THE USE-POTENTIAL OF *CORNUS MAS* L. IN URBAN PLANTATIONS IN NORTH-WEST EUROPE BASED ON HABITAT STUDIES IN NORTH-EAST ROMANIA AND REPUBLIC OF MOLDOVA

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Abstract: *Traditionally, a limited number of species and genera dominate the tree stock in streets and urban sites. Over the past few decades, a growing proportion of those commonly used species have shown increasing difficulties in coping with the conditions at urban sites. Impermeable surfacing increasing storm water run-off and the urban heat island effect has resulted in tree decline and an increase in disease in urban tree habitats. This negative trend, combined with the challenges of climate change and the threat of further disease and pest attacks in the future have led to considerable and persistent argumentation for the necessity of using a more varied and stress-tolerant selection of tree species at urban sites. From the perspective of northern parts of Central Europe and adjoining milder parts of Northern Europe (in the following abbreviated to the CNE-region), it is unlikely that the species-poor native dendroflora can contribute a large range of tree species with extended tolerance of the environmental stresses characterising to e.g. paved sites within urban areas of the region. This paper present extensive fieldwork carried out in north-east Romania and in the adjacent part of the Republic of Moldavia 2009 in order to identify the use-potential of Cornus mas L. as a city-tree through dendroecological studies. The data obtained in the field were compared with corresponding data from paved and park environments in urban Copenhagen. In this comparison the result shows that the study trees experience warmer and drier site conditions than park environments in Copenhagen while the paved environment in Copenhagen experience drier site conditions than the case in the studied sites. However, if a proper design and technique is used in paved sites with a greater infiltration into the planting pits the site situations gets much more similar to the studied sites indicating that Cornus mas have also a use potential in paved environments in the CNE-region where they can develop into old and healthy trees where the space for high and broad trees does not fit.*

Key words: urban trees, *Cornus mas* L., dendroecology, urban environments, site adapted species use

INTRODUCTION

Traditionally, a limited number of species and genera dominate the tree stock in streets and urban sites, and recent surveys in European and North American cities show that a few species/genera continue to dominate (Pauleit et al., 2002; Raupp et al., 2006; Bühler et al., 2007). Over the past few decades, a growing proportion of those commonly used species have shown increasing difficulties in coping with the conditions at urban sites. Impermeable surfacing increasing storm water run-off and the urban heat island effect has resulted in tree decline and an increase in disease in

urban tree habitats (Pauleit, 2003). This negative trend, combined with the challenges of climate change and the threat of further disease and pest attacks in the future (e.g. Tello et al., 2005; Raupp et al., 2006), have led to considerable and persistent argumentation for the necessity of using a more varied and stress-tolerant selection of tree species at urban sites (Duhme and Pauleit, 2000; Pauleit, 2003).

Water stress is widely argued to be the main constraint for tree growth and health in the urban environment (e.g. Whitlow and Bassuk 1986; Craul 1999). Research on the drought tolerance of trees has classically focused on physiological reactions in the water balance/water use in terms of transpiration rates, sap flow measurements and the hydraulic architecture of the tree (e.g. Kozlowski et al., 1991; Sperry et al., 1998; Breda et al., 2006; David et al., 2007; West et al., 2007). These investigations give valuable information at the tree level but they are limited in their practical everyday use for urban tree planners, arborists etc. (Roloff et al., 2009). Dendroecological studies, as presented in this paper, can contribute to an ecological knowledge that will help evaluate the reaction, tolerance and performance of different trees species to different stressors. It would be a first step in the selection process for 'new' tree species for urban sites, and according to Roloff et al. (2009), this kind of dendroecological description is seldom or never available for most species.

In natural habitats, trees have been stress-tested and selected over evolutionary periods of time. Some species have developed an extensive plasticity and tolerance to a range of environmental conditions, while others have specialised in certain habitat types (Rabinowitz 1981; Gurevitch et al. 2002). For instance, steep south-facing mountain slopes with thin soil layers or warm and dry steppe environments represent distinct habitat types where the environmental parameters that define the particular habitat and separate it from other habitats have shaped the evolution of plants. Such environmental parameters also screen out many potential colonising species not suited to the particular habitat. Investigating the ecological background and performance of species growing in habitats where they experience drought during the growing season and winter temperatures similar to inner-city environments of a particular area/region could be a great help in the identification of trees for future selection for use at urban sites (Flint 1985; Ware 1994; Ducatillion and Dubois 1997; Sæbø et al. 2005; Roloff et al. 2009).

From the perspective of northern parts of Central Europe and adjoining milder parts of Northern Europe (in the following abbreviated to the CNE-region), it is unlikely that the species-poor native dendroflora can contribute a large range of tree species with extended tolerance of the environmental stresses characterising to e.g. paved sites within urban areas of the region (Duhme and Pauleit 2000). However, other regions with a comparable climate but with a rich dendroflora may have the potential to contribute new tree species and genera for this purpose (Takhtajan 1986; Breckle 2002; Roloff et al. 2009). In northeast Romania and in the Republic of Moldavia, on the eastside from the Carpathian Mountains, large areas of steppe vegetation occur due to warm and dry climates (Breckle 2002) with a climate and site situation comparable to inner city environments in the CNE-region.

Cornus mas L. is a medium sized tree which has had an increasingly greater use in public greeneries the last decades in the CNE-region based on its generous spring flowering and popular fruit settings and autumn colours. However, since the experience of the species in public plantations is limited new innovating research methods have to been developed in order to gain larger knowledge and experience of the species. This paper present extensive fieldwork carried out in north-east Romania and in the adjacent part of the Republic of Moldavia 2009 in order to identify the use-potential of *Cornus mas* as a city-tree through dendroecological studies. The study especially focused on:

- Identification of habitats in north-east Romania and in the adjacent part of the Republic of Moldavia where tree species are exposed to seasonally dry and warm conditions.
- Characterisation of the performance of *Cornus mas* in these geographical area.
- Presentation and discussion the use-potential of *Cornus mas* regarding use in urban sites in northern Europe.

The findings from the field survey were compared against two different site situations in the inner city environment of Copenhagen (Denmark), which was used as an example to illustrate growth conditions in a large city of the northern CNE-region: 1) The present climate and site situation of urban paved sites; and 2) urban park environments.

MATERIAL AND METHODS

Case study area

North-east Romania and the Republic of Moldavia have a temperate-continental climate with hot summers, long, cold winters and very distinct seasons. Due to the higher summer temperatures and lower rainfall compare to Western Europe, large steppe forest systems are located in this area (Breckle 2002). The field studies were carried out in these steppe forests during September-November 2009 in six different areas, all with a climate similar to that at urban sites in the CNE-region. Data on the climate in the field study areas were taken from the nearby meteorological stations of Iasi (Sîrbu, 2003; Ursu, (2005), while data for Copenhagen were taken from DMI (2009). In selecting the exact location of the plots for the study, special attention was paid to areas with homogeneous site conditions with mature forest trees, including *Cornus mas*. Total 13 study plots were including in the study, strategically placed within recognised forest stands. Plot size was 20 m x 20 m.

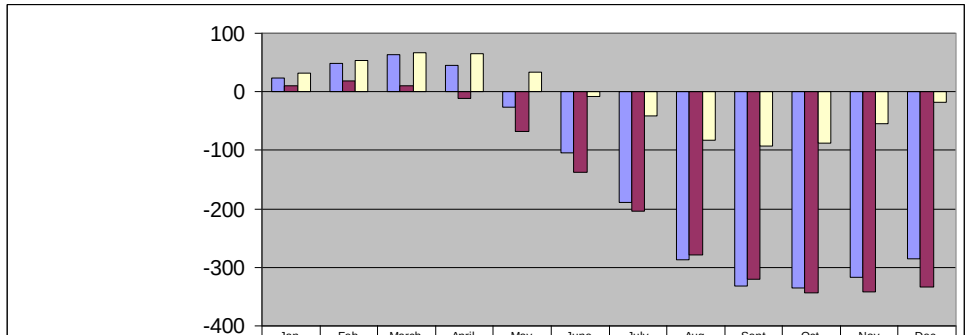
Measurement of plot data

In order to link the match between the natural habitats and the urban conditions in the CNE-region, soil texture, humus content and pH value were determined. Soil samples were collected at three different depths (0-20, 20-30, 30-50 cm) from 10 pits randomly distributed in each field plot (Klute, 1986; FAO, 2006). The replicate samples for each depth and site were pooled before analysis (FAO, 2006). Soil texture was analysed using the soil grain analyser method, organic matter using the $K_2Cr_2O_4$ method (Sims and Haby 1971), and pH using the potentiometric determination method (soil/water = 1:2).

In order to evaluate the growth and performance of the tree species in the study plots, trunk diameter at breast height (DBH) at 1.3m height, total tree height and tree age were determined for each individual tree in the plots. The tree heights were measured with a clinometer (Haglöf Vertex IV). To establish age, all trees were subjected to drilling for year ring counts as close to the ground as possible (Grissino-Mayer, 2003). Moreover, the trees positions in thevegetation structure were surveyed to distinguish canopy from understorey.

Calculation of potential water stress and growth

In order to evaluate the growth pattern of *Cornus mas* at the study sites, the height and DBH were divided by age, allowing annual tree growth for the sites to be calculated (figure 2). Since water stress is the main concern for urban trees (e.g. Whitlow & Bassuk, 1986; Craul, 1999) the potential water stress (water netto difference) in the study plots was calculated (figure 1). In calculating potential evapotranspiration the regression by Thornthwaite (1948) where used, with monthly potential evapotranspiration based on the values of temperature, number of sunshine hours per day and cloudiness. Sunshine hours per day were estimated on a monthly basis by combining information about day length (Meeus, 1991) and days with rainfall as an indicator for cloudiness (Ursu, 2005). Estimates of water run-off for the studied woodlands were based on P90 (2004) with an assumed 10% run-off.



	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Iasi	24,3	48,9	63,2	44,4	-26,9	-103,5	-189,6	-287	-331,8	-336	-317	-285,5
Copenhagen (Paved sites)	10,8	18	11,1	-11,7	-67,6	-137	-204,1	-278,8	-320,3	-342,7	-342	-333
Copenhagen present (Park environments)	32,4	54	67,5	65,7	33,8	-8,6	-41,5	-83,2	-92,9	-87,1	-55,2	-18

Fig. 1. Calculated potential evapotranspiration (mm) in the study area and in urban paved environments and park environments of Copenhagen today.

RESULTS

Site conditions

The soil texture was comparable at all study plots, with high levels of clay (mean 24.0%) and silt (mean 49.6%) and low organic matter content (mean 3.5%). In terms of climate the study forests in Northeast Romania and Moldova have a lower precipitation compare to Copenhagen additionally with a much warmer summer climate with a much more effective evapotranspiration as a result. This uneven match between the study area and Copenhagen is visibly in figure 1, where the water net difference between study plots and park environments in Copenhagen has a clear discrepancy. The water net in the study plots show negative figures in May and the remaining season while park environments in Copenhagen show a negative water net in June with a less dramatically trend during the remaining season (fig. 1). However, when comparing the water net difference between the study plots and paved sites in Copenhagen a much closer matching is visibly due to much drier site conditions in paved sites due to effective water runoffs. In paved sites in Copenhagen the calculated water net show negative figures already in April and the remaining season. Moreover, the negative water net

difference is larger in paved sites of Copenhagen from April to July while the study plots show larger negative water nett during August and September (fig. 1).

Plant development and performance

In total, there were 84 individuals of *Cornus mas* in the studied plots. The age range of the *Cornus mas*, including in the study, where 12-64 years, the height range where 2-11 meter and the diameter size (DBH) range where 1.6-10.8 centimetres. All the individuals of *Cornus mas* in the studied plots where located in the lower tree layer with other high growing tree species above them. The calculated growth, presented in Figure 2, show a yearly average height growth of 0.16 meters and a yearly average diameter increment of 0.17 centimetres. Based on these average growth numbers it can be concluded that *Cornus mas* in this climate and on this soil can reach to 2.4 meters high individuals in 15 years while they can reach 8 meters in height in 50 years.

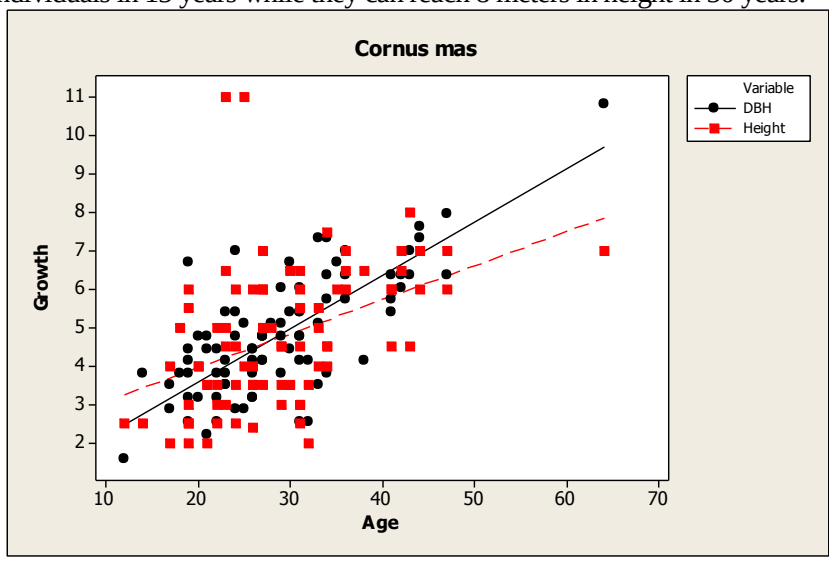


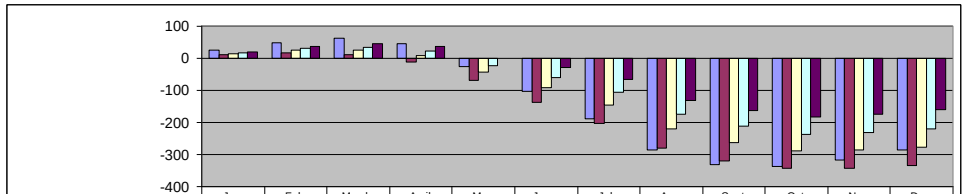
Fig. 2. Height increment (m) and DBH increment (cm) of all *Cornus mas* in the study plots.

DISCUSSIONS

Site conditions

The evaluation of site conditions revealed high levels of clay and silt in all plots. Although the soil humus content at the sites was low (mean 3.5%), the water-holding capacity in the study sites can be considered very good (Craul, 1999). These favourable growth conditions counteracted the cumulative water deficit calculated for the study sites (figure 1). For example, although there was a 26.9 mm deficit, water was probably accessible to the trees for much longer periods due to the good water-holding capacity of the soil. Moreover, since silt has very good capillary water transporting capacity, groundwater can be transported upwards from depth and become accessible for the trees. Therefore, the apparent close match between cumulative water deficit between the study sites and paved sites in Copenhagen is actually inaccurate in terms of the drought stress experienced by the trees. Moreover, it is anyhow accurate to conclude that *Cornus mas* in the study sites experience

warmer and drier site conditions then trees in park environments in Copenhagen. Further, based on the result in this study it is possible to conclude that *Cornus mas* can tolerate more stressful growth conditions than park environment in the CNE-region and in order to include the species also in paved environment it is necessary to design and construct suitable growth conditions with greater water infiltration which increase the use-potential for the species. In an attempt to evaluate the match between urban paved sites in Copenhagen and the natural study sites, calculations were made for different rates of water run-off at the urban paved sites (figure 3). The results showed a much smaller net water deficit when run-off was reduced, from 70% in the original calculations to 50, 40 or 30%, which clearly shows the importance of proper planning and design for provide suitable site conditions and prevent run-off.



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Iasi	24,3	48,9	63,2	44,4	-26,9	-103,5	-189,6	-287	-331,8	-336	-317	-285,5
Copenhagen (Paved sites - 70%)	10,8	18	11,1	-11,7	-67,6	-137	-204,1	-278,8	-320,3	-342,7	-342	-333
Copenhagen (Paved sites - 50%)	13,1	24,7	25,5	7,3	-42,9	-90,1	-144,6	-220,6	-262,2	-288,3	-286,4	-277,7
Copenhagen (Paved sites - 40%)	16,3	31	34,9	22	-21,9	-59	-105,2	-175,6	-212,4	-236	-230,6	-218,8
Copenhagen (Paved sites - 30%)	19,5	37,3	44,3	36,7	-0,9	-27,9	-65,8	-130,6	-162,6	-183,7	-174,8	-159,9

Fig. 3. Table 1. Effect of reducing run-off rate to 50%, 40% or 30% on cumulative net water balance in paved sites in Copenhagen compared with the study area.

Plant development and performance

In total, 84 *Cornus mas* were included in 13 study plots. All of the *Cornus mas* in the study occurred in the lower tree layer where they experience cooler conditions since the above standing trees crown modify positively the wind, humidity, and temperature microclimate for the species in the understorey layer (Oliver, Larson 1996). However, due to *Cornus mas* position in the understorey the species show great abilities to tolerate shady growth conditions which is important in the use of the species in urban environments where the urban structure with buildings create local really shady conditions.

The experience of *Cornus mas* in culture is that the species have a rather slow growth which the results from the study confirm where the study trees have a average yearly height growth of 0.16 meters.

Moreover, due to earlier and not recorded variation in the species compositions in the stands additionally with earlier competition situations, the analyse of the growth data presented in the paper should be interpreted with some consideration. However, the growth and development data can anyhow act as a guideline in the species development in these climate and site situations. To get even more accurate data it is important to test *Cornus mas* origin from this area in urban plantations in the CNE-region. From these plantations local experiences can be gained but dendroecological studies in climates and in natural site situations similar as urban environments of the

CNE-region can be used as a first selection step in order to concentrate on species with a high potential instead testing randomly since selection of trees is a time-consuming process.

CONCLUSIONS

This study examined the potential of *Cornus mas* for use as an urban tree in northern parts of Central Europe and adjacent, milder parts of Northern Europe (the CNE-region), based on habitat studies in north-east Romania and in the adjacent Republic of Moldavia.

The data obtained in the field were compared with corresponding data from paved and park environments in urban Copenhagen.

In this comparison the result shows that the study trees experience warmer and drier site conditions than park environments in Copenhagen while the paved environment in Copenhagen experience drier site conditions than the case in the studied sites. However, if a proper design and technique is used in paved sites with a greater infiltration into the planting pits the site situations gets much more similar to the studied sites indicating that *Cornus mas* have also a use potential in paved environments in the CNE-region where they can develop into old and healthy trees where the space for high and broad trees does not fit.

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