Training course outline

MODULE 4

Development and application of molecular methods in organic breeding

Task 1.4 - WP1

TRAINERS (or responsible partner): ***FiBL(lead), UPV, KIS***

SECTION 1: Info on the module for *trainees*

Identity card and case study data

Below you'll find all the information you need to produce one or more learning activities: the training objective and the pedagogical modality chosen (face-to-face, virtual classroom, self-study), parameters that form the framework of your exercise, a list of learning activities and a list of pedagogical resources from which you can draw (but you're free to invent new ones) to design your learning activity.

1. TRAINING THEMATIC- Background (Maximum 500 words)

Molecular methodologies are essential to support breeding. The efficiency of phenotypic and agronomic evaluation and selection on the field can be increased thanks to previous knowledge about the info present in the DNA, in the shape of molecular markers and DNA polymorphisms. Molecular markers may help to perform DNA-polymorphisms-based screening of genotypes at the plantlet stage for some traits and/or certain genetic backgrounds linked to specific DNA profiles, known as marker-assisted selection (MAS) and genomic selection. To achieve and tune such direct applications on breeding, other techniques, experiments and experimental populations must be developed and studied previously. Thus, Genome Wide Association compares the performance of large populations which segregate for traits of interest vs their genetic profile (based on DNA polymorphisms), with the aim of identifying specific DNA polymorphisms highly linked to the trait(s) of interest. Experimental populations build from parent lines which differ for those traits of interest are then essential for these assessments. The present module is aimed at training on the fundamentals of all these concepts.

2. TRAINING STAKES AND OBJECTIVES

Describe here the training stakes for this audience and the general training goal to achieve at the end of the training

Training stakes and the general training goal for the target audience you have chosen

1. The training course aims to:
Main issues related to MAS and genomic selection. From their implementation and application on breeding to the studies and experimental populations used in their development.

2. Structure of the module and training
This module 4 is divided into four units:
- Genome Wide Association (GWA) and its potential for understanding the genetic basis of complex traits
- Genomic Selection and its potential in organic breeding
- Application of molecular marker-based selection in practical breeding
- Overview on experimental populations (e.g. NILs, RILs, introgression families, MAGIC) and their role in molecular breeding approaches

3. At the end of the training, the trainee will be able to:
- Learn how to develop experimental populations useful for MAS and genomic selection

- Understand the fundamentals on how to link genetic profiles to traits of interest
- Learn the advantages of molecular markers and DNA profiles and examples of their application in breeding

3. STRUCTURE OF THE TRAINING MODULE

Insert a summary table showing the module structure, units, and their duration.

MODULE #4 – Application and development of molecular methods in organic breeding	6.5 hours
Unit one: *Genome Wide Association*	2 hours
Unit two: *Genomic Selection*	1.5 hour
Unit three: *Application of molecular marker-based selection in practical breeding*	1.5 hour
Unit four: *Experimental populations (NILs, RILs, introgression families, MAGIC)*	1,5 hours

4. TARGET AUDIENCE

Target audience(s)

Students
Researchers
Breeders

Precise the target audience

Students: wide range, but minimum since University undergraduates on Agronomy, Biology, Biotechnology, to MSc in Plant Breeding and Biotechnology, PhD students

Researchers: early stage career researchers in agronomy and plant breeding

Breeders: and more specifically organic breeders who want to learn about and apply molecular markers in their breeding programmes

Check the "pre-requisite" level of the trainees

Intermediate

Check the type of crop concerned by the training

Vegetables
Cereals

5. MODALITIES

Online workshop

6. EVALUATION METHODS

Online quizes and homeworks the week after the session

7. MATERIAL AVAILABLE FOR BUILDING THE LEARNING ACTIVITY(IES)

The learning resources for this topic require that you connect to the internet with your computer, as part of the info showed are online databases, online simulators and softwares for genomic analysis, GWAs, etc. Also, some scientific papers to widen the details about the topics given will be also mentioned and adviced for future reading. They will be provided and mentioned during the main presentations.

Examples:

- All the useful tools to perform GWAS practical examples, apart from the demonstration from the lecturers can be found online in the following sources:

  Tassel5

  https://www.maizegenetics.net/tassel

  https://www.youtube.com/watch?v=73hD5n-OOJc&list=PLdf-U83sN48OPSQ-DqL3AgqKOvu8nUoMT

  Info on how to download and instal Tassel 5.0 is also provided at the end of the presentation
- A review about high throughput phenotyping platforms can be found in the link:

  https://www.youtube.com/watch?v=zw02B_oWL9k
- Data for homework and presentation (unit 1) can be found on the following github subpage:

  https://github.com/jmartinezpoq/LiveSeeding_Module4/tree/master/Unit1_PracticalExercices
- All material about genomic selection (Unit 2) will be provided on github subpage https://github.com/mischn-dev publicly accessible, also after the workshop. The material includes a step-by-step tutorial in a markdown shape, including code examples and its results. Besides, training data will be provided as additional files, and a list of relevant references
- Some scientific papers of interest for units 3 and 4:

  Ceccarelli S, Grando S (2020). Evolutionary plant breeding as a response to the complexity of climate change. iScience 23: 101815. doi: 10.1016/j.isci.2020.101815

  Döring TF, Annicchiarico P, Clarke S, Haigh Z, Jones HE, Pearce H, Snape J, Zhang J, Wolfe MS (2016). Comparative analysis of performance and stability among composite cross populations, variety mixtures and pure lines of winter wheat in organic and conventional cropping systems. Field Crops Research 183: 235-245. doi: 10.1016/j.fcr.2015.08.009

SINKOVIČ, Lovro, TAVAKOLI HASANAKLOU, Hourieh, NEJI, Mohamed, PLESTENJAK, Eva, DOLNIČAR, Peter, MEGLIČ, Vladimir, PIPAN, Barbara. Combining multi-criteria decision analysis with agro-morphological-biochemical-molecular traits of interest for use in breeding in promising common bean breeding lines (Phaseolus vulgaris L.). *Cogent food & agriculture*. Dec. 2024, vol. 11, issue 1, [article no.] 2439551, 17 str., ilustr. ISSN 2331-1932. https://www.tandfonline.com/doi/epdf/10.1080/23311932.2024.2439551?needAccess=true, https://dirros.openscience.si/IzpisGradiva.php?id=21062&lang=slv, dCOBISS, DOI: 10.1080/23311932.2024.2439551.

PLESTENJAK, Eva, NEJI, Mohamed, SINKOVIČ, Lovro, MEGLIČ, Vladimir, PIPAN, Barbara. Genomic insights into genetic diversity and seed coat color change in common bean composite populations. *Frontiers in plant science*. 2024, vol. 15, [art. no.] 1523745, str. 1-19, ilustr. ISSN 1664-462X. https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2024.1523745/full#h7, https://dirros.openscience.si/IzpisGradiva.php?id=21310&lang=slv, dCOBISS, DOI: 10.3389/fpls.2024.1523745. [COBISS.SI-ID 223803395]

SINKOVIČ, Lovro, BLAŽICA, Vanja, BLAŽICA, Bojan, MEGLIČ, Vladimir, PIPAN, Barbara. How nutritious are french beans (Phaseolus vulgaris l.) from the citizen science experiment?. *Plants*. 2024, vol. 13, iss. 2, art. 1314, str. 1-21, ilustr. ISSN 2223-7747. https://www.mdpi.com/2223-7747/13/2/314, dCOBISS, DOI: 10.3390/plants13020314.

SEDLAR, Aleš, ZUPIN, Mateja, MARAS, Marko, RAZINGER, Jaka, ŠUŠTAR VOZLIČ, Jelka, PIPAN, Barbara, MEGLIČ, Vladimir. QTL mapping for drought-responsive agronomic traits associated with physiology, phenology, and yield in an Andean intra-gene pool common bean population. *Agronomy*. 2020, vol. 10, iss. 2, str. 1-18, graf. prikazi, tabele. ISSN 2073-4395. https://www.mdpi.com/2073-4395/10/2/225/pdf, DOI: 10.3390/agronomy10020225.

PIPAN, Barbara, MEGLIČ, Vladimir. Diversification and genetic structure of the western-to-eastern progression of European Phaseolus vulgaris L. germplasm. *BMC plant biology*. 2019, vol. 19, št. 442, str. 1-16, ilustr. ISSN 1471-2229. DOI: 10.1186/s12870-019-2051-0.

8. TRAINING TECHNIQUES

Check one or several learning activities you have chosen to develop

Expositive methods – which emphasize the 'absorption' of new Information. The learner need to listen, read, observe.	x Presentation: organized information on a specific topic □ Demonstration of how a task can be performed x Worked examples with comment and explicit reference to the theory x Case studies real, significant cases related to the topic □ other + Survey and feedback
Application methods – which emphasize the active processes that	□ Demonstration and practice of a gesture or procedure □ Analysis and diagnosis of a "virtual" case study (described in writing, audio or video recording)

learners use to perform procedural and principle-based tasks and build new knowledge	x Guided search for resources and production of a summary x Role-playing or simulation x Project: apply the principles and concepts learned in your own environment
Collaborative methods – which emphasize the social dimension of learning and engage learners in sharing knowledge and performing tasks in a collaborative way.	x Guided online discussions (chat, forum, video or audio conference): debate, exchanges □ Collaborative work: application methods involving group collaboration (longer, more complex tasks) x Tutoring or even peer assessment: pairing up, for example, to assess each other's work/production.

SECTION 2: Info on the module for trainers

2.1 THE DURATION OF THE PLANNED ACTIVITY, ITS VARIOUS STAGES AND TIMING

Describe the duration, stages, and timing of the activities in each unit

Unit 1 (UPV-Neus Ortega-Albero)
1) Sharing instructions about the session, and main concepts to be learned – 5 min, 2) Main presentation from the trainer, description of useful materials and way to collect and prepare data (both phenotypic and genotypic) - 30 min, 3) General Discussion, questions from trainees (10 min), 4) Main presentation from the trainer, description of GWA procedure, including presentation of the softwares used - 30 min, 5) General Discussion, questions from trainees (15 min), 6) Evaluation of trainees 1: questions relative to issues exposed during presentations (Quiz, 10 min in total; response provided by e.mail to the trainer) 7) Conclusions, follow-up and prospects (what have we learnt today?, 5 min). 6) Evaluation of trainees 2 (proposal of individual homework, based on papers aimed at GWA and provided by trainer, performed individually during the next week and provided to trainer by e.mail)

Unit 2 (FiBL – Michael Schneider)
1) Sharing instructions about the session, and main concepts to be learned – 5 min, 2) Main presentation, description of the concept, sharing useful materials - 30 min, 3) Question round (5 min), 4) Guided training using a provided script and example data (30 min) 5) Conclusion and representation of results (10 min) 6) final Quiz (10 min).

Unit 3 (KIS-Barbara Pipan & FiBL – Teresa Lazzaro)
1) Sharing instructions about the session, and main concepts to be learned – 5 min, 2) Main presentation, description of the concept, sharing useful materials about application of molecular marker-based selection in practical breeding (common bean and white lupin examples)- 30 min, 3) Question round (5 min), 4) Guided training using a provided script and example data (30 min) 5) Conclusion and representation of results (10 min) 6) final Quiz (10 min).

Unit 4 (UPV Neus Ortega-Albero & KIS-Vladimir Meglic)
1) Sharing instructions about the session, and main concepts to be learned – 5 min, 2) Main presentation from the trainers, description of useful complementary materials available (provided by the trainer and/or available online) - 45 min, 3) General Discussion, questions from trainees - 20 min 4) Evaluation of trainees: questions relative to issues exposed during presentations (Quiz, 15 min in total; response provided by e.mail to the trainer) 5) Conclusions, follow-up and prospects (what have we learnt today?) - 5 min.

INSTRUCTIONS

Describe the instructions you're going to give trainees for carrying out the activity. Ideally, write down these instructions

UNIT 1 – The structure of the unit will be shortly explained in the first 5 min.
In summary, be ready :
i) to follow online presentation in their two parts
ii) take notes of main issues treated and participate on the general discussion of each part
as iii) there will be a short quiz for evaluation of the whole unit and…
iv) finally, you will be also evaluated through a homework (during the next week) based on a scientific paper. The work will consist of making a summary on the main issues treated and results obtained, supported on a guided template provided by trainers.

UNIT 2 - The structure of the unit will be shortly explained in the first 5 min.
In summary, be ready:
(i) to follow online presentation
(ii) downloading data and R code from a github site.
(iii) Run the example code, following an extended exercise.
(iv) Prepare for a short quiz at the end of the session

UNIT 3 - The structure of the unit will be shortly explained in the first 5 min.
In summary, be ready:
(i) to follow online presentation
(ii) to get the basic information about molecular breeding in general
(iii) a summary about molecular breeding in common bean and white lupin.
(iv) Prepare for a short quiz at the end of the session

UNIT 4 – The structure of the unit will be shortly explained in the first 5 min.
In summary, be ready:
i) to follow online presentation
ii) take notes of main issues treated and participate on the general discussion
as iii) there will be a quiz for evaluation of the whole unit

MATERIALS

Describe the materials provided for trainees to carry out the activity (resources, Internet links, etc.) and specify how they will use the resources, and describe the link between the resources and the activity

UNIT 1 – During the presentation, several online resources will be shared with the trainees. Other online presentations (video casts) to widen the info on GWA will be also provided. These materials will be useful to widen the info provided for their knowledge. Also include data for the homework on a github subpage (to be developed in the week after the course and provided to the trainer):

Tassel5
https://www.maizegenetics.net/tassel
https://www.youtube.com/watch?v=73hD5n-OOJc&list=PLdf-U83sN48OPSQ-DqL3AgqKOvu8nUoMT
Info on how to download and instal Tassel 5.0 provided at the end of the presentation
A review about high throughput phenotyping platforms can be found in the link:
https://www.youtube.com/watch?v=zw02B_oWL9k
Data for homework and presentation on:
https://github.com/jmartinezpoq/LiveSeeding_Module4/tree/master/Unit1_PracticalExercices

UNIT 2 - Several online resources will be shared with the trainees via a github pages. The material includes a summary of the presentation, training data, a running example, and additional information on the topic.

UNIT 3 - The material includes a summary of the presentation, two practical examples on common bean and lupins were presented, and additional information on the topic.

UNIT 4 – This unit is mainly theoretical (i.e. overview and examples of experimental populations), During the own presentation, several examples on a range of crop species of populations, research projects (e.g. ECOBREED) where they were developed, and scientific papers will be mentioned, so that the trainees can widen the info searching for these research initiatives and publications:

PLANNED INTERACTION BETWEEN TRAINEES AND/OR WITH THE TRAINER

Describe it and specify in particular if it's remote (virtual class, self-training) the support used (chat tool, collaborative writing document, collaborative whiteboard, survey, etc.).

The four units: Remote virtual class (synchronous, through TEAMS or similar platforms), chat tool for questions during presentation (questions not replied during the virtual online class will be replied later in a document, which will be shared to the mail list of trainees), and quizs to be solved in 10-20 min.

EVALUATION

Describe how you are going to assess what you have learned. Please note that the skills assessed must relate to the training objective you have formulated. If it's a quiz, true/false, MCQ, etc., write down the questions you might ask.

The four units: short quiz (10-20 min, depending on the unit) during the lesson + individual homework in some units (during the week after the lesson, provided to the trainer by e.mail once finished for evaluation).