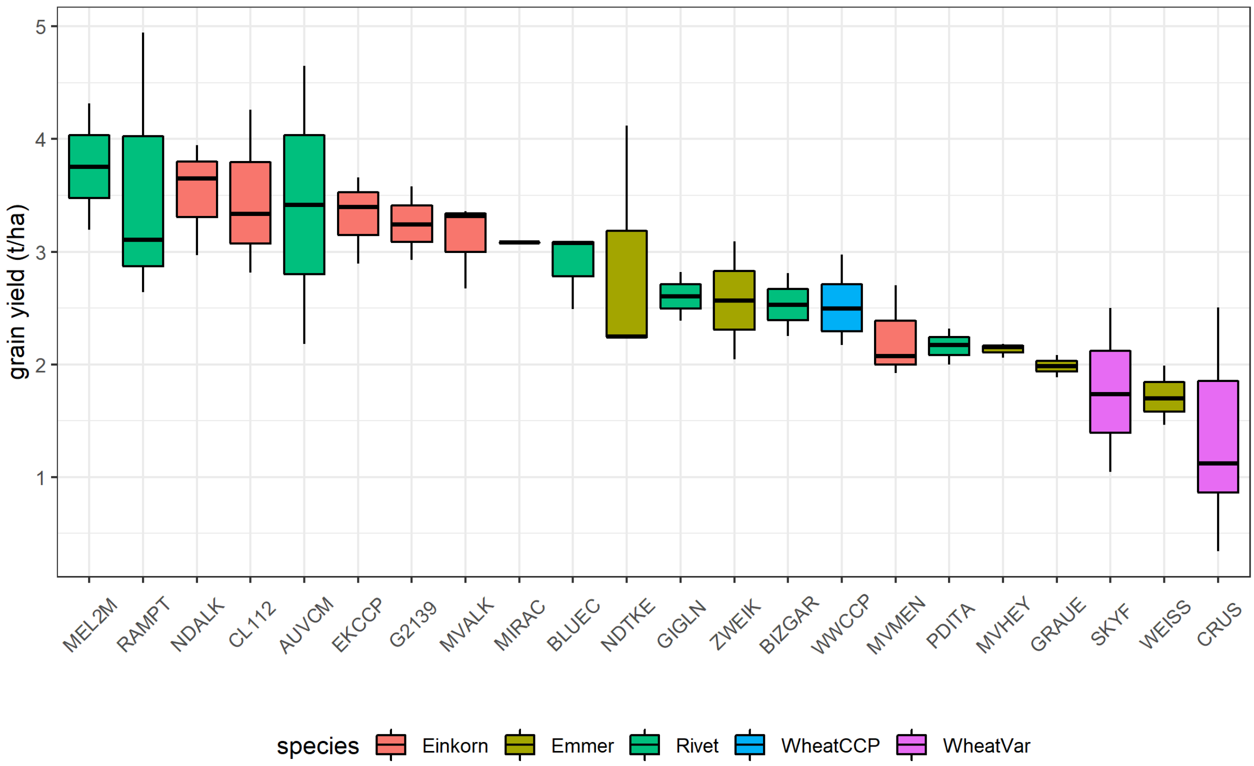

Fig. 2. Grain yield of einkorn, emmer, rivet wheat, bread wheat composite cross population (CCP), bread wheat commercial varieties in the 2017 trial.

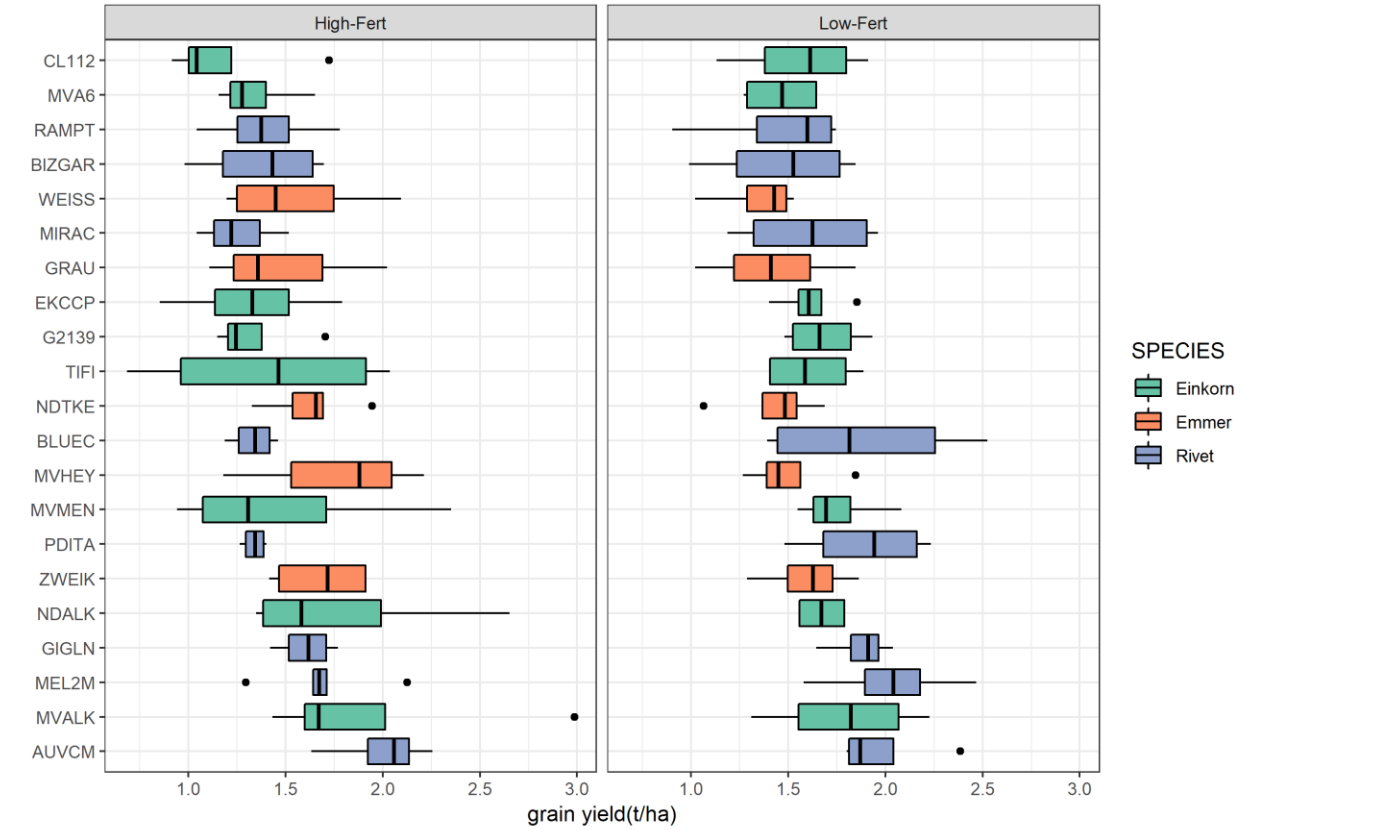

Fig. 3. Grain yield of einkorn, emmer and rivet wheat accessions in the 2018 trial divided by rotational position: "High-Fert" (left-hand side) is a field following a two-years grass-clover ley, "Low-Fert" (right-hand side) is a field following a crop of spring oats.

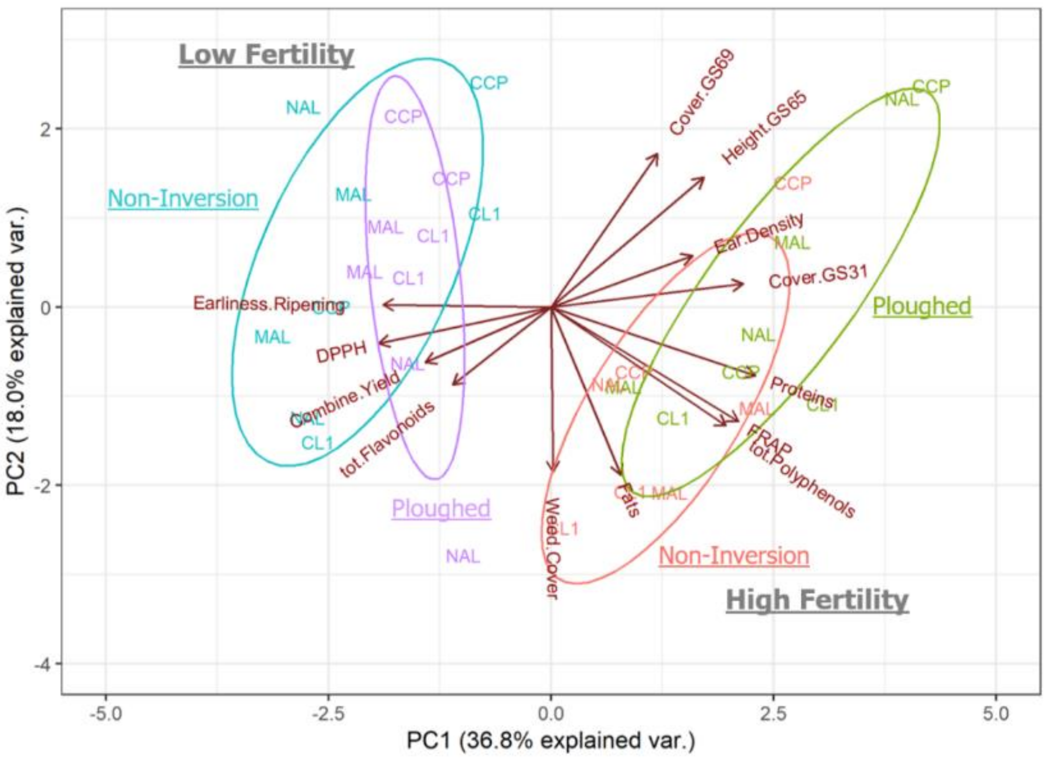

Fig. 4. Principal component analysis of the 2018 trials results on einkorn. Explanatory variables are grain yield (Combine.Yield), antioxidant capacity (DDPH), earliness, canopy cover at crop anthesis (cover.GS69), height at crop anthesis (Height.GS65), ears density, canopy cover in late winter (Cover.GS31), grain protein content, total grain polyphenols content,

grain fats content, weed cover at crop anthesis, total grain flavonoids content. “High Fertility” and “Low Fertility” indicate the two positions in rotation, with a 2-years grass-clover ley and spring oats as preceding crop, respectively. “Non-Inversion” and “Ploughed” indicate a shallow non-inversion tillage (depth 10cm approximately) and a ploughed system (depth 25 cm), respectively.

Hulled wheat variety tests in organic farming in Hungary

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Abstract

13 emmer and 5 einkorn accessions have been tested in organic farming under marginal sandy soil conditions of Nyíregyháza (East Hungary) since 2015 to assess performance and evaluate their potential for local cultivation. Tolerance of abiotic and biotic stresses, grain yield and quality traits have been determined. Most winter varieties adapted well producing grain yield above 3 t/ha in average. Sensitivity to sowing date, frost, weeds and diseases influenced cultivation success, however, einkorn was resistant to leaf fungal diseases. Taking into account the market price of ancient cereals, emmer and einkorn can be a good alternative for organic growers, also on marginal soils.

Rationale

Hulled wheat species (including emmer, einkorn and spelt) have the longest been cultivated and consumed from ancient times by humans, though modern agriculture has neglected them despite their excellent nutritive value. Besides increasing biodiversity of agricultural production, their cultivation and wider dietary utilization would lead to healthier feeding habits and healthier population. This is why we choose to investigate, in the frame of the DIVERSIFOOD Horizon 2020 project, emmer (Triticum turgidum ssp. dicoccum) and einkorn (Triticum monococcum) land races and varieties to be tested under organic conditions from 2015. We received 13 emmer and 5 einkorn accessions from Pro Specie Rara, Switzerland, Plant Diversity Centre (NÖDIK), Hungary, Centre for Agricultural Research, Hungarian Academy of Sciences, Martonvásár, and Louis Bolk Institute, the Netherlands. 10 of the tested emmer varieties are winter types, 3 spring types. All einkorn varieties are winter types. The same accessions were sown in Hungary, the UK, Cyprus, and the Netherlands. The aim of the trials is to assess the performance of ancient cereal varieties under organic conditions, and to evaluate the potential of their local cultivation based on i) small plot research trials and ii) large plot on-farm participatory tests.

List of accessions

	Name/code of the variety	Common name/origin	number of replicates	
			2015	2016-
Winter emmer	Mv Hegyes	registered variety HU	4	4
	NÖDIK Emmer	German landrace	4	4
	GT 143	Schwarzwerdender	3	4
	GT 196	Zweikorn	1	4
	GT 381	Schwarzer Samtemmer	1	4
	GT 831	Blauemmer	3	4
	GT 1399	Grauer	2	4
	GT 1400	Schwarzbehaarter	3	4
	GT 1402	Weisser behaarter	1	4
	GT 2140	"Züblin" WS	3	4
Winte r	Mv Alkor	registered variety HU	4	4
	Mv Menket	registered variety HU	4	4

	NÖDIK Einkorn	Morocco	4	4
	Tifi	registered variety NL	4	4
	GT 2139	unknown	1	4
Spring emmer	GT-1669	landrace	2	4
	GT-1971	landrace	3	4
	Holland spring emmer	variety candidate	4	4

Location(s)

At the Research Centre of Nyíregyháza in East Hungary, the experiment was sown in marginal clayey sand and sandy soil conditions, with pH basic in 2015/2016 and acidic in 2016/2017 and 2017/2018. In Füzesgyarmat the soil type is clayey loam. Both sites are flat, at low altitude, and belong to the Great Hungarian Plain.

Climate

The average climate is more like the continental type with hot, often dry summer and cold winter. In 2015/16 there were average conditions, in October with higher, in December and April with lower than average precipitation values. It became wet from May to July, which favoured fungal diseases. In 2016/17: there was higher than average precipitation in November, while December was dry, January, spring and summer were more wet than at average. Temperature was lower than usual in November and January. In 2017/18 there was a higher than average autumn rainfall (Sept., Nov., Dec.). March was colder than usual with snow cover, delaying plant development, while April was warmer - resulting in an opposite effect.

Trial design and management

At the Research Centre of Nyíregyháza in East Hungary, the experiment was sown in marginal sandy soil on 10 m2 plots, in 2015 in 1-4 replications (with respect to the availability of seeds) in an incomplete, and from 2016 in four replicates - in a complete block design. On farm multi-variety tests were also started in 2017 with one location, Füzesgyarmat, and are on-going, involving three sites since the autumn of 2018. Winter survival, weed and disease scores, morphological, phenological and yield parameters were recorded each year in the Nyíregyháza trials.

Statistical analyses were performed using SPSS Version 22 statistics software package for data 2016-2017. In order to identify the significant differences between groups of variables Kruskal Wallis H test was used. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. To detect differences between the results of the first two years, Mann-Whitney U test was applied. For data from 2018, in the case of parameters with normal distribution the means and standard deviations were determined.

Main variables assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Plant development	Using the Zadok scale, determined regularly during the vegetation period	quantitative but not linear (time) scale
weed coverage	estimation of the surface coverage of the monocot and dicot weeds after harvest	%
diseases	A.) determination of the infection frequency (referred to as incidence)- % of infected plants/spikes in the field; B.)infection severity: disease coverage -% of the area of plant/spike infected; A and B both determined in each replication/plot C.) in 2016: Fusarium incidence and severity on the 10 spikes collected before harvest from each plot (replications) – microscopic visual check	% (maximum values are reported here in case there were more reporting dates)

Crop productive performance (yield, yield components)

Trait	How it has been assessed	Type of data available
Grain yield	Whole plots harvested with a combine harvester and the grain yield (hulled) was measured after cleaning.	t/ha
Hectolitre weight	one litre of hulled grains (spikelets) measured	kg/100L
Thousand spikelet weight	5×200 spikelets (containing usually 2 grains in emmer and one in einkorn) were measured	g

Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	**How it has been assessed**	**Type of data available**
Protein content	using the Kjeldahl method, measuring the nitrogen content (applying the factor 5,7), counting back to the dry weight (which was determined based on the NIR moisture value)	%
NIR protein and moisture content	Perten Inframatic 8611, wheat calibration	%

Main results

Though the plants were exposed to marginal growing conditions, most accessions showed good adaptability but there were also some exceptions. Spring emmer varieties were not well-suited to this environment (e.g. weeds, sand blasts in 2017), so they could not be recommended for cultivation under such conditions. Furthermore, one emmer accession, which was proposed for both winter and spring sowing, was lost in the first year due to weak frost tolerance. Most of the winter varieties, both emmer and einkorn, however, were found to thrive and produce grain yield over 3 t/ha in 3-year average. In favourable years (2016 and 2018), the best emmer accessions produced around 4t/ha. Although some einkorn varieties could yield around 5 t/ha in the best year (2016), this species reacted to the variability of crop year with higher yield fluctuations than emmer.

The most important factors affecting cultivation success besides climatic components were sensitivity to sowing date, frost, weed infestation and diseases. Einkorn proved to be resistant to the occurring leaf fungal diseases (leaf spot diseases, leaf rust and yellow rust). Both species were, however, susceptible to *Fusarium* to a varying extent depending on the year and the variety.

Protein content of the grain samples from the on farm trials exhibited a variation among emmer accessions, while einkorn had rather constant protein values.

Discussion and Conclusion

Emmer and einkorn accessions tested in this experiment were subject to marginal growing conditions under organic management in East-Hungary. Most accessions showed a good adaptability, although rusts, frost hardiness, and sensitivity to sowing date were limiting factors of successful cultivation for some varieties. Weed infestation due to poor coverage proved to be a problem, especially for spring emmer types. Some winter emmer and einkorn landraces outperformed registered varieties in terms of grain yield, and can be advised for on-farm testing, which will be continued further on. Taking into account the market prices of ancient cereals in the past years, emmer and einkorn can be a good alternative for organic growers, also on marginal soils.

Emmer trials in the Netherlands

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Abstract

Testing and selecting best emmer wheat accessions for Dutch circumstances and Bemmel, The Netherlands

List of accessions

Crop	Accession	Origin
Emmer	GT-1399 Grauer	Switzerland
Emmer	GT-1400 Schwartzbehaarter Winteremmer	Switzerland
Emmer	GT-1402 Weisser behaarter Winteremmer	Switzerland
Emmer	GT-143 Schwarzwerdende Winteremmer	Switzerland
Emmer	GT-1669 Schwarzer Eschikon	Switzerland
Emmer	GT-196 Zweikorn	Switzerland
Emmer	GT-1971 Weisser	Switzerland
Emmer	GT-2140 Zublin	Switzerland
Emmer	GT-381 Schwarzer Samtemmer	Switzerland
Emmer	GT-831 Blau-emmer	Switzerland
Emmer	Nödik Tönke	Hungary
Emmer	MV Hegyes	Hungary
Emmer	NL-LD	NL

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Germination	Ranking from 1-9	Rank
Winter survival	Ranking from 1-9	Rank
Lodging	Ranking from 1-9	Rank
Maximum plant height	Measuring cm	Cm
Timing of flowering	Ranking from 1-9 (9 is early)	Rank
Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
Yield	Measuring yields per plot in gram (hulled)	Grams/m2
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	**How it has been assessed**	**Type of data available**
Nutritional components	Sedimentation value (Zeleny) of 2 accessions (based on flour)	%
Nutritional components	Total dietary fibre content (Dry matter results after drying at 70°C) of 2 accessions	%
Nutritional components	Fructans and protein concentrations of 2 accession	%

Nutritional components	Gluten index	%

Trial background and evolution

The trial is initiated by researchers of the LBI but the location was selected on the basis of the present farmer, who is very interested in breeding local landraces of cereals. The farmer already was breeding and selecting old local wheat land races. He sells his cereals to local backers. The farm is located in a nature park, a nice setting for visitors. During the growing season an interested group of consumers and backers visit the farm weekly. The farmer was keen on diversifying his farm, and therefore was enthusiastic for having the test site with ancient cereals on his farm.

Trial design and management

The ancient cereals are tested within an organic setting, without the use of chemicals, hardly any mechanical weed suppression and low input of organic manure.

The trial was sown every year with a special test site sowing machine (1.5m wide, GPS assisted). Weeding was done manually. Harvesting was done with a special test site combine.

In the first year (2015-2016) 13 emmer wheat accessions were tested, without replications. The second season (2016-2017) 9 emmer accessions were sown in a randomized block design, with 4 replications.

The third year (2017-2018) 4 emmer accessions were selected and sown in a randomized block design with 4 replications. 3 other emmer accessions were included in demonstration plots around the test site.

Main results

The yields of the accessions in the first year were very low due to logging. The second year the yields improved, but were still low (on average 1.0 t/ha hulled). The plant morphology (for example the colouring of the ear), differed a lot between the accessions. Commercial production of the emmer accessions is therefore probavly only an option for the Netherlands if no capital investment is needed for land use.

Due to very different wheather conditions during the first and the second years' trial, we now have an impression of how the different accessions react on extreme wet and extreme dry Dutch circumstances. Logging and drought resistence were therefore the most important plant characteristics during the two trials that determined the yield. Due to a high plant height (>120 cm), some accessions were susceptiple for logging. With these experience – together with the selection of the stakeholders- we were able to select the accessions with the best potential for the Netherlands. The selected accessions are Nödik Tönke, Dutch white emmer, Zweikorn (GT-196) and Weisser emmer (GT-1971 ; see attachement).

Discussion

Due to the low yields of the emmer accessions visiting farmers were not very interested in the production of emmer, but for production on estates and nature area's the crop is interesting due to the aesthetics. The accessions looked very different, coloured beautifully. Furthermore, the crop leaves space so sunlight reaches the soil which gives weeds a chance. Normally farmers do not favour weeds, but on our test site in the nature ark, this resulted in several Red lists plant species. There were several accessions with highest yields (1.13-1.28 t/ha, hulled, see attachment). During the stakeholder field meetings, the farmers were mostly interested in the dark coloured emmer wheat accessions.

The nutritional value of 2 different emmer accessions was determined. Additionally emmer flour and emmer bread was analysed (see attachment).

Conclusion and next steps

For the new test site 4 of the 13 emmer accessions have been selected on the basis on yield, logging tolerance and farmer preference (plant health). Additionally, 3 accessions were sowed in the demonstration plots around the test site. The new test site was sowed on the 2nd of November 2017. The plot size is 12 x 1,5m. With 4 replications and

the yield of additional demonstration plots the possibly yields of this year will potentially result in sufficient material for a backing test with 3 emmer accessions.

The test site itself will be used again to demonstrate farmers, backers and consumers the agronomic characteristics of the ancient cereals and to select the accessions with the best potential for Dutch circumstances.

Einkorn trials in the Netherlands

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Abstract

Testing and selecting best einkorn accessions for Dutch circumstances in Bemmel, The Netherlands

List of accessions

Crop	Accession	Origin
Einkorn	COL-122	?
Einkorn	-	UK
Einkorn	GT-2139 Einkorn	Hungary
Einkorn	MV Alkor	Hungary
Einkorn	Nödik Alakor	Hungary
Einkorn	MV Menket	Hungary
Einkorn	Tifi	NL

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Germination	Ranking from 1-9	Rank
Winter survival	Ranking from 1-9	Rank
Lodging	Ranking from 1-9	Rank
Maximum plant height	Measuring cm	Cm
Timing of flowering	Ranking from 1-9 (9 is early)	Rank
Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
Yield	Measuring yields per plot in gram (hulled)	Grams/m2
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	**How it has been assessed**	**Type of data available**
Nutritional components	Sedimentation value (Zeleny) of 5 accessions (based on flour)	
Nutritional components	Total dietary fibre content (Dry matter results after drying at 70°C) of 3 accessions	
Nutritional components	Fructans and protein concentrations of 1 accession	

Trial background and evolution

The trial is initiated by researchers of the LBI but the location was selected on the basis of the present farmer, who is very interested in breeding local landraces of cereals. The farmer already was breeding and selecting old local wheat land races. He sells his cereals to local backers. The farm is located in a nature park, a nice setting for visitors. During the growing season an interested group of consumers and backers visit the farm weekly. The farmer was keen on diversifying his farm, and therefore was enthusiastic for having the test site with ancient cereals on his farm.

Trial design and management

The ancient cereals are tested within an organic setting, without the use of chemicals, hardly any mechanical weed suppression and low input of organic manure. The trial was sown every year with a special test site sowing machine (1.5m wide, GPS assisted). Weeding was done manually. Harvesting was done with a special test site combine.

In the first year (2015-2016) 7 einkorn accessions were tested, without replications. The second season (2016-2017) 7 einkorn accessions were sown in a randomized block design, with 4 replications. The third year (2017-2018) 4 einkorn accessions were selected and sown in a randomized block design with 4 replications.

Main results

It was very nice to have the einkorn accessions in the trial field with ancient cereals, as it is the oldest cereal crop known from history. However, the yields of the accessions were very low. The yield gap between the Dutch accession Tifi and the other accessions from Hungary and UK was large. It is therefore questionable if commercial production of the new einkorn accessions is an option for the Netherlands.

Due to very different weather conditions during the first and the second years' trial, we now have an impression of how the different accessions react on extreme wet and extreme dry Dutch circumstances. Logging and drought resistance were therefore the most important plant characteristics during the two trials that determined the yield. Due to a low plant height (<120 cm), einkorn is not susceptible for logging, but we had the impression that the crop has a small rooting system compared to other cereals and therefore is more susceptible for drought. With these experience – together with the selection of the stakeholders- we were able to select the accessions with the best potential for the Netherlands. The selected accessions are Tifi, Nödik Alakor, GT-2139, and einkorn from UK.

Discussion

Due to the low yields of the einkorn accessions (on average 1,43 t/ha hulled), farmers were not very interested in the production of einkorn. There was 1 accession that showed some more potential (Tifi), which reached a yield of 2,35 t/ha (hulled).

During the stakeholder field meetings, the farmers were more interested in some of the emmer wheat and rivet wheat accessions.

The nutritional value of 5 different einkorn accessions were determined. Unfortunately, not all lab analyses could be done. The low sedimentation values of the einkorn accessions (3-4) show that einkorn has a low gluten concentration compared to other ancient cereals (rivet wheat = 15.6; emmer wheat is 15.5).

Conclusion and next steps

There was a large difference in the yields between einkorn accession Tifi and the other accessions. For the new test site 4 of the 7 accessions have been selected and sowed on the 2nd of November 2017. The plot size is 12 x 1,5m. With 4 replications and the yield of additional demonstration plots the possibly yields of this year will potentially result in sufficient material for a backing test with two einkorn accessions.

The test site itself will be used again to demonstrate farmers, backers and consumers the agronomic characteristics of the ancient cereals and to select the accessions with the best potential for Dutch circumstances.

Einkorn trials in Italy

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Abstract

The main objective of the trial is to evaluate the genetic resources of underutilized species for agronomical interests and nutritional and nutraceutical properties to improve food quality. The Einkorn available collection (UNIFI - Tuscany) is composed by 64 Monococco x Beoticum crosses (MXB) and 9 parental Monococco lines (M). Considering the poor amount of seeds, in the agronomic season 2015-2016, einkorn accessions were reproduced in order to replicate seed, confirm agronomic trait and evaluate nutritional and nutraceutical qualities.

Location(s)

The trial were carried out in Tuscany (Italy).

List of accessions

5 accessions (Francesca; Cordiana; Silvano; line 1157II3 1/4B62 P1; line 1157II3 1/4B62 P6) and 3 samples deriving from a cross between T. boeoticum x T. monococcum (Beo 432x Mono 386; Beo 432x Mono 1326 P1; Beo 432x Mono 1326 P6).

List of traits assessed

Crop productive performance (yield, yield components)		
Plant habitus	Field evaluation	height of the plant
Plant habitus	Field evaluation	height of the ear
Plant habitus	Field evaluation	brittle/non brittle rachis
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Nutraceutical	Spectrophotometric analyses	Content of free, bound and total polyphenols (mg of polyphenols/g of flour)
Nutraceutical	Spectrophotometric analyses	Content of free, bound and total flavonoids (mg of flavonoids/g of flour)
Nutraceutical	Spectrophotometric analyses	Antioxidant activity (DPPH and FRAP test)

Trial background and evolution

The main objective of the activity is to improve agronomic performance of Tr. monococcum. In particular, different genotypes of einkorn and 64 crosses between Tr. beoticum and Tr. monococcum were evaluated to identify samples with non-brittle rachis.

Together, nutritional and nutraceutical evaluations were performed, to ensure also an improvement in food quality.

Trial design and management

A completely randomized experimental design were adopted.

Main results

Only 4 samples (3 crosses MXB and 1 einkorn accession) showed non brittle rachis. During the agronomic season 2016/2017 and 2017/2018 seed obtained in the first agronomic season were reproduced and evaluated for agronomic, nutritional and nutraceutical compounds (see Table 1).

Beo 432 x Mono 1326 //P7 showed statistical differences with the other genotypes for ear weight and total kernel weight. In addition, differences were also observed between einkorn varieties (Cordiana, Francesca, Silvano) and the other accessions for number of spikelet and kernel. Plants of line 1157 and the 3 crosses MxB showed high level of nutraceutical compounds; Beo 432 x Mono 1326 //P7 showed the highest level of FPC.

Table 1. Mean values of agronomic traits measured in the einkorn accessions (line 1157//P1; line 1157//P2; Cordiana; Francesca and Silvano) and in the MxB crosses (Beo 432 x Mono 1326 //P6; Beo 432 x Mono 1326 //P1; Beo 432 x Mono 1326 //P7) during the agronomic seasons 2016/17 and 2017/18. Different letters in a column indicate statistically different values.

Genotypes	ear lenght (cm)	ear weight (g)	n. of spikelets	n. of kernel	total kernel weight (g)
Line 1157//P1	8.24 ± 0.9	1.82 ± 0.4 (a)	35.4 ± 2.5 (b)	32.9 ± 3.9 (bc)	1.80 ± 0.4 (a)
Line 1157//P2	8.37 ± 0.9	1.99 ± 0.5 (a)	35.4 ± 3.5 (b)	33.6 ± 3.9 (bc)	1.98 ± 0.5 (a)
Beo 432 x Mono 1326 //P6	8.28 ± 0.9	1.90 ± 0.4 (a)	35.8 ± 2.9 (b)	33.5 ± 3.8 (bc)	1.87 ± 0.4 (a)
Beo 432 x Mono 1326 //P1	7.90 ± 0.7	1.63 ± 0.5 (a)	33.3 ± 2.8 (b)	30.2 ± 3.6 (c)	1.61 ± 0.5 (a)
Beo 432 x Mono 1326 //P7	8.15 ± 0.9	1.08 ± 0.3 (b)	30.02 ± 3.2 (c)	24.4 ± 4.6 (d)	1.02 ± 0.3 (b)
CORDIANA	8.84 ± 1.0	1.81 ± 0.4 (a)	39.3 ± 2.1 (a)	34.6 ± 3.3 (abc)	1.77 ± 0.4 (a)
FRANCESCA	8.62 ± 0.7	1.79 ± 0.4 (a)	39.06 ± 2.2 (a)	35.5 ± 2.5 (ab)	1.76 ± 0.4 (a)
SILVANO	8.96 ± 0.9	1.73 ± 0.4 (a)	40.6 ± 2.5 (a)	38.2 ± 3.3 (a)	1.67 ± 0.4 (a)
	n.s.	***	***	***	***

Table 2. Mean values of phenolic compounds and antioxidant activities oberved in the einkorn accessions (line 1157//P1; line 1157//P2; Cordiana; Francesca and Silvano) and in the MxB crosses (Beo 432 x Mono 1326 //P6; Beo 432 x Mono 1326 //P1; Beo 432 x Mono 1326 //P7) during the agronomic seasons 2016/17 and 2017/18. Different letters in a column indicate statistically different values.

Genotypes	FPC mg GAE/100g	BPC mg GAE/100g	FFC mg GAE/100g	BFC mg GAE/100g	FRAP mmol Fe2+/100g	DPPH umol TE/ g
Line 1157//P1	138.31 (ab)	115.63	102.32 (a)	78.02 (a)	0.88	2.3 (ab)
Line 1157//P2	145.21 (ab)	123.43	78.09 (b)	70.31 (a)	0.90	2.6 (a)
Beo 432 x Mono 1326//P6	121.29 (ab)	113.21	105.09 (a)	79.21 (a)	0.85	2.1(ab)
Beo 432 x Mono 1326//P1	141.05 (ab)	103.23	111.87 (a)	74.34 (a)	0.91	2.3 (ab)
Beo 432 x Mono 1326//P7	160.78 (a)	109.45	98.09 (ab)	60.92 (ab)	0.86	2.3 (ab)
CORDIANA	115.88 (b)	111.23	70.67 (b)	45.01 (b)	0.84	2.7 (a)
FRANCESCA	119.06 (b)	108.21	106.64 (a)	88.06 (a)	0.94	2.4 (a)
SILVANO	133.72 (ab)	114.21	73.09 (b)	79.32 (a)	1.01	2.8 (a)
	*	ns	*	*	ns	**

Abbreviation: FPC (free phenolic content); BPC (bound phenolic content); FFC (free flavonoid content); BFC (bound flavonoid content).

Discussion

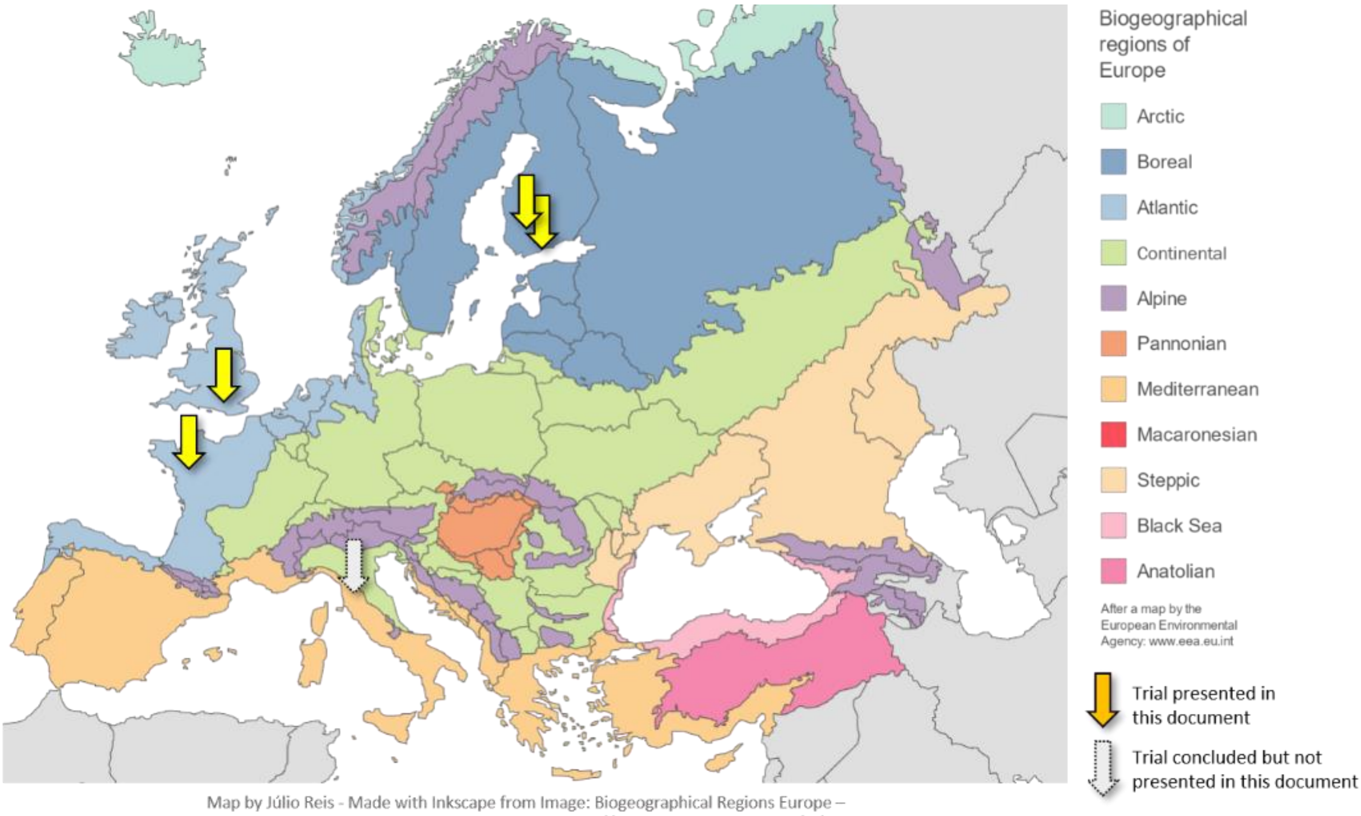
Recent research has underscored the good nutritional quality and relevant potential for human consumption of einkorn. In particular, einkorn is known for its broad variation for many nutritional and nutraceutical compounds. The reappraisal of einkorn quality evidenced that kernels are rich in protein, fructans and microelements contents. In addition, the several antioxidant compounds contribute to the excellent nutritional properties of its flour. At the same time, einkorn shows some negative agronomic traits, such as low yields and non-brittle rachis. The experimental activities can contribute to the constitution of new einkorn lines, combining nutritional characteristics and improved agronomic traits.

Conclusion and next steps

Seed reproduced during the trial confirm the good nutritional and nutraceutical performance of einkorn accession and MxB crosses. Additional field trials will be carried out to confirm experimental data obtained in the preliminary tests.

Buckwheat

Fagopyron esculentum



Map by Júlio Reis - Made with Inkscape from Image: Biogeographical Regions Europe – Map (intl).png by the European Environmental Agency, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=804348

Five populations/landraces used to create new populations - France

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Abstract

The aim of this trial is to compare two methods of creation of new buckwheat populations from five buckwheat landrace parents. These populations were previously observed in France, UK and Cyprus during the first year of the project. Then, the populations were used to create new diverse populations using two methods. In the first method, CCP – Composite Cross Populations – we crossed manually each parent with each other and cultivate the bulk of the seeds resulting from these crosses. In the second method, we simply sow a mix of the five parent landraces. We call this second trial a dynamic population. The evolution assessed through a phenotypic study of the grains from the two methods, compared with the grains from the five parents.

Location(s)

The trial in 2017 was located in Chavagne (Ferme des Petit Chapelais), near Rennes, in a farmer's field, on two 100 m² patches. In 2018, the trials were repeat on three places: (1) Argentré, (2) Retier and (3) Chavagne, in Britany.

List of accessions

Populations parents

1) 'Le petit gris': local population (from Bain de Bretagne) adapted by farmers to the pedoclimatic context of northwestern France (Brittany) with a good rate of flour extraction.

2) 'Le petit prussien': early local population (because of a low branching potential).

3) Billy: commercial population which has a large seed size and therefore a good deshulling potential.

4) Spacinska: commercial population with relatively stable yields and good processing potential either for flour (good rate of flour extraction) or for deshulling (relatively large seed size).

5) Kaiomchasta: population multiplied from genetic resources accessions and with good rusticity

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Grain color	Macroscopic observation	Qualitative
Grain pattern	Macroscopic observation	Qualitative
Pattern color	Macroscopic observation	Qualitative
Grain shape	Macroscopic observation	Qualitative
Grain size	Macroscopic observation	Qualitative
Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
Thousand Kernel Weight (TKW)	Weighing grain samples (10 samples of 10 grains)	Average
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		

Trait	How it has been assessed	Type of data available
Presence of *Fagopyrum tataricum*	Macroscopic observation	Quantitative

Trial background and evolution

This work is developed in “Renaissance des céréales mineures” project results (about evaluating and developing diversity through participatory research). Thus, the objectives of this work were to search how to create diversity, by assessing two strategies of diversity creation: a CCP (Composite Cross Population) and a dynamic population, both creating from the same populations observed in France and UK. The new populations, after this multiplication, will be distributed to farmers next year for on-farm breeding.

Trial design and management

The trials have been sown on May 16th, 2017 in a farmer’s field, in two plots of 100 m², one for the CCP, and the other for the dynamic population, to obtain enough seeds to start on-farm breeding activities in 2018.

CCP was sown from the progenies of the crossing two by two from the 5 parents, e.g. 225 grains from each of the 25 progenies (225*25=5625 grains). For the dynamic population, 1125 grains of the progenies of the five parents have been sown (1125*5=5625).

Since the germination was very low, a second sowing has been performed to complete the plots 10 days later, with 10000 grains in each plot (CCP: 25*400=10000, and dynamic population: 5*2000=10000).

Weeding has been performed on 26th and 27tt June. The plots were harvested on 26th and 28th September, with a hand scythe, and then sheaves of entire plants have been dried under plastic tunnels. The threshing of the sheaves took place on 15th October.

In 2018, the grains used for the trials were the ones harvested during the previous year. The trials were sown between mid-May and mid-June 2018, in three locations.

Farms	CCP surfaces	Dynamic population surfaces
Argentre (1)	60 m²	60 m²
Retrier (2)	200 m²	200 m²
Chavagne (3)	250 m²	250 m²

Main results

As the trials aim to amplify the initial diversity and initiate participatory breeding to evaluate the interest of both methods, we have only performed few measurements to describe the experimental populations and their internal diversity of grain quality.

Comparison of parents and harvested grains MKW (Mean Kernel Weight)

MKW is an interesting phenotypical trait since it is associated with the size of the seeds, and then their ability to deshulling. Two parents have deshulling ability, Spancinska and Billy, and the 3 others can only be used to produce flour. Among parent landraces, three varieties have lower MKW (figure 2): Kaiomchasta (19,5g), Petit Gris (19,1g) and Petit Prussien (16,7g). Spacinska is intermediary (24,3g) whereas Billy presents clearly a more important MKW (37,4g). There were not significant differences between the CCP and the dynamic population (figure 7 and 8). The various environments seem to promote either one or the other population. Future trails will confirm this observation.

Phenotype comparison of parent landraces with harvested CCP and dynamic population: colour differences

Parental varieties colours are clearly differentiated (figure 1). Petit Gris and Petit Prussien are mainly silver, Spacinska and Kaiomchasta are black, brown, and cream, whereas Billy is mainly black and brown, and is also the only one to have a red grain amount reaching 10%. The dynamic population presented more silver grains and less black grains than the CCP in 2017 (figure 5). This year, the percentage of Black grains appears equivalent in both populations (figure 6). Cream, red and brown were equally distributed in both populations. So, each population is different and has its own capacity to evolve. The CCP and dynamic population seem to increase each year the ratio of medium-sized grains at the expense of small and large grain (figure 3 and 4).

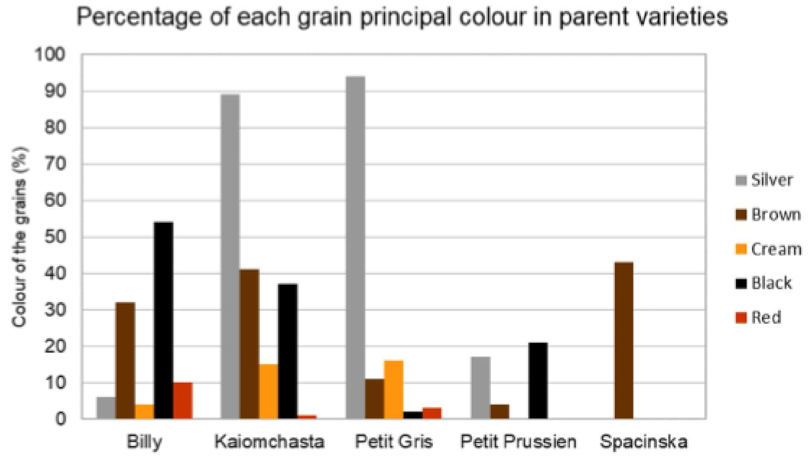

Figure. 1. Percentage of each grain principal colour in parents

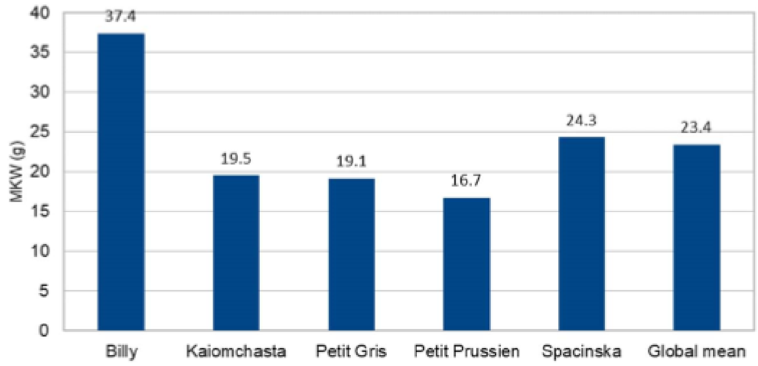

Figure. 2. Mean MKW of the five parents and the

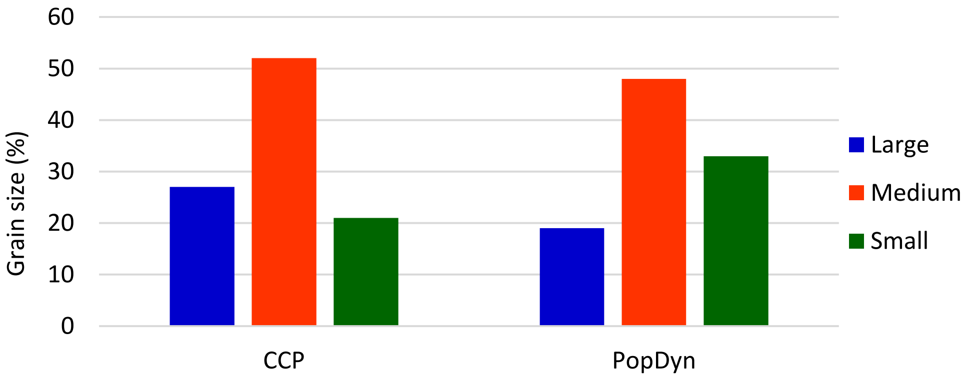

Figure.3. Size of the CCP and dynamic population grains 2017

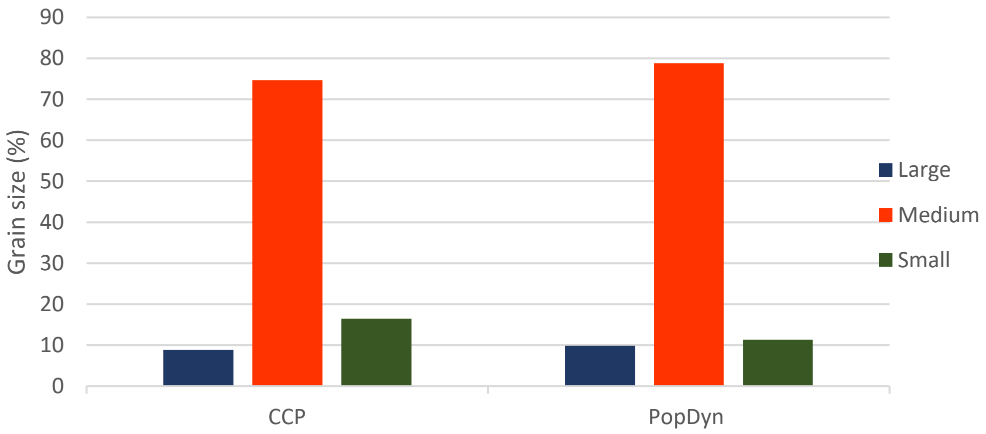

Figure. 4. Size of the CCP and dynamic population grains 2018

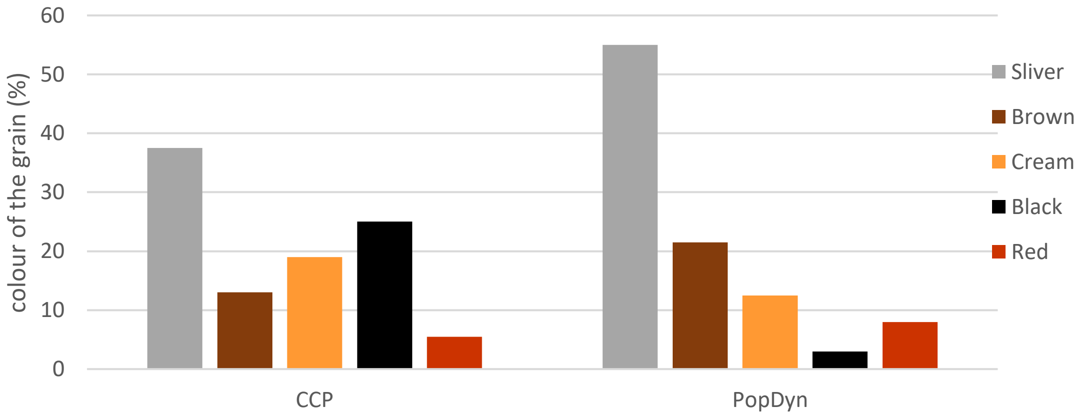

Figure. 5. Percentage of each main colour in CCP and population dynamic 2017

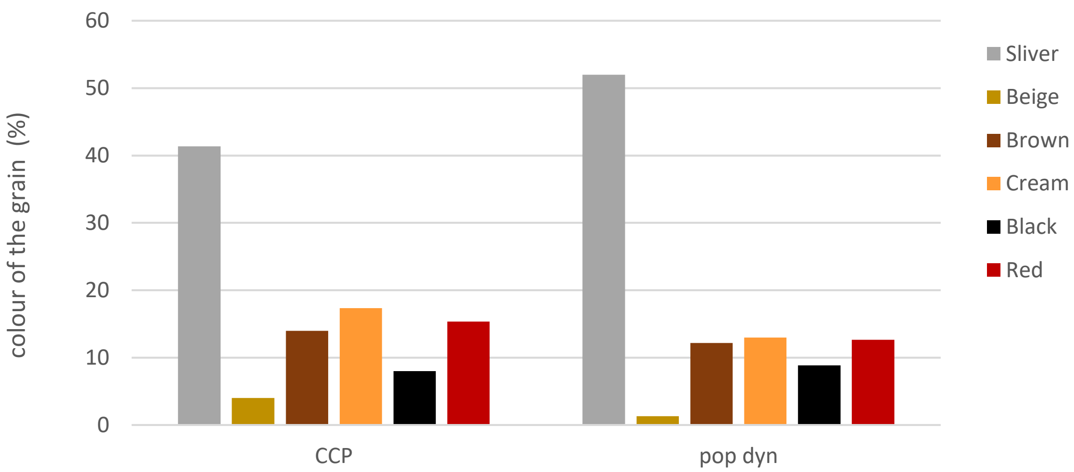

Figure. 6. Percentage of each main colour in CCp and population dynamic 2018

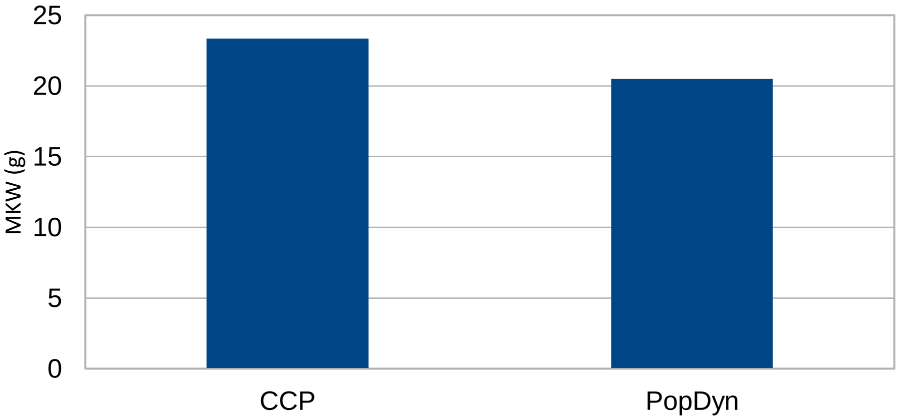

Figure. 7. Mean of CCP and dynamic populations MKW

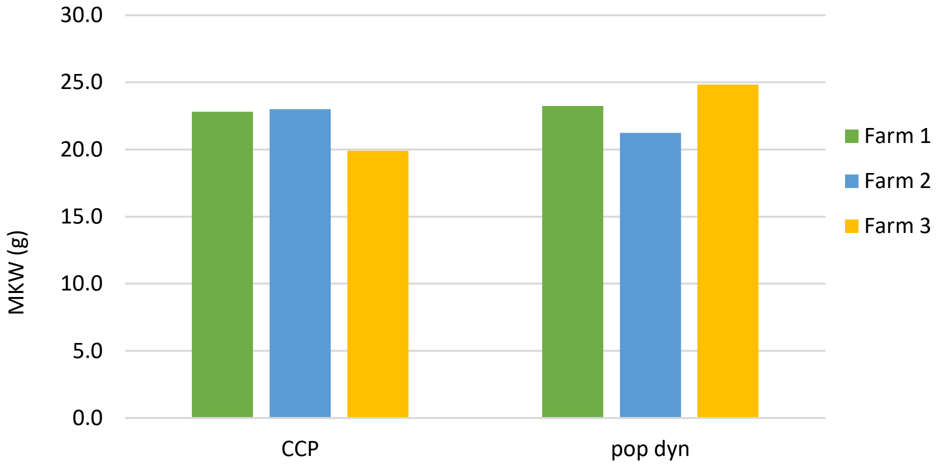

Figure. 8. Mean of CCP and dynamic populations MKW on three farms 2018

Discussion

Our first phenotypic observations have detected a major difference on CCP and dynamic population in which the seed quality traits of Petit Gris and Petit Prussien seemed to be more expressed (more than 50%) than Billy's traits. Manual pollination performed to create the CCP seemed to have a better distribution of all the parents' diversity. In the dynamic population based on natural pollination, instead, Billy, Kaiomchasta and Spacinska traits are less represented.

Conclusion and next steps

The distribution between traits is more balanced in the CCP than in the dynamic population in the initial phase of the breeding process. The environment appears to influence the populations sometimes in a divergent way or in a convergent way.

During the next steps, we will continue to observe the evolution of both populations in the farms under the selection of both environment and farmer. Also, a third population was created in this project and observed. This last population is a mix of 200 buckwheat varieties, that will be compared with the others.

Five buckwheat landraces and their mixture in UK organic farming

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Abstract

Buckwheat can have a role as a grain crop in the UK, responding to increasing market demand and supporting local value chains. However, it is currently mainly grown as a cover crop. Five landraces and their mixture have been tested, showing that the main constraint is to successfully harvest in a humid climate where ripening is not synchronous and plant biomass tends to stay green all along the season. The better yielding accessions are the most competitive and biomass-productive.

Location(s)

Sonning experimental farm, Reading (Berkshire) UK, 2016

List of accessions

Five accessions provided by INRA and their mixture were tested

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	How it has been assessed	Type of data available
Ground cover	Visual estimate	%
Phenology	BBCH Growths stages at different dates	BBCH GS
Height		Cm
Biomass production	Biomass sampling pre-harvest	g/m2
Weed biomass	Biomass sampling pre-harvest	g/m2
Crop productive performance (yield, yield components)		
Trait	How it has been assessed	Type of data available
Grain yield	Cutting, drying and combining	t/ha
Harvest Index	Biomass sampling pre-harvest	%
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	How it has been assessed	Type of data available
Average grain weight		g

Trial background and evolution

Buckwheat in UK organic farming is currently mostly used as a cover crop. The aim of this trial was to test its potential as a grain crop, alongside the known agroecosystem services it can provide, first weed suppression. The main constraint observed was the difficulty of harvesting grains in a water non-limiting climate where flowering and grain production proceeds continuously and plant biomass keeps being green. The trial was suspended in 2017 and it is planned to be restarted in 2018.

Trial design and management

An RCB with four replicates was drilled in late May 2016 in the experimental farm of the University of Reading. Two out of four blocks were assessed during the season because of suboptimal crop establishment in the top and bottom of the field. 0.5m^2 quadrate samplings were collected prior to harvest in August 2016. Harvest was performed by a

hand power scythe on green biomass when most of the grains appeared ripen. The biomass was then to dry and then combined.

Main results

Grain yield was relatively poor, with an average of 0.6t ha^{-1}, but with accessions 'Spacinska' and 'Petit Prussien' being the highest yielding (up to 1.1 t ha^{-1}). Weed suppression was strikingly differentiated by accessions. 'Petit gris' and the mixture were the worst competitors (almost 80g m^{-2}), whereas 'Spacinska' and 'Petit prussien', the ones with the highest yield and biomass production (up to 700g m^{-2} dry weight) allowed an insignificant amount of weed biomass to be produced. The highest Harvest Index, 10%, was found in 'Billy', which performed as an average weed competitor. Overall, Yield and Biomass production were negatively correlated to weeed biomass and Harvest Index, and independent on height and early ground cover, as shown in a Principal Component Analysis explaining 82% of total variation.

Discussion, conclusions and next steps

A very competitive crop, Buckwheat grain production in the UK may be constrained by difficulties in harvest due to the lack of a proper dry period preventing the crop to dry enough for combining. Some farmers are producing buckwheat grains and test different approaches to harvest. However their production is limited to determined types.

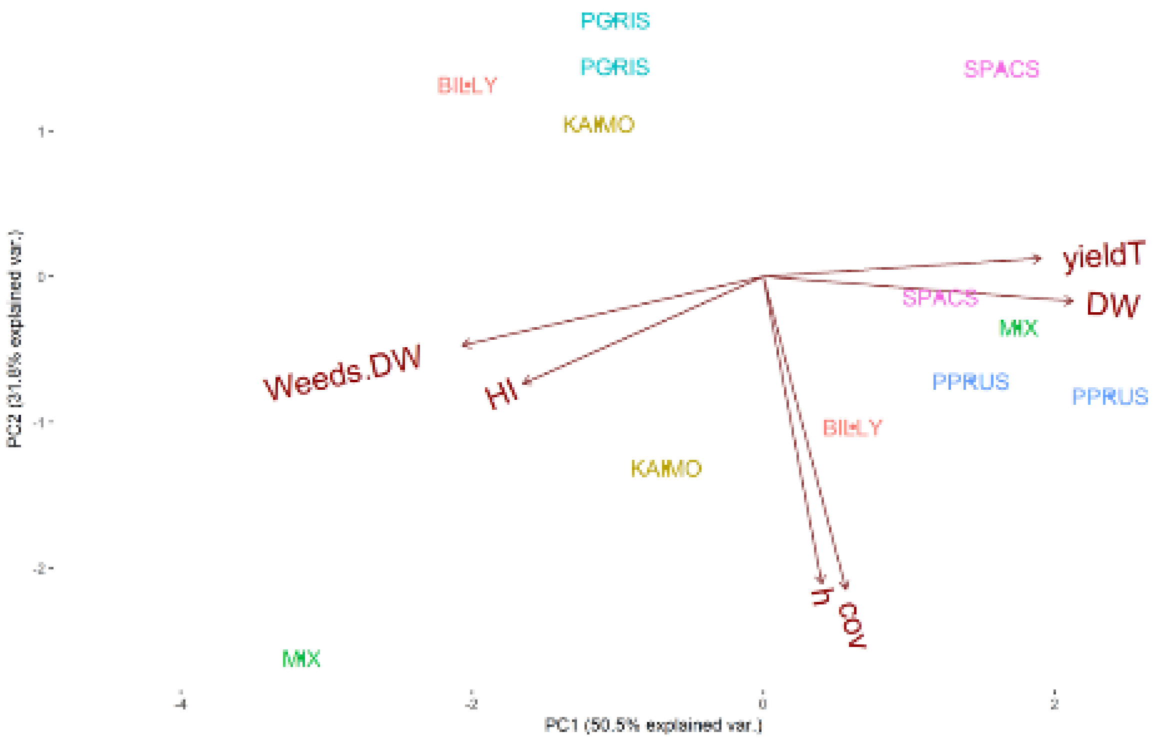

Fig. 1. Principal Component Analysis of Buckwheat accessions traits in 2016.

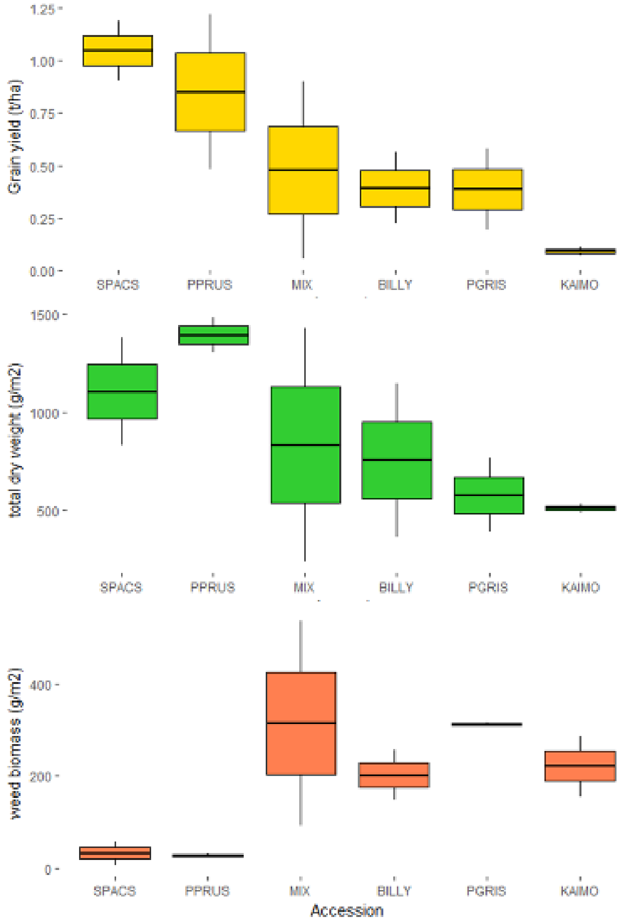

Fig. 2 Grain Yield, Total dry biomass and Weed biomass by Buckwheat accession in UK trial 2016.

Buckwheat management and yields in two regions in Finland

Responsible partner LUKE – Country FINLAND

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Abstract

The aim was to produce information on the yields, managements and reasons to cultivate buckwheat from two major regions in Finland. The samples were taken from farms situated in Tuusula and in Mänttä-Vilppula, belonging to Uusimaa and Pirkanmaa regions, respectively. Buckwheat yield and other productivity parameters differed between the studied regions. The yields and oher traits associated to productivity were always better or higher in Uusimaa comparing to Pirkanmaa. As a conclusion, in 2018 the temperature sum reached in both regions high enough to produce equally high yield, in 2016 and 2017 only temperature sum in Uusimaa. More complicated factors affecting the seed production and flowering may exist, which needs to be studied more.

Rationale

Cultivation of buckwheat restarted in the province Pirkanmaa (1995), where the mill Keskinen (http://keskisenmylly.fi/) specialised to buckwheat upgrading and farmer's cooperative (https://www.tattariosk.fi/) started to make contracts. In about 2009, the yields of buckwheat cultivated in Pirkanmaa province started to decrease, at the same time the cultivation move gradually to another region, Uusimaa province, located about 200 km south from Pirkanmaa. In practice, the average yield in Pirkanmaa decreased and at the same time the number of farmers and the buckwheat yield in Uusimaa increased. Buckwheat was chosen to DIVERSIFOOD project, since there was a need to know, why the seed yield decreased markedly in the original area (Pirkanmaa), and could this happen in the future to the other regions as well. The aim of the study was to collect information on the yields, cultivation practises and motives behind the buckwheat cultivation. We wanted to know, is there variation on the cultivation practises how much the farmers yield differed between Pirkanmaa and Uusimaa. The research idea was discussed with farmers in 2015-2016. During the 3 years the samples have been taken by Luke, about 30 farmers have provided the background information requested by the form send by email.

List of accessions

Farmers cultivated the local buckwheat accession, which is called 'Keskinen' according to the mill Keskinen upgrading the yield.

Location(s)

The samples were taken from Uusimaa and from Pirkanmaa. In Uusimaa, most of the farms situated around Tuusula (60°24′10″N, 025°01′45″E), and in Pirkanmaan around Vilppula (62°01′20″N, 024°30′35″E). Tuusula (Uusimaa) is about 30 – 100 m above the sea level, Vilppula (Pirkanmaa) is on average 100 – 150 m above the sea level. The chare of the different soil type in Uusimaa and in Pirkanmaa was as follows : coarse mineral soil (30 % (U) and 65 % (P)) ; clay (65 %(U) and 25 % (P)) and organic soil (5 % (U) and 10% (P)).

Climate

The accumulated temperature sum (the sum of average daily temperatures – 5◦C in each day) during the growing season in 2016, 2017, and 2018 in South-Finland (Uusimaa) was about 1420, 1165 and 1725, respectively. In Central part of Finland (Pirkanmaa) the temperature sum in 2018 was about 1600. The mean average temperature sum (1981-2010) for South- Finland is 1275 C and for Central part of Finland 1148 C. Precipitation during the growing season in 2016, 2017, 2018 in South Finland was 270, 390 and 260 mm, respectively, whereas the average

precipitation (1991-2010) is 355 mm. Precipitation during the growing season in 2018 in Central part of Finland was 110 mm, respectively, whereas the average precipitation (1991-2010) is 287 mm.

Trial design and management

Fields were pre-selected: only fields, where buckwheat has not been cultivated earlier were chosen. Farmers took care on the farming, from soil preparing to harvest. Luke took the samples from the crop and soil just before the harvest, and carried out the analyses. The samples and information were collected three following years (2016, 2017, 2018), from two different regions (Uusimaa and Pirkanmaa), and from 7 – 10 farmers/region/year. Crop and weed samples were taken from the area of 2 x 0,25 m2. Background information including managements, harvested yield and the motives to grow buckwheat, were requested afterwards.

Main variables assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
weeds	from the samples, 2 x 0,25 m2	kg/ha
length of the crops	measured from 10 plants/sample	cm
biomass of the stems and leaves	dried samples were fractionated to seeds and to the waste	kg/ha
mineral N content of the soil	soil sample taken at the end of growing season	kg/ha
plant diseases infected stems was analysed.	The stems of ripened plants were placed on selective agar medium plates. The incidence of *Fusarium, Botrytis* and *Rhizoctonia* infected stems was analysed.	number of fungal pustules/agar dish

Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
number of crops, density	counted 2 x 0,25 m2	number/m2
seed yield of the sample	dried samples were fractionated to seeds and to the waste	kg/ha
seed yield according to farmer	estimated or weighted by farmer	kg/ha
Harvest index HI	dried samples were fractionated to seeds and to the waste	share (seed yield/total biomass)
TSW (1000 seed weight)	from the dried seed sample	g
Seed yield of the sample (kg/ha) /seed yield accroding to the farmer (kg/ha)	utilization of data obtained	kg/ha / kg/ha

Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	How it has been assessed	Type of data available
N content of the seed	analysed from the dried seed sample, un-hulled	%
protein content of the (unhulled) seeds	calculated from N content of the (unhulled) seeds by multiplying 6,25	%

Main results

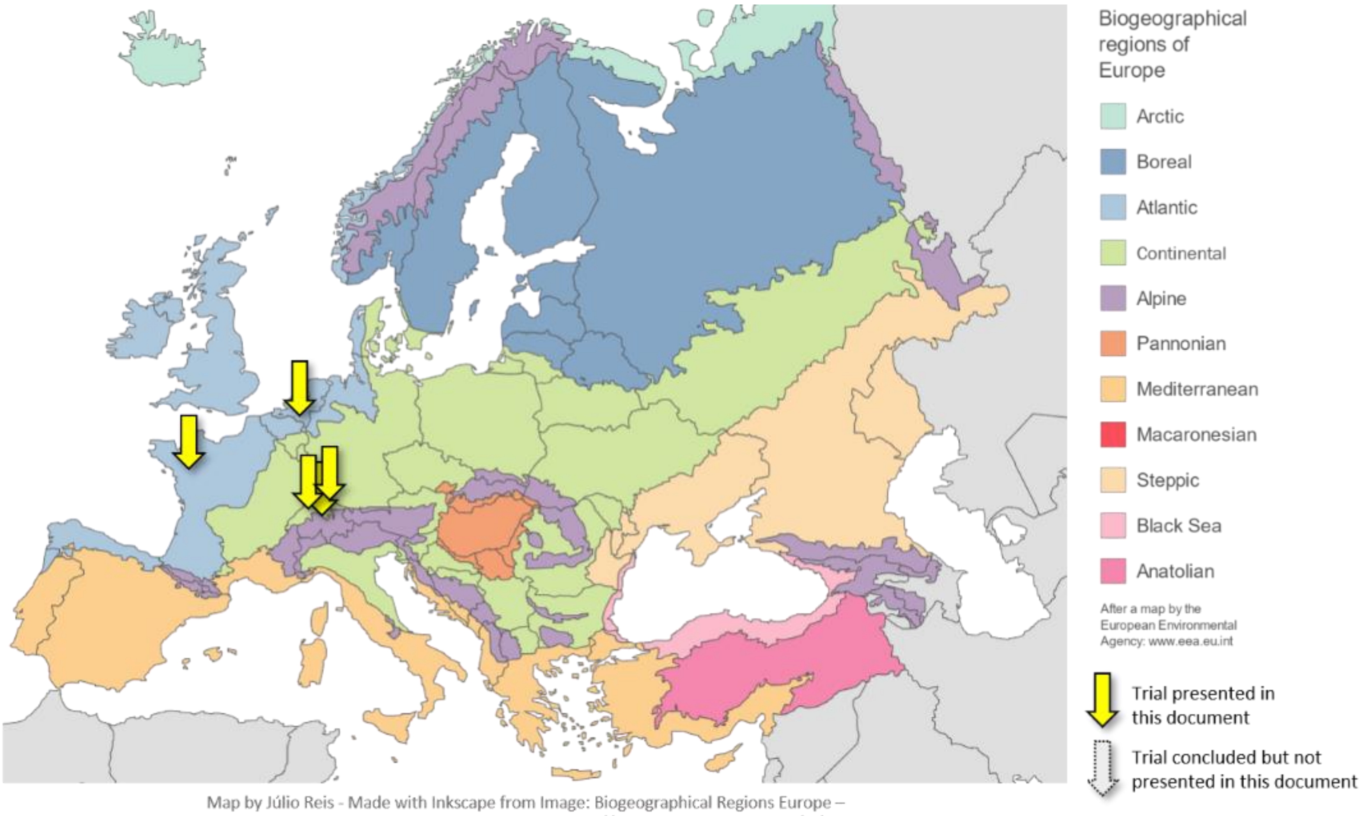
The data from three years and two regions show, that most of the traits differed between locations [seed yield (both sample and farmers estimation, p < 0,01), protein yield (both, from sample and farmers estimation p<0,01), weeds (p<0,03), plant density (p<0,01), plant height (p<0,07 – close to significant), weight of the samples (p<0,01)]. Less differences were observed between years, and few significant interactions between year x location was observed (seed yield of samples p<0,05; seed protein content p<0,02, plant density p<0,01). The average yield of samples from Uusimaa and Pirkanmaa were 1690 and 1065 kg/ha (s.e.186), respectively and the average yield according to farmers estimation from the same regions were 740 and 400 kg/ha (s.e. 99,9), respectively.

Discussion and Conclusion

Buckwheat seed setting seems to be different in the studied regions, usually. The mean of traits describing productivity, except protein content, of the seeds were always better or higher in Uusimaa comparing to Pirkanmaa. The distance between the growing regions is about 180 km, also 'average' soil type differed (clay vs coarse mineral soil). However, the most important factor causing the differences, maybe the temperature. The accumulated temperature sum in 2018 was very high in both regions (1723 ◦C vs 1600 ◦C) and also the potential seed yield (seeds from the samples) were almost the same (1472 kg/ha vs 1466 kg/ha), whereas in other years (2016 and 2017) the temperature sum and the seed yields were higher in Uusimaa. As a conclusion, in 2018 the temperature sum reached in both regions high enough to produce high and equal seed yield. But, also more complicated factors may exist, since there was interaction between region and year for seed yield and protein content. It is know, that long days may not favour the induction of flowering. For example, about 182 km to north means that the daylight is longer in Pirkanmaa comparing to Uusimaa regions, but this needs to be studied more.

Broccoli

Brassica oleracea



Map by Júlio Reis - Made with Inkscape from Image: Biogeographical Regions Europe – Map (intl).png by the European Environmental Agency, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=804348

Broccoli open-pollinated and F1-hybrids in the Netherlands

LBI – Netherlands

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Abstract

Because of the limited availability of CMS-free F1-hybrids of Broccoli, we have evaluated two OP varieties and four OP breeding lines of broccoli for their suitability as alternative for F1-hybrids. Evaluation was conducted in 2016 and 2017 with very different weather and soil conditions. In terms of yield, one OP variety and one breeding line have a yield potential similar to F1-hybrids. However, mainly because of higher levels of diversity, at this stage these plant materials are mostly of interest for direct marketing and short production chains. Either these OP materials are further improved through breeding to make them of interest for the anonymous market or multiple chain players in the anonymous market are prepared to adapt to working with broccoli with higher levels of diversity.

Location(s)

BD-farm De Beesrche Hoeve, Oostelbeers, the Netherlands

List of accessions

Cultivar	Breeder (Distributer) [Country]	Breeding method	Listed
Covina F1	Bejo [NL]	SI	EU-Variety catalogue
Calinaro	Kultursaat e.V. (Bingenheimer) [DE]	OP	EU-Variety catalogue
Haitabu (124)	Saat.gut [DE]	OP	EU-Variety catalogue
Sat 30	Satvia-Rheinau AG [CH]	OP	Breeding line
Sat 31	Satvia-Rheinau AG [CH]	OP	Breeding line
KSV BRO CHE GRE G	Kultursaat e.V. [DE]	OP	Breeding line
KSV BRO TH LIM 19-28	Kultursaat e.V. [DE]	OP	Breeding line

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	How it has been assessed	Type of data available
General stand	Visual	Score 1-9

Crop productive performance (yield, yield components)		
Trait	How it has been assessed	Type of data available
Yield ha Q1, Q2 irregular and small Yield ha Q1 and Q2 Yield dt ha Q1 Yield dt ha Q2 Yield not marketable	By weighing and combining data of all harvesting times	Numerical

avg head weight Q1 avg head weight Q2		
harvesting % (of all plants)	Counting	Numerical
harvest window (in days)	Counting days between start and end of harvest	Numerical
Reasons for rejection colour (to yellow) hollow stems rot (including spots in flower) head to loose head to flat to coarse (open, ready for flowering) leafs in the flower scars, corky parts head off shape	Counting and weighing	Numerical
Outer appearance head: colour head: intenstiy of colour head: texture head: curvature head firmness length of branching at base prominence of secondary heads	Visual	Score 1-9

Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)

Trait	How it has been assessed	Type of data available
Taste	By tasting	Score 1-9

Trial design and management

- Sown: by a specialised plant raiser
- Planted and harvested by hand
- Experimental design: CRBD
- Statistical analysis: ANOVA

Main results

The two major outcomes are the following:

- Some OP varieties (Calinaro) and breeding lines (KSV Che) have a yield potential similar to F1-hybrids (Figure 1). However, the OP material has also more unmarketable yield (head off-shape, irregular, hollow stems, irregularity in flower formation, etc). Another aspect that needs improvement is the high level of diversity (mostly in colour), which is not wanted in anonymous markets.
- The second major outcome is that the best performing OP material (Calinaro and KSV Che) showed the smallest yield difference between 2016 and 2017 (comparable to Covina F1). This suggests that they are relatively stable in yield. Both trials were conducted in suboptimal conditions. The season of 2016 can be described as poor in the beginning with good soil mineralisation towards the end of the season benefiting late varieties (Covina F1 and KSV The), whereas in 2017 crop establishment was good, but soil mineralisation reduced towards the end of the trial, being a disadvantage to the late breeding line KSV The.

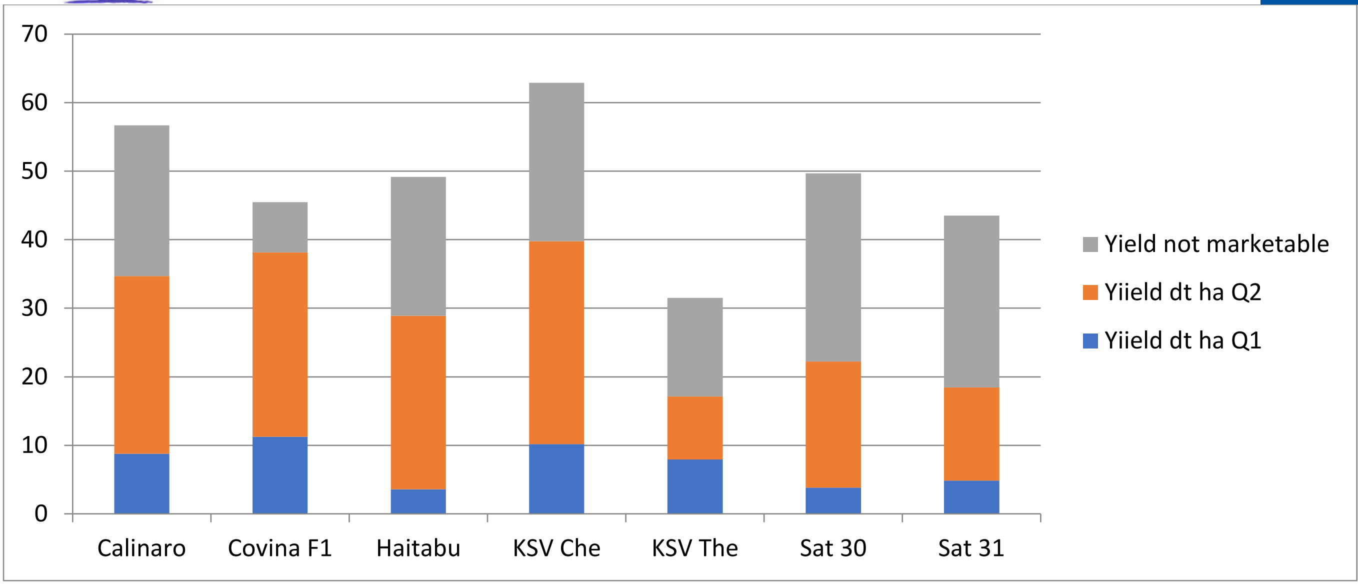

Figure 1: Average yield (separated in three classes: Yield first quality (Q1), Yield second quality (Q2) and Yield not marketable, all in dt/ha) of OP varieties and breeding lines of broccoli with one F1-hybrid as reference in a biodynamic farm in the Netherlands over the seasons 2016 and 2017

Discussion

The results show that it is possible to develop OP varieties of broccoli with yield similar to F1-hybrids. However, further breeding in OP varieties is needed to improve uniformity in outer quality to stimulate the uptake of OP varieties in farmer for anonymous markets in addition to short production chains.

Broccoli open-pollinated and F1-Hybrids in Switzerland

FiBL – Switzerland
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Abstract

From 2015 till 2017 FiBL conducted on farm field trials to compare the performance of open pollinated (OP) broccoli populations with F1 hybrids. The trials were aligned with trials at LBI (2016-2017) and ITAB (2017) and the harvested samples were analysed for glucosinolate content by ARI. While the total yield of the best OP varieties were comparable with hybrid varieties, the harvesting period was prolonged and the homogeneity required for supermarkets was not yet met. However, health promoting glucosinolate content were increased for OP varieties. Thus, in future more communication is needed to counter balance the demand of the markets for uniformity and importance of nutritional quality. OP varieties can be sold without problems in farmers shops and local vegetable baskets.

Location(s)

Switzerland: 2015) Fehraltorf (ZH), 2016) Therwil (BL), 2017) Villigen / AG

List of accessions

Broccoli varieties and breeding line tested (not each accessions was tested in each year):

KSV BRO CHE GRE G;	2016	Kultursaat e.V., mid-early; breeding line
KSV BRO CHE GRE bG;	2017	Kultursaat e.V., mid-early; breeding line
KSV BRO TH LIM 19-28,	2016, 2017	Kultursaat e.V., mid-late; breeding line
Haitabu (line 124),	2015-2017	saat.gut e.V.; early, breeding line/ registered variety
Calinaro,	2015-2017	Bingenheimer Saatgut AG; early, registered variety
Sat 30	2016-2017	Sativa-Rheinau AG, early, breeding line
Sat 31	2015-2017	Sativa-Rheinau AG, mid-early, breeding line
Sat 32	2015	Sativa-Rheinau AG, mid-early, breeding line
Batavia F1	2015-2017	Bejo, SI – Hybrid, mid-early, registered variety (Standard)
Covina F1	2015-2017	Bejo, SI – Hybrid, mid-late, registered variety (Standard variety in Organic)
Fiesta F1	2016	Bejo, SI – Hybrid, mid-late, registered variety
Chronos F1	2015	Sakata, CMS-Hybrid, mid-early
Ironman F1	2017	Syngenta, CMS-Hybrid, mid-late, registered variety (standard in conv. farming)

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	How it has been assessed	Type of data available
Plant height	Evaluation after UPOV 2, Characteristic N° 1	Notes of 4 replicates (2016, 2017) and 1 replicat (2015)

[2] UPOV TG/151/5(proj.1) Broccoli, 2016-05-19

Leaf attitude	Evaluation after UPOV 1, Characteristic N° 2	Notes of 4 replicates (2016, 2017) and 1 replicat (2015)
Crop productive performance (yield, yield components)		
Trait	How it has been assessed	Type of data available
Yield 1st, 2nd quality, not marketable	Weight per plot and harvest cycle	2015 of 1 replicat, 2016 of 3 replicats 2017: none crop failure
Numbers of flowers	Count per plot and harvest cycle	See above
Visual quality of harvest produce	Evaluation after UPOV 1, DUS Characteristic N° 15,18,20,23, 27 among others	See above
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	How it has been assessed	Type of data available
Glucosinolates content	Laboratory analysis by Michalis Omirou of ARI	2015, selected varieties 2016, all varieties 2 replicates

Trial background and evolution

Farmers did not know organic OP-varieties of broccoli. Researchers of LBI, ITAB and FiBL select the most promising OP-Lines in order to compare to F1 hybrids derived from Selfincompatibility (SI) and cell fusion derived CMS. The performance in terms of marketable yield and quality of the OP varieties will be known.

Trial design and management

Plantlets were grown and planted on-farm, with assistance of FiBL staff. Harvest was performed by FIBL staff with assistance of staff from the farm.

Randomized block system, 4 replicates (2016 and 2017), 2015 without replicates

ANOVA, after data transformation (evaluation datas only) and test on Homogeneity of Variances and normal distribution. Post test= Tukey HSD

Main results

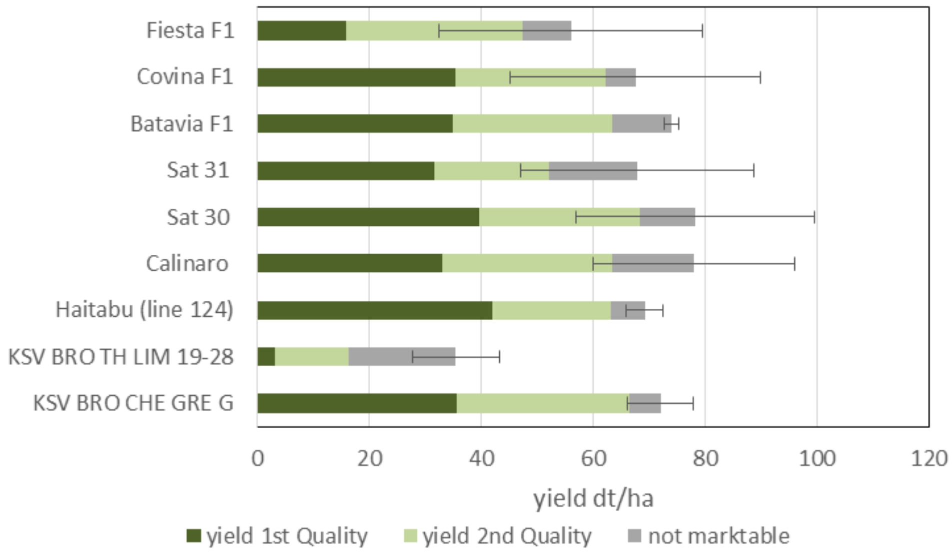

Fig1. Yield of broccoli varieties in 2016. Means of 3 replicats and standard deviation.

Table 1. Reasons for rejection of 1st Quality 2016

Variety	weight per flower (g)	not 1st quality	resons for 2nd quality or not marktable (% of flowers)										
			yellow flower	holes in stem	rot	to loose	to flat	coarse grained	leafs in flower	scarces	not reguarly	to smal	to big
KSV BRO CHE GRE G	232	49%	26%	0%	13%	0%	0%	17%	7%	0%	22%	9%	0%
KSV BRO TH LIM 19-28	169	90%	64%	1%	9%	1%	2%	4%	0%	1%	3%	13%	0%
Haitabu (line 124)	190	52%	18%	0%	37%	8%	12%	25%	4%	0%	4%	4%	0%
Calinaro	229	67%	37%	1%	10%	3%	4%	17%	5%	0%	9%	10%	0%
Sat 30	243	63%	15%	1%	27%	1%	5%	23%	8%	1%	0%	12%	0%
Sat 31	198	61%	26%	2%	24%	5%	0%	19%	13%	3%	11%	6%	0%
Batavia F1	249	64%	8%	1%	49%	1%	3%	6%	4%	6%	11%	10%	0%
Covina F1	182	56%	1%	10%	44%	3%	0%	9%	0%	6%	9%	10%	0%
Fiesta F1	186	76%	6%	12%	57%	1%	0%	11%	1%	0%	1%	6%	1%

Autumn 2016 and 2017 was a difficult season to grow broccoli, because of wet climate (Alternaria black spots in the flower) and a heavy attack with the pest swede midge (Contarinia nasturtii). Due to this problems yield was only half as good as expected in 2016 and in 2017 it resulted in a complete crop failure. In the trial in Switzerland the cultivar "Sat 30", "GRE G" and "Haitabu" showed the best marketable yields 2016 (Fig. 1), in 2015 Sat 31 showed best results among OP varieties. Major flaws in quality compared to hybrid cultivars were: more side shoots (all OP cultivars), yellow colour of the flower (LIM 19-28, GRE G, Calinaro, Sat 31), grain size too big or too unregularly (Sat 30, Sat 31, GRE G), flowers to flat (Haitabu) and leaves within the flower (e.g. Sat 31) (Table 1). Highest glucosinolate content was achieved for the OP Calinaro and Haitabu.

Discussion

In our experiments overall yield of the best OP varieties were comparable with hybrid varieties. However, with respect to all trials the marketable yield was lower as the OP varieties didn't met the requirements of uniformity needed to sell produce to supermarkets. The difference in supermarket quality parameters were especially visible, if the crop performance was good (2015). Presently the market totally neglects the importance of nutritional quality (e.g., glucosinolate content). Here the OP show a clear advantage. The most promising OP breeding lines were still in breeding process and a development in terms of improved homogeneity can be expected. Due to difficulties in seed production, there was no breeding progress in certain OP varieties during the project (esp. Sat 30 and 31). The OP varieties have potential in certain direct marketing concepts (e.g. vegetables baskets or farmers shop). While supermarkets favour on uniform products, more emphasis should be put on nutritional quality. Thus, consumers and retailors need to be convinced about the advantage of more diverse broccoli products. At the same time the breeders need to improve homogeneity of harvesting time to reduce production costs.

Conclusion and next steps

Meanwhile first varieties of OP broccoli in crown-typ where available. However, the breeding process has still to be continued, in order for satisfactorily results for vegetable growers. Further tests under different conditions with improved breeding lines are needed. FiBL will test the best 6 broccoli cultivars in 2018, as in 2017 yield data could not be collected in Switzerland due to severe infestation of swede midge (Contarinia nasturtii) resulting in deformed plants. Stakeholder workshops will be continued in order to replace cell fusion based CMS F1 hybrids by OP broccoli varieties with sufficient yield stability, taste and high glucosinolate content.

Glucosinolates content of broccoli florets

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Analysis of glucosynolate content of broccoli florets

Abstract

The main objective of our activity is to assess the glucosinolate (GSL) content of broccoli florets derived from different varieties and regions (France, Switzerland and Netherlands). Samples have been received from France and Switzerland and analysed in LC-MS ion trap (Amazon SL, Bruker Germany). The different genotypes varied in their glucosinolates content while origin had a significant effect on individual GSL and their content.

Location(s)

Switzerland and France

List of accessions

- KSV BRO CHE GRE 6_191016
- KSV BRO CHE GRE 6_041016
- Haitabu (line 124) OP
- Calinaro OP
- Sat 30
- Sat 31
- Batavia F1
- Corina F1
- Fiesta F1
- KSV TH LIM 19-28

List of traits assessed

Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
Biomass production	Weight of above ground biomass measurement	Quantitative (g)
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	**How it has been assessed**	**Type of data available**
Glucosinolates	LC-MS ion trap	Concentration (µmol/kg dw)
N content	TKN	Concentration (%)

Main results

The main findings of this trial are the following:

- There is no significant variation of GSLs content within open pollinated varieties compared to F1-varieties

– There is a significant variation among the different varieties regarding GSLs profiles.
– Climatic conditions is a crucial factor controlling GSLs content

Discussion and conclusion

Our findings clearly show that GSLs varied across the varieties and cultivation areas. Total indolyl GSLs namely Glucobrassicin and 3-Methoxy-GBS are the main individual GSL found in Haitabu and Calinaro Open pollinated varieties which exhibited the highest content of these compounds. Glucoraphanin was the main individual aliphatic GSL found in this trial and open pollinated varieties had slightly higher content compared with that found in hybrids.

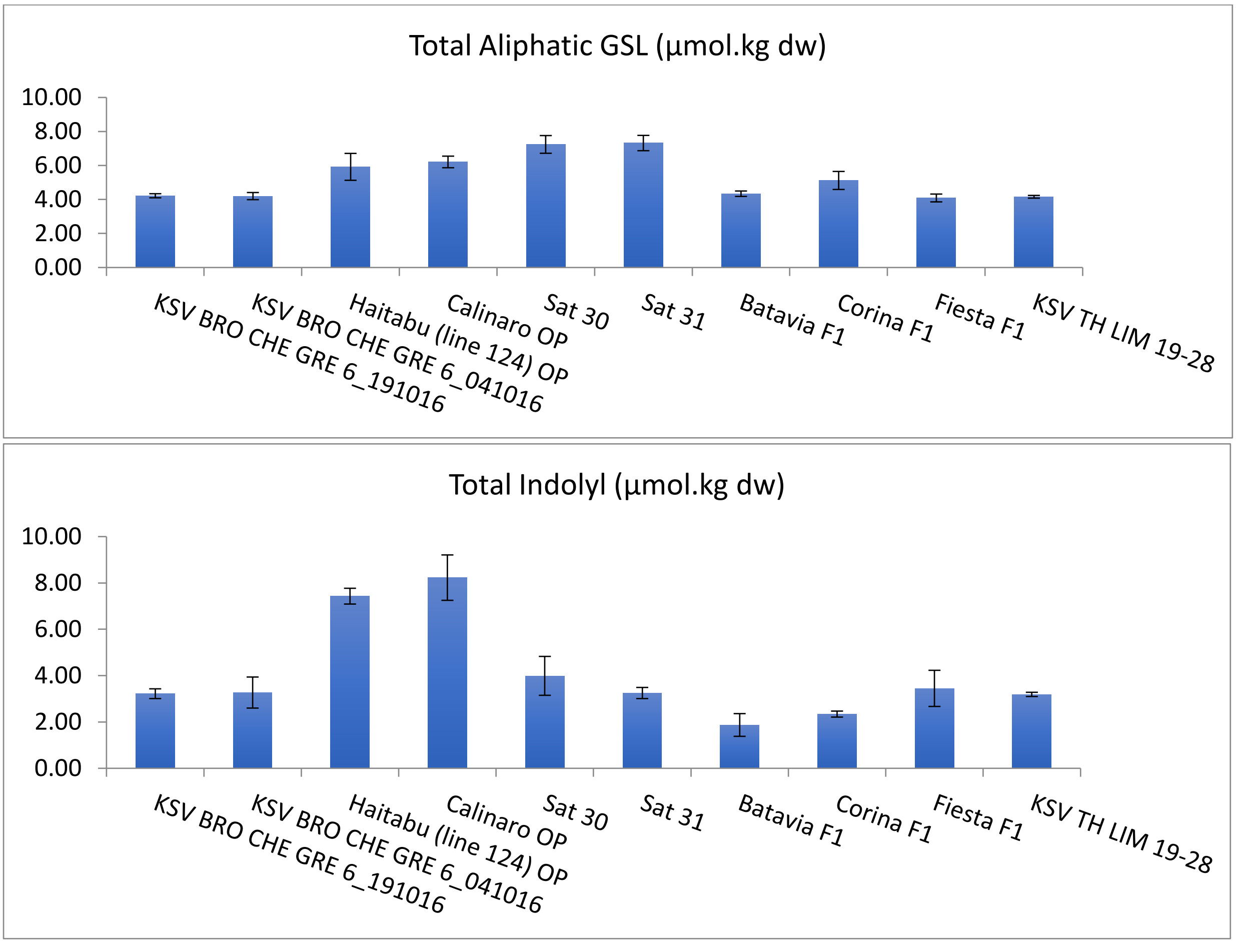


Figure 1 Total Aliphatic and Indolyl GSL concentration from different broccoli varieties

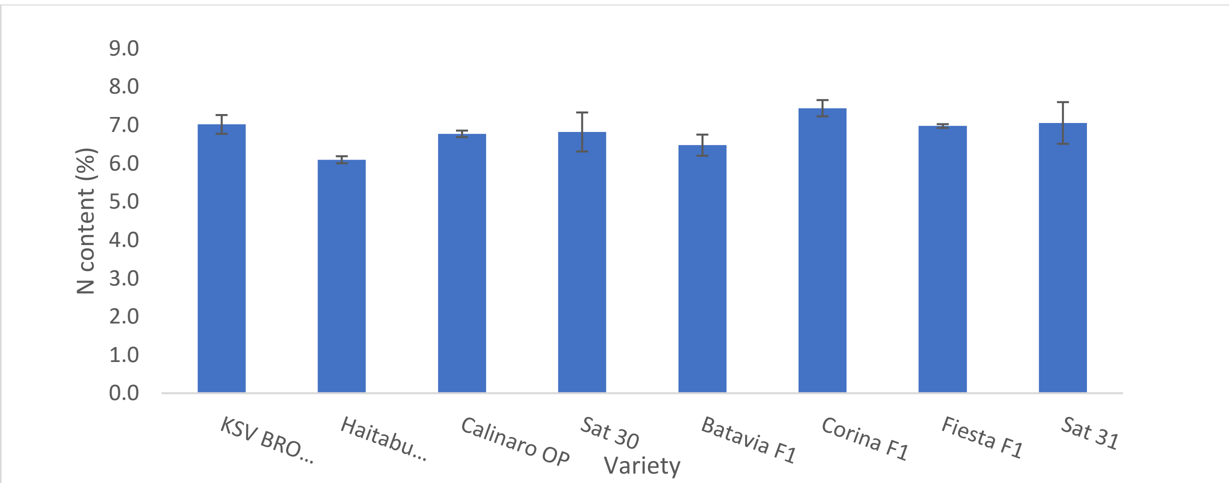


Figure 2. Total N content (%) of broccoli florets derived from different broccoli varieties

Exploring Brassica genetic resources - Brittany

INRA and RSP, Responsible Véronique Chable - Veronique.chable@inra.fr

Abstract

Breton farmers wished to evaluate accessions of landraces of Di Jesi and green cauliflowers and several forgotten types of cabbages. The first objective was to find a way to produce seeds from these accessions in Breton conditions. In 2016, some accessions of Di Jesi were isolated. Experimental methods for seed production failed in 2017 in Finistère but one accession has been multiplied in Ille et Vilaine. Other strategies were explored in 2018. Meanwhile, 65 accessions of cabbages were requested from French Genebank: autumn and winter types were collectively evaluated on farm in 2017 then, spring type evaluation and multiplication was tested in 2018.

Location(s)

- Di Jesi and green types of cauliflowers: in two Breton departments Ille et Vilaine (35) and Finistère (29), (1) at Ghislain Savigny's farm, Jardin Kermaron at Saint Erblon 35320 and (2) at Michel Rozec's farm at Cleder (29) and at PAIS (IBB) station at Lycée agricole de Suscinio, at Morlaix (29)
- Brussels sprouts at Ghislain Savigny's farm, Jardin Kermaron at Saint Erblon 35320 and at Jean-Martial Morel's farm, Ferme de Lesnelay, Chavagne 35310.
- Cabbage experiments at Jean-Martial Morel's farm, Ferme de Lesnelay, Chavagne 35310.

List of accessions (see supplementary material at the end of the chapter)

- Di Jesi and green types of cauliflowers from HRI genebanks UK
- Cabbage and Brussels sprouts from Centre de Ressources Génétiques *BrACySol* (CRBB), UMR INRA IGEPP, F-35653 Le Rheu, France

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	How it has been assessed	Type of data available
Beginning of production	date	Date of the first plant with a marketable product
Length of production		Nb of days
Crop productive performance (yield, yield components)		
Trait	How it has been assessed	Type of data available
Vigor of the plants	qualitative	score
% of yielded plants	quantitative	%
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		
Trait	How it has been assessed	Type of data available
Colour of curd	qualitative	description
Form of curd	qualitative	description
Bead size on the curd	qualitative	description

Trial background and evolution

The initiative came from Kaol kozh association, member of RSP, partner of DIVERSIFOOD, and collaborating with the PAIS (Plateforme agrobiologique d'IBB à Suscinio - IBB Initiative Bio Bretagne). We have started from cauliflowers for which the producers are quite autonomous now. The idea is to increase the cultivated diversity of Brassica trying new genetic resources (cabbages, Brussels sprouts) or also reconsiderind accessions for which we have failed several years ago.

Trial design and management

For each accession, few seeds are provided by the genebanks. It is not possible to plan experimental designs with replications. The first objective is to screen and select the most adapted accessions, then to amplify them in order to be able to initiate a true selection with a large number of plants.

Main results

We are in a very preliminary phase for which the objective is to detect the best accessions and to try to multiply them in Breton conditions.

Case of Jesi (3 successive strategies):

Selection in the field during a normal production period, then cuttings were produced from mother plants selected in the fields (the mother plants were transplanted and cuttings were grown in greenhouse). They had been separated into 2 pools (the early ones - 3220, 4826, 5347, 11765 - and the production core period - 4830, 5458, 5327).

Sowing in counter-season for spring flowering of the rest of seeds

As the two first strategies failed (the plants died before or during flowering) new request at HRI genebank has been done for 2018, one part for planting in the spring (flowering summer and seeds in autumn) at PAIS and the second part, the late maturing accessions, at Plouescat. Seed had been obtained in large quantity in the second group. Sowing had been performed in January 2019 for selection and new multiplications.

Purple cauliflowers case:

The counter-season sowing was performed for 4 accessions (Natalino-3421, Cavolfiore of sicilia violetto-5295, Gigante di Napoli-4824, Cavolfiore di sicilia violetto-), but sanitary problems prevented the seed production. In 2019, new trials will be launched for this type which interests a lot the farmers.

Verde di Macerata:

One accession will be multiplied again at the PAIS in 2019 since farmers experessed again their interest for this group.

Brussels sprouts:

At the Jardin de Kermarron (in 35), Ghislain Savigny succeeded to produce seeds one accession of Brussels sprouts which performs well in his garden. At the Farm of La lesnelay, no accessions presented an interest for selling: too small and too hard.

Cabbages:

This trial was very interesting for farmers because they discovered forgotten types. Two trials were organised in order to better observe the accessions because some were supposed to produce in winter and other in spring. Nevertheless, some plants were not observed because they were not cultivated in their normal period. At the end of this first year of observation, seven of the accessions (in bold in the table) were distributed in 3 farms for multiplication under isolated conditions.

Turnips :

Besides all activities already engaged, a new crop has been explored in 2018: forgotten local turnips, but they did not answer to the need of the farmers. As for many accessions, only seeds had been conserved; no information and know-how had been preserved where they had been collected on farm in the Western part on France in the years 1983-1985.

Discussion

These explorations of genetic resources for crops which had not previously adapted need several steps, starting with the evaluation of the potential quality of the product and health of the plants, and with the research of efficient strategies for seed multiplication to perform selection in the other hand. Di Jesi type, an untapped cauliflower type, only grown in Italy, is a very good example of adaptation of a new Brassica group in Brittany. The quality of the product and the crop health are quite satisfying, but seed production is not straightforward. Through trials and errors, farmers are looking for the best methodology to produce seeds in their conditions. In 2018, a good production was obtained, which allows starting a true programme of on farm plant breeding.

For cabbage, only 7 of 15 observed accessions during autumn and winter seasons will be multiplied in 2018. The farmers need to organise locally and collectively some isolated plots for multiplication. They need to plan the multiplication of all interesting accessions.

Conclusion and next steps

The farmers are organising themselves for all the steps: from the choice of the type of plants to be explored to the trials to adapt seed production.

Supplementary material

List of Di Jesi and green cauliflowers explored in 2015 and 2016

Type	Type of landrace	Accession identification (HRI Genebank UK)
CF Green	Verde di macerata	3011741
CF Green	Verde di macerata	03004848A
CF Green	Verde di macerata	3005364
Di Jesi	Di Jesi	3005458
Di Jesi	Precoce di jesi	3005347
Di Jesi	Precoce di jesi	3004826
Di Jesi	Di Jesi	3005363
Di Jesi	Precoce di jesi	3011765
Di Jesi	Precoce di jesi "speedy"	3011735
Di Jesi	Di Jesi	3004828
Di Jesi	Precoce di jesi	3004827
Di Jesi	Di Jesi precoce	3003220
Di Jesi	Di Jesi	3004830
Di Jesi	Di Jesi a pella liscia	3005327

List of violet broccoli and cauliflowers explored in 2015 and 2016

Type	Type of landrace	Accession identification (HRI Genebank UK)
Violet Broccoli	Purple cape	Bra 1432
Violet Broccoli	Cavolfiore di Sicilia Violetto	4005295
Violet Broccoli	Cavolfiore di Sicilia Violetto	4011736
Violet Broccoli	Cavolfiore di Sicilia Violetto	5431
Violet Broccoli	Gigante du Napoli	4824
Violet Broccoli	Purple cape broccoli	2932
Violet Broccoli/cauliflower	Rosalind	Bra 1856
Violet Broccoli/cauliflower	Natalino	3003421

List of Brussels sprouts explored in 2016

Brussels sprout	**BR FR62 0003**

Brussels sprout	BR FR62 0004
Brussels sprout	BR FR62 0005
Brussels sprout	BR FR62 0006

List of cabbage accessions evaluated in 2017 and 2018

		Score 1 to 5 (very good)	
accession	Name of the variety	Winter	Spring
PO FR00 0003	Cœur de Bœuf		3
PO FR00 0004	Cabus de noël		1
PO FR00 0005	Cabus express		4
PO FR00 0006	Marché de Copenhague	3	
PO FR00 0007	Nantais gros	3	
PO FR00 0008	Nantais hatif		4
PO FR00 0009	De chateaurenard		4
PO FR00 0010	Merveille	3	
PO FR00 0011	De Louviers		5
PO FR00 0012	Milan Aubervilliers	1	
PO FR00 0013	Milan de Pontoise	4	
PO FR00 0014	Milan Gros des Vertus	3	
PO FR00 0015	Milan Ostara		1
PO FR00 0016	Milan Roi d'hiver Original	1	
PO FR00 0017	Milan tardif de Langendyk	1	
PO FR00 0018	Milan très hâtif de la St Jean		3
PO FR00 0019	Hâtif de Langendyk		NO
PO FR00 0020	Tardif de Langendic	1	
PO FR00 0021	Tête de Nègre	1	
PO FR00 0022	Bacalan de Rennes		4
PO FR00 0023	Bacalan hâtif		4
PO FR00 0024	De Brunswick		NO
PO FR00 0025	De Vaugirard d'Hiver		1
PO FR00 0026	Quintal d'Alsace		1
PO FR00 0027	Marché de Copenhague		1
PO FR00 0028	Milan Aubervilliers		1
PO FR00 0032	Milan Gros des Vertus	1	
PO FR00 0033	Milan pointu d'hiver	4	
PO FR00 0034	Roi d'Hiver	3	
PO FR00 0035	Grosse cote C. Beurre	3	
PO FR00 0036	Milan de Pontoise race de Cergy Peltier	3	
PO FR00 0037	Milan Gros des Vertus Peltier	3	
PO FR00 0038	Bacalan de Rennes		3
PO FR00 0039	Bacalan de St Brieuc		4
PO FR00 0040	Cœur de Bœuf		NO
PO FR00 0041	Noël ardoisé	3	
PO FR00 0042	Précoce de Louviers	4	
PO FR00 0043	Milan de Pontoise	1	
PO FR00 0044	Bacalan de Rennes de Drageons		4
PO FR00 0045	Bacalan hâtif de Rennes		3

PO FR00 0046	De Vaugirard		1
PO FR00 0047	Nantais Gros	4	
PO FR00 0048	Nantais hâtif		1
PO FR00 0049	Nantais très hâtif de Drageons		4
PO FR00 0050	De chateaurenard		3
PO FR00 0052	Précoce de Louviers de Drageons		4
PO FR00 0053	Précoce de Tourlaville de Drageons		3
PO FR00 0054	Quintal d'Alsace	?	
PO FR00 0055	Frisé Vert Grand	4	
PO FR00 0056	Milan Aubervilliers		NO
PO FR00 0057	De la St Jean		3
PO FR00 0058	Milan de Pontoise	1	
PO FR00 0059	Des Vertus	3	
PO FR00 0060	Milan pointu d'hiver	3	
PO FR00 0061	Roi d'Hiver	3	
PO FR00 0062	Tête de Nègre	3	
PO FR00 0063	Bacalan de Rennes		4
PO FR00 0064	Bacalan hâtif de St Brieuc		5
PO FR00 0065		3	
PO FR00 0066		3	
	NO : non observed		

Example of trial implementation with the following accessions:

- Di jesi a pella liscia (5005327) 55 plants
- Verde dimacerata (011741) 27 plants
- Di Jesi (3004830) 70 plants
- Caliviore si sicilia violeto (005431) 76 plants
- Precose Di Jesi (4827) 28 plants
- Gigante Di Napoli (004824) 59 plants
- Precocissimo Di Jesi (5347) 46 plants
- Precoce Di Jesi – speedy- (011735) 43 plants
- Di Jesi (5363) 34 plants
- Verde Di macerata (5364) 36 plants
- Precoce Di Jesi (11765) 46 plants
- Caliviore di sicilia violeto (11736) 25 plants (no appearent violet plant)
- Precoce Di Jesi (4826) 38 plants
- Verde de Macerata (4848) doute étiquetages 10 plants
- Precoce Di Jesi (3220) 70 plants
- Di Jesi (5448) 67 plants
- Caliviore di sicilia violeto (5295) 62 plants
- Di Jesi (004828) 62 plants
- Purple Brocoli (2929) 50 plants environs
- Natalino (3421) 54 plants
- Rosalind (1856) 60 plants

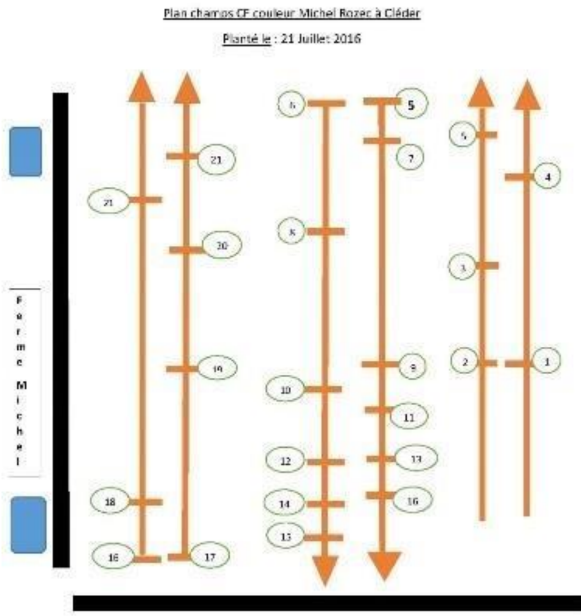
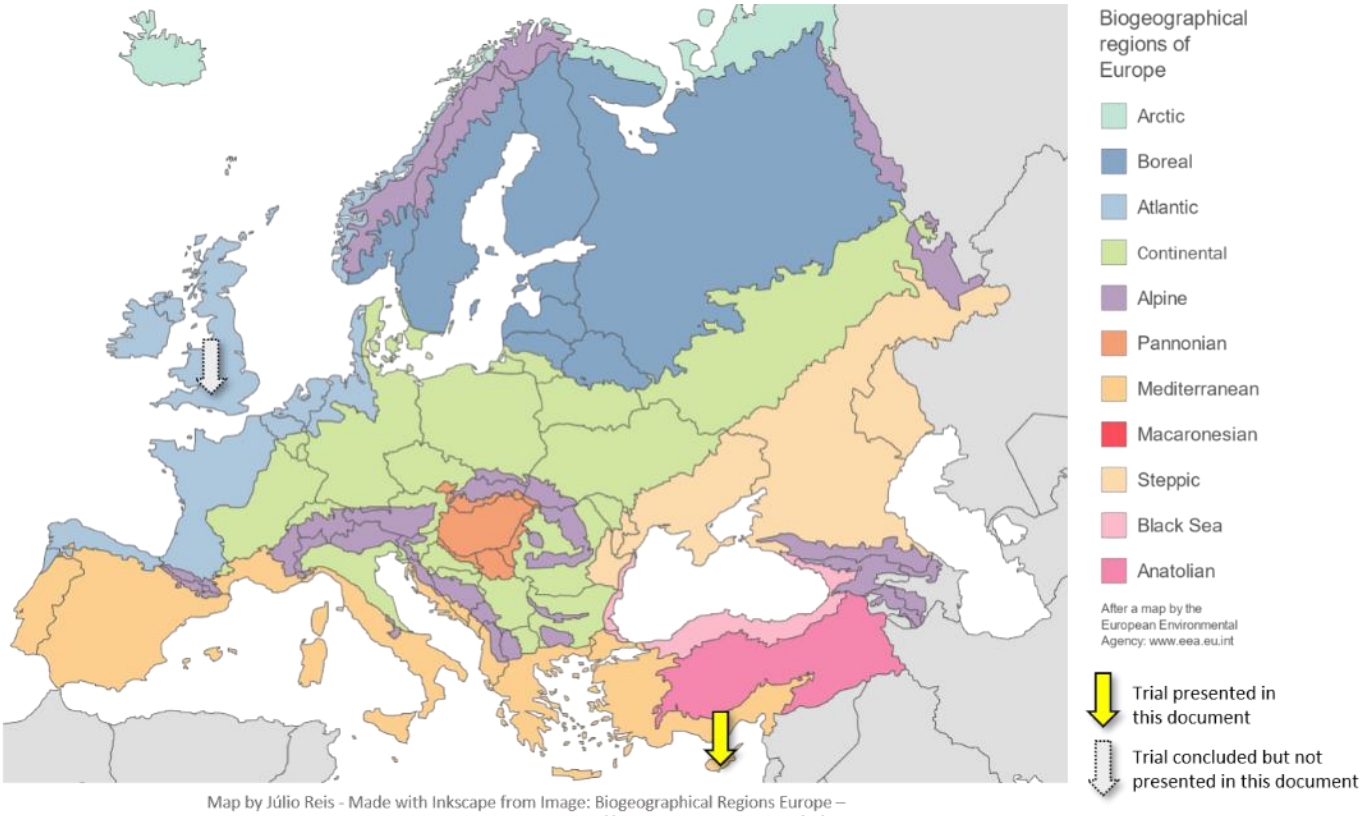


Fig. 1. Example of a field experimental plan

Fig. 2. Trials for Cabbage at Jean-Martial Morel’s farm and one example of untapped cabbage (Grosse Côte de Beurre)

Chickpeas

Cicer arietinum



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Chickpeas productivity and rhizosphere-related traits assessments in Cyprus

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Abstract

We evaluated 7 different chickpea genotypes received from the National Gene Bank of Agricultural Research Institute. The objective was to evaluate and assess the productivity of these genotypes and evolve them using rhizosphere related traits. In particular, we assessed the mycorrhizal colonization capacity of these genotypes as well as the volume of extraradical mycelium (ERM). Our findings show that the different genotypes exhibit variable biomass productivity and yields. Genotype had a significant effect on AMF colonization as well as ERM. We found a strong AMF dependence on some varieties and this was associated with P nutrition. Surprisingly we found that one genotype stimulated the formation of extensive ERM suggesting that the genotype could be more adaptive under abiotic stress conditions. This genotype was further examined during 2017 about its ability to extend the ERM under drought conditions but this was not confirmed. Totally, 13 genotypes selected during 2016-2017 trials were evaluated during 2017-2018 growing season. AMF colonization as well as nutrient content was evaluated and associated with plant traits like yield and biomass production. Our findings are similar with those found during 2016-2017 however selection process seems to affect AMF colonization. Fine-tune studies should follow to assess the environmental impact on AMF-chickpea interactions.

Location(s)

Zygi experimental station ARI, Cyprus

List of accessions

7 selections from National Gene Bank (2016-2017)

13 selections derived from the breeding process of 2016-2017 (2017-2018).

List of traits assessed

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Height	Field measurements	Quantitative (cm)
Crop productive performance (yield, yield components)		
Trait	**How it has been assessed**	**Type of data available**
Biomass production	Weight of above ground biomass measurement	Quantitative (g)
Microbiome performance (type of functional microbial guilds)		
Trait	**How it has been assessed**	**Type of data available**
AMF colonization	Light microscopy of stained maize root segments	Quantitative (%)
ERM	Light stereoscopy	Quantitative (cm/cm2)
Crop quality performance (organoleptic, processing, nutritional, nutraceutical, immaterial)		

Trait	How it has been assessed	Type of data available
N, P, K content	Elemental Analysis	Quantitative (% or ppm)
Ca, Mg, Fe, Mn, Cu, Zn	Elemental Analysis	Quantitative (% or ppm)

Trial background and evolution

The initiative was taken by ARI group and key decisions during the course of the trials have been taken after data analysis and inspection by interested farmers who visited the trials. Farmers visit was organized by ARI in collaboration with the Ministry of Agriculture and particularly with the extension service of the Department of Agriculture. Quantitative data are available.

Trial design and management

Drought experiment was implemented under a Complete Randomized Design. Two-way ANOVA and regression analysis was performed to evaluate the results. The relationship between microbiome related traits (AMF colonization) and plant performance was assessed using Pearson correlation matrices. During 2017-2018 a randomized complete design was implemented where two different genotypes were tested for their tolerance to drought. In detail, 2 different water levels were implemented and nutrient (N, P, K) levels, biomass production and AMF root colonization and ERM was assessed.

Main results

The main findings of this trial are the following:

- There is great variability between the different genotypes
- Genotype affects AMF colonization
- There is a general trend of increased biomass when AMF colonization is high in some genotypes.
- Drought tolerance is related to plant genotype and likely to AMF associations that are affecting nutrient uptake in plants under stress (Fig 8 and 9).
- AMF colonization genotype specific (Fig 2, 3, 4 and 7).
- Macro and micronutrient content is genotype depended (Table 1).

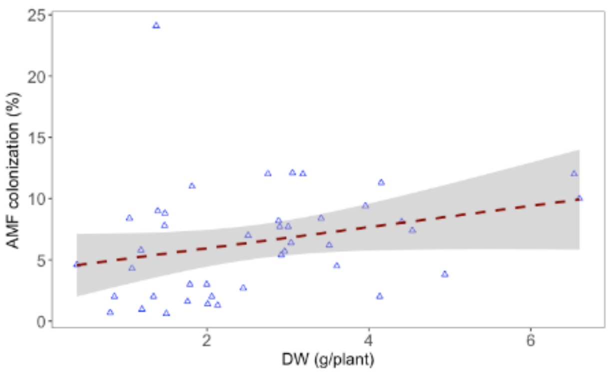


Figure 1. Linear Regression between chickpea biomass and AMF colonization in all genotypes

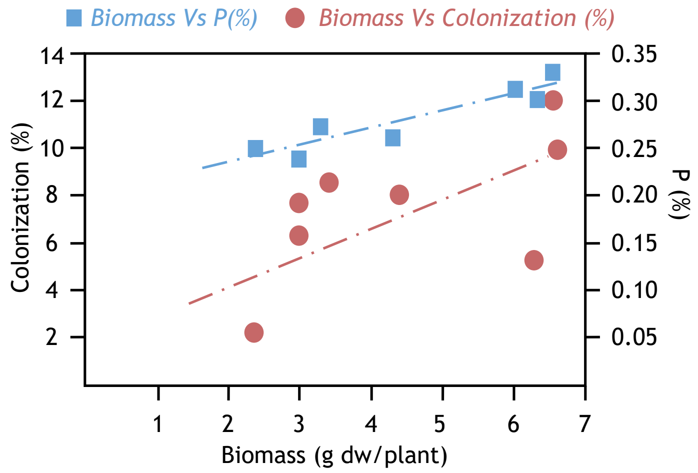


Figure 2. Relationships between biomass production (g dw/plant), AMF colonization and P content (%) in Genotype 1

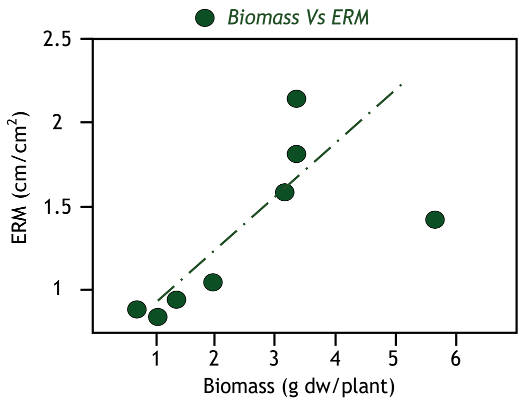


Figure 3. Relationship between biomass production (g dw/plant) and extraradical mycelium (cm/cm2) in genotype 2

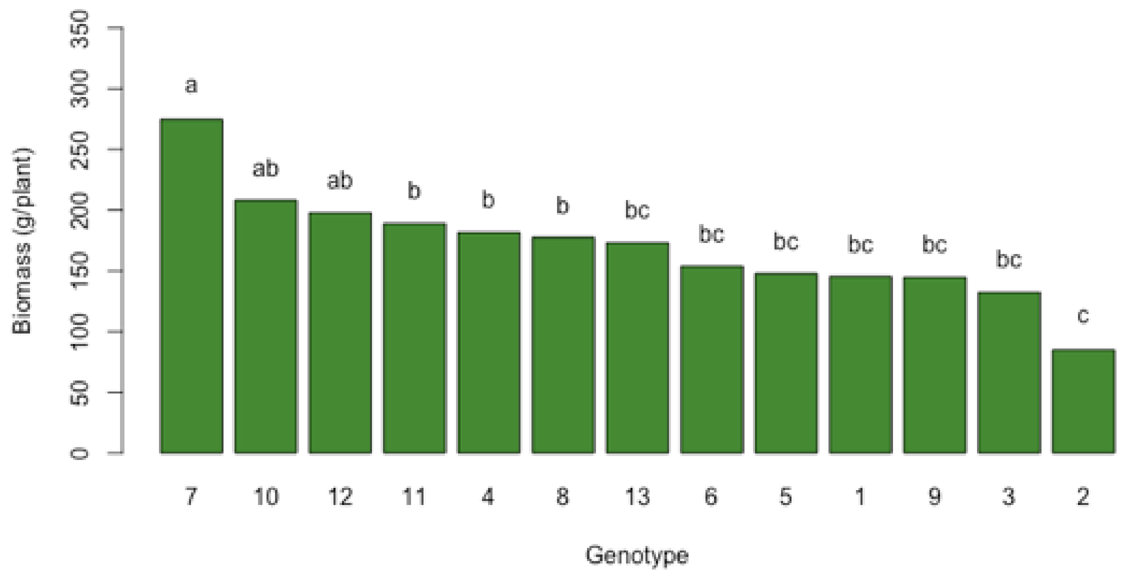


Figure 4. Above ground biomass of 13 different chickpea genotypes (g/plant in dw) (Growing period 2017-2018)

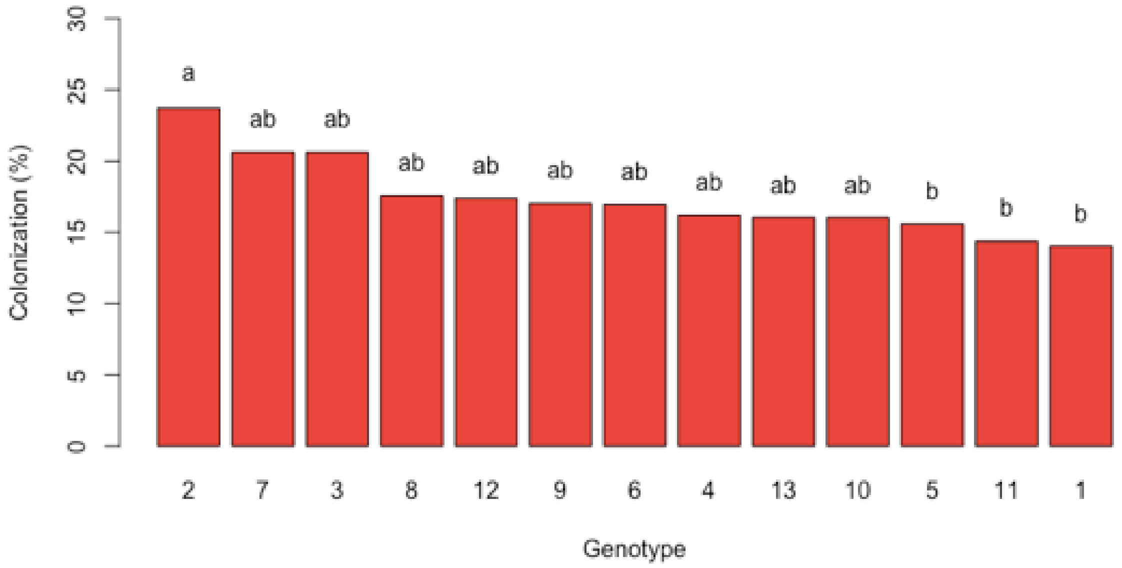


Figure 5. AMF colonization of 13 different chickpea genotypes (%) (Growing period 2017-2018)

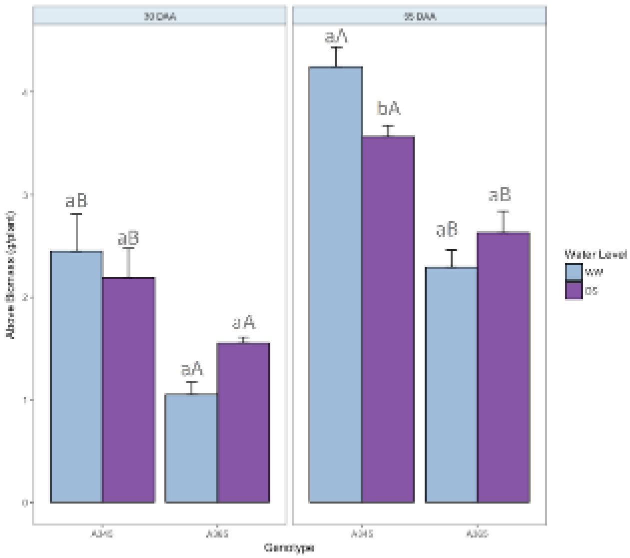


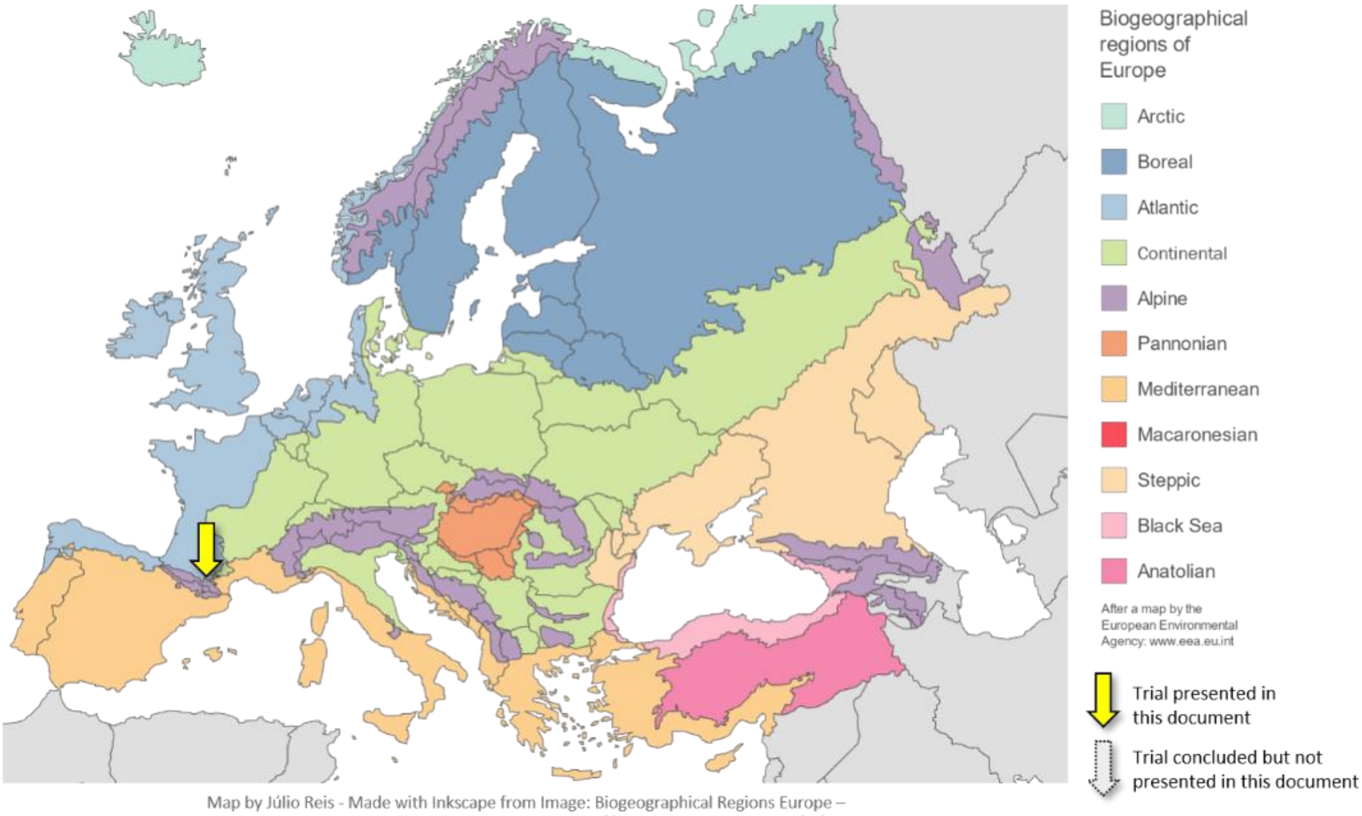
Figure 6. Above ground biomass in two different chickpea genotypes grown under drought stress conditions

Discussion

Overall, we found a significant positive correlation between biomass production, P plant content and AMF colonization while biomass production was positively associated with N, P and C content (Fig. 5). Genotype has a significant effect on AMF colonization as well as extraradical mycelium formation that is genotype specific (Fig 2, 3 and 4). However the latter was not confirmed in a recent experiment either under control or drought conditions indicating that plant as well as soil conditions control ERM formation. Our findings are indicating complex interactions between genotypes and functional mycorrhizal communities and functional traits like ERM should be further studied to reveal any associations with plant breeding important traits. Water deficit has a detrimental effect of AMF colonization as well as nutrient uptake of chickpea genotypes. The importance of AMF association with chickpea plants is reflected to a better response of A345 to drought.

Chestnut

Castanea sativa



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Characterisation and multiplication of local varieties in Ariège, France

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Abstract

The work on chestnut is done by Rénova, member of RSP in Ariège, south-west of France in collaboration with RSP. Since the last update, things evolved in response to peasants' needs as well as difficulties in the setting of some experiments. The experiment take place into a more wide scope which is chestnut chain in Ariège from production to the market.

Three experiments are carried out within the Project:

- characterisation of local varieties regarding phenologic aspects and pest resistance
- multiplication of local varieties in different conditions through graft
- evaluation of fruit consumption regarding processing and organoleptic quality.

Location(s)

Ariège, south-west France

List of accessions

Crop species	List of accessions
Castanea sativa	Pato de Llop
Castanea sativa	Bazis 2
Castanea sativa	Bazis 3
Castanea sativa	Bazis 5
Castanea sativa	Fine de Montfa
Castanea sativa	Latrappe 3
Castanea sativa	Castéranne
Castanea sativa	Mandrats 2
Castanea sativa	Mandrats 4
Castanea sativa	Mandrats 6
Castanea sativa	Noire Paulo

List of traits assessed

Fifty trees are observed. Two varieties (Pato de Llop and ine de Montfa) are present several times (i.e. several trees) and act as a control. The trees are in the forest in chestnut area. The objective is to describe and to graft them in order to disseminate interesting trees. All phases of the project are discussed with farmers and researchers when they are present. It is a farmer led project and researchers are not highly involved.

Crop development and agro-ecological performance (phenology, weeds, diseases, …)		
Trait	**How it has been assessed**	**Type of data available**
Budburst	note date for each tree. The measures are done within three weeks in april/may.	Categories are: very early, early, middle, late, very late

Flowering	note female and male flowering date. Measures are done within june/july	
Fruit-forming	note date when fruit fall on the ground. Measures are done in end september/october.	Categories are : early, middle, late, very late.
Chestnut gall wasp (*Dryocosmus kuriphilus*) sensitivity		Categories are : not sensitive, middle sensitive, sensitive, very sensitive.

2. multiplication of local varieties in different conditions through graft

Two kind of graft are done: graft on reject tree and graft from sowing:

- Autumn 2016: harvest 4000 chestnut fruit on 29 trees and are stored.
- January 2016: sowing in high density in little square
  - 60 square sown in chestnut forest area
  - 60 « twin » square sown in a dedicated tree nursery.
- January 2017: selection of the best performing tree in the tree nursery and transplantation in the « twin » square in the forest. Selection of the best performing tree in the forest. The two trees are put side by side in the square in the forest.
- 2018: evaluate differences between the two trees coming from two selection process (nurserie or in situ). The best one will be grafted.

3. evaluation of fruit consumption regarding processing and organoleptic quality

Four tests are performed:

1. variety tests: sanitary aspect after harvest calibre, peeling, organoleptic quality, cooking behaviour.
2. process tests: harvest technics, cleaning, storing.
3. nutritional tests (end 2017)
4. cooking tests (end 2017) in collaboration with local artisans

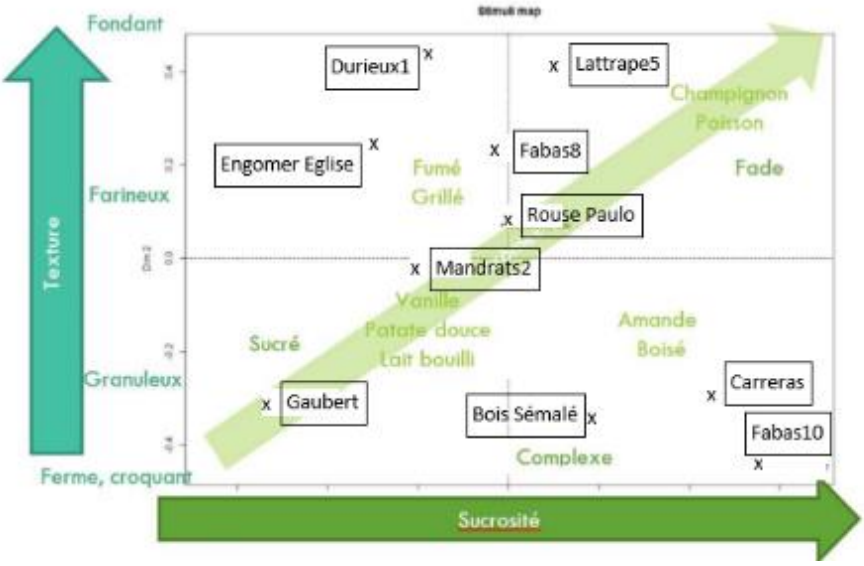
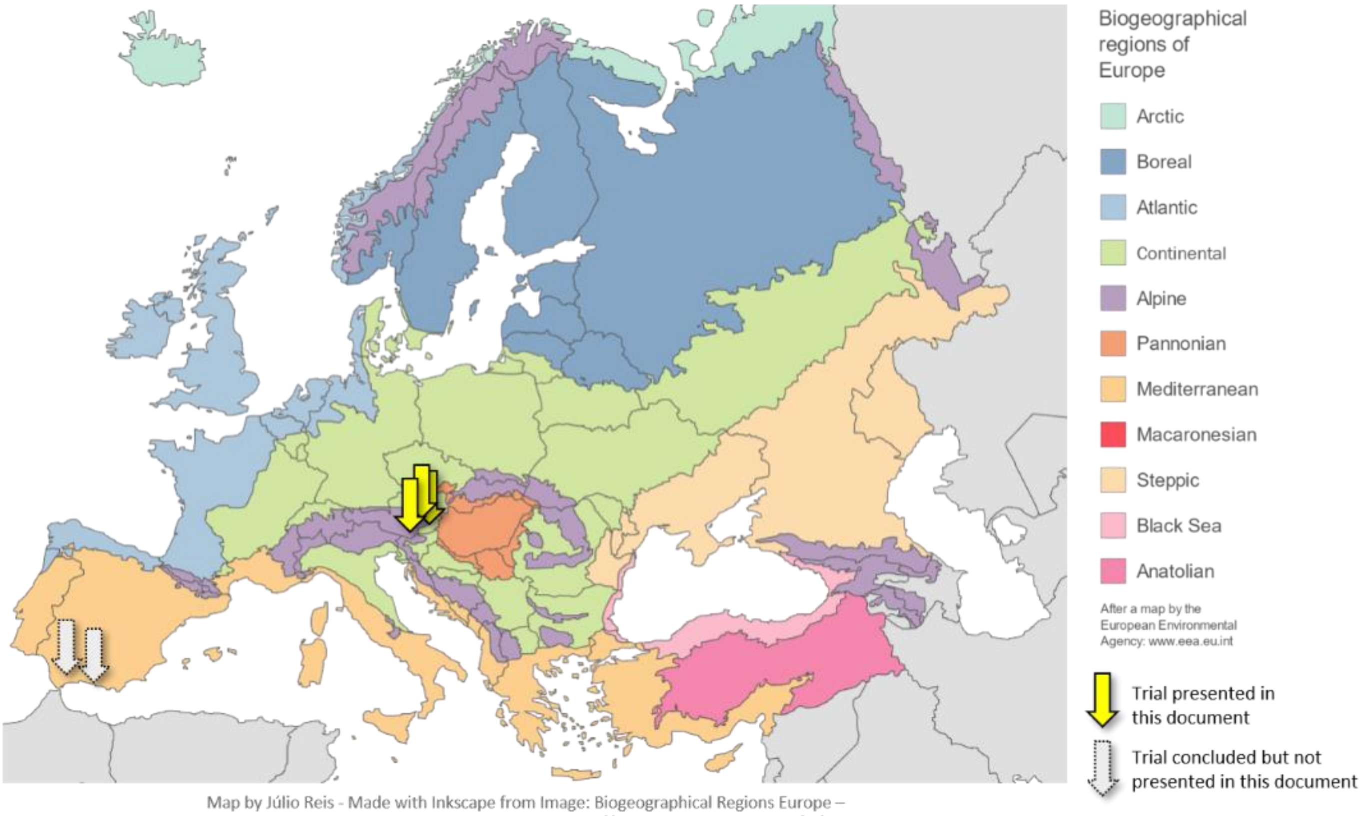


Fig. 1. Results of organoleptic quality of ten chestnut accessions.

Tomato

Lycopersicon esculentum



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Screening tomatoes for partial leaf mould resistance

ARCHE NOAH – Austria. Philipp Lammer – philipp.lammer@arche-noah.at

Abstract

Together with the "Bauernparadeiser" working group (a participatory tomato breeding initiative) Arche Noah is looking for open-pollinated varieties with partial resistance to leaf mould (Passalora fulva, syn. Cladosporium fulvum).

In very dens collaboration with farmers we conducted on-farm screenings in 2016 and 2017. These results have been used to design an in-depth trial with 20 varieties on three locations in 2018. The main objective is to identify promising resistant cultivars for further breeding work.

Rationale

In Austria tomatoes are mostly grown in protected cultivation systems. The production is dominated by intensive glasshouses, oriented towards high yields and highly dependent on energy and technology. However, especially in the organic sector many farmers rather prefer low-input seasonal production in polytunnels. But without intensive heating some fungal pathogens causes more severe problems. The most devastating threat to yield stability is leaf mould (*Passalora fulva*, syn. *Cladosporium fulvum*).

In the past this pathogen was successfully controlled with monogenic resistances (hypersensitive response). But during the past few years new races emerged in central Europe that are virulent on almost all available hybrid and open-pollinated varieties. While most breeding work was focused on monogenic resistances very little attention was given to partial leaf mould resistance.

Together with the working group "Bauernparadeiser" (a participatory tomato breeding initiative) Arche Noah is looking for open-pollinated varieties with partial resistance to Cladosporium fulvum. We've already shown that there are detectable differences in the resistance level. Now we conduct broader screenings to identify promising cultivars for further breeding work.

Location(s)

2016 and 2017:

- Kainbach bei Graz (Styria, organic farm 'Jaklhof')
- Wies (Styria, research station 'Versuchsstation für Spezialkulturen Wies')

2018:

- Kainbach bei Graz (Styria, organic farm 'Jaklhof')
- Nitscha (Styria, organic farm 'Biohof Scharler')
- Ruprechtshofen (Lower Austria, research station 'Zinsenhof')

Climate

The locations in Styria (especially Kainbach and Nitscha) are characterised by Illyrian climate with high temperatures and relatively high rainfall during the growing season. Frequent thunderstorms cause particular high air humidity that provides ideal growing conditions for leaf mould (*Passalora fulva*, syn. *Cladosporium fulvum*).

In Ruprechtshofen temperatures in summer are more moderate as well as rainfall and humidity. There is a noticeably influence by the Alps. Compared to Styria, the fungal disease pressure in this region is much lower.

Trial design and management

The plants were grown integrated in the usual organic production. For the trials a block in the middle of the polytunnel was chosen to minimize boundary effects. We used plots of 4 or 5 plants and 2 replicates in a randomized complete block design.

Main variables assessed

Trait	How it has been assessed	Type of data available
Partial leaf mould resistance	Visual scoring	Quantitative

Main results

The screenings 2016 and 2017 have shown that there are relevant differences in partial leaf mould resistance, as you can see in the following plots. (The y axis shows leaf mould infestation, shown as an index value). The red line shows the median of the susceptible standard variety ('Striped Roman') and the blue line shows the median of the resistant standard variety ('De Berao Braun'). The yellow line is the middle between the both lines, just for better orientation.

In the trials in 2018 again significant differences in the resistance level against leaf mould have been found. Especially the varieties 'Resi'; 'Ruthje', 'Zuchtlinie Culinaris' and 'Glossy Rose Blue' showed a highly efficient resistance against leaf mould on all sites.

Discussion and Conclusion

The trials again confirmed that there are significant differences in the level of partial resistance against leaf mould. Further, several resistant varieties could be determined that could be used as sources of resistance in future participatory breeding programs.

However, in the next year further trials on different locations are necessary to find out if the potentially resistant varieties show efficient resistance to all common pathotypes in Central Europe. For example on the location Jaklhof first symptoms on 'Ruthje' have been observed in 2018, while the variety was completely resistant in the years before. Similar observations have been reported from other regions (e.g. in the north and south-west of Germany).

However, beside 'Ruthje' there are two other resistances from different backgrounds that seems to be true alternatives that has not yet been used extensively in breeding. On the one hand, this is the resistance from the varieties 'Resi' and 'Zuchtlinie Culinaris'. On the other hand, 'Glossy Rose Blue' shows partial but sufficient resistance. Therefore, our further participatory breeding work will focus on these resistances.