AGFORWARD
Agroforestry for Europe

Research and Development Protocol for Silvopastoral Management of High Value Timber Plantations in Spain

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1 Context

The AGFORWARD research project (January 2014-December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to the second objective. This report contributes to the second objective. It contributes to the initial research and development protocol (Milestone 10 (3.3)) for the participative research and development network focused on the use of agroforestry in high value tree systems.

2 Background

Cavitation is the formation of vapor bubbles in a flowing liquid in a region where the pressure of the liquid falls below its vapor pressure. In vascular plants, this phenomenon can occur in the xylem when the tension of the sap within a vessel becomes high enough that dissolved air within the sap expands to fill vessels. As a consequence, vapor-filled (embolized) conduits no longer hold sap and xylem hydraulic conductance decreases, leading to stomatal closure, the abscission of leaves, shoot dieback and eventually to plant death (Tyree and Sperry 1989; Vilagrosa et al. 2012)

There are several factors affecting xylem cavitation. Cavitation, as well as loss of hydraulic conductivity, occurs when drought leads to water deficit in plant tissues. Drought related cavitation is commonly observed on trees from water-limited environments such as the Mediterranean region, even if they have developed mechanisms to tolerate stress. Low temperatures can also have long-term effects in the hydraulic functions of trees, as freezing of the conducting elements leads to the formation of gas bubbles thus inducing embolism. A third factor causing embolism, but one that has received less attention, are pathogens that induce water stress in their hosts by reducing hydraulic conductivity (Lambers et al., 2008).

Species differ considerably in their vulnerability to cavitation. The less vulnerable species are usually the more desiccation-tolerant (Lambers et al., 2008). For example, among the *Quercus* species found in the Iberian peninsula, *Q. coccifera* is the least vulnerable to drought-induced cavitation whereas *Q. robur* and *Q. pyrenaica* show higher vulnerability (Vilagrosa et al. 2012). There are also phenotypic differences in vulnerability to cavitation. Sun-exposed branches of *Fagus sylvatica* have been shown to be less vulnerable than branches of the same tree that grow in the shade (Cochard et al., 1999). Within the same plant, different organs have also different vulnerabilities to cavitation with root systems being the most susceptible and woody stems the least susceptible (Vilagrosa et al. 2012).

In recent years in Spain, wild cherry (*Prunus avium* L.) has been planted in former agricultural land with the objective of producing high quality timber. These tree plantations are managed intensively, with frequent irrigation, fertilization and weed control in order to promote fast growth and thus reduce tree rotation to just 25 to 30 years. However, after several years of high diameter and height growth, wild cherry trees show severe symptoms of cavitation and embolism and much slower growth rates. A recent study has showed that *P. avium* was, among 10 *Prunus* species, the third more vulnerable to cavitation (Cochard et al., 2008). Therefore serious doubts have now been raised about the appropriateness and feasibility of producing high quality timber by growing wild cherry trees in intensively-managed plantations in harsh Mediterranean climatic conditions, even if water and fertilization is abundantly supplied.

Field observations of frequently pollarded trees have led us to think of pollarding as a management practice to enhance tree diameter growth. Pollarding has been practiced by cherry fruit tree growers for many years to control the height of their trees and thus facilitate fruit harvest. It has also been a common practice on fodder trees, such as *Fraxinus angustifolia,* to provide livestock with fodder in times of scarcity. In both cases pollarded trees have continued to grow in diameter, with the oldest trees reaching up to almost 1 m in diameter despite having been pollarded many times during their lifetime. Therefore if pollarded, wild cherry timber trees may also continue to grow and produce a lower portion of the stem with the minimum length (about 3 m) and diameter required for sawn timber.

This trial is part of a broader programme of collaboration between the UNEX and the forestry company Bosques Naturales with the goal of improving the economic and environmental outcomes of timber plantations through agroforestry practices including intercropping, sheep grazing and pasture establishment with leguminous species.

3 Objective of experiment

Our hypothesis is: pollarded cavitated wild cherry timber trees will exhibit the same or even higher diameter growth rate than unpollarded cavitated trees.

4 System description

Two-year old bare-root seedlings of wild cherry (*Prunus avium* L.) (clone Eurocherry C-9) were planted in 2004 at 5 m x 5 m spacing. During the first three years trees were pruned in winter. Afterwards branch pruning was conducted every spring until the year 2011. From 2011 to date, only epicormic branches were removed. Herbicide weed control on the tree line and mechanized weed control on the alley is applied every year.

5 Experimental design

Five pairs of plots (total of 10 plots) were randomly selected in the plantation. Each plot contains 3 rows of trees with 6 trees per row (i.e. 18 trees). Treatments were randomly assigned to the plots. The experiment consists of the following treatments:

1. Pollarding
2. Unpollarded trees (control)

In autumn 2014, before trees shed their leaves a photograph was taken of each tree in order to be able to identify later on in winter, during the pollarding operation, the portion of the stem with live/death branches. Then in early February 2015, trees were pollarded using the photograph as a guide indicating the height at which the trees should be cut (Figure 1).

Figure 1. Pollarding of wild cherry timber trees

6 Measurements

Tree height and the diameter at breast height (dbh) were measured in early February 2015, the same day trees were pollarded. The length and the diameter at the base of the pollarded section of the tree were also measured (Tables 1 and 2). Every year dbh and tree height will be measured. In the summer hemispherical photographs may also be taken to assess leaf area index.

Table 1. Mean diameter at breast height and height of trees in control plot in February 2015

Plot	Diameter at breast height (cm)	Height (m)
P1	17.5	6.2
P4	18.7	7.6
P5	19.7	8.0
P7	17.0	6.9
P9	19.6	6.1

Table 2. Mean diameter at breast height (dbh) and height (H) of pollarded trees, and length and diameter at the base of pollarded section in February 2015

Plot	Diameter at breast height (cm)	Height (m)	Pollarded stem	
			Dbase (cm)	Length (m)
P2	18.6	8.1	9.1	4.7
P3	18.8	8.1	8.3	4.3
P6	19.4	8.0	8.5	4.3
P8	15.7	7.2	8.3	4.5
P10	18.2	7.3	8.5	3.8

7 Acknowledgements

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8 References

Cochard H. (2006) Cavitation in trees. C R Physique 7:1018–1026.

Cochard H., Barigah T. S., Kleinhentz M. and Eshel A (2008). Is xylem cavitation resistance a relevant criterion for screening drought resistance among Prunus species? Journal of Plant Physiology 165: 976—982.

Lambers H., Stuart Chapin III F. and Pons L. T (2008). Plant Physiological Ecology. Springer 2nd Edition. New York.

Tyree M. T. and Sperry J. S. (1989). Vulnerability of Xylem to Cavitation and Embolism. *Annu. Rev. Plant Phys. Mol. Bio*. 40: 19-38.

Vilagrosa A., Chirino E., Peguero-Pina J.J., Bariagh T. S., Cochard H. and Gil-Pelegrín E (2012). Xylem Cavitation and Embolism in Plants Living in Water-Limited Ecosystems. In: Aroca R. (ed.), Plant Responses to Drought Stress. Springer-Verlag, Berlin: 63-109 (Chapter 3).