National Research Council
Institute of Agro-Environmental and Forest Biology

Eurochestnut Network
Thematic group Climate Change

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Group members
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Anthropogenic Climate Change (ACC)

Environmental effects

- Rising of CO_2 concentration
- Increase of average temperature and winter warming
- Changes in precipitation regimes
- Increased frequency of drought events
- Increased frequency of extreme meteorological events and fires (storms, heavy rains, heatwaves)

Impact of ACC on plants of temperate zones

- General advancement of spring phenology
- Longer growing season
- Reduced winter chilling
- Increased asynchrony between plants and associated species (herbivores, pollinators)
- Increased frequency of stress events (drought + heat)
- Migration and contraction of optimal geographic range
- Spreading of exotic and invasive species

These effects are already occurring and are expected to enhance
In the next decades

Experimental evidence of impacts on chestnut

Advancement of phenology

Long term study (1963-2008) on phenology of *Castanea mollissima* in China.
Advancement of flowering date and expansion of growing season (Guo et al. 2013).

Mitigation of climate change by American chestnut

Study on the **carbon sequestration** capacity of ***Castanea dentata*** (American chestnut)
American chestnut had more **rapid growth and** greater **aboveground biomass** than *Juglans nigra* L. and *Quercus rubra* L. . (Jacobs et al., 2009).
Chestnut can be considered as a relevant **species for mitigation of ACC**

Modelling and prediction of geographic range in American chestnut

USDA Climate Change Atlas (Land Scape Research Group, 2014, URL http://www.nrs.fs.fed.us/atlas).
Multi-stage approach to predict suitable species habitats under current and future climates.
The future habitat of American chestnut is predicted with medium model reliability.

NO SPECIFIC STUDIES ARE AVAILABLE ON THE RESPONSE OF EUROPEAN CHESTNUT TO ACC

Strong points that support the research on chestnut

- Chestnut is **widely distributed**, **economically important**, **multipurpose tree**.
- A severe **decline of chestnut** is occurring caused by ACC, pests and diseases.
- **No experimental data about long-term impact** on European chestnut.
- The present **management**, **cultivation** and **breeding** systems **do not consider adaptability to ACC**
- New optimized **cultivation systems could mitigate** the impact of ACC
- The **interaction between ACC and chestnut parasites** is poorly investigated.
- Changes in flowering **phenology** and **fertility** caused by **ACC affect genetic diversity**, of wild chestnut and and **fruit production**.
- Predictive **maps** of the **optimal geographic habitat** of *C. sativa* are needed to define strategies **for conservation and management**.

Weak points that limit the research on chestnut

- At EU scale **chestnut is perceived as a secondary species**, despite its **economic importance at local scale**.
- Difficulties to get **funds for long term research** (field trials)
- Difficulties to get **funds to establish new innovative plantations**.
- **Integration of adaptation to ACC into selection** requires implementation of new breeding programmes.
- **Modelling and prediction** of chestnut geographic distribution **requires deep knowledge** of its response to environmental stresses

Opportunities

Available resources

- Field trials with natural wild chestnut (provenances)
- Collections of cultivated chestnut and full-sib progenies
- Genome sequence of *Castanea mollissima* as reference for genomic studies
- Extensive data on the genetic diversity of European wild chestnut

Risks

- Extreme meteorological events impose additional uncertainty
- The success of mitigation and conservation programs requires stronger link between scientists, policy makers and stakeholders
- Higher interest by stakeholders on short-term than long-term objectives

Research objectives

- 1 Deeper knowledge on the environmental adaptation of cultivated and wild genetic resources
- 2 Identification of genes and epigenetic mechanisms involved in environmental adaptation.
- 3 To guarantee a reservoir of variation to counteract future environmental changes
- 4 Mitigation of biotic and abiotic stress
- 5 New rootstocks and cultivars adaptable to climate change and parasites
- 6 Modelling of ecological dynamics in relation to climate change.

Management objectives

- 1 Monitoring and prediction of chestnut dynamics, to predict vulnerable and optimal areas.
- 2 Strategies for conservation and sustainable management, which consider the adaptability to climate change.
- 3 International coordination of management and policy on large geographical and temporal scale.
- 5 Optimized management and cultivation practices to mitigate impacts on the existing plantations and new ones
- 6 New cultivation systems with selected plant material and optimized management

Thanks for your attention

Research actions 1:

- Study of genetic diversity of populations and cultivars in situ (aim 1)
- New field trials in different environments to study adaptive traits ex situ (aim 1)
- Study of phenotypic, genetic and epigenetic variation ex situ (aims 1, 2)
- Monitoring of present and long-term dynamics of genetic resources (aims 1, 6).
- Genetic mapping and association mapping to identify genes for adaptation (aims 2).
- Development of molec. and epigenetic markers for breeding and conserv.tion (aims 3, 5).
- Development of biotech breeding strategies to obtain improved cultivars (aim 5).
- Sequencing and annotation of *Castanea sativa* genome (aims 1, 5).
- Characterization of germplasm for new plantations (aim 5).
- Crossing programmes to obtain new adaptable genetic resources. (aim 5)

Research perspectives

Actions 2:

•Indices and models for gene conservation and breeding based on scientific knowledge and the predicted climate scenario (aim 3)
•Setup of a long-term monitoring plan and an European network to collect climatic and phenological data and monitor response to ACC (aims 6)
•Development of a predictive model of the response of European chestnut to climate change (aim 6).
•Criteria and guidelines for protection/conservation of genetic resources (aims 3).
•Studies on the interactive effect between climate change and pathogens/pests (aim 4).

Management perspectives

Actions 1 . Long-term Environmental and Genetic monitoring

- Fine-scale mapping of the geographic distribution (aim 1)
- Development of remote sensing tools and climate services for chestnut (aim 1)
- Vulnerability assessment of areas where chestnut is at risk. (aim 1)
- Modelling and prediction of ecological response as Decision Support System (aim 1)

Actions 2. Banking for the future

- Selection of hotspots of ical diversity for in situ conservation. (aim 2, 4)
- International plan for conservation and sustainable management. (aim 3, 4).
- Ex situ germplasm collections at multiple locations for conservation and long term evaluation (aim 2).

Actions 3. **Innovative breeding and management**

- Innovative tools for integrating climate science into management planning (i.e. Climate Services). (aim 2, 5)
- Restoration strategies and assisted migration based on range prediction (aim 2, 5).
- Propagation material with enhanced resilience against abiotic stressors. (aim 5, 6).
- Application of innovative breeding, MAS, cis-genesis, genome editing (aim 6).
- Development of optimized agronomic techniques to mitigate impacts of climate change and biotic factors on old grown up trees (aim 5)
- New cultivation systems in pilot plantations with selected germplasm and optimized management (aim 5).

Strategies to mitigate the impact of global warming

Genetic diversity and phenotypic plasticity

Long term strategies to mitigate climate change should guarantee a reservoir of genetic and ecological diversity of the target species

Genetic diversity enable species to adapt to changing environments

In the short term, plasticity is likely to be more important than genetic adaptation.

Management actions

Examples: reducing harvesting intensity and reducing habitat fragmentation.

Assisted migration

Innovative but controversial option to facilitate species survival and conservation.

This approach has not yet been properly risk assessed and widely used

NO STRATEGIES TO MITIGATE THE IMPACT OF CLIMATE CHANGE ON CHESTNUT, HAVE BEEN IMPLEMENTED SO FAR

Ex situ studies on European chestnut

The **adaptive diversity** was evaluated in ***ex situ* comparative field trials**.
Common garden studies on provenances from the distribution range, highlighted variation in **phenotypic plasticity** and **response to water stress**, dependent on the ecological conditions at the origin (Fernandez-Lopez et al 2005; Lauteri et al 1996; Pliura and Eriksson 2002; Tchatchoua and Aravanopoulos 2010a, 2010b).
Variation among provenances was observed in photosynthetic capacity, $^{13}C/^{12}C$ isotope discrimination (Δ), water use efficiency (WUE), bud burst (Lauteri et al 1999). (Lauteri et al 1996).
Variation in response to water regime was studied in progenies of *C. sativa* cultivars originating from two origins in the Iberian Peninsula (Northern and Central-Southern Spain) (Ciordia et al., 2012). Variation found in physiological and morphological traits suggests that Spanish chestnut stands have potential to respond to the increased drought over the present century.

These results suggest that there is genetic basis to drought tolerance and phenology which thus calls for a larger survey of the genetic variation for these traits in material from the whole distribution area of the species.

Adaptation of trees to climate change

Impact on plants of temperate climates

- General advancement of spring phenology
- Longer growing season
- Increased asynchrony between plants and associated species (herbivores, pollinators)
- Increased frequency of stress events (drought + heat)
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Critical points for discussions

- We need scientific contribution in breeding and management/cultivation.
- Assisted migration (controversial, not enough experience)
- Biotech techniques and innovative breeding.
- Old grown cultivated plants (contribution from specialists)
- Coordination and sustainability of European field trials / collections for long term research
- Assembling and integration of the thematic group. Identification of shared and specific topics / actions.
- Involvement of producers, stake holders, policy makers in management actions and their governance. Old plantations and new ones.

H2020 – Selected calls

•**BB-03-2017: Adaptive tree breeding strategies and tools for forest production systems resilient to climate change and natural disturbances**
Type of Action: Research and Innovation action.

•**SFS-04-2017: New partnerships and tools to enhance European capacities for in-situ conservation**
Type of Action: Coordination and support action