PROJECT REPORT ON:

DELIVERABLE WP2: D2.4; Report on capacity building training 2 /Student Visits to program countries HEIs

Building Capacity in Plant Breeding and Biotechnology Education and Research through Partnership Program (BREEDTECH)

Submitted by BREEDTECH Project team
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1.0 Executive Summary

The BREEDTECH Program aims to strengthen research and innovation in sustainable agriculture and climate resilience across Africa and the Middle East. This report describes the training activities organized for staff from Higher Education Institutes (HEIs), with workshops held at Scuola Superiore Sant'Anna (SSSA) in Pisa and the Institute of Field and Vegetable Crops (IFVCNS) in Serbia. These sessions were designed to provide students with essential skills in advanced breeding technologies and interdisciplinary research. The first workshop was conducted at SSSA from May 5–9, 2025, followed by the second at IFVCNS from September 22–26, 2025. Participants learned how to integrate modern breeding tools into crop improvement. Overall, these trainings boosted participants' technical knowledge, systems thinking, and collaboration abilities for developing innovative educational programs. The training content was based on the needs identified in D2.2.

This document reports in detail the SSSA and IFVC training outcomes, and concludes with a reflection on lessons learned, proposing actions to improve the impact of future training interventions.

2.0 SSSA training

The target group addressed by the BREEDTECH Student Training Workshop consisted of undergraduate and graduate students from Kenyan, Ethiopian, and Palestinian higher education institutions. These students were selected based on their academic focus in agricultural sciences, plant breeding, genetics, and biotechnology. A total of 8 students participated in the workshop, representing diverse academic backgrounds, including plant genomics, crop science, and biotechnological applications in agriculture. We had a total of 9 participants from Kenya (Laikipia and Egerton) and Palestine (An-Najah and Al-Quds). Unfortunately, we did not have participants from Ethiopia since the appointed students failed to receive the visa in due course. In order not to lose their opportunity, the team in Pisa agreed to host these students during the Staff Training event planned for September 2025, but visa was rejected again.

This training was structured over a period of five consecutive days, each designed to build progressively from foundational genetic concepts to hands-on laboratory skills and applied analysis. The training combined theoretical lectures, interactive discussions, and practical sessions, with each day focusing on a specific theme. The outcomes reflected participants' improved understanding of molecular genetics, enhanced technical competencies, and preparedness to apply these techniques in their own research or institutional settings. The following sections provide a day-by-day breakdown of the training activities, key topics covered, and the corresponding outputs and outcomes (Fig. 1).

Fig. 1. Course participants on SSSA grounds

2.1 Structure of the course

The first day of the training workshop began with an introductory roundtable session designed to set the tone for the days ahead. Participants and trainers introduced themselves, shared their academic or professional backgrounds, and discussed their expectations for the workshop. The morning lecture sessions focused on fundamental principles of genetics, structured into three thematic parts to progressively build participants' understanding: i) the uniqueness of the genetic approach, ii) therelationship between genotype and phenotype, the molecular role of DNA, and iii) the application of genetic markers and maps. In the afternoon, the focus shifted to practical preparations. A lecture introduced the principles and workflow of DNA extraction and PCR, highlighting key techniques, challenges, and the importance of accuracy. The session also included a comprehensive orientation on laboratory safety, ensuring participants were well-prepared for the hands-on sessions to follow.

On Tuesday students engaged in a comprehensive hands-on laboratory session focused on fundamental molecular biology techniques. The day began with sampling leaf material from bean and maize plants, followed by sample preparation using liquid nitrogen, mortars, and pestles. Students then carried out DNA extraction and quantified the DNA using a Nanodrop spectrophotometer. This was followed by setting up PCR reactions, preparing agarose gels, and performing gel electrophoresis to visualize the amplified DNA. The session concluded with a preliminary discussion of the results. The training approach combined brief theoretical introductions with practical activities. Each method was clearly explained before the hands-on exercises to ensure students understood the objectives and procedures. Participants were divided into small groups, each supported by a facilitator who guided them through the tasks and provided individual support where needed.

Wednesday's session aimed to bridge foundational genetic knowledge with advanced technologies, demonstrating how these approaches can be used to unravel complex trait regulation, improve crop performance, and address challenges in agriculture and biotechnology. The lectures on day three provided a comprehensive overview of genomics, covering the basics of the genome, its physical composition, and structure, including the genomes of cell organelles. It explored genomic features such as coding sequences (genes), repeat regions (including tandem and interspersed repeats, with a focus on transposable elements). The second part introduced transcriptomics, emphasizing the importance of coding and non-coding RNAs in the functioning of living organisms. It discussed how dynamic gene expression regulation impacts cell differentiation and phenotypic plasticity, with examples of non-coding RNAs and their significance. The lecture also reviewed the development of techniques for studying the transcriptome, highlighting dominant modern technologies.

Thursday was dedicated to building a comprehensive understanding of trait and genotype association analysis. The session began with an in-depth overview of the theoretical foundations and biological relevance of identifying genetic markers linked to phenotypic traits. This background was followed by clear and intuitive explanations of key methodologies, particularly Genome-Wide Association Studies (GWAS) and Quantitative Trait Loci (QTL) mapping. These concepts laid the foundation for a practical, hands-on segment using the TASSEL software platform. The training walked participants through a full association mapping workflow. This included the installation of the TASSEL software, quality control checks for genotype data, and relatedness analyses using kinship matrices, principal component analysis (PCA), and multidimensional scaling (MDS). The session culminated in performing GWAS using TASSEL.

Friday focused on advanced genetic tools for plant breeding, specifically Genome-Wide Association Studies (GWAS), genomic prediction, and genome editing. Building on day 4, the session aimed to deepen understanding of how these genomic techniques can improve crop traits and productivity, particularly for smallholder farmers in developing economies. The day included a blend of lectures, discussions, and real-world case studies to connect theory with practical applications. This approach allowed participants to engage with both the scientific principles and the practical use of these technologies in breeding programs. Active participant engagement fostered a collaborative learning environment, enhancing the relevance of the content.

Overall, the training was highly appreciated with an average score of 9.5/10 (Fig. 2). The evaluation showed unanimous satisfaction with the competence of trainers and their ability to transfer knowledge: 100% of participants rated both aspects a10. This highlights the trainers' mastery of the subject and their success in communicating complex ideas in an accessible manner. The course content received a strong average relevance score of 9.4, likely due to the careful mapping of students' training needs conducted earlier on during preparation. This high rating reflects significant satisfaction with the content's scope and focus, which participants noted aligned well with both current job market demands and their research needs. The structure of the training course also received strong feedback, with an average score of 9.1 Similarly, the quality of the practical sessions was considered excellent at 9.7. These responses underscore the value placed on hands-on experiences, particularly in applying learned techniques. Regarding the usability of the acquired skills, this aspect scored 8.9. Finally, participants rated how well the course matched their existing work needs, giving it an impressive average score of 9.1. Similarly, the course's effectiveness in improving participants' skills received an even higher average score of 9.6. These results underscore the strong demand for continued capacity-building workshops and ongoing engagement to further support research development.

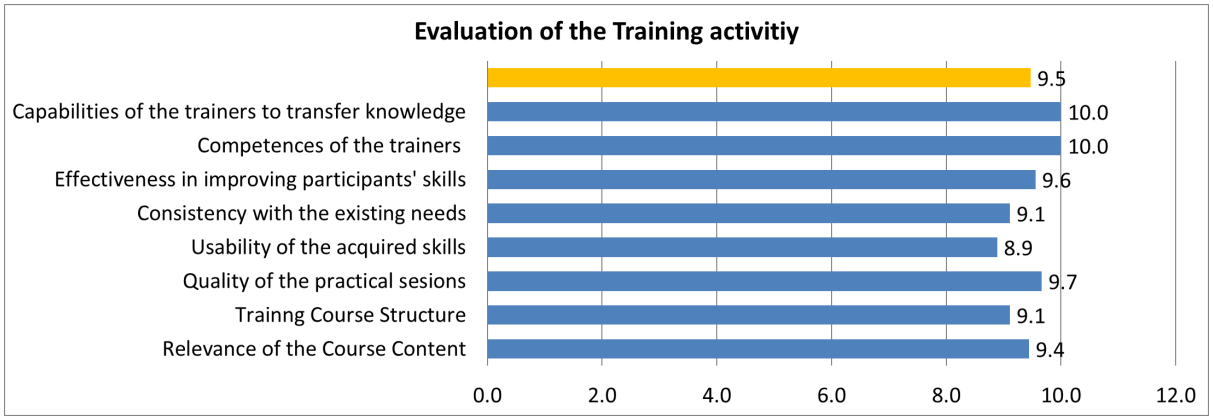

Fig. 2. Evaluation of the SSSA Training Activity. Average scores given by participants (0 = very poor; 10 = excellent) for different aspects of the course.

Participants praised the course for its practical, comprehensive approach, relevant job market skills, effective use of Tassel software, and clear instruction from knowledgeable trainers. The hands-on training enhanced understanding of genetic principles and biotechnology's role in agriculture. However, limited time for practical sessions was a recurring concern. Suggestions included extending the workshop to two weeks, introducing theory online before in-person labs, broadening crop coverage, lowering the participant-to-instructor ratio, and adding post-training mentorship or support.

2.2 IFVCNS training

In IFVCNS, participants took part in theoretical, field and laboratory sessions on classical breeding, tissue culture, molecular breeding, high-throughput phenotyping, seed production and data analysis. The training also offered students opportunity to learn more on commercial breeding, practical application of -omics tools in crop improvement, as well as get first hand experience and information form the IFVCNS staff involved both in development and commercial application of new tools and technologies in breeding. In addition to the technical sessions, the workshop provided opportunities for networking, and discussions on actual problems and challenges in crop improvement and agriculture in Mid-East and Africa, and possibilities of the application and transfer of the knowledge gained during the training in the student's respective countries. The target group trained within the 2nd BREEDTECH Student Training Workshop consisted of 5 master and PhD students from Kenyan, Ethiopian, and Palestinian higher education institutions with backgrounds in plant breeding, plant production and crop protection. There were 2 participants from Kenya (Egerton), 2 participants from Ethiopia (Oda Butum and Haramaya) and 1 from Palestine (Al-Quds). Unfortunately, there were no participants from Lakipia and An-Najah and some of the students from other Universities did not manage to come to the training either because the appointed students failed to receive the visa in due course or due to travel restrictions faced by some students from Palestine.

Fig. 3. Course participants on IFVCNS grounds

This training was done during five consecutive days, designed to provide student theoretical basis in crop improvement methods, tools and data analysis and then enable students to gain practical skills and hands-on training in the lab and in the field. The training combined theoretical lectures, interactive discussions, as well as practical sessions, with each day focusing on specific themes. Unfortunatelly, 4 students missed the first day of the training, hence the program had to be adjusted. Because of this, only one student participated in the first day of the training and did lab work – DNA extraction and gel electrophoresis.

2.3 Structure of the course

On Monday, the only student that was present engaged in a hands-on laboratory session focused on fundamental molecular biology techniques. The day began with sampling leaf material from wheat plants, followed by sample preparation using mortars and pestles. Student then carried out DNA extraction and quantified the DNA using a Nanodrop spectrophotometer. This was followed by preparing agarose gel, and performing gel electrophoresis to visualize the extracted DNA. Each step was explained in detail as to ensure that student understood the objectives and procedures.

Tuesday began with tour-de-table and participants and trainers introduced themselves, shared their academic or professional backgrounds, and discussed their expectations for the workshop. The lectures on the second day were devoted to classical breeding and were structured into four thematic parts: i) use of genetic resources in breeding, ii) inbred line breeding, iii) hybrid breeding and iv) breeding for resistance. Those sessions enabled students to learn about principle of plant breeding, different tools and approaches used, and were supported by practical examples and solutions that could be applied in their respective countries.

Lectures on the Wednesday aimed to build up on what was learned on the second day and demonstrate to students modern tools that are applied in breeding as to accelerate it and make it more efficient. The lectures comprised: i) tissue culture, ii) molecular breeding and iii) HTPP in lab and in the field. The lectures were interactive with demonstrations of the actual experiments and work in the lab and field, along with some mobile phone applications that could be used for plant phenotyping. Students also took part in quiz where they were asked questions related to the lectures. The students actively asked questions, but their understanding of the methods and information provided varied depending of their background. This showed that although the program and topics of the training course were chosen and approved by the professors, more attention should be paid to the selection of the students and their knowledge level. Key outcomes included discussions on possibilities of the application of those modern tools in the breeding programs in less developed countries.

Thursday, the fourth day of the training, was dedicated to seed production as the final stage in breeding process, along with the different aspects of the data analysis. From practical examples students learned on important factors for successful seed production and the rules and regulations that need to be respected. They were shown how Excel could be used for complex data analysis, as well as basic principles of integrated analysis of different data. The lectures were interactive with lecturers using examples from their own work, as to make the lectures more understandable to the students. Although there were many questions, it could be observed that most of the students had difficulty to follow the lectures on data analysis and that the next trainings on data analysis could be on more basic level. This was particularly obvious during quiz session where students were asked to choose adequate statistical methods and tests for the specific experiments.

In the morning session of the Friday students visited germplasm collection and breeding nurseries of different field crops. There they were introduced to the basic principles of the field work and learned particularities of the both non-commercial and commercial breeding of different crops. They were also able to see in the practice the application of the methods they were introduced to on the second day of the training. During this session students were also shown speed breeding facility, along with the demonstration of the use of drones for HTPP in the field. In the afternoon, the students prepared in vitro grown plants for phenotyping and scanned prepared samples using WinRHIZO. They also learned how to analyse and interpret obtained data. They were also shown the basic of root phenotyping and steps and requirements to successfully prepare rhizotrons for imaging and data analysis. This session, along with the morning session related to speed breeding and use of drones for HTTP enabled students to see in practice the application of the modern breeding tools they were introduced to in the third day of the training. scanning a hands-on training on plat emasculation, which is one of the crucial steps in breeding process.

The evaluation collected feedback from the participants to assess the effectiveness, relevance, and delivery of the course. Participants represented all three countries involved in the project and consisted of master and PhD students and one staff. Overall, the training was highly appreciated with an average score of 9.3/10 (Fig. 4). The evaluation showed high satisfaction with the competence of trainers and their ability to transfer knowledge with average mark 9.8. This confirms the right choice of the trainers, but also their ability to convey the knowledge to such diverse group of students. The course content received a strong average relevance score of 9.4, reflecting participants' satisfaction with the content's scope and focus. The structure of the training course also received strong feedback, with an average score of 9.2. Similarly, the quality of the practical sessions was considered excellent at 9.6. These responses underscore the importance of the hands-on sessions. Regarding the usability of the acquired skills, this aspect scored 8.4. Finally, participants rated how well the course matched their existing work needs, giving it an impressive average score of 9.4. The course's effectiveness in improving participants' skills received average score of 9. These results underscore the strong demand for continued capacity-building workshops and ongoing engagement to further support research development.

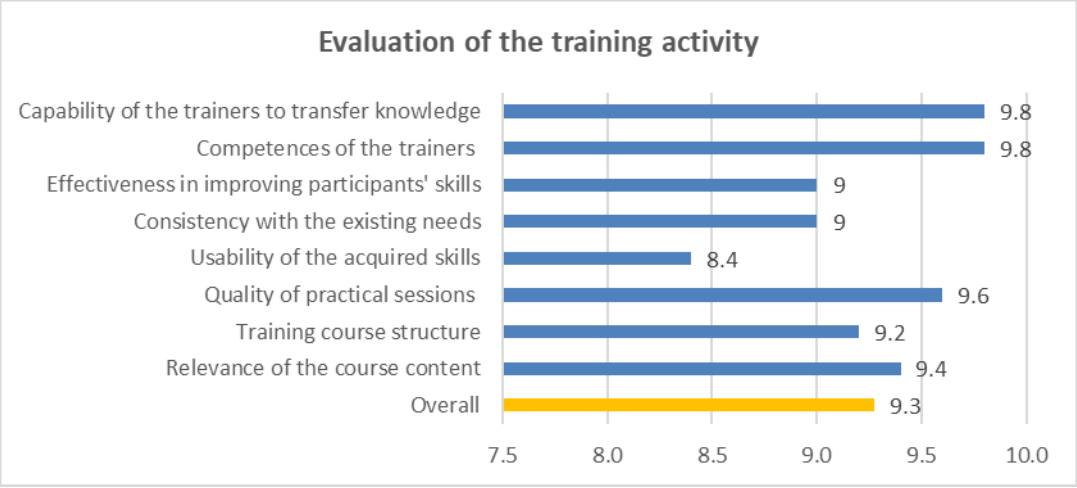

Fig. 4. Evaluation of the IFVCNS Training Activity. Average scores given by participants (0 = very poor; 10 = excellent) for different aspects of the course.

In the open-ended responses, several strengths of the course were highlighted. Participants appreciated how well the training was structured and organized; with strong scientific content. They found the trainers very qualified and appreciated their teaching and interaction method. They also appreciated that the training was supported with practical observations and examples from practice using up-to-date and applicable case studies. They also commended good time management of the sessions and found the training nice and attractive. However, the evaluation also pointed to a few areas needing improvement. The most frequently cited weakness was that the training was too short and that it should last two weeks, to allow for more lab work and thorough discussions. Hence, they found course too intensive, especially sessions regarding data analysis, with a lot of new information over a short period of time. They also noted that more practical sessions are needed, also more focused on practical aspects that can be immediately implemented in their respective universities. Finally, they suggested organizing future agricultural trainings that include the topic of sustainable agricultural practices, as countries in Africa and the Middle East are greatly affected by climate change.

2.4 Concluding remarks

We consider BREEDTECH student Training Workshop as successful in achieving its goals of capacity building and knowledge exchange in advanced plant breeding and biotechnology, as supported by scoring (Fig. 2 and Fig. 4). Importantly, many attendees expressed a strong interest in maintaining long-term engagement and research collaboration beyond the workshops. Students were talented, bright, and eager to learn. Nevertheless, the trainings were not without their challenges. Firstly, participation was hampered by travel restrictions, which limited the ability of some invited students to attend in person. This inevitably affected the diversity of perspectives and experiences represented during the sessions, and hindered the possibility for these students to participate in the program altogether. This means that students did not learn from the program, and that the program suffered for the lack of perspective brought about by students. Finally, we found that the communication between responsible staff at HEIs and students was not always optimal. Students lacked basic informations about the courses, even with regards to procedures for visa requests and travel planning. This resulted in several students missing the courses or part of the courses, especially at IFVCNS. We suggest that in future efforts HEI may organize student forums to discuss and organize the travels accordingly. Another challenge encountered is the lack of support in travel organization for participants. Students often times did not have credit cards and could not secure accommodations at SSSA and IFVCNS locations. This required project participants from host institutions to sometimes use their personal money to secure accommodation to students. This is because travel money was on the sending institutions rather than on the hosting institutions, and the latter could not work in securing accommodations and supporting in travel costs. We believe that the best course of action would have been to budget for a travel agent that could have helped in navigating in the complexities of travel arrangements. Besides budgeting travel agent, we also think that it is of utmost importance to initiate end execute student selection as early as possible, with also having in rooster more students than the number that is planned to be trained, as to be able to have replacement in the cases when some students either do net get visas or could not travel for other reasons. When planning and budgeting the trainings, hybrid format, at least for the theoretical parts, should be also considered, along with the options to record the lessons and demonstrations of the lab work. Addressing these challenges will be critical for enhancing the impact and relevance of future programs.

2.5 Way forward

To address the challenges encountered with participation, particularly those arising from travel restrictions and visa issues, we have organized a new training workshop, not originally planned, to be held in Sweden in June 2026. The training will be open to all HEIs and will be contributed by all EU partners of BREEDTECH. This upcoming event is designed to bring together both students and staff, and organize a blended training that is designed to provide a valuable opportunity for the two groups to interact, share perspectives, and collaborate directly. By fostering dialogue and cooperation between participants, the training aims to strengthen collective efforts toward achieving the broader objectives of the project and to promote sustained engagement across diverse backgrounds