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Nancy, France

EPIC iufro

IUFRO

Interconnecting Forests, Science and People

125th Anniversary Congress 2017

INRA SCIENCE & IMPACT

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INSTITUT DES SCIENCES ET INDUSTRIES DU VIVANT ET DE L'ENVIRONNEMENT

PARIS INSTITUTE OF TECHNOLOGY FOR LIFE, FOOD AND ENVIRONMENTAL SCIENCES

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Preface

As main scientific organizers, we, Francis Colin and Robert Rogers, welcome you to Nancy and the conference.

There have always been researchers interested in the topic of epicormics. We include ourselves in this group. These researchers have individually presented findings of their investigations related to epicormics in a variety of research publications, symposia and other scientific venues. As we reviewed the literature it seemed to us that over recent years interest in the study of epicormics has increased to where there is now a critical mass of research and researchers devoted to this topic. Thus, it seemed timely, especially because of the planned 125th Anniversary Meeting of IUFRO in nearby Freiburg, Germany, to organize a meeting solely to address research activities related to epicormics. Thus EPIC-IUFRO was born.

The aim of this EPIC-IUFRO Conference, the first ever focusing on this topic, is to assess the state of the art in epicormic development and control on trees, and specifically address the need for further research. It is an opportunity for interested researchers to build a collective, cooperative international research community about epicormic formation on forest and urban trees and other related aspects. Included in this effort are the main themes of epicormics: structural botany, physiology and genetics, ecology, tree care, wood quality and forest management.

This informational article summarizes the conference program, announces a schedule of conference presentations with links to corresponding abstracts, contact information, and also contains a Guide for Authors-Annals of Forest Science.

Our thanks and appreciation go to all who have contributed to organizing this conference:

- The scientific committee: Siegfried Fink Professor of Botany at the Freiburg University (Germany), Yves Caraglio Botanist researcher at CIRAD AMAP Montpellier (France), Geoffrey Burrows, Professor at the Charles Sturt University (Australia), Michael Saunders Associate Professor at the Purdue University, West Lafayette, (USA), and Steve Meadows Principal Silviculturist at the Southern Research Station of the USDA Forest Service, Stoneville (USA) ; within this committee these people have worked together with us, Robert Rogers (Emeritus Professor of Forestry at the University of Wisconsin-Stevens Point (USA) conference co-organizer and Francis Colin (Researcher at INRA Grand Est Nancy, Research Unit "LERFOB"), conference organizer
- The organizing committee: Elodie Taillefumier, Corinne Martin, Nathalie Morel and Charline Freyburger
- And our sponsors: the President of INRA Centre of Grand Est – Nancy, AgroparisTech, the LABEX Arbre, the GIPEBLOR, the GDR Bois and the IUFRO organization celebrating its 125th anniversary.

I hope you have an enjoyable and productive time here in Nancy at the EPIC-IUFRO Conference.

Schedule

Thursday evening, September 14th — 17h00 - 20h00

St Georges' Room - AgroParisTech Nancy

- Registration and ice-breaker
- Welcome speech

Friday, September 15th, — 8h30-19h00

Jacamon 1' Room - AgroParisTech Nancy

- Morning 8:30 - 12:40
  - Short introduction
  - Session 1
    - Break
  - Session 2
- Lunch at St Georges' room - AgroParisTech Nancy
- Afternoon 14:20 - 19:00
  - Session 3
    - Break
  - Session 4
    - Wrap-up
- Conference banquet 20:00 -

Saturday, September 16th — 10h00-17h00

INRA Centre Grand Est – Nancy

- Morning 10:00 - 12:30
  - Introduction to the research team and technical Platform
  - Workshop 1: X-Ray Computed Tomography
- Lunch 12:30 - 14:00
- Afternoon 14:00 - 16:30
  - Workshop 2: Terrestrial Lidar

Presentations on Friday, September 15th

8:45 – 9:00 *Conference introduction*

Session 1

End of session 1

10:20-10:35 *INRA and AgroParisTech presentation*

10:35-11:00 Break

Session 2

End of session 2

12:20 - 14:00 Lunch

Session 3

End of session 3

15:20 - 16:00 Break

Session 4

End of session 4

17:20- Wrap-up

Presentation abstracts

Genetic Determinism of Branching Traits on *Quercus Robur* Through QTL Analysis

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Keywords: pedunculate oak, computed tomography, epicormic, latent bud, QTL

Abstract

Introduction. Since epicormics may seriously impair the wood quality of oaks which are the most important hardwoods in French forestry, successive projects were carried out. This last project quantified the genetic effect on growth, branching and especially epicormics traits built from either X-Ray computed tomography (CT) or external observations.

Objective. The aim was to analyze and localize the Quantitative Trait Locus (QTLs) of the branching of pedunculate oak and especially the epicormics branching.

Methodologies and Material. This project used a full-sibs family issued from an interspecific crossing of *Quercus robur* planted in two sites in North-eastern France (CH) and South-western France (BR) with quite different environment and silvicultural intervention. In the first study, 1m-long logs of 2 replicates of 166 genotypes from BR were scanned by CT; growth, wood quality and branching traits were deduced on which a QTL analysis was performed. In a second study, a QTL analysis was performed with traits deduced from external observation made on standing trees on 2 replicates of 176 genotypes in BR and 160 genotypes in CH. The impact of the two observation methods and environments on the stability of the QTLs was then evaluated.

Results. The QTL analysis revealed a high genetic control for latent bud production mainly. An obvious interaction between QTLs and sites was highlighted. Several "hot-spots" on the genetic map of oak were identified for the epicormic traits while an independent genetic control was suggested for the sequential branches. An analysis of the common physiological denominators of these coincident traits suggests that their genetic controls are related to either the regulation of the axillary meristem initiation or to bud dormancy.

Conclusion and perspectives. These results showed that the genetic control is high only for the latent bud production. It can be deduced that the environment effect is involved more in the fate of these latent buds. The quality of the oak stands can be thus improved by both silviculture practices and also by seed selection in early stage. Since the oak genome was recently sequenced, a bioinformatics analysis is being performed on these regions for testing whether or not the candidate genes involved in plant hormones biosynthesis and regulation could explain the underlying molecular determinants of epicormic traits.

Coppices: Determinisms of Sprouting and Production

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Keywords: climatic change, determinisms of sprouting, forest management, short rotation

Abstract

Coppices, either traditional or modern, take a critical position in the forest area and silvicultural regimes within the present environmental context. The question indeed arises on the future of this resource in the situation of climatic change and increasing demand for fuelwood and chemicals: will the resource be sufficient to fulfil new needs? And how will these particular silvicultural regimes respond to global change? One prerequisite to answer these questions is to re-examine the developmental features of the stumps and the environmental factors influencing sprouting and coppice production, depending on the species-specific adaptation to climatic changes and ability to sprout.
This presentation aims basically at analyzing the determinisms of sprouting and sprouts production.
The introduction is dedicated to the assessment of the forest resource of traditional coppices, coppices-with-standards and modern short rotation coppices (SRC) with a specific focus on species specificities and regional diversity. The past and current valorization of their biomass is also remembered.
The sprouting ability is then tackled considering the epicormic potential and composition of stumps.
The determinism of sprouting is analyzed according to:

a. soil and climate conditions,
b. silvicultural management (planting density, harvest cycles, etc.),
c. Inter- and intra-specific variability and genetics.

Specifically, for SRC, the goal is the production of numerous resprouts after harvest. This production has been shown to tightly depend *(1)* on species (poplar, willow, black locust, and eucalypt being the most common fast growing and resprouting species used for SRC) as well as on genotypes within species, and *(2)* on environmental conditions (including pedoclimate, management, and their interactions with genotypes). In terms of management, a crucial factor is the period of the year at which the harvest is realized; indeed, an optimum remobilization of storage compounds in perennial organs (roots and stump) before harvest will allow an optimum regrowth during next growing season.
The future of coppices is finally discussed and research needs deduced.

Epicormics on Beech: Distinction Between Sequential and Epicormic Branches on Suppressed Poles

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Keywords: shade-tolerance, overstory, wood quality, crown structure

Abstract

European beech is known for its shade-tolerance resulting in old pole-sized trees in the understorey of other species, often oak and beech. For practitioners, the issue is to be able to decide whether these poles can be kept to comprise the future stand when the overstorey trees will be logged. They could comprise the future stand only if growth resumes substantially and their quality improves after stand opening. In fact, these poles are often covered with epicormics shoots forming an actual secondary crown under the sequential one. The boundary between these two types of crown is not always easy to discern especially because several epicormics shoots are as old and as large as the sequential ones.

The objective of this study is to design a set of morphological criteria that objectively distinguish epicormic from sequential branches.

After several morphological criteria to be recorded externally was defined, 109 branches were sampled on 14 beech poles from the Brides Forest in northeastern France. The trunk zones where these branches were inserted were dissected. The type of knot either sequential or epicormic was then defined according to the direction of the knot and the presence of a bud track coming from the trunk pith before the knot.

A logit model was then fit to the data: the response variable being the type of branch and the dependent variables being the criteria recorded externally. The most significant criteria were retained providing a guide for deciding whether a branch is epicormic or sequential.

This very useful guide for beech poles needs to be validated on branches sampled in other stands and other phenotypes of beech trees especially trees in evenaged or mixed stands.

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Oak Epicormics: Feasibility of Detection by Terrestrial Lidar

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Keywords : inventory, wood production, wood quality, wood grading

Abstract

The development of terrestrial Lidar (TL) for forest inventories concern not only wood production but also wood quality, at tree, stand and resource level. Several tree attributes affect standing tree quality. Among them, epicormics may degrade the wood quality at least by one grading class for oak especially (Meadows and Burkhardt 2001). Moreover, quality is rarely of the highest class, due predominantly to the most detrimental epicormic types: sprouts, burls and picots. In a more general context, a prerequisite to better valorize the broadleaved resource is to better know it. TL appears to be a valuable method of resource characterization and for defining appropriate silvicultural methods for limiting the prevalence of epicormics.

The objective of this presentation is to report on evaluating the feasibility of using TL for detecting the different types of epicormics and for grading standing oak trees.

A computing method was designed for detecting (Nguyen et al. 2016), identifying and quantifying branching defects, cracks and harvesting damages, at the stem surface. Before its launching as an inventory tool, this method needs to be evaluated. To do this, fifty-eight sessile oak (*Quercus petraea*) trees were sampled in the St Jean forest in northeastern France. They were graded up to 4m by a forestry expert, TL-scanned, climbed for recording all the epicormic types and finally harvested for X-ray computed tomography. As a preliminary study, only half of the data were examined here.

The results consist mainly of comparisons between the grading classes, the number of epicormics observed and the number of epicormics detected by T-Lidar. The discrepancies between these three quality characterizations give an opportunity to discuss their respective accuracy, to revise defect distinction and to further T-Lidar developments and instructions for optimal utilization in forests.

We can conclude that the methodology is very promising. It would be applied not only to standing trees for completing yield quantification but also to log piles in the forest, log yards in sawmills and finally for academic purposes, especially studies on the effect of silviculture and site conditions.

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Effect of Stand Density and Mixture on the Secondary Epicormic Crown on Sessile Oak

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Keywords: secondary crown, silviculture, stand density, sessile oak, TLS

Abstract

One of the most impressive expressions of epicormics is the emergence of a secondary crown with large epicormic branches inserted under the primary crown with sequential branches. However, the conditions promoting this secondary crown under alternative silvicultural practices aiming at optimizing productivity and increasing resilience to climatic extreme events remain unclear. Quantifying crown characteristics in mature stands has been difficult in the past as field-based methods are labor intensive and imprecise. Conversely terrestrial laser scanning (TLS) seems to be a promising technique; this remote sensing technique provides in fact high spatial detail and accuracy of crown morphology- during the leafless season.

The objective of this experiment is to test the effect of stand density and mixture on the development of the sequential and epicormics crowns measured with TLS.

Sessile oak (*Quercus petraea*) was selected since it is the most important economic species in French forestry and a species prone to epicormics and to develop a secondary crown. Sessile oak trees were sampled in two experiments where we tested the effect of a gradient of local competition conditions resulting from moderate and heavy thinning interventions and from mixture in: (i) a pure oak forest in Tronçais; (ii) a mixture with *Pinus sylvestris* in Orléans forest. The crowns were quantified by their volume.

The results are explained in terms of volume of the epicormic crown according to the usual tree descriptors, primary crown volume, stand density and mixture.

The conclusion addresses the feasibility of quantifying crown characteristics by TLS and the possibility of designing oak silviculture for optimizing trunk growth and increasing resilience with a limited secondary crown.

Epicormic Shoots: Tree Growth Indicators

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Keywords: tree architecture; diagnosis; forest management

Abstract

The high frequency of extreme climate events and the consequences for French forests have boosted efforts to monitor and describe trees, such as launching participatory initiatives (http://www.obs-saisons.fr/) or the rating of tree decline (http://agriculture.gouv.fr/mots-cles/sante-des-forets).
The decline concept often relies on considering foliage density and branch death used to establish tree status. More recently, it has proved useful to be able to provide a predictive character for subsequent tree development. It was in this context that epicormic shoots proved to be a major element in the diagnosis of tree architecture.

We shall begin by describing the relations between growth and epicormic shoot development, then we shall present criteria that can be used for a diagnosis. Distribution in the tree and the organization of the epicormic branching system set in place are key elements for qualifying reactivity on the one hand, and the fate of the tree on the other hand. Tree architecture can be considered in terms of development, resilience, stress and irreversible decline.

The different criteria that can be used to establish a predictive diagnosis have been grouped in the form of a key available for a certain number of hardwood and softwood species of the temperate forests of France. In most of these keys, epicormic shoots are a central point in the sequence of observations and the questions raised.

Work was then undertaken to compare these criteria with radial growth, the growing environment, or the leaf deficit, to validate the proposed diagnosis and the contribution made by taking epicormic shoots into account.
For practical purposes, these keys have been developed in the form of an embedded application for tablets and mobile phones.
In this applied context, and in order to increase our knowledge and their operational transpositions for tree management, some questions remain to be addressed, such as the links between the origin of the meristem and the type of offshoots set in place, survival or growth resumption (total or partial reiteration) and the degree of anchorage in the support structure and its sturdiness (level of risk and dangerousness).

Epicormic Shoots in Plant Architecture: Epiphenomenon or General Habit?

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Keywords: plant architecture; reiteration; growth forms

Abstract

“Sudden and excessive exposure of trees often results in stimulation of dormant buds on the main stem or branches to produce epicormic shoots…” (Kozlowski 1971) As a general fact, epicormic shoots are related to trees and to traumatic responses or to the consequences of stress.
Great variation exists among species in such epicormic expression (e.g. Angiosperms *vs* Gymnosperms, etc.) and these shoots can occur at different steps of plant development.
Plant architecture describes the spatial and temporal axis arrangement during ontogenesis. In many plants, development involves two kinds of bud activation: without delay as an immediate branching mechanism, or with a regular and short delay (e.g. one growth cycle), as delayed branching. In all cases, this branching habit is characteristic of the species and corresponds to sequential branching.
Among tree architectures, some commonly use latent meristems: Koriba’s or Prevost’s architectural models are illustrative examples. In these cases, epicormic shoots are an integral part of the plant species’ architecture: bud outgrowth results from an internal equilibrium between existing branches and gives rise to a new branching system ensuring the continuity of plant development.
There are other situations where epicormic shoots also contribute intrinsically to plant architecture i) basal succession of a new branching system, as for establishment growth in shrubs or herbaceous plants; ii) basitonic mobilization of latent buds at the base of some individuals or a branching system; iii) direct contribution to crown development in some large tropical trees.
Of course, epicormic shoots are involved in tree traumatism responses. Such responses may be associated with cambial growth and with global plant physiology. But this response combined with a detailed architectural approach allows a relevant diagnosis regarding the fate of individual development.
Conclusion and perspectives: epicormic shoots appear to be more frequent during plant architecture development, rather than being just a stress trait indicator. In some cases, meristems are not able to survive a long period, just a few years after their establishment, while in other cases they can survive a hundred years thanks to many meristem/bud strategies; this is a specific ability with a major impact on plant ecology and evolution.

Epicormics and Sprouts on Oaks and Beech: Review and Research Perspectives at Bud, Tree and stand scales.

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Keywords : coppice, tomography, epicormic potential, stem elongation

Abstract

Among the more than 500 species comprising the genus *Quercus* and *Fagus*, several accompany the development of civilizations for centuries through their valuable housing, furniture, barrel and fuel wood, bark drugs and tannins, fruits as human and animal food, ornamental and recreation services and even spiritual meaning. During this co-evolution, humans took advantage of- or had to face with- epicormics, sprouts and reiterates. For instance the sprouting capacity founded the coppice forest regime which allows the fuelwood supply of the early stages of industrial activities.
This paper aims at (1) reviewing the main results gained on epicormics, sprouts and reiterates on oak and beech and (2) wording new working hypothesis to be tested optimally in the framework of international collaborations. Epicormics, sprouts and reiterates are considered at collar, trunk, crown and stand levels. The main focus is put on structural, silvicultural (Spiecker, 1991) and genetic aspects (Meier and Saunders, 2013) while functional and ecological aspects are less considered. Two useful concepts have been introduced and used: the epicormic potential (Fontaine et al., 2001) and the epicormic composition. X-ray computed tomography put a recent impetus to these studies (Colin et al., 2010). From our own research results and a thorough analysis of the international literature, the review is organized according to three critical points: the bud response to internal and external changes, the formation of the epicormic potential related to the stem elongation, and then the fate of the epicormic potential and composition on the trunk. This latter depends on the current and past growth conditions especially reflected in the annual increments of the radial growth, the crown structure and the stand undestorey.
International efforts must be put on epicormics studies focused on a few biological models, optimally species from which the genome has been sequenced. Biological models are thus proposed as well as working hypothesis to be tested. Comparisons of oak and beech species and maybe a coniferous species prone to epicormics would be fruitful since they have different shade tolerances, wood anatomies and epicormics behaviors.

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Prediction of Epicormic Branch Production After Thinning in Bottomland Hardwood Stands in the Southern United States

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Keywords: epicormic branches, thinning, stand density, crown class, bottomland hardwoods

Abstract

Epicormic branches are twigs that develop from dormant buds along the main bole of many hardwood trees. These buds may be released at any time during the life of a tree in response to a variety of stimuli. Because they produce knots in the underlying wood, epicormic branches frequently cause reductions in both log and lumber grade and a significant loss of value in the stand and the lumber produced from it. Consequently, the presence of epicormic branches can be a serious problem in management of hardwood forests for high-quality sawtimber production. There is a lack of understanding of the effects of various factors on the production of epicormic branches. Field foresters and timber markers need the ability to accurately predict the propensity of individual hardwood trees to produce epicormic branches in response to thinnings and other types of partial cuttings. Data from 11 different studies were pooled to evaluate the influences of several stand and tree characteristics on production of epicormic branches in both undisturbed and thinned stands of bottomland hardwoods in the southern United States. Stand characteristics evaluated include initial basal area, residual basal area after thinning, and percent basal area removed; tree characteristics evaluated include initial diameter-at-breast-height, crown class, number of pre-existing epicormic branches, and species. Each characteristic was examined individually and in combination with other characteristics to develop regression equations to predict the number of epicormic branches on the butt logs of residual hardwood trees at various time intervals (up to 15 years) after thinning. Separate analyses were performed for each of eight different species: green ash (*Fraxinus pennsylvanica* Marsh.), sweetgum (*Liquidambar styraciflua* L.), overcup oak (*Quercus lyrata* Walt.), swamp chestnut oak (*Q. michauxii* Nutt.), cherrybark oak (*Q. pagoda* Raf.), water oak (*Q. nigra* L.), Nuttall oak (*Q. texana* Buckley), and willow oak (*Q. phellos* L.), as well as for the red oaks (cherrybark, water, Nuttall, and willow oaks) as a group and for all species combined.

Out of the Furnace and into the Greedy Muzzle

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Keywords: fire; herbivory; preventitious bud; adventitious bud; plant architecture; bud protection

Abstract

The ability to develop a new shoot from a dormant bud, *i.e.* epicormic resprouting, is crucial for trees growing in frequently disturbed environments. However, we still dispose of scarce information regarding the plant traits defining a good epicormic resprouter. In this talk, I will summarize our observations on 63 tree species growing in a savanna-forest mosaic (Hluhluwe-iMfolozi, South Africa) with frequent fires and an ecologically functional megafauna. I will more specifically address the following questions: (1) Which parts of the plant architecture are resprouting and which are “abandoned” to the consumers? (2) Which bud attributes confer increased resprouting after fire and herbivory? (3) Does it matter for species survival after disturbance and does it affect their distribution? To answer these questions, we described the architectural composition of 63 tree species and performed macro-anatomical observations of their buds on trunks, branches and twigs. We assessed how bud traits impacted the performance of trees by surveying how trees resprouted after fire and how it influenced their distribution in 256 sites with varying fire frequencies and herbivory pressure. I will discuss how the bud properties are integrated into coherent functional strategies that are well related to the ecological behaviour of trees in savannas.

Within species, protection of buds varied according to the life span of axis categories (trunk, branch, twigs, short shoots): the longer lived, the better protected. This level of protection translated directly into greater post-fire resprouting and survival of trees. Species with low bud protection occurred in fire-prone biomes only if they could root-sucker. The pressure exerted on trees by meso-browser herbivores, contrary to fire, mostly affects the periphery of the canopy. Accessory buds allowing compensating losses due to leaf and stem removal by resprouting were found to be distributed not only in the perennial axis categories but also in peripheral axis categories. Accessory buds played a role both in resprouting after cutting but also in displaying leaves inside of costly defensive structure (cage architecture).

To conclude, the analysis of bud properties related to resprouting is a promising avenue to understand and predict the ecological behaviour of species. We will propose some perspectives about critical missing information that would help to better link bud structures to ecological behaviour.

Resprouting in Conifers – A Review

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Keywords: gymnosperm, coppice, epicormic, anatomy, leaf axil, bud, meristem

Abstract

Compared to angiosperm trees the conifers are generally regarded as poor resprouters as very few are able to resprout following major disturbance, e.g. after being cut down (coppiced) or after top kill from crown fire. Part of this poor resprouting performance appears to be related to a lack of epicormic and/or coppice buds or meristems in the trunk and large branches. This, in turn, is apparently related to the production of a high proportion of ‘blank’ or ‘empty’ leaf axils.
While Holthusen found blank leaf axils in almost all of the 28 species of conifers he investigated, subsequent investigations have found axillary meristems in the apparently blank axils of a range of species (studies of Burrows and Fink). While angiosperms usually produce fully formed axillary buds, these conifer axillary meristems did not develop an apical dome, leaf primordia or vascular connections. In the investigated Cupressaceae the meristems were eventually lost with periderm formation, while in the Araucariaceae the meristems were long lived.

Many assessments of conifer resprouting list a few species that are known to be good resprouters but an extensively referenced review of the topic has not been conducted (but see “Vegetative reproduction in conifers and ginkgo” on “The Gymnosperm Database”). A comprehensive literature review of resprouting and vegetative reproduction in conifers was conducted. Information on 80 genera was compiled from about 120 references and websites. A listing of 22 conifer genera in which at least one species has been recorded as coppicing or resprouting after substantial damage follows (full listing is available from the author):

Araucariaceae (*Agathis, Araucaria, Wollemia*)

Cupressaceae (*Actinostrobus, Cunninghamia, Cupressus, Juniperus, Sequoia, Sequoiadendron, Taxodium, Tetraclinis, Widdringtonia*)

Pinaceae (*Keteleeria, Pinus, Pseudotsuga*)

Podocarpaceae (*Manoao, Phyllocladus, Podocarpus*)

Taxaceae (*Amentotaxus, Cephalotaxus, Taxus, Torreya*)

A much wider range of genera with a well developed resprouting capability was recorded than would be expected from the usual observation that ‘conifers are poor resprouters’. All families had several resprouting genera except the monospecific Sciadopityaceae. Apart from resprouting from the trunk base and the stem, buds were also recorded arising from more specialised structures such as lignotubers, burls and underground stems. In some of the larger genera (e.g. Cupressus, Juniperus, Pinus, Podocarpus) it appeared that only a relatively small proportion of the species were resprouters.

More anatomical studies are needed, especially of: (i) apparently blank leaf axils, (ii) unusual structures for conifers (e.g. lignotubers) and (iii) why there can be high variability in resprouting capacity in a single genus and within genera of the same family.

Untangling the Effects of Crown Vigor and Genetics on Epicormic Expression: A Long-Term Study of The Response in *Quercus Alba*

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Keywords: white oak, progeny test, epicormic composition, release treatments

Abstract

Expression of epicormic branching during stand development is increasingly understood to be a complex interaction among several environmental and genetic factors. Prior research has focused on environmental factors, such as the influence of bole insolation on stimulation of epicormic sprouting, or the relationship between individual tree vigor and epicormic dynamics. Research on genetic factors, on the other hand, is less prevalent and largely focuses on interspecific differences among species in epicormic expression. Genetic differences within a species have been speculated for many species and demonstrated for far fewer, with most reporting quite weak genetic control.

Here, we report on a long-term, longitudinal study in a *Quercus alba* (white oak) plantation in southern Indiana, USA. In 2010, we installed a series of crop tree release and pruning treatments within a regional half-sib progeny test site in order to isolate the relative influences of tree vigor and progeny-level genetic variation on epicormics development. Three-year results from this study, reported in Meier and Saunders (2016), found few statistically significant genetic effects; they speculated that pre-treatment differences in epicormic composition across all families were a more important driver of epicormic development in the short-term than were the increases in tree vigor associated with the release treatments or genetic factors. This presentation will summarize recently collected data after an additional four growing seasons, and try to further illuminate the relative longer-term effects of both crown vigor and genetics in epicormics expression.

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The Role Epicormics Play in Forestry of the United States: A Silvicultural Perspective

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Keywords: branching, regeneration, defect, wood quality, regeneration, reproduction

Abstract

I present my view of the phenomenon of epicormics and how it relates to silvics, silviculture and forest products within the United States. Questions of interest that I address here are 1) when were epicormics first recognized, 2) what species are affected, 3) why are they important, and 4) what effect do they have on silvics, silviculture, and wood products. My report is compiled from library research. I began searching the literature related to this topic starting about 1930. An early account reported epicormic branching in old-growth Appalachian hardwoods (Jemison & Schumacher, 1948). They relate that "forest managers who use the selection method of harvest cutting in Appalachian hardwood stands have long pondered the extent and importance of epicormic branching following cutting." Widely accepted in the past is the notion that many hardwoods produce epicormic branches, while such branches are rare in conifers. However, Lanner (1992) dispels this concept by reporting that a number of conifers, e.g., *Larix, Pseudotsuga, Abies, Picea, Tsuga*, as well as, *Sequoia, and Sequoiadendron* produce epicormic branches not necessarily due to an injury response, per se, but as a normal life-history trait of replacing their crowns thereby prolonging their life span. Nonetheless, there are many studies that show that epicormic branching develops in response to stimulation by some sort of external influence or disturbance. Among such disturbance factors are injury, disease, fluctuating temperatures, drought and light intensity changes. While the temptation is to conclude anthropogenically that epicormic branches/sprouts are somehow deleterious, the ability of some species to produce such structures are bound to their life histories and ultimately to their survival under unfavorable growing conditions. A familiar example is the many oak species that can sprout because of damage to the main trunk induced either naturally (drought, windstorm, fire, wind) or by human activity (cutting). This is a reproductive strategy that often gives oaks an advantage over other species whose sprouting ability and sprout survival are less capable (Johnson, Shifley, & Rogers, 2009). On the other hand, recent studies show that epicormic branches can seriously affect the production of high quality sawtimber (James S Meadows, 1995; James S. Meadows, 2001).

Epicormic branching occurs widely among many tree species effecting their life histories (crown development and regeneration) and effects the value of wood products derived from these species.

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Rates of Survival of Epicormic and Lignotuberous Shoots Produced by Stressed *Eucalyptus obliqua* Lherit. Seedlings are Influenced by Root Tip Growth and the Presence of Leaves.

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Key Words: Lignotuber, epicormic shoot, decapitation, root tip, photosynthate

Abstract

Seedlings of *Eucalyptus obliqua* L'Herit, of approximately 300mm height and with a stem caliper above the lignotuberous swelling of 3-4mm grown under ideal greenhouse conditions, were stressed by decapitation or exposure to different levels of heat stress by exposure to temperatures ranging from 40-120°C for from 2 to 128 minutes. Some seedlings were also subjected to repeated doses of these stresses. Lower temperatures and shorter exposure durations were often sub-lethal and decapitation to the same extent as heat killing of plant tissues elicited similar levels of epicormic and lignotuberous shoot production and growth.

Decapitated plants with different numbers of leaves left intact showed different rates of epicormic and lignotuberous shoot survival. Supplementary carbohydrate supply to decapitated plants was done by placing plastic tubing over the cut stems and injecting a sucrose solution. Using specially designed containers, the root systems of the seedlings could be inspected daily to determine whether the root tips were healthy and selected root tips were monitored to determine if and when they had resumed growth after treatment.

Survival rates of epicormic and lignotuberous shoots were enhanced in decapitated plants by the presence of healthy, functional leaves. Supplementary feeding of decapitated seedlings with a glucose solution gave slightly higher rates of shoot and plant survival, suggesting that the production of photosynthate by the leaves was at least partly responsible for this improvement.

The re-commencement of growth after significant stress through the development of either epciormic or lignotuberous shoots was preceded by root tip growth. Root tip growth usually commenced 2-3 days before epicormic or lignotuberous shoot growth could be detected. If root tips did not re-commence growth after the imposition of stress, then epicormic and lignotuberous shoots did not develop and the plants invariably died.

Depending on the level of stress imposed, the usual order of regeneration was from epicormic buds higher up in the branches, then epicormic buds on lower branches, then epicormic buds on the trunk and finally lignotuberous buds. Lignotubers and the shoots they produce are a last-resort survival mechanism (Moore 2015). In repeatedly stressed plants, lignotuber size often increased as lignotuberous buds swelled and then were repressed by the growth and development of epicormic shoots higher on the stem.

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Epicormic Shoots and Growth Plasticity of Fruit Trees in Response to Horticultural Manipulations

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Keywords: peach, apple, neoformation, bud latency, reiteration

Abstract

As with other perennial and polycarpic plants, fruit trees initiate many meristems in either terminal or axillary positions along shoots. During tree ontogeny, some meristems give birth to reproductive organs or to vegetative shoots whereas others remain latent. In temperate fruit trees, bud latency is usually initiated during shoot growth and prolonged during a dormancy period, possibly over several seasons and years thus allowing pools of latent buds to be accumulated. Because branching patterns are often organized in successive zones of distinct bud fates, latent buds are located at the base and/or ends of growth units or in the axils of axillary branches. These buds may be activated months or years after their formation, often after biotic or abiotic stresses, giving birth to epicormic shoots.

In fruit trees, many horticultural manipulations such as pruning (heading or thinning cuts for training practices) or arching make use of latent bud pools to promote epicormic shoot outgrowth. When the tree is young and healthy, the intensity of pruning or arching correlates with that of epicormic shoot development: the older the wood on which pruning or arching is preformed the longer the epicormics. It also depends on the rootstock used. In all cases, the variation in length of epicormics relies on the tree capability to develop neoformation. This capability is pronounced in the *Prunus* and *Malus* species and thus they exhibit great plasticity in response to manipulations. However, the development of epicormic shoots is controlled by physiological and specific architectural rules. In this presentation, we will exemplify characteristic epicormic shoot development that can be obtained after pruning, arching or fruit load manipulations in several fruit tree species. We will interpret them with respect to the classical concepts of the reiteration process and architectural development but also regarding the tree physiological conditions resulting from the current year climatic conditions or from consecutive years of growth and reserve accumulation.

Latent buds: Review on Structure and Physiology with a Special Focus on Oak

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Keywords : epicormic structures, transformation, dormancy, physiology

Abstract

From the very petty cotyledonary region to the widely extended crown top of mature trees, latent buds are stored to be utilized all along the life of the trees, in case of favourable or constraining, abrupt or gradual environmental changes, biotic or abiotic damage. Their variety of structures is more or less related to their ability to burst and the production of epicormic shoots or other types of epicormics. Their physiology is unfortunately poorly understood compared to that of terminal buds in terms of hormone control, vascularization, water and carbon supply, cell wall changes, and genomics. Latent buds, by their decisive role in the ontogeny, ecology and the economic influence of epicormics deserve a significant research impetus.

In order to promote this impetus, this paper aims to review the structural and physiological aspects of latent buds, focusing on oak, and to propose research perspectives.

Microscopic observations of oak buds according to their sizes and their position within the annual shoots and along the tree trunk are thoroughly interpreted together with their connection from the wood to the bark (Fontaine et al., 1998, 1999). First steps of the transformation from a latent bud into another epicormic type are thus considered based on a longitudinal survey (Fontaine et al. 2001) and cross section observations of epicormic traces in the wood (Morisset et al., 2012).

The physiology of latent buds is tackled by remembering the few experiments carried out in the 80's, on oak mainly, and by attempting to extend and adapt to latent buds the recent results gained on terminal and axillary buds of emblematic model plants. Dormancy is specifically considered.

Results are provided according to five points: (1) bud structure and neighbouring tissues, (2) statistics on latent bud burst, (3) updated review of bud dormancy and physiology and (4) interpretation of past experiments on oak.

Several questions not yet answered are thus posed, prioritized and several hypotheses worded. Perspectives of further researches are finally envisaged.

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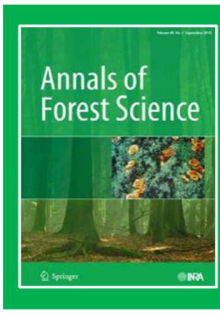

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