Boxwood Blight in Turkey: Impact on Natural Boxwood Populations and Management Challenges

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Lehtijärvi, A., Doğmuş-Lehtijärvi, H.T. and Oskay, F. 2017. Boxwood Blight in Turkey: Impact on Natural Boxwood Populations and Management Challenges. *Baltic Forestry* 23(1): 274-278.

Abstract

There are approximately 1000 ha of natural populations of *Buxus sempervirens*, a small evergreen tree widely used in ornamental landscaping, in Turkey. These populations usually occur as an understorey in forests. Since the outbreak of boxwood blight epidemics in the Eastern Black Sea region in 2011 approximately 90% of the trees in the affected areas have died. In this paper we discuss the possibilities to save boxwood in Turkey.

Keywords: boxwood blight, Turkey, disease management

Introduction

Importance of Buxus spp. in Turkey

Boxwood (*Buxus sempervirens* L.) is a small evergreen tree, widely used in ornamental landscaping as individual specimens or in hedges, parterres and groups. It is among one of the most important ornamental plants in the municipalities in Turkey. Seedlings are produced by state and municipality nurseries and to less extent by private ones (Anon. 2015). In addition to ornamental plantations there are approximately 1000 ha of native boxwood populations. These populations, comprising mostly of *Buxus sempervirens* L., usually occur as an understorey in forests. The distribution covers the Black Sea and the Marmara Sea regions but there are also small populations in the Mediterranean region. These populations have suffered significant damage over centuries due to harvesting of the valuable wood and unplanned cutting of shoots for floricultural usage. As part of efforts of sustainable usage of boxwood harvesting is regulated and some exceptional populations have been selected as genetic reserves.

Boxwood blight and its spread

Traditionally, boxwood was regarded to be free of serious pests (Henricot et al. 2008). In mid-1990s a new disease, boxwood blight, appeared on boxwood plants in the United Kingdom and spread throughout Europe (Henricot et al. 2000, Henricot 2006). The disease is caused by two closely related fungi of unknown origin, *Calonectria pseudonaviculata* (Crous, J.Z. Groenew. and C.F. Hill) L. Lombard, M.J. Wingf. and Crous 2010 (syn. *Cylindrocladium buxicola* Henricot, G1 clade) and *Calonectria henricotiae* Gehesquière, Heungens and J.A. Crouch (G2 clade) (Gehesquière et al. 2016). Near-clonal genetic background of both species indicates that they are invasive alien species introduced as single asexually spreading isolates (Gehesquière et al. 2016). Since boxwood is among one of the most popular ornamental plants in the world, spread especially via trade of plants probably contributed to the rapid spread of the disease (Henricot and Culham 2002). Distribution of the disease is not limited to Europe; boxwood blight is also known in New Zealand since the late 1990s (Crous et al. 2002) and it was first observed in North America in 2011 (Douglas 2011, Ivors et al. 2012). Boxwood blight affects many commercial boxwood species and their varieties, among which *B. sempervirens* and its varieties are the most susceptible ones (Henricot 2006, Henricot et al. 2008, LaMondia 2015).

Both fungal species can grow in temperatures ranging between 5 and 30° C, with high growth rates at temperatures ranging from 15 to 25 ^{o}C and observed optimum at 25 ^{o}C (Henricot and Culham 2002, Gehesquière et al. 2016). Mycelial growth of *C. henricotiae* is faster than that of *C. pseudonaviculata* at 20 ^{o}C and higher temperatures (Gehesquière et al. 2016). The life cycle of the fungi in optimal conditions can be as short as one week. The spread of the fungi occur asexually by conidia, which are sticky indicating that they are disseminated by rain splash or a vector. At warm temperatures (18-25 ^{o}C) and high humidity spore germination starts three hours and penetration of the leaves five hours after inoculation. Penetration occurs directly or via stomata by hyphal growth, without formation of specific infection structures (Henricot 2006). Mycelium of the pathogens can survive prolonged periods up to several years in leaf litter on the soil surface or buried in the soil. Survival can be facilitated by formation of microsclerotia (Henricot 2006, Dart et al. 2015).

In this paper we give an overview of the health situation of natural *Buxus sempervirens* populations in Turkey since the outbreak of boxwood blight and discuss some disease management options to save the remaining boxwood trees as well as the serious threat caused by another invasive pest, the box tree moth.

Boxwood blight epidemic in Turkey

Disease outbreak and spread in Turkey

In Turkey, boxwood blight was first detected and identified in the end of 2011, in the Eastern Black Sea region in Trabzon and Artvin provinces (Akıllı et al. 2012). It is not known how and when the pathogen was introduced to Turkey. Nevertheless, the disease seemed to have made a jump from Western and Central Europe to the Eastern Black Sea region and Iran (Gorgiladze et al. 2011, Akıllı et al. 2012, Mirabolfathy et al. 2013). According to official reports boxwood blight epidemics in the region broke out more or less simultaneously: in 2010 in Georgia (Gorgiladze et al. 2011), in 2011 in north-eastern Turkey (Akıllı et al. 2012), and in 2012-2013 in Southern Russia (EPPO 2016). It is possible that the disease has been present in the Eastern Black Sea region for several years before the reported disease outbreaks, as the earliest, unpublished observations of symptoms similar to boxwood blight are from the Caucasus in 2007 (Marc Kenis, Iryna Matsiakh, personal communication). Although details about techniques used in identification of the pathogen in connection of these observations are not known, the observations are most likely correct. However, several factors, including the complexity of natural ecosystems, a time lag between the arrival of an invasive pathogen and outbreak of a disease as well as trade of boxwood, may make tracing of the boxwood blight outbreak to its source difficult or impossible (cf. Brasier 2008).

The break out of the epidemics in north-eastern Turkey was observed in November 2011, one year after detection of the disease in Georgia in Mtirala National park located 15-30 km from the Turkish border (Gorgiladze et al. 2011). At that time, the disease was spreading epidemically in the natural *B. sempervirens* populations in Trabzon and Artvin provinces. Devastating effects were visible in the end of 2012 in some of the populations near the Black Sea coast; in affected areas up to approximately 90% of the boxwood plants were completely defoliated (Lehtijärvi et al. 2014). Distribution of the disease was approximately 200 km along the coast from Georgian borders towards west and 3 to 25 km along the steep, moist river valleys to the south. However, possibly due to scattered distribution of the *B. sempervirens* populations in the river valleys the populations located further south (inland) were still free of infection or showed only the very first signs of arrival of the epidemic.

Impact of boxwood blight on the natural populations

In November 2012, the degree of damage in the affected areas (Lehtijärvi et al. 2014) indicated that the boxwood blight epidemics threatened the existence of the natural boxwood populations in the Eastern Black Sea region of Turkey. Boxwood trees growing as understory and dense groups were often completely defoliated. At that time some of the severely defoliated box wood plants were producing epicormic shoots, mostly at the lower part of the trunk. However, it is unclear which proportion of the plants was able to recover. A revisit to one of the sites in 2015 indicated that such a recovery was not common. Owing to the optimal conditions for the life cycle of the fungus during several months in the affected area repeated infection of the foliage and shoot axis in both the epicormic and normal shoots is likely a reason for failure in recovery. The progress of the damage followed a pattern: defoliation progressed from base to the top of the trees, and in case of complete defoliation, drying of the tree from top to down. A minor proportion (≤10%) of the boxwood plants had survived the disease. They were scattered and had at least a limited green top in the canopy. The situation seems to be similar throughout the affected areas also in 2016 (Metin Karadağ, personal communication). Natural boxwood vegetation in the near future is likely to consist of single boxwood individuals scattered in the landscape.

Signs of potential genetic resistance in populations and individuals

In the end of 2012, one to two years after the outbreak of the epidemics in north-eastern Turkey, even in the most severely affected sites single boxwood plants with variable proportion of green canopy were present (Lehtijärvi et al. 2014). Similar observations made in March 2015, in one of the locations, indicated that some of the plants were either more resistant or had escaped the disease. The trees with no or little signs of defoliation were often growing in special locations in the affected stands: under rock cliffs, scattered in on a hill slope with other tall plants and on slopes facing southwest to west. These observations indicated that in spots where air currents carrying conidia within rain splash could not reach, or where the leaf wetness period was shorter due to sunshine infection pressure on the plants was lower.

Ongoing and planned projects / research in Turkey

National Pest Risk Analysis report concerning boxwood blight was prepared in 2015. In addition, survey work on distribution of the disease in Turkey has been conducted and a distribution map is under preparation (Anon. 2015).

Management options to mitigate the impact on natural boxwood populations

Silvicultural management options

During boxwood blight epidemics effects of silvicultural management strategies may be insignificant. However, in post epidemics situation silvicultural methods may help to reduce infection pressure on surviving boxwood individuals. For instance, increased aeration and solar radiation resulting from removal of upper canopy layer could diminish leaf wetness period and thereby lower the new infections. Creation of gaps between boxwood individuals by thinning operations may somewhat reduce infections. The spread of the disease in boxwood hedge can be very rapid in one autumn (Rosander 2012). Within severely defoliated boxwood vegetation recovery via regrowth from epicormic shoots or root suckers could be promoted in a scattered pattern using e.g. 100 m spacing between the plants. It is important that the boxwood plants between these recovery spots are left to die naturally, or if harvested, the remaining stumps killed with a herbicide to create gaps free of boxwood shoots and foliage. Inoculum of boxwood blight in upper soil layer in the recovery spots could be reduced by flaming the surface (Dart et al. 2012).

Alternative *Buxus* species

While usage of less susceptible boxwood species or varieties, such as *Buxus sinica* (Rehder and E.H. Wilson) M. Cheng var. *insularis* (LaMondia 2015) would not solve the issue of saving the natural boxwood populations, replacement of susceptible boxwood with them in ornamental usage would help to reduce the spread of the disease. In long term it would also eliminate reinfection of the natural stands from ornamentals. This would be beneficial if the surviving, possibly more resistant boxwood individuals in the affected region will be used in efforts to recover the original boxwood vegetation.

Chemical control

Due to obvious lack of resistance against the blight among the *B. sempervirens* plants (Henricot et al. 2008) control of the disease with fungicides would be the only short term alternative to save the boxwood populations. However, there are only limited possibilities to use fungicides in the infected areas, due to the risk of the chemicals ending up in the rivers and therefrom to households. Moreover, the climatic conditions in the river valleys during growing season, temperature ranging from 15 to 25 °C and precipitation occurring on average every second day, are optimal for the fungus.

Potential threat caused by other pests on *Buxus sempervirens*

Box tree moth

In addition to boxwood blight, the most threatening one of the few currently-known pests that can have significant influence on boxwood populations is the box tree moth *Cydalima perspectalis* (Walker). This invasive alien species of East Asian origin was first found in 2007 in Germany. To date the distribution of this moth covers most of Europe (EPPO, 2016). Box tree moth had reached western part of Turkey by 2011 when it was found in the European part of Istanbul, and has since then spread at least approximately 300 km eastwards. It is highly likely that distribution of this pest will cover large parts of that of *B. sempervirens* in Turkey in the near future. The moth is spreading from the Caucasus via Georgia towards the Turkish border (Marc Kenis, Iryna Matsiakh, personal communication). The moth can cause complete defoliation and death of a boxwood plant. It is difficult to evaluate what impact the boxwood moth can have in the boxwood populations surviving from the disease epidemic.

Fungal species

Other disease agents observed on boxwood in the forests infected with the boxwood blight were *Pseudonectria buxi* (DC.) Seifert, Gräfenhan and Schroers (syn: *Volutella buxi*), *Puccinia buxi* Sowerby and *Dothiorella candollei* (Berk. and Broome) Petr.(syn: *Macrophoma candollei* (Berk. and Broome) Berl. and Voglino). These fungi were also reported in these forests or in other regions of Turkey or on ornamentals previously (Göbelez and Karaca 1954, Göbelez 1962, Gürcan 1976, Hüseyin et al. 2005, Lehtijärvi et al. 2014, Hüseyin and Selçuk 2014).

Volutella blight, caused by *P. buxi*, was one of the major boxwood diseases and was considered the primary cause of boxwood decline in many countries (Shi and Hsiang 2014). The pathogen usually reported to co-occur on *C. buxicola* infected plants, thus regarded to increase the impact of the disease (Henricot et al. 2000, Šafránková et al. 2012, 2013). However in an inoculation test, a non-significant effect of their co-occurrance was found (Oskay et al. 2015).

Phytophthora citricola Sawada is another important pathogen isolated from rhizosphere soil of diseased boxwood seedling from a nursery in Turkey (Aday Kaya 2014). Some other fungi, worth to mention, associated with boxwood reported from Turkey are: *Diplodia buxicola* Sacc, *Rosellinia buxi* Fabre (Hüseyin et al. 2005, Selçuk et al. 2010, Lehtijärvi et al. 2014, Hüseyin and Selçuk 2014).

Possibilities for *ex situ* conservation of Turkish boxwood

Boxwood can be easily propagated with cuttings, which opens up a possibility for *ex situ* conservation of the genetic diversity that still could be recovered from the natural populations. Careful selection of disease free shoots from the surviving individuals could be collected, propagated and cultivated in an area free from the disease. The high variation in climate in different parts of Turkey would allow *ex situ* conservation of a collection of Turkish boxwood genotypes in areas with suitable climate but lacking natural boxwood populations. More expensive alternative would be to maintain a genotype collection in glasshouses located in the dry inner Anatolia where boxwood does not grow naturally. These boxwood reserves could be used in resistance breeding programs and replanting of the areas affected by the epidemic if and when the areas have become free of the disease.

Conclusions

Due to obvious lack of resistance against the blight among the *B. sempervirens* plants (Henricot et al. 2008) control of the disease with fungicides would be the only short term alternative to save the boxwood populations. Although there are several preparates that are effective, none of them is certified for usage in forest in Turkey. Moreover, there are only limited possibilities to use fungicides in the infected areas, due to the risk of the chemicals ending up in the rivers and therefrom to households. Owing to the optimal climatic conditions for the fungus in the river valleys during several months, i.e. high humidity and temperature ranging from 15 to 25 °C, repeated fungicide treatments would be necessary. Combination of silvicultural management of the remaining boxwood and *ex situ* conservation may be the best long time strategy to save the remaining genetic diversity.

References

Aday Kaya, A.G. 2014. Türkiye'nin Batısında Yer Alan Orman Fidanlıklarında Geniş Ve İğne Yapraklı Fidan Türlerinde Kök Çürüklüğüne Neden Olan Ökaryot Patojenlerin Belirlenmesi [Determination Of Root Rot Causıng Eukaryote Pathogens On Decıduous And Conıferous Seedlings In Forest Tree Nurseries In Western Turkey]. PhD Thesis, Süleyman Demirel University, Isparta, Turkey, 126 pp. (in Turkish with English abstract)

Akıllı, S., Katırcıoğlu, Y.Z., Zor, K. and Maden, S. 2012. First report of box blight caused by *Cylindrocladium pseudonaviculatum* in the Eastern Black Sea region of Turkey. *New Disease Reports* 25: 23.

Anonymous, 2015. *Cylindrocladium pseudonaviculatum=Cylindrocladium buxicola* (Şimşir yaprak yanıklığı) Hakkında Zararlı Risk Analizi [*Cylindrocladium pseudonaviculatum=Cylindrocladium buxicola* (Boxwood blight) Pest risk analysis] GKGM Risk Değerlendirme Daire Başkanlığı. (in Turkish, Unpubl.,) 22 pp.

Brasier, C.M. 2008. The biosecurity threat to the UK and global environment from international trade in plants. *Plant Pathology* 57(5): 792–808.

Crous, P.W., Groenewald, J.Z. and Hill, C.F. 2002. *Cylindrocladium pseudonaviculatum* sp. nov. from New Zealand, and new *Cylindrocladium* records from Vietnam. *Sydowia* 54: 23–33.

Dart, N. L., Arrington, S. M., and Weeda, S. M. 2012. Flaming to reduce inocula of the boxwood blight pathogen, *Cylindrocladium pseudonaviculatum* in field soil. Online. *Plant Health Progress*. DOI:10.1094/PHP-2012-1026-01-BR. Available at http://www.plantmanagementnetwork.org/pub/php/brief/2012/flaming/

Dart, N., Hong, C.X., Craig, C.A., Fry, J.T. and Hu, X.R. 2015. Soil inoculum production, survival, and infectivity of the boxwood blight pathogen, *Calonectria pseudonaviculata*. *Plant Disease* 99(12): 1689–1694.

Douglas, S.M. 2011. Boxwood blight – a new disease for Connecticut and the U.S. Available at www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/boxwood_blight-_a_new_disease_for_connecticut_and_the_u.s.__07-20-12_r.pdf (accessed May 16, 2016).

EPPO 2016. EPPO Global Database (available online). https://gd.eppo.int

Gehesquière, B., Crouch, J. A. Marra, R. E. Van Poucke, K. Rys, F. Maes, M. Gobin, B. Höfte M. and Heungens, K. 2016. Characterization and taxonomic reassessment of the box blight pathogen *Calonectria pseudonaviculata*, introducing *Calonectria henricotiae* sp. nov. *Plant Pathology* 65(1): 37–52.

Gorgiladze, L., Meparishvili, G., Sikharulidze, Z., Natsarishvili, K. and Davitadze, R. 2011. First report of box blight caused by *Cylindrocladium buxicola* in Georgia. *New Disease Reports* 23: 24.

Göbelez, M. 1962. La mycoflore de Turquie 1. *Mycopathologia Applicata* 19: 296–314.

Göbelez, M. and Karaca I. 1954. Türkiye Mikroflorası için yeni Mantarlar [New fungi for the Turkish Mycoflora]. *Ziraat Dergisi*, Sayı 119. (In Turkish).

Gürcan, A. 1976. Bazı süs bitkileri ve gölge ağaçlarının fungal hastalıkları üzerinde arastırmalar [Investigations on the fungal diseases of some ornemental plants and shadow trees]. Ankara Universitesi Basımevi. Ankara. (In Turkish).

Henricot, B. 2006. Box blight rampages onwards. *The Plantsman* 5: 153–157.

Henricot, B. and Culham, A. 2002. *Cylindrocladium buxicola*, a new species affecting *Buxus* spp., and its phylogenetic status. *Mycologia* 94: 980–997.

Henricot, B., Pérez Sierra, A., and Prior, C. 2000. A new blight disease on *Buxus* in the UK caused by the fungus *Cylindrocladium*. *Plant Pathology* 49(6): 805.

Henricot, B., Gorton, C., Denton, G. and Denton, J. 2008. Studies on the control of *Cylindrocladium buxicola* using fungicides and host resistance. *Plant Disease* 92(9): 1273–1279.

Hüseyin, E. andSelçuk, F. 2014. Coelomycetous fungi in several forest ecosystems of Black Sea provinces of Turkey. *Agriculture and Forestry* 60(2): 19–32.

Hüseyin, E. Selçuk, F. and Gaffaroglu, M. 2005. Material on the micromycetes of Box tree (*Buxus*) and *Rhododendron* from Turkey. In Proceeding of the XVI Symposium of Mycologists and Lichenologists of Baltic States. Cesis, Latvia, September 21-25, 2005: 62–68.

Ivors, K.L., Lacey, L.W., Milks, D.C., Douglas, S.M., Inman, M.K., Marra, R.E. and LaMondia, J.A. 2012. First report of boxwood blight caused by *Cylindrocladium pseudonaviculatum* in the United States. *Plant Disease* 96(7):1070.

LaMondia, J.A. 2015. Management of *Calonectria pseudonaviculata* in Boxwood with Fungicides and Less Susceptible Host Species and Varieties. *Plant Disease*, 99(3): 363–369

Lehtijärvi, A., Doğmuş-Lehtijärvi, H. T. and Oskay, F. 2014. *Cylindrocladium buxicola* is threatening the native *Buxus sempervirens* populations in Turkey. *Plant Protection Science* 50(4): 227–229.

Mirabolfathy, M., Ahangaran, Y., Lombard, L. and Crous, P.W. 2013. Leaf blight of *Buxus sempervirens* in northern forests of Iran caused by *Calonectria pseudonaviculata*. *Plant Disease* 97(8): 1121.

Oskay, F., Doğmuş-Lehtijärvi, H.T. and Lehtijärvi, A. 2015. Impact of Boxwood Blight Pathogens; *Cylindrocladium buxicola* and *Pseudonectria buxi* on *Buxus balearica* and *Buxus sempervirens*. IUFRO 2015 WP 7.02.02 Foliage, Shoot and Stems Diseases of Forest Trees& WP 7.03.04 Diseases and Insects in Forest Nurseries, Uppsala, Sweden, 7-12 June2015: 48,.

Rosander, C. 2012. Buxbomssjuka – utbredning och spridningshastighet på Malmös kyrkogårdar [Box blight – distribution and spread rate in the churchyards of Malmoe. MSc Thesis, SLU, Alnarp, Sweden, 34 pp. (In Swedish with English summary)

Šafránková, I., Kmoch, M. and Holková, L. 2012. First report of *Cylindrocladium buxicola* on box in the Czech Republic. *New Disease Reports*, 25: 5.

Šafránková, I., Holková, L. and Kmoch, M. 2013. Leaf spot and dieback of *Buxus* caused by *Cylindrocladium buxicola*. *Plant Protection Science*, 49(4): 165–168.

Selçuk, F., Hüseyin, E., and Şahin, A. 2010. Contrıbutıon to Study of Turkey Mycobiota IV. The New Records of Microfungi with Asci To Forest Phytocoenose of Rize Province. *Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi*, 11(2), 53–60.

Shi, F., and Hsiang, T. 2014. *Pseudonectria buxi* causing leaf and stem blight on *Buxus* in Canada. *European Journal of Plant Pathology*, 138(4): 763–773.