DIVERSify: Designing InnoVative plant teams for Ecosystem Resilience and agricultural Sustainability

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Partner logos here?

History of Changes		
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0.2	9-3-2021	Initial draft complete
0.3	14-3-2021	Reviewed version by Alison Karley
0.4	17-3-2021	Evaluation section added
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1.0	30-03-2021	Final version

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Executive Summary

The main objective of WP5 is to set-up an open data e-infrastructure for collecting, summarising and publishing the 'plant teams' trial data produced in the project (in WP4 and WP2), as well as from external sources. The DIVERSify decision aid, named 'CropMIXER' and available at http://cropmixer.source.gr/, was designed as a web-based tool for exploring the datasets produced and collated by the project. The tool is aimed primarily at agricultural advisors, providing a means of searching agronomic information in intercropping trial datasets to support decisions about plant team choice and management in different cropping systems and regions of Europe.

For the development of the Decision Aid, two main activities proceeded in parallel: firstly, the collection and alignment of datasets; and, secondly, the development of the tool itself, proceeding in iterative cycles of design, development and evaluation. Project partners Agroknow and L&F SEGES have worked closely to define the optimal set of input, output and metadata parameters that have been included in the final version of CropMIXER, with the support and feedback of the rest of the consortium.

This report explains the iterative methodology used for the development of the tool, the design requirements, how the design was implemented, and presents the interface and functionality of the final version of the tool. It also describes workshops and evaluation activities with agronomists and farmers who tested the tool.

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1. Introduction

The main objective of WP5 is to set-up an open data e-infrastructure for collecting, summarising and publishing the data produced in field trials in the DIVERSify project (WP4, WP2), as well as from external sources, that can be used further in developing a decision aid tool for agronomists and other agricultural advisors.

The decision aid, originally termed 'PlanDS: Plants Decision System', was envisaged as a tool allowing agricultural advisors (in conventional, organic and integrated systems) to explore the plant teams datasets produced and collated by the project, enabling them to make informed decisions about optimal plant team selection and management in different cropping systems and regions of Europe.

For the development of the Decision Aid, two main activities proceeded in parallel. Firstly, the datasets were sourced, collected and aligned in a common data/metadata template (D5.1 Report on standards and protocols for plant trait and agronomic data collection). Secondly, the tool was developed in iterative cycles of design, development and evaluation. A first (mock-up) implementation of the decision aid was delivered in month 26, based on a preliminary set of expected inputs and outputs, and shared internally within the consortium for validation and refinement. Agroknow and L&F SEGES have worked closely to define the optimal set of input, output and metadata parameters that have been included in the final version of the tool.

The name of the tool has also been extensively discussed within the consortium, evaluating different concepts and ideas, leading to changing the name to CropMIXER. The decision on the name was combined with a discussion about its logo and branding. The new name of the tool will be used in the remainder of the document.

This report outlines i) the iterative methodology used for the development, ii) the history of the design, showcasing the main requirements and different instances of the design efforts, iii) implementation aspects, iv) the interface and functionality of the final version of the tool, and v) user feedback and future outlook.

2. Interface design methodology

Following a user-centered, iterative design methodology, Agroknow in collaboration with SEGES created a series of designs for the prototype of the Decision Aid CropMIXER. These designs have been reviewed and validated internally, firstly by L&F SEGES, and then by members of the consortium. **Figure 2** to **Figure 3** present representative examples of the early designs and interactive prototypes of the tool, used to stimulate discussion and refinement of the tool functionality.

During this process the issue of responsive design of the tool for mobile devices has been discussed to fully understand the relevant user needs. As a result, Agroknow and SEGES opted for a design that favours presentation of the content in larger screens, PCs and laptops, as well as tablets, instead of

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mobile phones. This design is in-line with the main objective of the tool, to support strategic planning in advance of crop planting rather than decision making directly in the field.

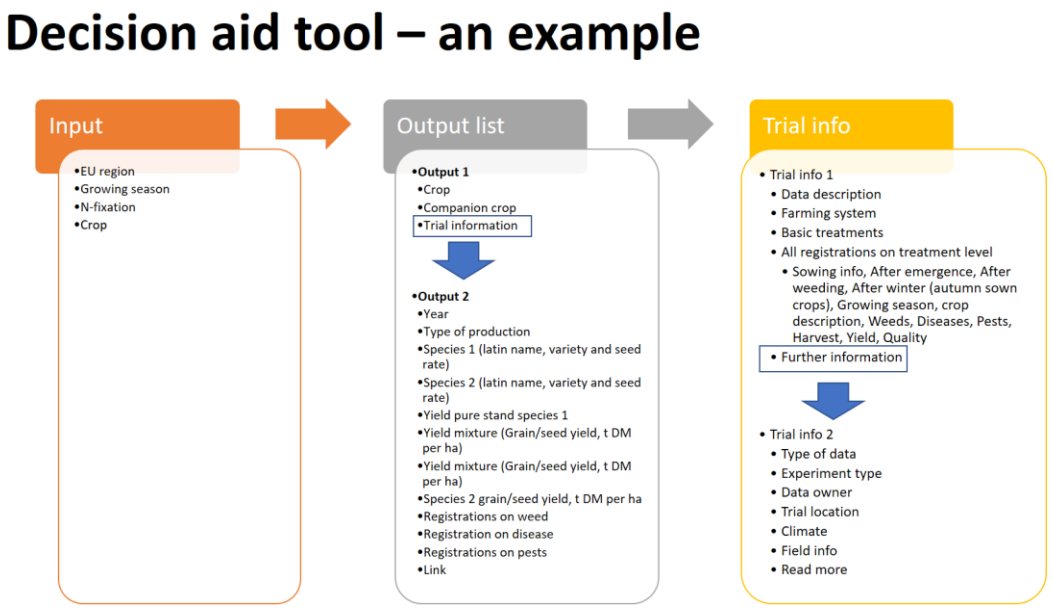

Figure 1 An early Decision Aid illustration, created to showcase the tool functionality

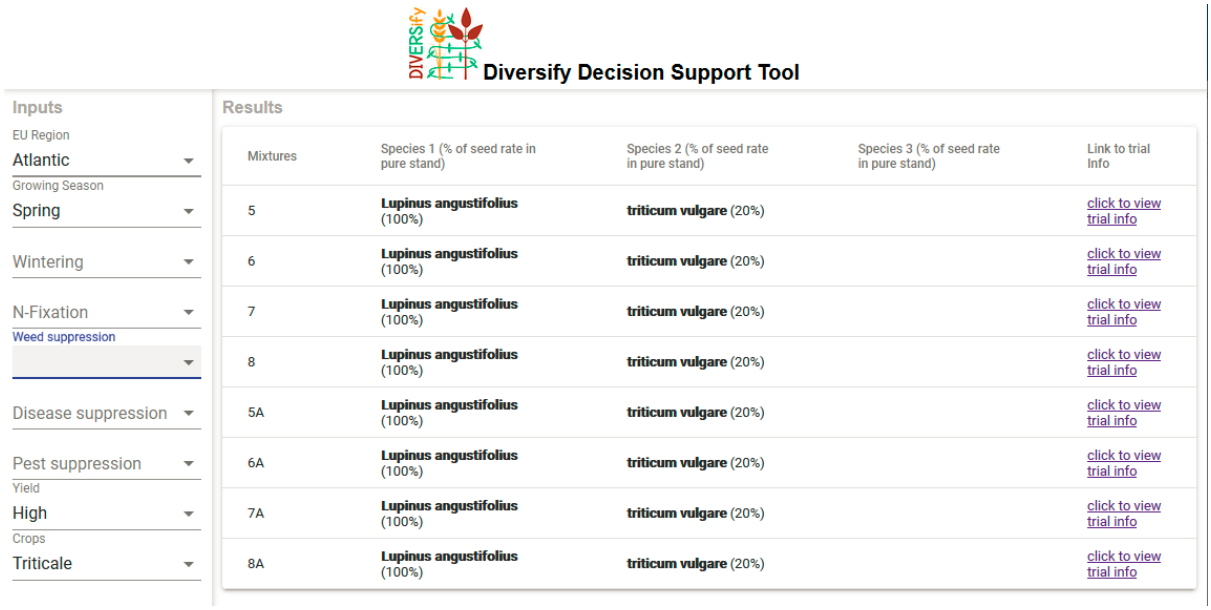

Figure 2 First version of the Decision aid interactive prototypes, delivered in month 26

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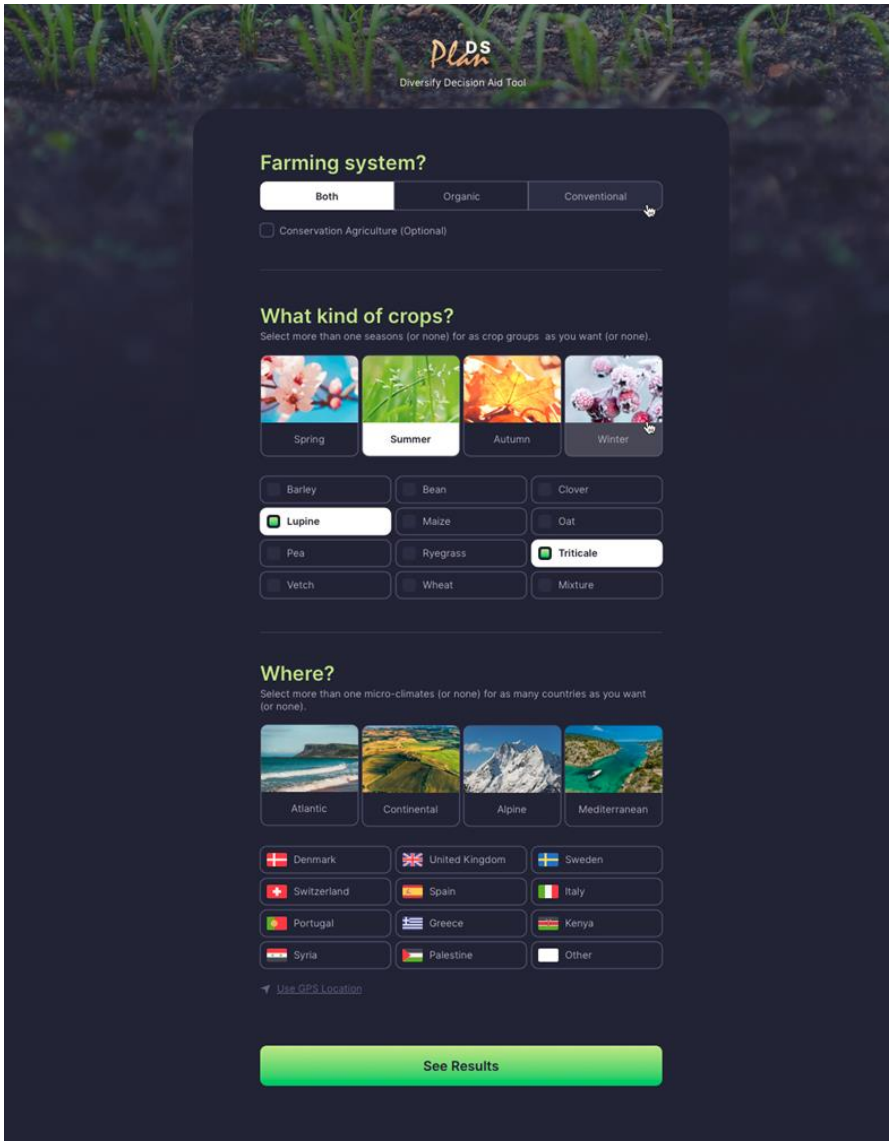

Figure 3 First version of the Decision Aid design

Following several iterations where the prototype designs were presented for review and then improved, they were finalized by month 44 with the development of the initial release planned to be completed and tested by month 46.

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3. CropMIXER interface and main requirements

As already mentioned, the design and development of the CropMIXER tool proceeded with a series of design prototypes, focusing in each case, on the data exploration functionality itself[1] (**Figure 2**) or on the user experience design of the tool (**Figure 3, Figure 3**). The prototype design of the tool presented in this section has also been the basis for the final implementation of the tool. **Figures 4 – 7** present representative screenshots of this design. For the creation of this final prototype design the inVision[2] tool was used.

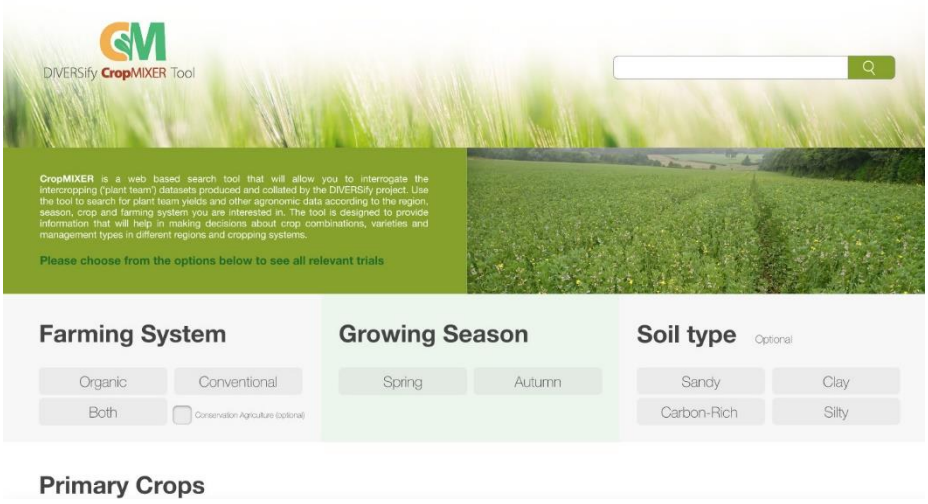

Figure 4 Decision Aid CropMIXER final design – main page.

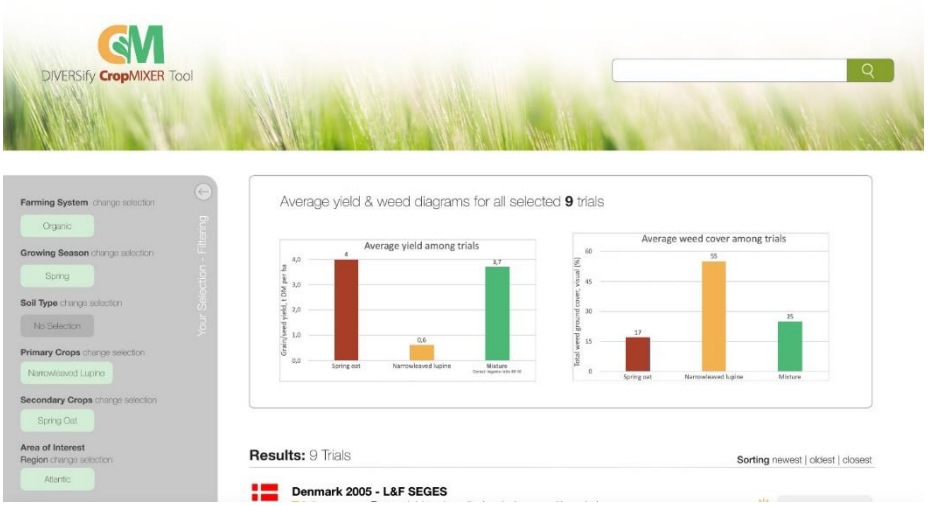

Figure 5 The Decision Aid CropMIXER final design – example search result screen

[1] First interactive design of the Decision Aid http://data.diversify.agroknow.com/decision-aid.html

[2] InVision | Digital product design, workflow & collaborationhttps://www.invisionapp.com

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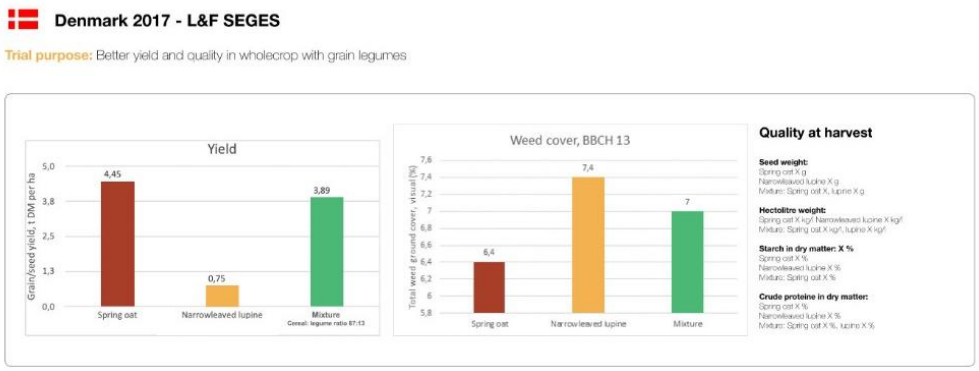

Figure 6 Decision Aid CropMIXER final design – example of trial details with summary diagrams.

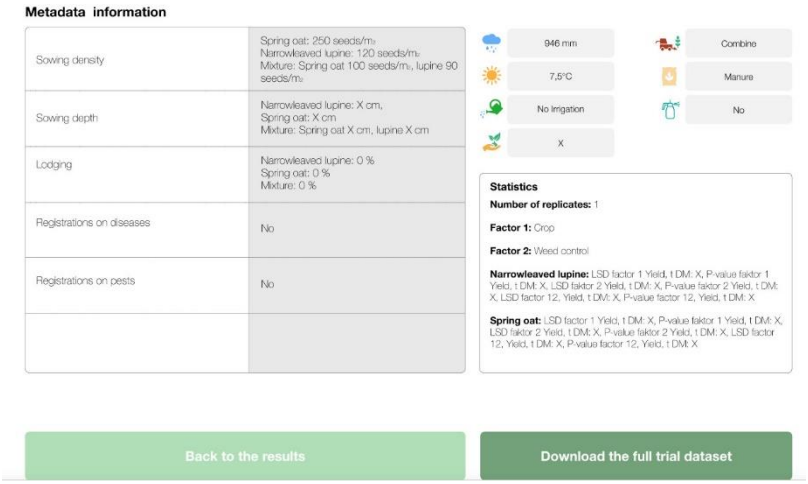

Figure 7 Decision Aid CropMIXER final design – example of trial details with metadata information.

The prototype design has been reviewed and corrected through a series of formative evaluation sessions with L&F SEGES and the whole consortium. This process led to updated prototypes and the final implementation of the tool, presented in the following section.

4. Implementation

The initial formative assessment of the tool led to adjustments to the functionality foreseen in the prototype design (presented in the previous section) and to substantial updates of the tool interface and its offered functionality.

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4.1. Technologies used

The DIVERSify CropMIXER tool is a web-based tool, developed on responsive frameworks for supporting ubiquitous access from laptop/PC or tablet devices. Its front-end is built in Javascript with a back-end built on PHP.

The tool front-end is developed as a Single Point Application (SPA), in javascript and the Svelte framework[3]. Svelte offers a new approach to building user interfaces, in comparison to traditional frameworks, shifting work that was previously done in the browser to the compile step. It is especially fitting for rr users with slower internet connections.

The CropMIXER back-end is built in PHP with a MySQL[4] database. MySQL is an open-source widely used database management system that facilitates effective and scalable management of the data through a stable and reliable connection to the application. The back-end communicates with the tool front-end through an appropriate API.

As the trial information datasets have been created in table format in Microsoft Excel sheets, there was a need to facilitate the import of the datasets to the back-end database. To this end, a migration system was developed in nodejs. This system is responsible for transforming and importing the datasets to the CropMIXER database.

4.2. Processing the database

For the development of CropMIXER, the collection and alignment of data was crucial. In the context of the data collection activities, project partners were contacted to complete the common data template with trial data from their institutions, with all appropriate support for any licensing queries. Additionally, some partners offered data sources from outside the DIVERSify project.

The datasets produced within the DIVERSify project and made available to the CropMIXER database comprise a total data volume of ~10-20 MB. The database was built initially from pre-existing trial data sources provided by the project partners, where the main contribution was Danish trials datasets from L&F SEGES over the period 1992 to 2015; smaller pre-existing trial datasets were also made available from partners in France, Austria and Scotland. This database has been expanded with trial data generated in the DIVERSify project, primarily from large-scale field trials conducted by partners and participatory farmers in WP4, and subsequently from small-scale plot trials conducted in WP2. Individual datasets range in size from 20-200 KB (WP4) and 1-5 MB (WP2); variables in these datasets suitable for use in the decision aid were summarised and the summary values (and accompanying meta-data) were transferred into the WP5 CropMIXER database template. The plant teams datasets included in the database originate from trials conducted in countries of Northern Europe (Denmark,

[3]https://svelte.dev

[4]https://www.mysql.com/

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UK, Sweden), continental Europe (Germany, Austria, Switzerland) and the Mediterranean region (Spain, Portugal, Italy, Lebanon, Morocco).

To make this dataset available for exploration through the CropMIXER tool, L&F SEGES first screened the datasets to standardise formatting and harmonise partner-specific differences when filling in the template to bring the dataset into a format suitable for import into the CropMIXER back-end database.

5. Final design

The CropMIXER tool, available at http://cropmixer.source.gr/, is designed for use by agronomists and other agricultural advisors to aid decision making about crop combinations when growing plant teams. It offers users the possibility to explore, in an intuitive manner, a rich database of datasets of plant teams trials produced and collated during the project **(Figure 8**).

Figure 8 Introduction to the CropMIXER tool

At the CropMIXER front page, the tool offers the option of selecting different trial characteristics to filter the database for relevant trials. The user selects the crop end use (grain or biomass) and the primary crop of interest (grouped into legumes and non-legumes), and also has the option of selecting the secondary crop. The most basic search returns a trial list for either grain yield or biomass yield of the selected crop(s). Other search settings can be selected at the front page or by filtering the list of trials returned by the initial search (**Figure *9*9, Figure *10*10, Figure 11**), and include any of the following options:

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- Farming system (organic, conventional, with the additional option of conservation agriculture)
- Growing season (Spring or Autumn sown crops)
- Soil type (sandy, clay, carbon rich or silty)
- Primary crop (grouped into legumes and non-legumes)
- Secondary crops (varies according to the primary crop selection)
- Region – Climate behaviour (Atlantic, Continental, Alpine, Mediterranean)
- Country

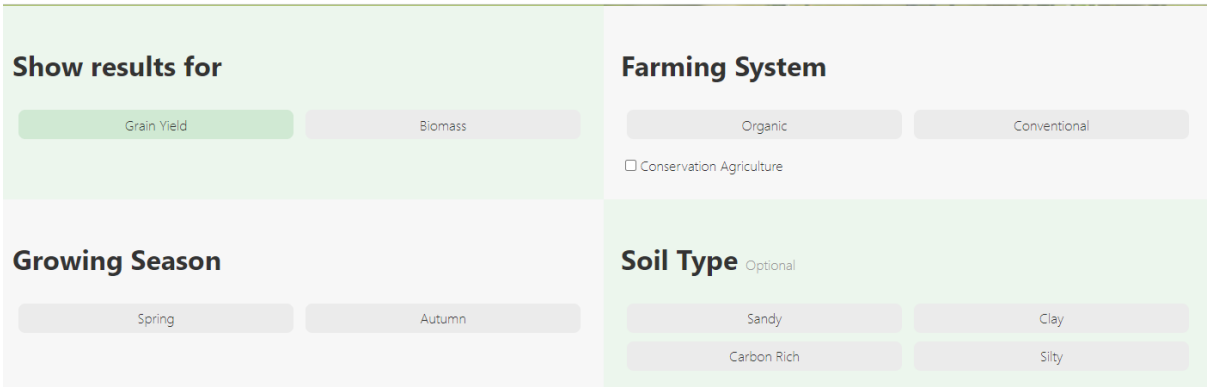

Figure 9 Selecting between grain yield and biomass results, and defining farming system, growing season and soil type, in the first page of the tool.

The crop selection options are shown in **Figure *10*10**. The primary crops are grouped, using tabs, as legumes and non-legumes. The user can either choose the relevant tab and select a crop of interest or they can view all available crops in the "All" tab and select from the complete list of available crops.

Depending on the primary crop selected, the user may see the available secondary crops that can be selected to explore relevant trials.

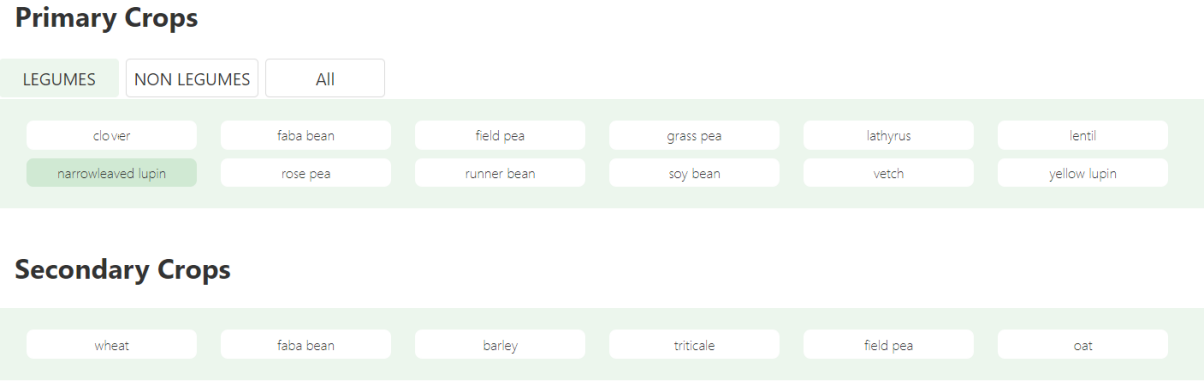

Figure 10 Selecting primary and secondary crop – a representative example using narrowleaved lupin.

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As last step (**Figure 11**), the user can constrain the search to specific geographic areas of interest, including a general pedoclimatic region and specific countries where trial datasets are available for that region.

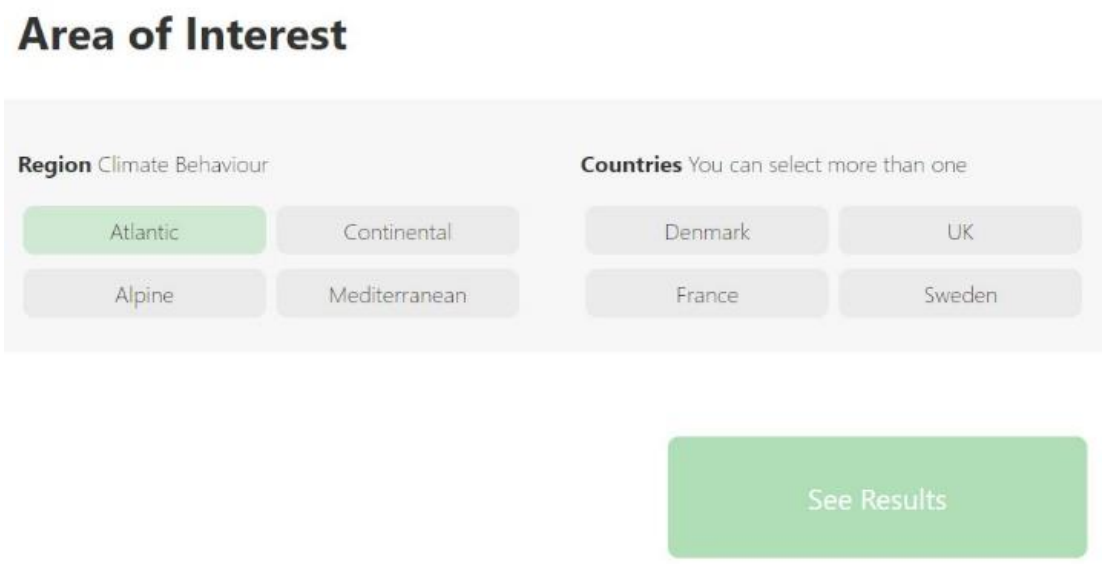

Figure 11 Selecting area of interest – representative example of the available countries of interest.

By selecting the button "See Results" the user may access the search results page (**Figure 12**). The list presents an overview of the trials that are relevant to the selected search parameters.

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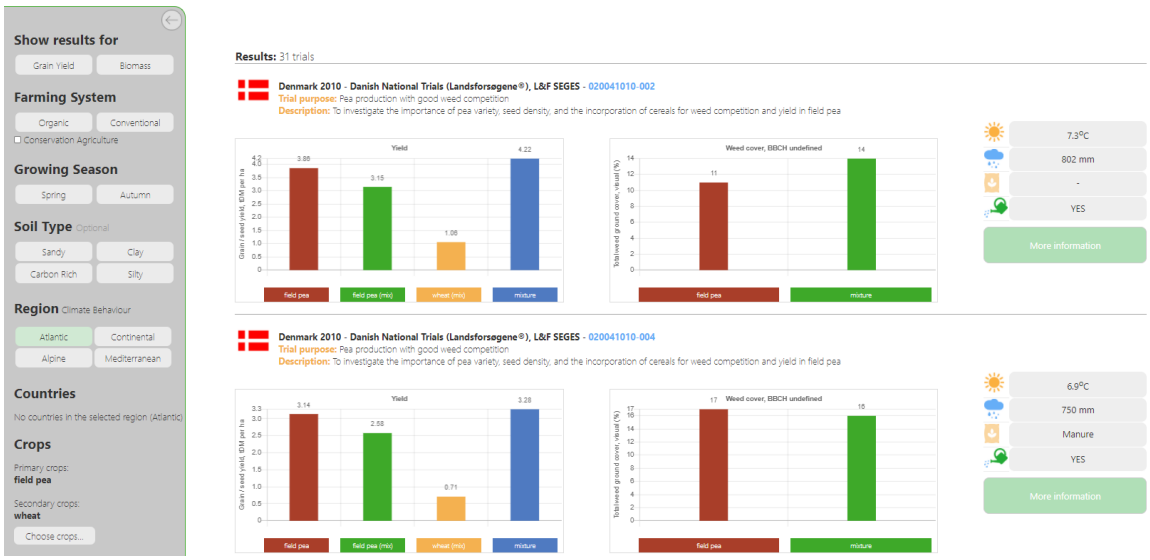

Figure 12 The CropMIXER results list page – a representative example for a search for trials that include field pea and wheat. The selection criteria are shown on the left side.

By clicking the button "More information" on the right side of each trial summary, the user can access details of individual trials, for instance the variety names of the crops, meteorological information and soil properties (**Figure 13** and **Figure 14**). This page provides a more detailed overview of the trial, with its general information and a list of treatments and trial meta-data.

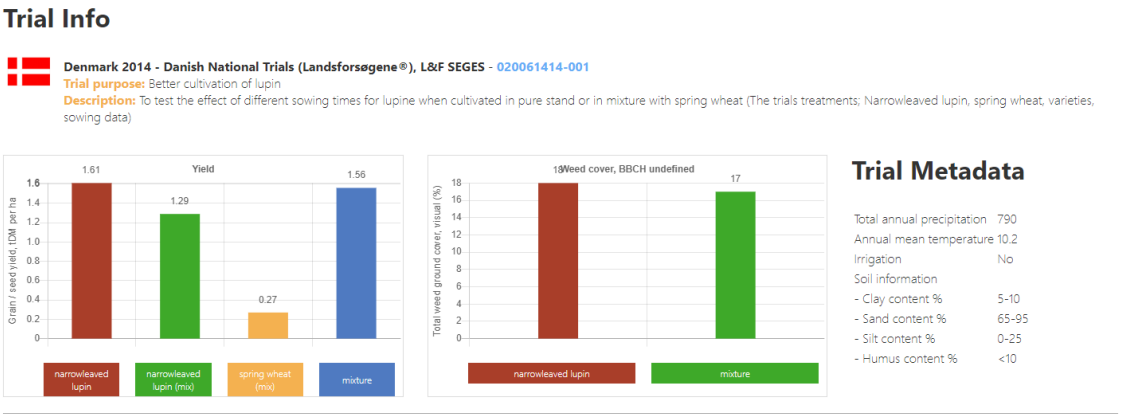

Figure 13 The CropMIXER trial details page – a representative example of meta-data information for an individual trial.

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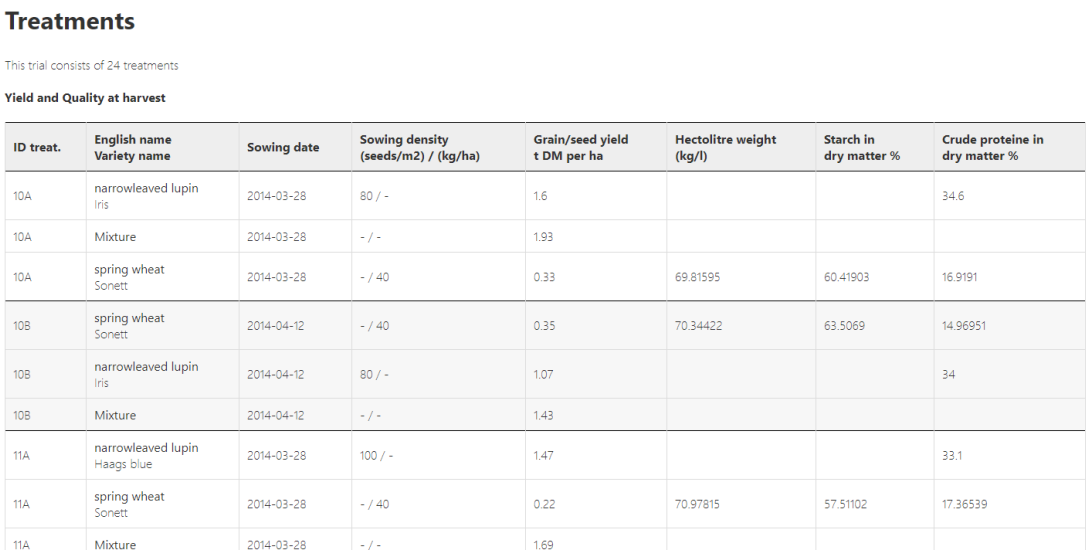

Treatments

This trial consists of 24 treatments

Yield and Quality at harvest

ID treat.	English name Variety name	Sowing date	Sowing density (seeds/m2) / (kg/ha)	Grain/seed yield t DM per ha	Hectolitre weight (kg/l)	Starch in dry matter %	Crude proteine in dry matter %
10A	narrowleaved lupin Iris	2014-03-28	80 / -	1.6			34.6
10A	Mixture	2014-03-28	- / -	1.93			
10A	spring wheat Sonett	2014-03-28	- / 40	0.33	69.81595	60.41903	16.9191
10B	spring wheat Sonett	2014-04-12	- / 40	0.35	70.34422	63.5069	14.96951
10B	narrowleaved lupin Iris	2014-04-12	80 / -	1.07			34
10B	Mixture	2014-04-12	- / -	1.43			
11A	narrowleaved lupin Haags blue	2014-03-28	100 / -	1.47			33.1
11A	spring wheat Sonett	2014-03-28	- / 40	0.22	70.97815	57.51102	17.36539
11A	Mixture	2014-03-28	- / -	1.69			

Figure 14 The CropMIXER trial details page – a representative example of more detailed information about treatments used in an individual trial.

6. Evaluation activities

The CropMIXER tool was evaluated using two approaches: i) practical workshops where the tool was presented and explained to users, who then spent time exploring the tool functionality and provided verbal feedback afterwards; and ii) feedback surveys completed by workshop participants at the end of the workshop.

6.1. Decision Aid workshops

Feedback workshops for Decision Aid testing were held as follows:

- 20th October 2020 and 25th March 2021 for partners in DIVERSify
- 5th March 2021 for UK stakeholders with farmers, agronomists and consultants
- 11th March 2021 for Danish agronomists and advisors in organic plant production.

At the first workshop the first prototype was presented for the partners in the project as well as the initial idea and implementation of the feedback from a workshop held with consortium partners at the DIVERSify General Assembly meeting in June 2019. At the workshop in October further feedback was collected for the design of the CropMIXER.

At the next two workshops, a near completed version of the CropMIXER was presented as well as the thoughts behind the tool. Participants were given the opportunity to test the tool and gave their

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feedback about the functionality of the tool. Along with the informal feedback discussions, the UK participants were asked to complete a short feedback questionnaire on the tool. The feedback will be used for future development of the Decision Aid in follow-on project activities.

Feedback points from the UK workshop:

- Function to choose both organic and conventional needs to be made clearer as an option
- One consultant had had high praise for the tool saying 'Important and vital tool once complete for consultants', however, did feel the tool wasn't a stage where it could be presented by a consultant to a farmer due to the gaps currently on this version on the tool
- The trial meta data is great function particularly the soil analysis. In future input data (Fertilisers etc.) would be of benefit
- For livestock farmers nutritional data (Protein etc.) alongside the biomass and yield option would be highly beneficial on a grassland perspective
- One participatory farmer would like to see stated how the crops were separated and what end use opportunities/markets the mixtures were used in
- One participant expressed interest for an option for carbon sequestration
- Majority of participants agreed that is good that the trial is linked so that more results can be analysed

Overall, all the participants involved found the tool worked well and the workshop very useful and can see definitely a future for the tool to be used by UK farmers, agronomists and consultants.

Feedback points from the Danish workshop:

- It would be very informative if the tool also could show data regarding catch crop.
- Nitrogen input as a parameter of search in the front page of the tool
- Preferably more information about energy content and protein rather than grain yield/biomass

The participants saw great potential in the tool. They thought it is very informative and gives useful information for agronomists and farmers.

6.2. Questionnaire results

The feedback questionnaire has been answered by 14 participants, the professional expertise of which is shown in **Figure 15**.

The feedback questionnaire consistent of three main parts:

- The standard User Experience Questionnaire
- The Net promoter score
- Positive and negative aspects of the tool

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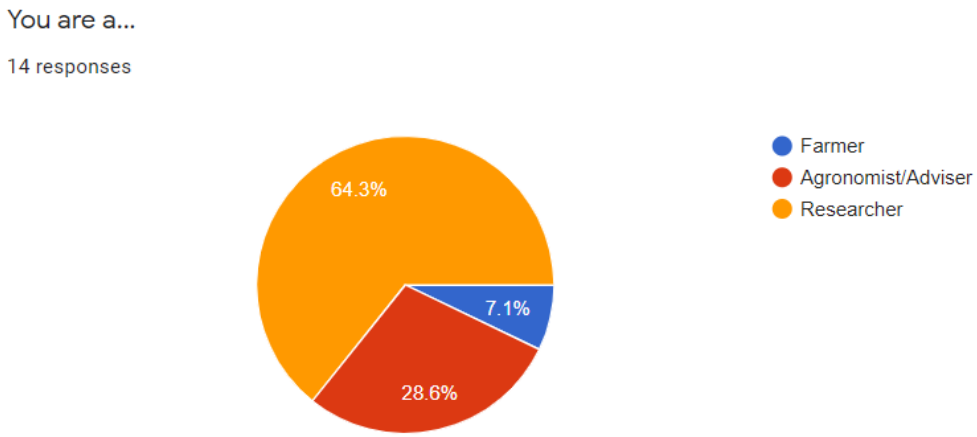

Figure 15 Professional profile of the participants that filled in the questionnaire.

6.2.1. User Experience Questionnaire results

The first part employed the short version of the User Experience Questionnaire (UEQ; https://www.ueq-online.org/), designed as a tool to record the general user impressions in relation to the User Experience (UX) aspects of the tool. The short version of the UEQ calculates two main scales, pragmatic and hedonic qualities. Pragmatic qualities include aspects like ease of use, learnability and efficiency whereas the hedonic qualities capture attractiveness and novelty.

As seen from the results per item (**Table 1** and **Figure 16**) and for the two scales (**Table 2** and **Figure 17**), the users' impression of the tool is positive in all aspects. According to the creators of the UEQ "in real applications in general only values in a restricted range will be observed due to the calculation of means over a range of different persons with different opinions and answer tendencies; for example, the avoidance of extreme answer categories means that values above +2 or below -2 are extremely unlikely to be observed. Thus, even a quite good value of +1.5 for a scale looks from the purely visual standpoint on a scale range of -3 to +3 not as positive as it really is." In this respect, the results concerning the UX aspects of the tool may be considered very positive.

Table 1 Summary of results for the UEQ items.

Item	Mean	Variance	Std. Dev.	No.	Negative	Positive	Scale	
1	1.4	0.9	0.9	14	obstructive	supportive	Pragmatic Quality	
2	1.1	1.5	1.2	14	complicated	easy	Pragmatic Quality	
3	1.1	1.1	1.1	14	inefficient	efficient	Pragmatic Quality	
4	0.6	1.5	1.2	14	confusing	clear	Pragmatic Quality	
5	1.8	0.8	0.9	14	boring	exciting	Hedonic Quality	
6	2.2	0.5	0.7	14	not interesting	interesting	Hedonic Quality	
7	1.6	1.2	1.1	14	conventional	inventive	Hedonic Quality	
8	1.6	1.0	1.0	14	usual	leading edge	Hedonic Quality	

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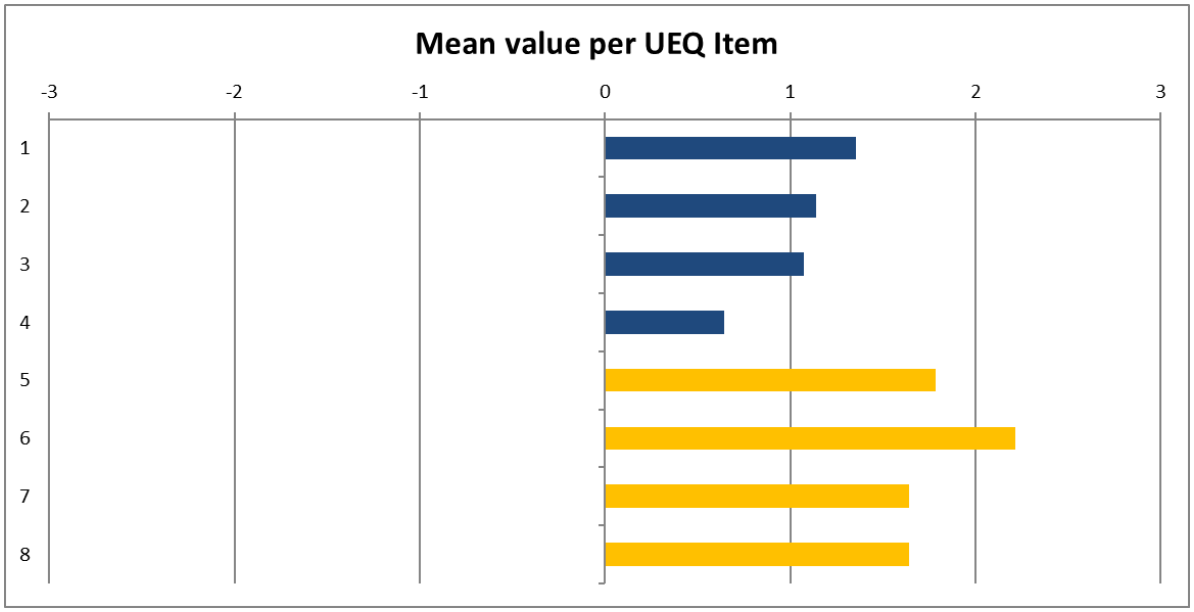

Figure 16 UEQ mean values for the Pragmatic (blue) and Hedonic (yellow) items shown in **Table 1**.

Table 2 Mean values for the two UEQ Scales and when combined (Overall).

Short UEQ Scales	
Pragmatic Quality	1.054
Hedonic Quality	1.821
Overall	1.438

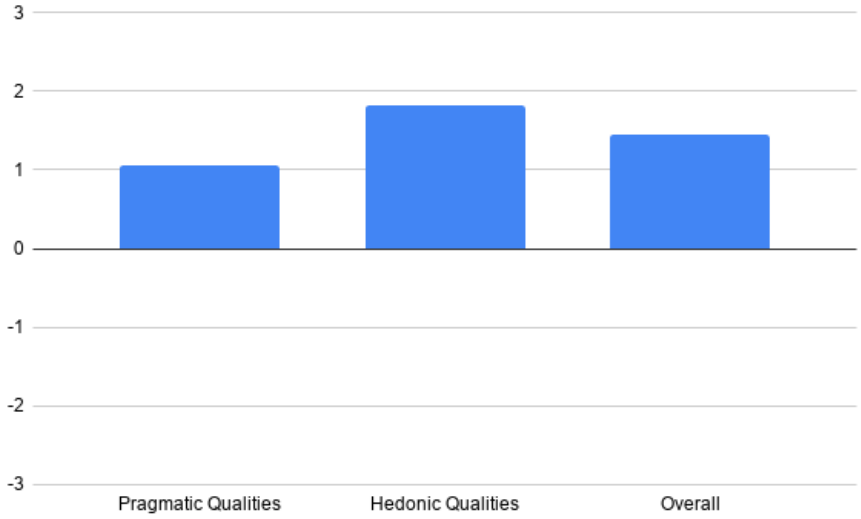

Figure 17 Mean values for the Hedonic and Pragmatic Scales and and when combined (Overall).

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The responses of the users in the open-ended questions substantiate the UX aspects of the tools, characterizing it as “intuitive and good to use” and a “great resource for bringing together so much information”. In terms of points for improvement, it was suggested to “make it clear upfront what data is there (grain yield, biomass, livestock feeding quality)” and also make the colours bolder for older or colour-blind users.

6.2.2. Net Promoter Score

The Net Promoter Score is calculated based on responses to a single question: ***How likely is it that you would recommend our company/product/service to a friend or colleague?*** The scoring for this answer is on a 0 to 10 scale.

Those who respond with a score of 9 to 10 are called **Promoters**, and are considered likely to exhibit value-creating behaviours, such as buying more, remaining customers for longer, and making more positive referrals to other potential customers. Those who respond with a score of 0 to 6 are labelled **Detractors**, and they are believed to be less likely to exhibit the value-creating behaviours. Responses of 7 and 8 are labelled **Passives**, and their behaviour falls between Promoters and Detractors.

The **Net Promoter Score** is calculated by subtracting the percentage of customers who are Detractors from the percentage of customers who are Promoters. For purposes of calculating a Net Promoter Score, Passives count toward the total number of respondents, thus decreasing the percentage of detractors and promoters and pushing the net score toward zero. **Figure 18** presents the summary of user responses for this question. These values lead to a calculated Net promoter score of 7 (calculation shown in **Figure 19**), establishing the tool in the positive category.

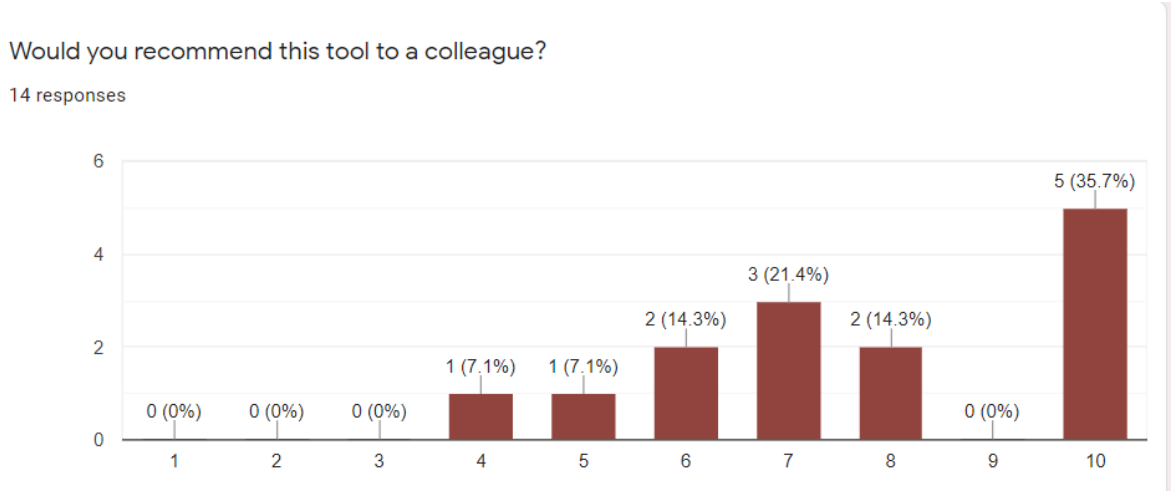

Figure 18 Responses to the Net promoter score question.

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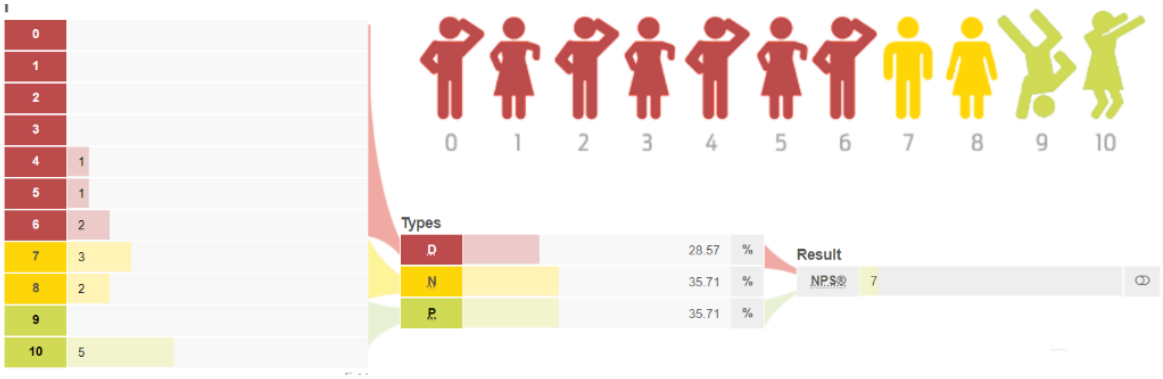

Figure 19 Calculation of the Net Promoter Score (http://www.npscalculator.com/).

Similarly, in response to the question whether users would use the tool in the context of their work, 64% provided very positive responses, with a score of 7 or higher (**Figure 20**).

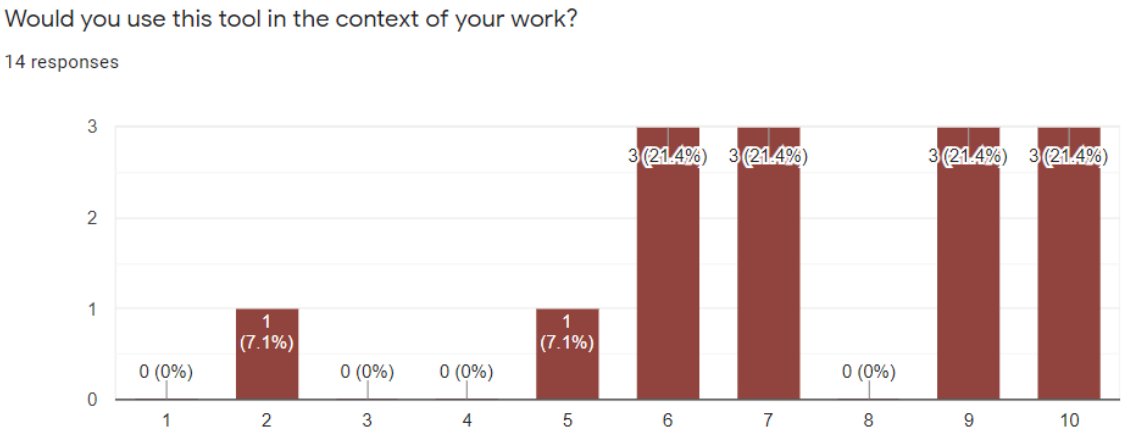

Figure 20 Participant responses to the question "Would you use this tool in the context of your work?"

7. Conclusions and future outlook

The CropMIXER tool has been designed, developed and evaluated in close collaboration with project partners (who generated the database) and representatives of its intended target user groups. As its evaluation revealed, the tool is considered potentially very useful resource for advisors. CropMIXER provides a means of accessing plant teams trial data produced in the DIVERSify project and from external data sources, including the wealth of data available from the Danish trials database. The database can be searched by the user through a simple interface by selecting a series of options to filter down to trials of interest. The trial data is provided in summarised form and the user can also access more details of the dataset behind the data summary. CropMIXER ensures that results from

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plant teams trials in DIVERSify are made available directly to farmers, advisers, agronomists and other users in a simple and accessible format, allowing the information to guide decisions about plant team selection and agronomy in different pedoclimatic zones of Europe and the Mediterranean.

In the future, the user feedback will be used to update and improve the tool through further cycles of iterative development and user testing, allowing improvements to be quantified through comparison with the user feedback presented in this report. The option of allowing users to add new data to the tool database will be explored in future development. The advisors in the Danish workshop, who were presented with the near-final version of CropMIXER, proposed a follow up workshop to evaluate the final version of the tool, when all datasets are available in the database. The template for the dataset has evolved during the process of programming. An updated version will be available for collection of future data for the CropMIXER tool, as well as an updated version of the guide to fill in the template.

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