Wood characterization of clones selected for valuable timber production: the case study of Italian wild cherry

Nocetti Michela[1], Brunetti Michele[1], Ducci Fulvio[2], Romagnoli Manuela[3]

Keywords: *Prunus avium*, valuable broadleaved, clonal test, breeding programme.

Abstract – As regards the valuable broadleaved tree species, the quality of wood production is a much more important topic than quantity. Therefore the comprehension of what "valuable timber" is, it is a matter of crucial importance. The work wants to summarize what is helpful to care about during an improvement programme aimed to high quality wood production. Afterwards, the case of wild cherry in Italy is illustrated, briefly describing the importance and the use of its wood in the Italian industry; the production in the Italian plantations; and, finally, the past genetic improvement programmes and the actual researches.

The selection of plus trees started in Italy during the decade of 1980 and followed mainly growth and tree architecture criteria; clones were then tested in plantations.

One of the first field tests aimed to investigate the variability of wood quality of cherry clones focused on the wound cicatrisation after pruning. Significant differences between clones were noticed.

Currently, a further investigation on wood characterization of cherry clones previously selected for timber production is ongoing in two trials. To date, physical and mechanical properties of wood have been measured and a significant clone effect was found out for all the studied traits.

Introduction

The importance of plantations in the industrial wood supply is growing in the last decades. While the global demand of wood (high quality timber as well as wood for energy) is constantly rising, the costs of natural forest wood is increasing because of the higher logging costs, the more restrictive regulations and the recent environmental costs.

[1] CNR – IVALSA. Istituto per la Valorizzazione del Legno e delle Specie Arboree, via Madonna del Piano 10, I-50019 Sesto Fiorentino (FI – Italy).

[2] CRA – SEL. Centro di Ricerca per la Selvicoltura, viale Santa Margherita 80, I-52100 Arezzo (Italy).

[3] University of Tuscia, DAF, via San Camillo de Lellis, I-01100 Viterbo (Italy)

Plantations produce about the 34% of the earth industrial wood demand but they could reach the 75% in 2050 (Sedjo 2001a). Therefore, the wood production in plantation could reduce the logging pressure in natural forest and help the environmental conservation such as ecosystem and biodiversity preservation and climate change mitigation.

Moreover, the genetic improvement of species used in the plantations to timber production can have many benefits that can be grouped in economical and ecological benefits. The economic benefits relay to the possibility to achieve higher productivity by the selection of major trees for growth rate and disease resistance, but higher quality timber may be obtained as well, if the desired wood traits are included in the improvement programme. The ecological benefits are the possible reduction of wood harvested in natural forests, as already stated, and the increasing of carbon sequestration, but also the possibility to plant *ad-hoc* selected trees in areas that have been degraded and characterised by stressing micro-climate conditions (cold, water deficit and frost) (Sedjo 2001b).

For such reasons it becomes important to explore the new opportunities of wood production in plantations; mainly as concerns the genetic tree improvement.

In the peculiar case of the valuable broadleaved tree species, the quality of wood production carries more weight than quantity. Therefore the comprehension of what "valuable timber" is, it is a matter of crucial importance.

In the following paragraphs we will try to summarize what is helpful to care about during an improvement programme aimed to high quality wood production. Afterwards, we will illustrate the case of wild cherry in Italy, briefly describing the importance and the use of its wood in the Italian industry; the production in the Italian plantations; and, finally, the past genetic improvement programmes and the actual researches.

The "valuable timber"

At the beginning of a breeding programme it is necessary to understand and to decide what traits are to be improved. Reasonably, the adaptation to specific environment conditions, the growth rate and the tree architecture (trunk straightness, branch number, dimension and angle), followed by the disease resistance are the most used traits in the forest tree breeding programmes. But it is not assured that such selection strategy might lead to improvement of wood characteristics as well. So, if the timber production is the final objective of the plantation, especially when we deal with valuable tree species, wood traits should be studied on trees previously selected following different criteria (Nocetti 2008).

First of all, the meaning of the term "wood quality" has to be clarified. It can vary amongst forestry and wood industry sectors and it can be defined as the whole of characteristics that makes the timber suitable for a particular end use. It includes the properties that influence the performance of

the end product and, moreover, the features which have an effect on the cost and the efficiency of the entire working process (log dimension and shape; presence of defects such as knots; and strict wood properties such as anatomical, physical and mechanical characteristics of wood) (MacDonald and Hubert 2002).

Therefore, the breeders should be aware of the genetic control of desirable timber traits to meet the needs of the industry; their correlation with the commonly recognised as "positive" traits (i.e. tree growth and architecture, disease resistance); and if and how the wood trait measured in the young tree can predict the same characteristic of the adult tree (Rozenberg and Cahalan 1997).

Up to now, the most studied species by the wood traits point of view are softwood. Among hardwoods various investigations can be found in the literature on *Populus* and *Eucalyptus*, whereas very little is known about the valuable broadleaved species (Zobel and Van Buijtenen 1989; Zobel and Jett 1995).

Finally, a further indispensable remark. It is necessary to keep in mind that the characteristics of the timber harvested in plantations represent the result of the close interactions of three key factors: the environment, the genetic factors and the cultural practices. All of them must be considered at the same importance level. The plantations of improved genotypes will not produce automatically high quality timber if not properly managed. It makes essential that breeders and silviculturists will work together in a thick collaboration (Hubert and Lee 2005).

The cherry wood in the Italian industry

In table 1, the main benefits and requirements for wild cherry cultivations are summarized. Besides the positive carbon-sink functions, the wide geographical range that makes it a native species in the most European countries, and the high landscape value due to the pleasant blooming, wild cherry provides an highly appreciated timber, used to lasting product manufacture.

It is considered in every respect a valuable species by the European timber market, particularly in Italy where the furniture industry is extremely important. The cherry timber is, in fact, mainly used for furniture, both as solid wood and veneer; cabinet making, flooring, decorative joinery and turnery.

At present, Italy is one of the main European users of cherry timber, but it has to be pointed out that the term "cherry timber" includes wild and sweet cherry (the last from trees for fruit production), but also black cherry (*Prunus serotina*), imported from North America to meet the high European demand of cherry wood.

The major problems of cherry wood, which can reduce the processing yield and the quality of the final product, are the numerous knots (cherry is characterized by high pruning needs), the presence

of green streaks (green vein) mostly in the European cherry, and the gum pockets, mainly in the American provenances.
The prizes of cherry timber can vary considerably due to the end-use (destination), wood quality (presence of defects, log dimension and form), but they are usually very high, reached (and sometimes exceeded) only by walnut.
In the following some examples of the prizes of roundwood, boards and veneer of both European and American cherry are reported. They are the result of personal interviews with Italian manufacturers.

Roundwood

European: from 300 to 550 Euro/m^3 (sawlogs)
from 800 to 1000 Euro/m^3 (veneer logs)
American: from 600 to 700 Euro/m^3

Boards

European (green): from 600 to 700 Euro/m^3 (3° selection)
from 800 to 1000 Euro/m^3 (2° selection)
from 1000 to 1100 Euro/m^3 (1° selection)
American (edge): from 1300 to 1500 Euro/m^3

Veneer (0.5-0.6 mm thick): from 2 to 5 Euro/m^2

As regards the cherry wood production in Italy, data on the overall amount are difficult to find, but the importance of the species has been raised since the last decades thanks to the EEC Reg. 2080/92 and the following rural development programmes, which gave considerable incentives to afforestation of agricultural lands with tree species for wood production.
From 1994 to 2000, 104141 ha have been planted in Italy with public incentives and about 75% of them consisted of broadleaved species (Colletti 2001). A large part of these new cultivated areas were planted with wild cherry. We can mention here the example of Piemonte, one of the north Italian regions where the arboriculture had a large development and where the wild cherry occupied the 48% (2000 ha) of the land planted with valuable broadleaved species, against walnut (1200 ha), pedunculate oak (500 ha) and ash (450 ha) (Licini 2007). The material used in the plantations was mainly of seed origin.
So it becomes evident the importance of the studies aimed to select and to improve the planting material to be used in the production of high quality cherry wood and the research on the best

cultural practices. Furthermore, the study of the wood properties of the improved planting materials is essential to complete the breeding programmes and it is surely useful when it becomes available to the arboriculturists by means also of the inscription of new cherry clones to the national Forest Clone Register.

Wild cherry breeding programmes in Italy

In the last years numerous breeding programmes have been developed for wild cherry in as many European countries, the greatest of which were in France and Germany (Kobliha 2002), and various studies on growth and morphological traits are available (Santi et al 1998, Muranty et al 1998, Curnel et al 2003, Martinsson 2001).

In Italy the genetic variability of wild cherry natural populations was investigated (Ducci and Proietti 1997). By means of electrophoretic analysis and some phenological traits, the size of the natural sucker groups of wild cherry was estimated and a minimum distance of 100 m between trees selected for improvement was assessed by Ducci and Santi (1997), in order to guarantee the genotype heterogeneity.

The selection of plus trees started during the decade of 1980 and followed mainly growth and tree architecture criteria. Clones were then tested in plantations established mainly by the Istituto Sperimentale per la Selvicoltura of Arezzo (CRA-SEL) and by the Dipartimento di Colture Arboree of Bologna University.

Minotta *et al.* (2000) in two clonal plantations situated in the Northern Apennine Mountains found out a general higher growth rate of the clones (except for one) in respect to the seedlings used as witnesses and a significant influence of the genotype to determine tree diameter and tree height.

Ducci *et al* (2006) reported the estimation of broad sense heritability of growth traits in 4 cherry clone plantations in central Italy and their correlation with architecture traits (stem form; branch size, number and angle). The main results were:

- the broad sense heritability can be very high for traits useful to selection;
- the broad sense heritability is higher when environment and soil conditions are homogeneous and clones can express their real potential;
- the *genotype x environment* interaction was generally low;
- the correlations between growth and architecture traits were generally low.

(for major details see Ducci *et* al 1990 and Ducci *et al* 2006).

Further investigations worked on the cherry clone resistance to *Phytophtora* sp., adjusting early screening tests for resistance selection (Barzanti *et al* 2004).

The variability of wood quality of wild cherry clones: the Italian research

One of the first field tests to investigate the variability of wood quality of cherry clones was carried out in the plantation located in the Northern Apennine Mountains, in order to examine the wound cicatrisation after pruning (Baldini *et al* 1997). A quick and effective wound closure is very important to protect the tree from pathogen attacks and, therefore, to keep the good properties of the timber.

The trail consisted of 4 clones (2 selected by CRA-SEL and 2 by the Bologna University) and some seedlings. The trees were pruned in February and the wound area covered by new wood tissues was measured in the following months.

The figure 1 shows the differences of percentage of covered wound area by clones and seedlings. As results of the analysis of variance, significant differences were noticed between clones, so it can be state that the genotype can have an important role to determine the cicatrisation process.

A further investigation on wood characterization of cherry clones previously selected for timber production is ongoing in two trials established by CRA – ISS. The sites description is reported in table 2.

The plantation in Marani was established in 1986; the plantlets were planted at a 3 x 3 m spacing and systematically thinned in 1995. In Forestello, because of the nitrogen and phosphorus poor soil, the cherry clones were planted mixed with Italian alder (*Alnus cordata* Lois.), in order to facilitate improvement in nutrition, thanks to the nitrogen-fixing ability of alder.

At the first site, 6 cherry clones, 8 ramets per clone, were sampled in spring 2006; at the Forestello site 2 of the 6 clones were not available, so only 4 clones, 4-7 ramets, and 3 witness trees (seed origin) were sampled in the following year (spring 2007).

In the field, the main dendrometric quantities were measured (diameter at breast high and every 2 m to calculate the trunk volume, total tree height). After felling, 1 m long log was cut and processed in the laboratory, where the following wood properties were determined:

- heartwood percentage area
- basic density
- maximum shrinkage
- shape factor (radial and tangential shrinkage ratio)
- wood hardness
- bending, compression and shear strength.

Small (transversal section of 20x20 mm) and clear (free of defects) specimens were used in the tests, according to ISO Standards. They were cut from the four radial planks of the log, both from heartwood and sapwood in order to investigate the intra-tree variability as well. A total of 990

specimens were collected for the physical properties determinations and 530 specimens for the mechanical tests.

Finally, microdensitometric measurements were carried out on thin radial sections and observations of the presence of the green vein were effected on each log.

Some results from the first trail (Marani) were presented during the workshop on wild cherry held in Italy the last year (Nocetti and Brunetti 2007).

Briefly, it was found out a significant clone effect for all the studied traits (growth and wood traits) from the analysis of variance (fig. 2), while the ramets inside each clone were quite homogeneous.

Currently, the investigation is becoming deeper thanks to the further analysis on the second site (Forestello), which will allows us to compare the same clones in two different locations.

High presence of green vein was noticed in the samples of Marani site, where clear differences between clones were also observed. On the contrary, in Forestello site the presence of green vein was not so frequent in the trees. It leads to presume an apparent genotype effect on the incidence of the green vein in the wood, but also the environmental conditions seem to play a very important role. Obviously all these speculations need further specific investigations.

Finally we can cite in a few words the study of Signorini (2006), that , in the framework of his PhD Thesis, analysed the colour of the wood in the same trees at Marani site. Some results of his work are published in Ducci et al (2006) where they reported a greater genetic influence on sapwood colour than in heartwood, probably because of the stronger environmental effect on the heartwood formation.

Conclusions

The valuable broadleaved species are so called because of the “valuable timber” that they can produce; therefore, it is essential to understand what valuable timber is, so that the proper way to produce it can be found out.

Studies on the genetic control of the wood traits and the correlation between them and the growth and architecture characteristics of the tree can be very helpful to breeders.

The rich Italian experience on genetic variability and breeding programmes of broadleaved species allows further investigations on the wood of the selected genotypes.

Finally, breeding programmes are extremely useful and they can provide improved genotype to wood production, but it must be emphasized again the importance to combine the improved genotype with the correct silviculture treatments.

References

Baldini S., Brunetti M., Fabbri P., 1997. Prove di potatura con impiego di strumenti diversi in una piantagione di ciliegio da legno. Annali dell'Istituto Sperimentale per la Selvicoltura, Arezzo XXV - XXVI: 345-361.

Barzanti G.P., Biancalani F., De Rogatis A., Ghelardini L., Guerri S., Santini A., 2004. Indagini preliminari per la messa a punto di test precoci di resistenza a *Phytophtora* sp. in alcuni cloni italiani di ciliegio da legno (*Prunus avium*). Forest@ 1(2):135-140. [online] URL: http://www.sisef.it/

Colletti L., 2001. Risultati dell'applicazione del regolamento CEE 2080/92 in Italia. Sherwood, 70: 23-31.

Curnel Y., Jacques D., Nanson A., 2003. First multisite clonal test of wild cherry (*Prunus avium* L.) in Belgium. Silvae Genetica, 52 (2): 45 – 52.

Ducci F., Germani A., Janin G., Proietti R., Signorini G., 2006 - Clone selection for wild cherry (*Prunus avium* L.) with special reference to some traits used. In: Report of the Sixth and Seventh Meetings of Euforgen Noble Hardwoods Network (M. Bozzano, M. Rusanen, P. Rotach and J. Koskela compilers), IPGRI, Rome: 53 -60.

Ducci F., Proietti R., 1997. Variabilità alloenzimatica nel ciliegio selvatico (*Prunus avium* L.) in Italia. Annali dell'Istituto Sperimentale di Selvicoltura, 25-26 (1994-1995): 81 - 104.

Ducci F. and Santi F., 1997. The distribution of clones in managed and unmanaged populations of wild cherry (*Prunus avium*). Canadian Journal of Forest Research, 27: 1998-2004.

Ducci F., Veracini A., Tocci A., Canciani L., 1990 – Primi risultati di una sperimentazione pilota di arboricoltura clonale da legno con *Prunus avium* L. Annali dell'Istituto Sperimentale di Selvicoltura, 21: 81 - 106.

Hemery G.E., 2007. Forest management and silvicultural responses to predicted climate change impacts on valuable broadleaved species. Short-Term Scientific Mission report for Working Group 1, COST Action E42: 73 pp.

Hubert J. and Lee S., 2005. A review of the relative roles of silviculture and tree improvement: the example of Sitka spruce in Britain and possible lessons for hardwood breeding. Forestry, 78(2): 109-120.

Kobliha J., 2002. Wild cherry (*Prunus avium* L.) breeding program aimed at the use of this tree in the Czech forestry. Journal of Forest Science, 48(5): 202-218.

Licini F., 2007. L'attuazione dei regolamenti comunitari per l'arboricoltura da legno. Presentation to the Workshop "L'arboricoltura da legno con latifoglie di pregio", Torino (Italy), 15-16 October 2007. [http://www.regione.pmn.it/montagna/eventi/convegni/arboricoltura.htm]

MacDonald E. and Hubert J., 2002. A review of the effects of silviculture on timber quality of Sitka spruce. Forestry, 75(2): 107-138.

Martinsson O., 2001. Wild cherry (*Prunus avium* L.) for timber production: consequences for early growth from selection of open-pollinated single-tree progenies in Sweden. Scandinavian Journal of Forest Research, 16: 117 – 126.

Minotta G., Santi I., Ponti F., 2000. Confronto tra cloni di ciliegio da legno (*Prunus avium* L.) in due località dell'Appennino settentrionale: risultati dei primi 13 anni di osservazione. Monti e Boschi, 6: 38-47.

Muranty H., Schermann N., Santi F., Dufour J., 1998. Genetic parameters estimated from a wild cherry diallel: consequences for breeding. Silvae Genetica, 47 (5-6): 249 – 257.

Nocetti M., 2008. Miglioramento genetico delle piante per la produzione legnosa con particolare riferimento ai caratteri del legno. Forest@ 5: 112-120. URL: http://www-sisef.it/forest@/.

Nocetti M. and Brunetti M., 2007. Caratterizzazione del legno di cloni di ciliegio impiegati in piantagioni di arboricoltura di pregio. Proceedings of the "Corso-Seminario sul modello del ciliegio selvatico", Montecchio Precalcino (VI) 26-27 giugno 2007, In press.

Rozenberg P. and Cahalan C., 1997. Spruce and wood quality: genetic aspects (a review). Silvae Genetica, 46(5): 270-279.
Santi F., Muranty H., Dufour J., Paques L.E., 1998. Genetic parameters and selection in a multisite wild cherry clonal test. Silvae Genetica, 47 (2-3): 61 – 67.
Signorini G., 2006. Studio sulla variabilità interclonale del colore del legno di ciliegio. PhD Thesis University of Florence, 172 pp.
Sedjo R., 2001a. From foraging to cropping: the transition to plantation forestry, and implications for wood supply and demand. Unasylva, 52(204): 24-27.
Sedjo R., 2001b. Biotechnology's potential contribution to global wood supply and forest conservation. Resources for the Future, Discussion Paper 01-51: 33pp.
Zobel B.J. and Jett J.B., 1995. Genetics of wood production. Springer Series in Wood Science, Springer-Verlag, 352 pp.
Zobel B.J. and Van Buijtenen J.P., 1989. Wood variation. Its causes and control. Springer Series in Wood Science, Springer-Verlag, 363 pp.

Impacts

Factor	*Comments*
Disease	Bacterial cankers
Pests	Deer
Drought	Resistant
Other	Temperature will increase vigour

Opportunities

Factor	*Comments*
carbon-sink	Fast growing and good longevity, range of durable products to lock carbon
ecosystem services	Native to much of Europe. High associated biodiversity. High landscape value.
stand design and management	Genetic stock important (canker resistance and form). Good in mixed forests. Light demanding. High pruning necessary.
Timber	Highly decorative and valuable. Uses – furniture, turnery, veneer.

Table 1 – Summary of *Prunus avium* impacts, benefits, cultivation requirements and timber use from Hemery 2007.

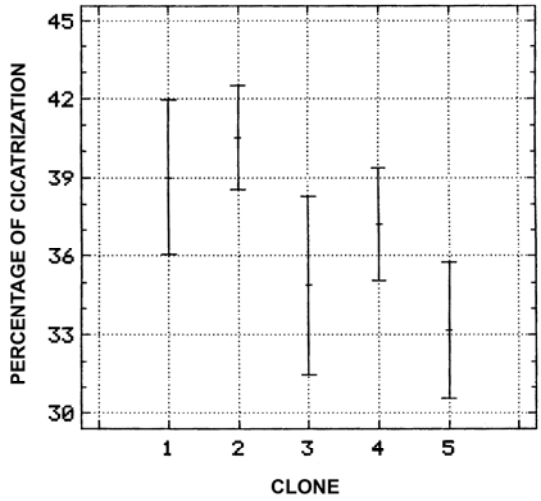

Figure 1 – Mean values of percentage of covered wound area and confidence intervals (95%) by clone (2-5) and seedlings (1).

Site characteristic	Forestello	Marani
Latitude	43° 34’ N	44° 27’ N
Longitude	11° 29’ E	12° 12’ E
Altitude	250 m a.s.l.	5 m a.s.l.
Soil	loam (44% silt, 30% clay)	silt loam (64% silt, 27% clay)
Mean annual Temperature	14 °C	13 °C
Annual precipitations	870 mm	650 mm

Table 2 – Description of Forestello and Marani sites.

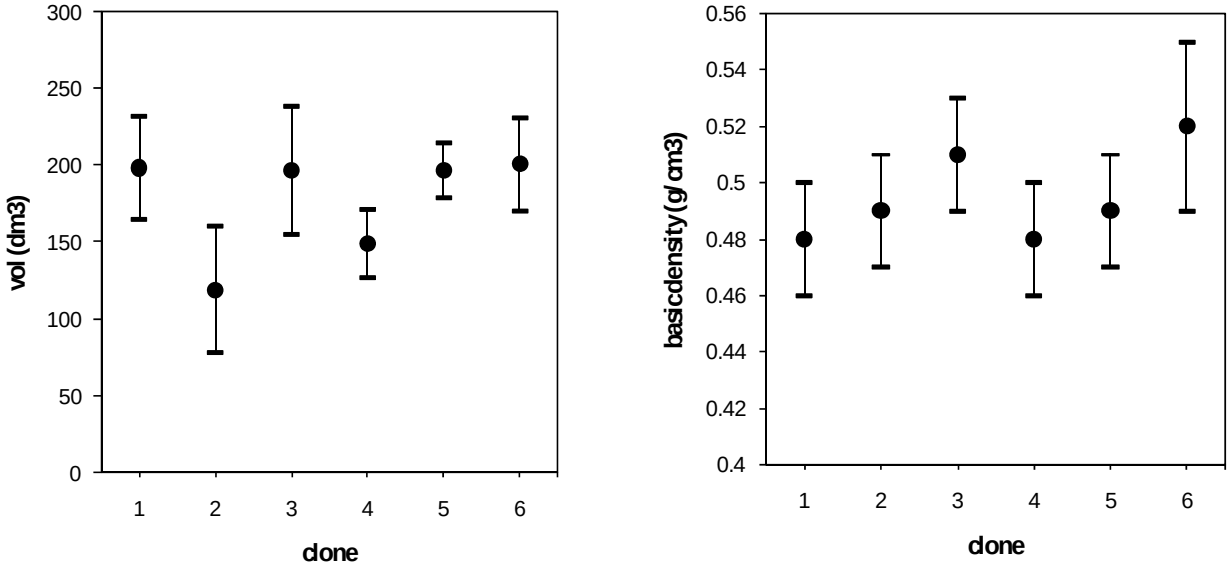

Figure 2 – Mean values and standard deviation of trunk volume and basic wood density by clone (Marani site).