



LEGATO

LEGumes for the Agriculture of TOMorrow

Collaborative project

Grant agreement no: 613551

SEVENTH FRAMEWORK PROGRAMME

THEME [KBBE.2013.1.2-02]

**[Legume breeding and management for sustainable
agriculture as well as protein supply for food and feed]**

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Training Course Report

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I. Report on the course

ADVANCES IN BREEDING AND AGRONOMY FOR IMPROVING SUSTAINABILITY AND QUALITY OF GRAIN LEGUME CROPS, Zaragoza (Spain), 16-20 October 2017

Interest of training

Legumes are among the most important sources of protein from plant origin, and key food components for achieving a balanced and healthy diet. Despite their beneficial attributes for human health, the consumption of legumes in Europe is very low, partly since many consumers are not aware of their high nutritive value and role in disease prevention.

Besides providing novel food and feed products, legume co-products can offer a further opportunity for increasing added-value. The European Union and other Mediterranean countries are major importers of legumes despite their potential for greatly increased production. N-fixing legumes can replace energy-costly nitrogen fertilizer inputs and decrease pathogen pressure in cropping systems. Thus, incorporating legumes in agroecosystems offers several benefits; for the environment, including reduced greenhouse gas emissions, and for the farmer by increasing the competitiveness of the value chain. The biodiversity of legumes also offers much potential for improving sustainability of agroecosystems and mitigating climate change, although challenges in the areas of yield stability, biotic and abiotic stress tolerance, persist. However, over the past decade several EU projects have addressed many of these issues, resulting in significant progress.

This multidisciplinary course was designed to cover the recent advances in disciplines related to increasing grain legume yield, cultivation and consumption.

By the end of the course, participants should:

- Understand the diversity and current status of legume cultivation including market opportunities.
- Be able to define key criteria for legume grain quality and take into account the use of co-products.
- Comprehend the mechanisms of legume-microbial interactions including biological nitrogen fixation.
- Better manage legumes in conventional and organic cropping systems with an emphasis on environmental sustainability.
- Be familiar with recent advances in application of genomics to breeding.
- Be aware of recent developments in legume breeding for yield, quality, and stress tolerance.
- Understand advanced methodologies for shoot and root phenotyping and their uses for breeding and enhancing plant performance.

Organization of the course

The course was jointly organized by the **International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)**, through the **Mediterranean Agronomic Institute of Zaragoza (IAMZ)**, and the **EU FP7 KBBE** research projects **LEGATO** (LEGumes for the Agriculture of TOmorrow) and **EUROLEGUME** (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed). The course took place at IAMZ and was given by well-qualified lecturers participating in these projects, coming from research centres and universities throughout Europe.

The course was held over a period of 1 week, from 16 to 20 October 2017, in morning and afternoon sessions.

Publicity leaflet

The publicity leaflet, containing the organizational aspects, the programme and the list of invited lecturers, is shown in **Annex 1**.

Participants

The course was designed for professionals with a university degree. It was intended for scientists interested in grain legumes with backgrounds in at least one of the following disciplines: agronomy, genetics, breeding, physiology. The course was also open to technical advisors and professionals from companies with these same qualifications.

Given the diverse nationalities of the lecturers, knowledge of English, French or Spanish was valued in the selection of candidates, since they were the working languages of the course. IAMZ provided simultaneous interpretation of the lectures in these three languages.

The deadline for the admission of applications was 16 June 2017.

A total number of 24 participants attended the full course, coming from 11 countries: Algeria (3), Austria (2), Chile (1), Egypt (1), Morocco (2), Palestine (1), Portugal (3), Spain (4), Tunisia (5) and Turkey (2).

Almost all the participants were already involved in the subject matter of the course, with previous experience in basic or applied research, working in universities, research centres or private companies. A list of participants is included in **Annex 2.1**, indicating country of origin, institution of employment and professional activity. Their complete work address can be found in **Annex 2.2**.

Annex 2.3 contains the grants awarded to participants by Legato and Eurolegume projects. 7 full scholarships were awarded covering registration fee payment, travel, full board accommodation and medical insurance. Legato project awarded 5 scholarships to participants from Algeria (2), Austria (1), Palestine (1) and Portugal (1). Eurolegume project awarded 2 scholarships to participants from Portugal. Also, Legato project awarded 7 scholarships covering only accommodation.

The orle and the group photograph of participants appear in **Annex 2.4** and **Annex 2.5** respectively.

Lecturers

A total number of 15 highly qualified lecturers from research centres, universities, associations and international centres in 8 different countries [Austria (1), France (5), Greece (1), Italy (2), Norway (1), Portugal (3), Spain (1) and Sweden (1)] took part in the course. The list of lecturers together with their full addresses figures in **Annex 3**.

Programme

The course was developed according to the programme and timetable shown in **Annex 4.1** and **Annex 4.2** with a total of 36 hours.

As a complement to the course, lecturers prepared documents, which were uploaded to our moodle platform, photocopied and distributed to participants. Also, participants were asked to present their own work/research results/activities through a poster presentation.

Evaluation of the course by participants and lecturers

A survey was conducted among participants and lecturers regarding the technical, pedagogical and organizational aspects of the course, the results of which are shown in **Annex 5.1** and **Annex 5.2**.

GLOBAL ASSESSMENT

Programme and lecturers

The programme followed what was foreseen either in theoretical or in practical sessions and the objectives were fully achieved. We had to readjust the time of one lecturer that had to share his talk with another one, but in the end he covered the two hours, as the second lecturer did not finally attend. Another lecturer gave his talk by video conference, since he could not travel to the course.

In the survey conducted among participants, the global score for the course was high (4.3 over 5), also valuing different aspects of the course with a good score, especially the organization (4.7). Replies concerning the benefit taken from the course for their professional activities were highly positive.

Participants have considered all topics included in the programme interesting. The time devoted to the topics was considered adequate in most cases. The time devoted to the practical sessions might have usefully been increased; this depended on the proposals made by lecturers, as commented by the scientific coordinator (SC) of the course. With the view to a possible new edition of the course, the SC underlined that too much time was spent on context and on the environmental benefits of legumes, and it would have been more useful to have had more interventions from breeders. Also the concerns of the lecturers who are researchers based in Northern or central Europe are different from those of the participants from Mediterranean countries. This issue has to be taken in consideration in the next edition.

In the participants' opinion, all lecturers provided adequate and good quality documentation (4.6).

The lecturers were given satisfactory appraisal. On average their presentations were considered to be of appropriate quality and the interaction with the participants was positively evaluated.

The level at which the topics were addressed was considered appropriate by the participants, with the exception of the lectures taught by J. Kreplak on "Advances in genomics and molecular tools". In this case the opinion among participants was divided.

Participants

In general, participants had a broad range of academic backgrounds and varied local environment. All participants were very motivated, which was immediately seen in the enthusiastic poster presentation. The vast majority were involved in breeding or genetic resource evaluation and exploitation, with very few having physiology, pathology, or agronomy backgrounds. Some participants benefited from active interactions with European or American laboratories, and could better position their research in an international context, whereas others were more isolated in this respect, and were able to profit from exchanges/contacts made during the course.


The degree of interaction between lecturers and participants and among the participants themselves was good.

Organization


Both lecturers and participants shared the opinion that the quality of the organization was very high. The collaboration of two projects, LEGATO and EUROLEGUME, in the organization of the course facilitated the development of a highly satisfactory activity, bringing together both material and human efforts in the development of a training programme of common interest for the countries of the Mediterranean region and other developing countries, enhancing scientific and technical knowledge and institutional and personal ties between professionals.

II. Annexes


Annex 1. Publicity of the course




CIHEAM
International Centre for Advanced
Mediterranean Agronomic Studies
Mediterranean Agronomic Institute of Zaragoza




LEGATO
LEgumes for the Agriculture of TOmorrow
LEGATO project - European Union





EUROLEGUME
2014-2017
EUROLEGUME project - European Union



Advanced Course

ADVANCES IN BREEDING AND AGRONOMY FOR IMPROVING SUSTAINABILITY AND QUALITY OF GRAIN LEGUME CROPS

Zaragoza (Spain), 16-20 October 2017

1. Objective of the course

Legumes are among the most important sources of protein from plant origin, and key food components for achieving a balanced and healthy diet. Despite their beneficial attributes for human health, the consumption of legumes in Europe is very low, partly since many consumers are not aware of their high nutritive value and role in disease prevention.

Besides providing novel food and feed products, legume co-products can offer a further opportunity for increasing added-value. The European Union and other Mediterranean countries are major importers of legumes despite their potential for greatly increased production. N-fixing legumes can replace energy-costly nitrogen fertilizer inputs and decrease pathogen pressure in cropping systems. Thus, incorporating legumes in agroecosystems offers several benefits: for the environment, including reduced greenhouse gas emissions, and for the farmer by increasing the competitiveness of the value chain. The biodiversity of legumes also offers much potential for improving sustainability of agroecosystems and mitigating climate change, although challenges in the areas of yield stability, biotic and abiotic stress tolerance, persist. However, over the past decade several EU projects have addressed many of these issues, resulting in significant progress.

This multidisciplinary course is designed to cover the recent advances in disciplines related to increasing grain legume yield, cultivation and consumption.

By the end of the course, participants will:

- Understand the diversity and current status of legume cultivation including market opportunities.
- Be able to define key criteria for legume grain quality and take into account the use of co-products.
- Comprehend the mechanisms of legume-microbial interactions including biological nitrogen fixation.
- Better manage legumes in conventional and organic cropping systems with an emphasis on environmental sustainability.
- Be familiar with recent advances in application of genomics to breeding.
- Be aware of recent developments in legume breeding for yield, quality, and stress tolerance.
- Understand advanced methodologies for shoot and root phenotyping and their uses for breeding and enhancing plant performance.

EU FP7 KBBE research projects LEGATO (LEgumes for the Agriculture of TOmorrow) and EUROLEGUME (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed). The course will take place at IAMZ and will be given by well-qualified lecturers participating in these projects, coming from research centres and universities throughout Europe.

The course will be held over a period of 1 week, from 16 to 20 October 2017, in morning and afternoon sessions.

3. Admission

The course is designed for 25 participants with a university degree. It is intended for scientists interested in grain legumes with backgrounds in at least one of the following disciplines: agronomy, genetics, breeding, physiology. The course is also open to technical advisors and professionals from companies with these same qualifications.

Given the diverse nationalities of the lecturers, knowledge of English, French or Spanish will be valued in the selection of candidates, since they will be the working languages of the course. IAMZ will provide simultaneous interpretation of the lectures in these three languages.

4. Registration

Application forms may be obtained from:

Instituto Agronómico Mediterráneo de Zaragoza
 Avenida de Montañana 1005, 50059 Zaragoza (Spain)
 Tel.: +34 976 716000 - Fax: +34 976 716001
 e-mail: iamz@iamz.ciheam.org
 Web: www.iamz.ciheam.org


Candidates should send the completed application form to the above address, accompanied by a detailed *curriculum vitae*, stating degree, diplomas, experience, professional activities, language knowledge and reasons for applying to the course. Copies of certificates should be enclosed with the application.

The deadline for the submission of applications is 16 June 2017. Applications from those candidates who cannot present their complete records when applying, or those requiring authorization to attend the course, may be accepted provisionally.

Selected participants will be exempt from payment of registration fees.

5. Scholarships

Candidates from CIHEAM member countries (Albania, Algeria, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Portugal, Spain, Tunisia and Turkey) and candidates participating in LEGATO and




CIHEAM
Instituto Agronómico Mediterráneo de Zaragoza
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E-mail: iamz@iamz.ciheam.org

See updated information at

www.iamz.ciheam.org

INFORMATION
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EUROLEGUME projects may apply for scholarships covering the cost of travel and full board accommodation in the Hall of Residence on the Aula Dei Campus.

Candidates from other countries who require financial support should apply directly to other national or international institutions.

6. Insurance

It is compulsory for participants to have medical insurance valid for Spain. Proof of insurance cover must be given at the beginning of the course. Those who so wish may participate in a collective insurance policy taken out by the IAMZ, upon payment of the stipulated sum.

7. Teaching organization

The course requires personal work and interaction among participants and with lecturers. The international characteristics of the course favour the exchange of experiences and points of view.

The course will be taught with a combination of lectures, practical sessions, case studies and discussions.

Participants will work in groups on several exercises that will allow them to put theory into practice, preparing and presenting a case study related to the insertion of legumes in cropping systems, getting acquainted with genome management tools and genome-enabled selection, and characterizing legume shoot and root architecture through image analysis.

Participants are asked to present their own work/research results/activities through a poster presentation, which will facilitate discussions with the lecturers of the course.

8. Programme

1. Overview (5 hours)
 - 1.1. Origin, biodiversity and genetic relationships of cultivated grain legumes
 - 1.2. Genetic resources of grain legumes: origin, collection, traditions, genetic clusters
 - 1.3. Diversity of growing regions and agricultural practices in Europe and the Mediterranean region
 - 1.4. Determining factors and limitations for legume grain yields and yield stability
 - 1.5. Food vs feed uses
 - 1.6. Market importance and trends
 - 1.7. Poster session and discussion
2. Quality of grain legumes and technological innovation in legume products and byproducts (2 hours)
 - 2.1. Nutritional quality of grain legumes
 - 2.1.1. Compounds affecting nutritional quality, health-beneficial properties, and organoleptic and processing qualities
 - 2.1.2. Evaluation and quantification of grain quality traits for human and animal consumption
 - 2.2. Innovative food products
 - 2.3. Added value of coproducts and residues from legumes
3. Advances in plant-microbial communities' interactions (2 hours)
 - 3.1. Rhizospheric partners and variety of interactions
 - 3.2. Feedback loop regulation: benefits for the plant nutrition
 - 3.2.1. Symbiont diversity and efficiency, and potential for inoculation
 - 3.2.2. Molecular characterization and selection of the best partners
 - 3.3. Innovative aspects of rhizobial inoculation *in situ*
4. Advances in agronomy (6 hours)
 - 4.1. Influence of management practices on legume crop yield and sustainability
 - 4.2. Agronomical systems involving grain legumes: benefits and challenges
 - 4.2.1. Crop rotations
 - 4.2.2. Intercropping and crop and variety mixtures
 - 4.3. Contribution of legumes to the environmental sustainability of agricultural systems
 - 4.3.1. Cover crops
 - 4.3.2. Legumes in organic cropping systems
 - 4.3.3. Legumes and climate change mitigation
 - 4.4. Group work on the insertion of legumes in cropping systems, assessing the benefit and advantages for the ecosystem (option 1)
5. Advances in breeding and genomics (5 hours)
 - 5.1. Advances in genomics and molecular tools
 - 5.1.1. Available genetic and genomic resources for pea and faba bean
 - 5.1.2. Pea gene expression atlas and pea genomic sequence exploitation
 - 5.1.3. Comparison of currently used genotyping methods and their applications in plant breeding
 - 5.1.4. Genomic selection
 - 5.1.5. Practical work on genome management tools and genome-enabled selection (option 2)
 - 5.2. Advances in breeding strategies for crop yield improvement
 - 5.2.1. Target regions and GxE interactions
 - 5.2.2. Global genetic resources: variation and exploitation
 - 5.2.3. Crop ideotypes
 - 5.2.4. Genomic selection: accuracy and incorporation in breeding schemes
 - 5.2.5. Other innovative breeding schemes (evolutionary, farmer-participatory, etc.)
 - 5.2.6. Breeding for specific utilizations: fodder, organic systems, intercropping
 - 5.2.7. Optimizing selection procedures (managed environments, trial designs, etc.)
 - 5.3. Advances in breeding for food and feed quality
 - 5.3.1. Importance of GxE interactions on grain legume quality
 - 5.3.2. Selection for quality traits in breeding programmes
6. New phenotyping methodologies, with emphasis on roots (5 hours)
 - 6.1. Image acquisition and treatment
 - 6.2. Associated tools
 - 6.3. Various platforms and their access
 - 6.4. Novel modelling approaches in phenotyping
 - 6.5. European and international initiatives and opportunities to join
 - 6.6. Practical group work on the characterization of legume shoot and root architecture through image analysis
7. Advances in plant adaptation to abiotic and biotic stresses (4 hours)
 - 7.1. Abiotic stresses
 - 7.1.1. Effect of the cropping system on managing environmental stresses
 - 7.1.2. Assessment of plant's response to abiotic stress including non-destructive imaging techniques
 - 7.1.3. Effect of abiotic stresses on the legume-rhizobia symbiosis
 - 7.1.4. Prediction of ideotypes adapted to withstand drought
 - 7.1.5. Identification of candidate genes and bacterial strains involved in the symbiotic plants' adaptation to abiotic stress
 - 7.2. Biotic stresses
 - 7.2.1. Effect of the cropping system on managing biotic stresses
 - 7.2.2. Novel and additional sources of resistance
 - 7.2.3. Identification and mapping of candidate genes for resistance
8. Final feedback from participants on the application of the course content to their own work (2 hours)

GUEST LECTURERS

P. ANNICCHIARICO, CREA-FLC, Lodi (Italy)
 A. BARROS, UTAD, Vila Real (Portugal)
 E.S. JENSEN, Swedish Univ. of Agricultural Sciences, Alnarp (Sweden)
 J. KREPLAK, INRA, Centre de Dijon (France)
 E. MUEL, Terres Inovia-Centre de Grignon, Thiverval-Grignon (France)
 N. NAZZICARI, CREA-FLC, Lodi (Italy)
 M. PRUDENT, INRA, Centre de Dijon (France)

B. REWALD, Institute of Forest Ecology, Vienna (Austria)
 E. ROSA, CITAB-UTAD, Vila Real (Portugal)
 D. RUBIALES, CSIC-IAS, Córdoba (Spain)
 A. TAMPAKAKI, Agricultural Univ. of Athens (Greece)
 R. THOMPSON, INRA, Centre de Dijon (France)
 C. SALON, INRA, Centre de Dijon (France)
 D. SAVVAS, Agricultural Univ. of Athens (Greece)
 I. VAAGEN, NIBIO, Grimstad (Norway)
 C. VAZ PATTO, ITQB, Univ. Nova de Lisboa (Portugal)





Curso Avanzado

AVANCES EN MEJORA GENÉTICA Y AGRONOMÍA PARA AUMENTAR LA SOSTENIBILIDAD Y LA CALIDAD DE LOS CULTIVOS DE LEGUMINOSAS DE GRANO

Zaragoza (España), 16-20 octubre 2017

1. Objetivo del curso

Las leguminosas son una de las fuentes más importantes de proteína vegetal y un componente clave para una dieta saludable y equilibrada. Sin embargo, a pesar de sus beneficios para la salud humana, el consumo de leguminosas en Europa es muy bajo, debido en parte al desconocimiento de los consumidores de su alto valor nutricional y de su papel en la prevención de enfermedades.

Los coproductos de las leguminosas, además de proporcionar nuevos alimentos y piensos, pueden suponer una oportunidad adicional de aumentar el valor añadido de este cultivo. La Unión Europea y otros países mediterráneos son grandes importadores de leguminosas a pesar del potencial que tienen para incrementar su propia producción. Las leguminosas fijadoras de nitrógeno pueden reemplazar el aporte de fertilizantes nitrogenados, reduciendo así el coste energético, y disminuir la presión de los patógenos sobre los sistemas de cultivo. De este modo, la incorporación de leguminosas en los agroecosistemas proporciona varios beneficios para el medioambiente, al reducir las emisiones de gases de efecto invernadero, y para el agricultor, al aumentar la competitividad de la cadena de valor. La biodiversidad de las leguminosas también supone una oportunidad importante para mejorar la sostenibilidad de los agroecosistemas y mitigar los efectos del cambio climático, aunque todavía persisten los retos de conseguir una mayor estabilidad del rendimiento y tolerancia al estrés biótico y abiótico. No obstante, en la última década varios proyectos de la UE han logrado progresos importantes en este sentido.

Este curso multidisciplinario se centra en los avances recientes en las disciplinas relacionadas con el aumento del rendimiento de las leguminosas de grano, del cultivo y del consumo.

Al final del curso, los participantes:

- Conocerán la diversidad y el estado actual del cultivo de las leguminosas, así como las oportunidades de mercado.
- Serán capaces de definir criterios claves para la calidad de las leguminosas de grano y tener en cuenta la utilización de coproductos.
- Comprenderán los mecanismos de las interacciones leguminosa-microorganismos y la fijación de nitrógeno biológico.
- Estarán capacitados para mejorar el manejo de las leguminosas en sistemas convencionales y ecológicos de cultivo, con énfasis en la sostenibilidad ambiental.
- Estarán familiarizados con los últimos avances en la aplicación de la genómica a la mejora.
- Conocerán los recientes desarrollos en mejora de leguminosas para rendimiento, calidad y tolerancia al estrés.
- Entenderán las metodologías avanzadas para el fenotipo de tallos y raíces y su utilización para mejora genética y potenciación del rendimiento de la planta.

2. Organización

El curso está organizado conjuntamente por el Centro Internacional de Altos Estudios Agronómicos Mediterráneos (CIHEAM), a través



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CIHEAM

del Instituto Agronómico Mediterráneo de Zaragoza (IAMZ), y los proyectos de investigación de la UE FP7 KBBE LEGATO (LEGumes for the Agriculture of TOMorrow) y EUROLEGUME (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed). El curso se celebrará en el Instituto Agronómico Mediterráneo de Zaragoza, con profesores de reconocida experiencia que participan en estos proyectos, procedentes de centros de investigación y universidades de Europa.

El curso tendrá una duración de 1 semana y se desarrollará, en horario de mañana y tarde, del 16 al 20 de octubre de 2017.

3. Admisión

El curso está previsto para 25 participantes con titulación universitaria. Está dirigido a científicos interesados en leguminosas de grano, con formación en al menos una de las disciplinas siguientes: agronomía, genética, mejora genética o fisiología. El curso también está abierto a asesores técnicos y profesionales de empresas con las mismas cualificaciones. Dada la diversa nacionalidad de los conferenciantes, en la selección de candidatos se valorarán los conocimientos de inglés, francés o español, que serán los idiomas de trabajo del curso. El IAMZ facilitará la interpretación simultánea de las conferencias en estos tres idiomas.

4. Inscripción

Las solicitudes deberán cursarse a:

Instituto Agronómico Mediterráneo de Zaragoza
Avenida de Montañana 1005, 50059 Zaragoza (España)
Tel: +34 976 716000 - Fax: +34 976 716001
e-mail: iamz@iamz.ciheam.org
Web: www.iamz.ciheam.org

Junto con el formulario de solicitud de admisión, deberá adjuntarse el *curriculum vitae* detallado, en el que figure, debidamente acreditado, titulación, experiencia, actividades profesionales, conocimiento de idiomas y motivo por el cual se desea realizar el curso.

El plazo de admisión de solicitudes finaliza el 16 de junio de 2017.

Los candidatos que no puedan presentar sus expedientes completos al efectuar la solicitud, o que deban obtener autorización previa para participar en el curso, podrán ser admitidos a título provisional.

Los participantes seleccionados estarán exentos del pago de los derechos de inscripción.

5. Becas

Los candidatos de los países miembros del CIHEAM (Albania, Argelia, Egipto, España, Francia, Grecia, Italia, Líbano, Malta, Marruecos, Portugal, Túnez y Turquía) y los candidatos que participan en los

Ver información actualizada en

www.iamz.ciheam.org

MIRE EL REVERSO PARA
CONSULTAR EL RESTO
DE LA INFORMACIÓN



proyectos LEGATO y EUROLEGUME podrán solicitar becas que cubran los gastos de viaje y de estancia en la Residencia del Campus de Aula Dei en régimen de pensión completa.

Los candidatos de otros países interesados en disponer de financiación deberán solicitarla directamente a otras instituciones nacionales o internacionales.

6. Seguros

Será obligatorio que los participantes acrediten, al inicio del curso, estar en posesión de un seguro de asistencia sanitaria válido para España. La organización ofrece, a aquellos participantes que lo soliciten, la posibilidad de suscribirse a una póliza colectiva, previo pago de la cantidad estipulada.

7. Organización pedagógica

El curso exigirá a los participantes un trabajo personal y una participación activa. Las características internacionales del curso favorecen el intercambio de experiencias y puntos de vista.

Las clases se complementarán con sesiones prácticas, estudios de casos y debates.

Los participantes trabajarán en grupos sobre varios ejercicios que les permitirán aplicar la teoría a la práctica. Prepararán y presentarán un estudio de caso relacionado con la inclusión de leguminosas en sistemas de cultivo, se familiarizarán con las herramientas genómicas y la selección genómica, y caracterizarán la arquitectura de tallos y raíces mediante análisis de imágenes.

Se solicitará a los participantes que presenten los resultados de su propio trabajo o investigación en formato póster para facilitar la discusión con los conferenciantes del curso.

8. Programa

1. Visión general (5 horas)
 - 1.1. Origen, biodiversidad y relaciones genéticas de leguminosas de grano cultivadas
 - 1.2. Recursos genéticos de leguminosas de grano: origen, recolección, tradiciones, clústeres genéticos
 - 1.3. Diversidad de regiones de cultivo y de prácticas agrícolas en Europa y la región mediterránea
 - 1.4. Factores determinantes y limitaciones para el rendimiento en grano de las leguminosas y la estabilidad del rendimiento
 - 1.5. Usos para alimentos vs. piensos
 - 1.6. Importancia en el mercado y tendencias
 - 1.7. Sesión de pósters y debate
2. Calidad de las leguminosas de grano e innovación tecnológica en productos y subproductos de leguminosas (2 horas)
 - 2.1. Calidad nutricional de las leguminosas de grano
 - 2.1.1. Compuestos que afectan a la calidad nutricional, las propiedades beneficiosas para la salud y las cualidades organolépticas y de procesamiento
 - 2.1.2. Evaluación y cuantificación de caracteres de calidad del grano para el consumo humano y animal
 - 2.2. Productos alimentarios innovadores
 - 2.3. Valor añadido de coproductos y residuos de leguminosas
3. Avances en las interacciones entre la planta y las comunidades de microorganismos (2 horas)
 - 3.1. Socios rizosféricos y variedad de interacciones
 - 3.2. Regulación del bucle de retroalimentación: beneficios para la nutrición de la planta
 - 3.2.1. Diversidad de simbiotes y eficiencia. Potencial para la inoculación
 - 3.2.2. Caracterización molecular y selección de los mejores socios
- 3.3. Aspectos innovadores de la inoculación con *rhizobium in situ*
4. Avances agronómicos (6 horas)
 - 4.1. Influencia de las prácticas de gestión en el rendimiento y la sostenibilidad del cultivo de leguminosas
 - 4.2. Sistemas agronómicos que incluyen leguminosas de grano: beneficios y retos
 - 4.2.1. Rotaciones de cultivo
 - 4.2.2. Cultivos intercalados y cultivos mixtos de diferentes especies o variedades
 - 4.3. Aportación de las leguminosas a la sostenibilidad ambiental de los sistemas agrícolas
 - 4.3.1. Cultivos de cobertura
 - 4.3.2. Leguminosas en sistemas de cultivos ecológicos
 - 4.3.3. Leguminosas y mitigación del cambio climático
 - 4.4. Trabajo de grupo sobre la inclusión de leguminosas en sistemas de cultivo, evaluando el beneficio y las ventajas para el ecosistema (opción 1)
5. Avances en mejora y genómica (5 horas)
 - 5.1. Avances en genómica y herramientas moleculares
 - 5.1.1. Recursos genéticos y genómicos disponibles para guisante y haba
 - 5.1.2. Atlas de expresión génica del guisante y explotación de la secuencia genómica del guisante
 - 5.1.3. Comparación de los métodos de genotipado utilizados en la actualidad y sus aplicaciones en la mejora genética vegetal
 - 5.1.4. Selección genómica
 - 5.1.5. Trabajo práctico sobre herramientas genómicas y selección genómica (opción 2)
 - 5.2. Avances en estrategias de mejora para incrementar el rendimiento del cultivo
 - 5.2.1. Regiones objetivo e interacciones GxE
 - 5.2.2. Recursos genéticos globales: variación y explotación
 - 5.2.3. Ideotipos de cultivo
 - 5.2.4. Selección genómica: exactitud e incorporación en programas de mejora
 - 5.2.5. Otros esquemas innovadores de mejora (evolutivos, participativos, etc.)
 - 5.2.6. Mejora para usos específicos: forraje, sistemas ecológicos, cultivos intercalados
 - 5.2.7. Optimización de procedimientos de selección (ambientes controlados, diseños de ensayos, etc.)
 - 5.3. Avances en la mejora para la calidad de alimentos y piensos
 - 5.3.1. Importancia de las interacciones GxE en la calidad de las leguminosas de grano
 - 5.3.2. Selección para caracteres de calidad en programas de mejora
6. Nuevas metodologías de fenotipado, con énfasis en raíces (5 horas)
 - 6.1. Adquisición y tratamiento de imágenes
 - 6.2. Herramientas asociadas
 - 6.3. Las diversas plataformas y cómo acceder a ellas
 - 6.4. Nuevos enfoques de modelización en fenotipado
 - 6.5. Iniciativas europeas e internacionales y oportunidades para unirse a ellas
 - 6.6. Trabajo práctico de grupo sobre la caracterización de la arquitectura de tallos y raíces mediante análisis de imágenes
7. Avances en la adaptación de la planta al estrés abiótico y biótico (4 horas)
 - 7.1. Factores de estrés abiótico
 - 7.1.1. Efecto del sistema de cultivo sobre el manejo del estrés ambiental
 - 7.1.2. Evaluación de la respuesta de la planta al estrés abiótico, incluyendo técnicas de imagen no destructivas
 - 7.1.3. Efecto del estrés abiótico sobre la simbiosis leguminosa-rhizobium
 - 7.1.4. Predicción de ideotipos adaptados para resistir la sequía
 - 7.1.5. Identificación de genes candidatos y cepas bacterianas que contribuyen a la adaptación de la planta simbiótica al estrés abiótico
 - 7.2. Factores de estrés biótico
 - 7.2.1. Efecto del sistema de cultivo sobre el manejo del estrés biótico
 - 7.2.2. Fuentes nuevas y adicionales de resistencia
 - 7.2.3. Identificación y cartografía de genes candidatos para resistencia
8. Discusión final con los participantes sobre la aplicación del contenido del curso a su propio trabajo (2 horas)

CONFERENCIANTES INVITADOS

P. ANNICCHIARICO, CREA-FLC, Lodi (Italia)
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 E.S. JENSEN, Swedish Univ. of Agricultural Sciences, Alnarp (Suecia)
 J. KREPLAK, INRA, Centre de Dijon (Francia)
 E. MUEL, Terres Inovia-Centre de Grignon, Thiverval-Grignon (Francia)
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 D. RUBIALES, CSIC-IAS, Córdoba (España)
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 R. THOMPSON, INRA, Centre de Dijon (Francia)
 C. SALON, INRA, Centre de Dijon (Francia)
 D. SAVVAS, Agricultural Univ. of Athens (Grecia)
 I. VAAGEN, NIBIO, Grimstad (Noruega)
 C. VAZ PATTO, ITQB, Univ. Nova de Lisboa (Portugal)





Cours Approfondi

PROGRÈS EN AMÉLIORATION GÉNÉTIQUE ET AGRONOMIE POUR ACCROÎTRE LA DURABILITÉ ET LA QUALITÉ DE LA CULTURE DES LÉGUMINEUSES À GRAINES

Zaragoza (Espagne), 16-20 octobre 2017

1. Objectif du cours

Les légumineuses sont une des plus importantes sources de protéines d'origine végétale, et sont des constituants essentiels pour une alimentation saine et équilibrée. Cependant, malgré leurs attributs favorables à la santé humaine, les légumineuses sont très peu consommées en Europe, en partie parce qu'un grand nombre de consommateurs ne sont pas conscients de leur forte valeur nutritive et de leur rôle pour la prévention de maladies.

Tout en apportant de nouveaux produits pour la consommation humaine et animale, les co-produits des légumineuses peuvent présenter une opportunité supplémentaire d'augmenter la valeur ajoutée de cette culture. L'Union européenne ainsi que d'autres pays méditerranéens sont de grands importateurs de légumineuses bien que possédant le potentiel pour accroître fortement leur production. Les légumineuses fixatrices d'azote peuvent remplacer les apports d'engrais azotés, coûteux en énergie, et diminuer la pression des pathogènes dans les systèmes culturaux. Ainsi l'introduction des légumineuses dans les agroécosystèmes permet plusieurs bénéfices : pour l'environnement, en réduisant les émissions de gaz à effet de serre entre autres, et pour l'agriculteur, en augmentant la compétitivité de la chaîne de valeur. La biodiversité des légumineuses offre aussi un grand potentiel pour améliorer la durabilité des agroécosystèmes et atténuer le changement climatique, bien que des défis persistent encore dans le domaine de la stabilité du rendement et de la tolérance aux stress biotiques et abiotiques. Toutefois, sur ces dix dernières années, plusieurs projets de l'UE se sont penchés sur nombre de ces questions, débouchant sur des progrès significatifs.

Ce cours multidisciplinaire vise à présenter les progrès récents dans des disciplines débouchant sur l'accroissement du rendement, de la culture et de la consommation des légumineuses à graines.

À l'issue du cours, les participants :

- Connaîtront la diversité et l'état des lieux de la culture des légumineuses y compris les opportunités de marché.
- Seront en mesure de définir les critères clés pour la qualité des légumineuses à graines et de prendre en compte l'utilisation des co-produits.
- Comprendront les mécanismes des interactions entre légumineuses et organismes microbiens, parmi lesquels la fixation biologique de l'azote.
- Pourront mettre en place une meilleure conduite des légumineuses dans les systèmes culturaux conventionnels et biologiques en particulier dans le sens de la durabilité environnementale.
- Seront familiarisés avec les derniers progrès en matière d'application de la génomique à l'amélioration génétique.
- Seront conscients des développements récents en amélioration génétique des légumineuses pour le rendement, la qualité, et la tolérance au stress.
- Comprendront les méthodologies avancées pour le phénotypage des tiges et racines et leurs utilisations pour l'amélioration génétique et pour de meilleures performances des plantes.

2. Organisation

Le cours est organisé conjointement par le Centre International de Hautes Etudes Agronomiques Méditerranéennes (CIHEAM), à travers



CIHEAM

Instituto Agronómico Mediterráneo de Zaragoza
Avenida de Montañana 1005, 50059 Zaragoza, Espagne.
Tel : +34 976 716000, Fax : +34 976 716001
E-mail : iamz@iamz.ciheam.org

l'Institut Agronomique Méditerranéen de Zaragoza (IAMZ), et par les projets de recherche UE FP7-KBBE LEGATO (LEGumes for the Agriculture of Tomorrow) et EUROLEGUME (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed). Le cours aura lieu à l'Institut Agronomique Méditerranéen de Zaragoza, avec des enseignants hautement qualifiés participant à ces projets, provenant de centres de recherche et d'universités d'Europe.

Le cours, d'une durée d'une semaine, se déroulera du 16 au 20 octobre 2017, les séances ayant lieu matin et après-midi.

3. Admission

Le cours est prévu pour un maximum de 25 participants diplômés de l'enseignement universitaire. Il s'adresse aux scientifiques s'intéressant aux légumineuses à graines et ayant une formation au moins dans l'une des disciplines suivantes : agronomie, génétique, amélioration génétique, physiologie. Le cours est également ouvert aux conseillers techniques et professionnels de compagnies possédant ces mêmes qualifications.

Étant donné les diverses nationalités des conférenciers, lors de la sélection des candidats il sera tenu compte de la connaissance de l'anglais, du français ou de l'espagnol, qui seront les langues de travail du cours. L'IAMZ assurera l'interprétation simultanée des conférences dans ces trois langues.

4. Inscription

Les demandes d'admission devront être adressées à :

Instituto Agronómico Mediterráneo de Zaragoza
Avenida de Montañana 1005, 50059 Zaragoza (Espagne)
Tel : +34 976 716000 - Fax : +34 976 716001
e-mail : iamz@iamz.ciheam.org
Web : www.iamz.ciheam.org

Le formulaire de demande d'admission devra être accompagné d'un *curriculum vitae* détaillé où doivent figurer, dûment justifiés, les diplômes, l'expérience, les activités professionnelles, les connaissances linguistiques ainsi que les raisons motivant la candidature à ce cours.

Les dossiers devront être envoyés avant le 16 juin 2017.

Les candidatures des personnes ne pouvant présenter leur dossier complet lorsqu'elles effectueront la demande, ou devant obtenir une autorisation pour suivre le cours, pourront être admises à titre provisoire.

Les participants sélectionnés seront exemptés du paiement des droits d'inscription.

5. Bourses

Les candidats de pays membres du CIHEAM (Albanie, Algérie, Égypte, Espagne, France, Grèce, Italie, Liban, Malte, Maroc, Portugal, Tunisie et Turquie) ainsi que les candidats participant aux projets LEGATO et EUROLEGUME pourront solliciter des bourses couvrant voyage et séjour en régime de pension complète à la Résidence du Campus d'Aula Dei.

Voir information actualisée sur

www.iamz.ciheam.org

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L'INFORMATION



Les candidats d'autres pays souhaitant bénéficier d'un financement devront le demander directement à d'autres institutions nationales ou internationales.

6. Assurances

Les participants devront justifier obligatoirement, dès le début du cours, qu'ils sont en possession d'une assurance médicale qui couvre l'Espagne. L'IAMZ peut offrir aux participants qui en feront la demande, la possibilité de souscrire une police d'assurance collective moyennant au préalable le paiement de la somme fixée.

7. Organisation pédagogique

Le cours exigera des participants un travail personnel et une participation active. Le caractère international du cours contribue à apporter des expériences et des points de vue divers, ce qui enrichit le programme du cours. Le cours s'appuiera sur une combinaison de conférences, sessions pratiques, études de cas et débats.

Les participants travailleront en groupes sur plusieurs exercices qui leur permettront la mise en pratique de la théorie. Ils prépareront et présenteront une étude de cas liée à l'insertion des légumineuses dans les systèmes culturaux, se familiariseront avec les outils de gestion du génome et la sélection génomique, et caractériseront l'architecture des tiges et racines des légumineuses à travers l'analyse d'images.

Les participants seront invités à présenter leurs activités ou les résultats de leur propre travail ou recherche à travers des posters, ce qui facilitera les discussions avec les conférenciers du cours.

8. Programme

1. Aperçu (5 heures)
 - 1.1. Origine, biodiversité et relations génétiques des légumineuses à graines cultivées
 - 1.2. Ressources génétiques des légumineuses à graines : origine, collecte, traditions, clusters génétiques
 - 1.3. Diversité des régions productrices et des pratiques agricoles en Europe et dans la région méditerranéenne
 - 1.4. Facteurs déterminants et limitations pour le rendement en graines des légumineuses et pour la stabilité de la production
 - 1.5. Utilisations en alimentation humaine vs alimentation animale
 - 1.6. Importance sur les marchés et tendances
 - 1.7. Session de posters et débat
2. Qualité des légumineuses à graines et innovation technologique liée aux produits et sous-produits des légumineuses (2 heures)
 - 2.1. Qualité nutritionnelle des légumineuses à graines
 - 2.1.1. Composés affectant la qualité nutritionnelle, les propriétés santé, et les qualités organoleptiques et de transformation
 - 2.1.2. Évaluation et quantification des caractères de qualité des graines pour la consommation humaine et animale
 - 2.2. Produits alimentaires innovants
 - 2.3. Valeur ajoutée des co-produits et résidus de légumineuses
3. Progrès liés aux interactions entre plantes et communautés microbiennes (2 heures)
 - 3.1. Partenaires rhizosphériques et variété des interactions
 - 3.2. Régulation des boucles de rétroalimentation : bénéfices pour la nutrition de la plante
 - 3.2.1. Diversité des symbiotes et efficacité, et potentiel pour l'inoculation
 - 3.2.2. Caractérisation moléculaire et sélection des meilleurs partenaires
 - 3.3. Aspects innovants de l'inoculation rhizobiale *in situ*
4. Progrès en agronomie (6 heures)
 - 4.1. Influence des pratiques de gestion sur le rendement et la durabilité de la culture de légumineuses
 - 4.2. Systèmes agronomiques où interviennent les légumineuses à graines : bénéfices et défis

- 4.2.1. Rotations de cultures
- 4.2.2. Cultures intercalaires et cultures mixtes de différentes espèces ou variétés
- 4.3. Contribution des légumineuses à la durabilité environnementale des systèmes agricoles
 - 4.3.1. Cultures de couverture
 - 4.3.2. Légumineuses dans les systèmes culturaux biologiques
 - 4.3.3. Légumineuses et atténuation du changement climatique
- 4.4. Travail de groupe sur l'insertion des légumineuses dans les systèmes culturaux, en évaluant les bénéfices et avantages pour l'écosystème (option 1)
5. Progrès en amélioration et génomique (5 heures)
 - 5.1. Progrès en génomique et outils moléculaires
 - 5.1.1. Ressources génétiques et génomiques disponibles pour le pois et la fève/ole
 - 5.1.2. Atlas d'expression des gènes du pois et exploitation des séquences génomiques du pois
 - 5.1.3. Comparaison des méthodes de génotypage utilisées actuellement et applications en amélioration
 - 5.1.4. Sélection génomique
 - 5.1.5. Travail pratique sur les outils de gestion du génome et la sélection génomique (option 2)
 - 5.2. Progrès des stratégies d'amélioration pour un meilleur rendement des cultures
 - 5.2.1. Régions-cibles et interactions GxE
 - 5.2.2. Ressources génétiques globales : variation et exploitation
 - 5.2.3. Idéotypes de cultures
 - 5.2.4. Sélection génomique : exactitude et incorporation dans les programmes d'amélioration
 - 5.2.5. Autres schémas d'amélioration innovants (évolutifs, participatifs, etc.)
 - 5.2.6. Amélioration pour des utilisations spécifiques : fourrage, systèmes biologiques, cultures intercalaires
 - 5.2.7. Optimisation des procédures de sélection (environnements sous gestion, conception d'essais, etc.)
 - 5.3. Progrès en amélioration pour la qualité en alimentation humaine et animale
 - 5.3.1. Importance des interactions GxE sur la qualité des légumineuses à graines
 - 5.3.2. Sélection pour les caractères de qualité dans les programmes d'amélioration
6. Nouvelles méthodologies de phénotypage, avec une attention particulière aux racines (5 heures)
 - 6.1. Acquisition et traitement d'images
 - 6.2. Outils associés
 - 6.3. Les diverses plates-formes et leur accès
 - 6.4. Nouvelles approches de modélisation en phénotypage
 - 6.5. Initiatives européennes et internationales et possibilités d'y adhérer
 - 6.6. Travail pratique de groupe sur la caractérisation de l'architecture des tiges et racines de légumineuses à travers l'analyse d'images
7. Progrès en adaptation des plantes aux stress abiotiques et biotiques (4 heures)
 - 7.1. Stress abiotique
 - 7.1.1. Effet du système cultural sur la gestion des stress environnementaux
 - 7.1.2. Évaluation de la réponse de la plante aux stress abiotiques, avec des techniques d'imagerie non destructives
 - 7.1.3. Effet des stress abiotiques sur la symbiose légumineuses-Rhizobium
 - 7.1.4. Prédiction des idéotypes adaptés pour supporter la sécheresse
 - 7.1.5. Identification de gènes candidats et de souches bactériennes intervenant dans l'adaptation symbiotique des plantes aux stress abiotiques
 - 7.2. Stress biotique
 - 7.2.1. Effet du système cultural sur la gestion des stress biotiques
 - 7.2.2. Sources nouvelles et additionnelles de résistance
 - 7.2.3. Identification et cartographie de gènes candidats pour la résistance
8. Discussion finale avec les participants sur l'application à leur propre travail du contenu du cours (2 heures)

CONFÉRENCIERS INVITÉS

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 E. MUEL, Terres Inovia-Centre de Grignon, Thiverval-Grignon (France)
 N. NAZZICARI, CREA-FLC, Lodi (Italie)
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 C. VAZ PATTO, ITQB, Univ. Nova de Lisboa (Portugal)



2.5 Group photograph



Annex 4. Programme

4.1. Course programme

ADVANCES IN BREEDING AND AGRONOMY FOR IMPROVING SUSTAINABILITY AND QUALITY OF GRAIN LEGUME CROPS

Zaragoza (Spain), 16-20 October 2017

PROGRAMME

- 1. Overview (2 hours lectures + 3 hours poster session and discussion)**
 - 1.1. Origin, biodiversity and genetic relationships of cultivated grain legumes (1.1 to 1.3: 1 h) (E. Rosa)
 - 1.2. Genetic resources of grain legumes: origin, collection, traditions, genetic clusters (E. Rosa)
 - 1.3. Diversity of growing regions and agricultural practices in Europe and the Mediterranean region (E. Rosa)
 - 1.4. Determining factors and limitations for legume grain yields and yield stability (1.4 to 1.6: 1 h) (F. Muel)
 - 1.5. Food vs feed uses (F. Muel)
 - 1.6. Market importance and trends (F. Muel)
 - 1.7. Poster session and discussion (3 h) (E. Rosa, R. Thompson, I. Vaagen, M. Rodrigues)
- 2. Quality of grain legumes and technological innovation in legume products and byproducts (2 hours)**
 - 2.1. Nutritional quality of grain legumes (1 h) (I. Vaagen)
 - 2.1.1. Compounds affecting nutritional quality, health-beneficial properties, and organoleptic and processing qualities
 - 2.1.2. Evaluation and quantification of grain quality traits for human and animal consumption
 - 2.2. Innovative food products (2.2 and 2.3: 1 h) (M. Rodrigues)
 - 2.3. Added value of coproducts and residues from legumes (M. Rodrigues)
- 3. Advances in plant-microbial communities' interactions (2 hours) (A. Tampakaki)**
 - 3.1. Rhizospheric partners and variety of interactions
 - 3.2. Feedback loop regulation: benefits for the plant nutrition
 - 3.2.1. Symbiont diversity and efficiency, and potential for inoculation
 - 3.2.2. Molecular characterization and selection of the best partners
 - 3.3. Innovative aspects of rhizobial inoculation *in situ*
- 4. Advances in agronomy (2 hours lectures + 4 hours practicals) (E.S. Jensen)**
 - 4.1. Influence of management practices on legume crop yield and sustainability
 - 4.2. Agronomical systems involving grain legumes: benefits and challenges
 - 4.2.1. Crop rotations
 - 4.2.2. Intercropping and crop and variety mixtures
 - 4.3. Contribution of legumes to the environmental sustainability of agricultural systems
 - 4.3.1. Cover crops
 - 4.3.2. Legumes in organic cropping systems
 - 4.3.3. Legumes and climate change mitigation
 - 4.4. Group work on the insertion of legumes in cropping systems, assessing the benefit and advantages for the ecosystem (option 1) (3 h group work + 1 h presentation of results) (E.S. Jensen, E. Rosa, B. Rewald, I. Vaagen)

- 5. Advances in breeding and genomics (2 hours lectures + 3 hours practicals)**
 - 5.1. Advances in genomics and molecular tools (2 h) (J. Kreplak, N. Nazzicari)
 - 5.1.1. Available genetic and genomic resources for pea and faba bean
 - 5.1.2. Pea gene expression atlas and pea genomic sequence exploitation
 - 5.1.3. Comparison of currently used genotyping methods and their applications in plant breeding
 - 5.1.4. Genomic selection
 - 5.1.5. Practical work on genome management tools and genome-enabled selection (option 2) (3 h)
 - 5.2. Advances in breeding strategies for crop yield improvement (2 h) (P. Annicchiarico)
 - 5.2.1. Target regions and GxE interactions
 - 5.2.2. Global genetic resources: variation and exploitation
 - 5.2.3. Crop ideotypes
 - 5.2.4. Genomic selection: accuracy and incorporation in breeding schemes
 - 5.2.5. Other innovative breeding schemes (evolutionary, farmer-participatory, etc.)
 - 5.2.6. Breeding for specific utilizations: fodder, organic systems, intercropping
 - 5.2.7. Optimizing selection procedures (managed environments, trial designs, etc.)
 - 5.3. Advances in breeding for food and feed quality (2 h) (C. Vaz Patto)
 - 5.3.1. Importance of GxE interactions on grain legume quality
 - 5.3.2. Selection for quality traits in breeding programmes
- 6. New phenotyping methodologies, with emphasis on roots (2 hours lectures + 3 hours practicals)** (B. Rewald, C. Salon)
 - 6.1. Image acquisition and treatment
 - 6.2. Associated tools
 - 6.3. Various platforms and their access
 - 6.4. Novel modelling approaches in phenotyping
 - 6.5. European and international initiatives and opportunities to join
 - 6.6. Practical group work on the characterization of legume shoot and root architecture through image analysis (3 h)
- 7. Advances in plant adaptation to abiotic and biotic stresses (4 hours)**
 - 7.1. Abiotic stresses (2 h) (M. Prudent)
 - 7.1.1. Effect of the cropping system on managing environmental stresses
 - 7.1.2. Assessment of plant's response to abiotic stress including non-destructive imaging techniques
 - 7.1.3. Effect of abiotic stresses on the legume-rhizobia symbiosis
 - 7.1.4. Prediction of ideotypes adapted to withstand drought
 - 7.1.5. Identification of candidate genes and bacterial strains involved in the symbiotic plants' adaptation to abiotic stress
 - 7.2. Biotic stresses (2 h) (D. Rubiales)
 - 7.2.1. Effect of the cropping system on managing biotic stresses
 - 7.2.2. Novel and additional sources of resistance
 - 7.2.3. Identification and mapping of candidate genes for resistance
- 8. Final feedback from participants on the application of the course content to their own work (2 hours)** (C. Vaz Patto, M. Prudent, D. Rubiales, I. Vaagen)

4.2. Course timetable

ADVANCES IN BREEDING AND AGRONOMY FOR IMPROVING SUSTAINABILITY AND QUALITY OF GRAIN LEGUME CROPS – Zaragoza (Spain), 16-20 October 2017

Hour	Monday 16	Tuesday 17	Wednesday 18	Thursday 19	Friday 20
9:00-10:00	Opening	Innovative food products. Added value of co-products and residues from legumes M. Rodrigues	Advances in breeding strategies for crop yield improvement P. Annicchiarico	Advances in breeding for food and feed quality C. Vaz Patto	Advances in plant adaptation to abiotic stresses M. Prudent
10:00-11:00	Origin, biodiversity and genetic relationships of cultivated grain legumes E. Rosa	Discussion based on posters' information E. Rosa, R. Thompson, I. Vaagen, M. Rodrigues	Coffee break		
11:30-12:30	Determining factors and limitations for legume grain yields and yield stability. Food vs feed uses. Market importance and trends F. Muel	Advances in agronomy E.S. Jensen (Video Conference)	Group work on insertion of legumes in cropping systems E.S. Jensen, E. Rosa, B. Rewald, I. Vaagen	New phenotyping methodologies, with emphasis on roots B. Rewald, C. Salon	Advances in plant adaptation to biotic stresses D. Rubiales
12:30-13:30	Nutritional quality of grain legumes I. Vaagen	Lunch break			
15:00-16:00	Advances in plant-microbial communities' interactions A. Tampakaki	Advances in genomics and molecular tools J. Kreplak, N. Nazzicari	Group work on insertion of legumes in cropping systems Group work on insertion of legumes in cropping systems Presentation of results E.S. Jensen, E. Rosa, B. Rewald, I. Vaagen	Practical work on genomics tools J. Kreplak, N. Nazzicari	Final feedback from participants on the application of the course content to their own work C. Vaz Patto, M. Prudent, D. Rubiales, I. Vaagen, C. Salon
16:00-17:00	Practical group work on the characterization of legume shoot and root architecture through image analysis B. Rewald, C. Salon				
17:00-18:00	Poster session				
18:00-19:00					