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Short research contribution

Seyed M. HOSSEINI[1*], Davoud KARTOOLINEJAD[1], Seyed K. MIRNIA[2], Zahra TABIBZADEH[2], Moslem AKBARINIA[1], Fatemeh SHAYANMEHR[1]

[1] Department of Forestry, Natural Resource Faculty, Tarbiat Modares University, Nour, Mazandaran, P.O. Box 46414-356, Iran, *e-mail: hosseini@modares.ac.ir
[2] Department of Soil Science, Agriculture Faculty, Tarbiat Modares University, Iran

THE EFFECTS OF *VISCUM ALBUM* L. ON FOLIAR WEIGHT AND NUTRIENTS CONTENT OF HOST TREES IN CASPIAN FORESTS (IRAN)

ABSTRACT: Caspian forests (in the region it is called – Hyrcanian Forests) with an area of about 1.9 million ha are located in north of Iran, in southern coast of Caspian Sea. It is exclusive site for some valuable species like *Populus caspica* Bornm., *Gleditsia caspica* Desf., *Parrotia persica* Meyer. and *Pterocaria fraxinifolia* (Lam.) Spach., and the forests are dominated by *Fagus orientalis* Lipsky, *Quercus castanifolia* C. A. M., and *Alnus glutinosa* Gaertn. The mistletoe (*Viscum album L.)* effects on the area and weight of leaves of the two host tree species (hornbeam *Carpinus betulus* L. and ironwood *Parrotia persica* Meyer.*)* were studied on a number of severely infected individuals and control trees in selected parts of Hyrcanian Forests. Almost 100 leaves from infested and non-infested branches of two host species were sampled in order to compare with control trees (non-infested trees growing near each host). Results showed, that area and weight of leaves taken from infested branches of ironwood were significantly lower (at 95% confidence level) than leaf area and weight in non-infested branches and control trees. The amount of K, Mn and Zn was higher in infested branches of both species compared to control trees. However, the amount of nitrogen in infected branches of ironwood was lower. The results suggest that *V. album* may have detrimental effect on leaf structure, physiology and chemical composition of strongly infested host trees.

KEY WORDS: mistletoe, host trees, ironwood tree, nutrient contents, leaf area

Nearly 1% of all angiosperm species are parasitic and about 40% of plant parasites are shoot parasites (stems and leaves), parasitizing the above ground parts of their host plants, while the other 60% are root parasites. Mistletoes – the predominant group of angiosperm shoot parasites – are fascinating and diverse group of plants found in wide range of ecosystems including boreal forests, tropical rain forests and arid woodlands (Norton and Carpenter 1998).

Mistletoes are the dominant members of the Santalales and *Viscum album* is just one of the over 1300 mistletoe species world wide. All are hemi-parasites (semi-parasite) of trees and shrubs, joining to the host *via* an intimate xylem-to-xylem connection called a *haustorium* (Watson 2001, Briggs 2003).

The white berry mistletoe, *Viscum album* L. is an epiphytic and hemi parasitic shrub growing on the branches of 452 different host species in 96 genera and 44 families such as *Salix*, *Populus*, *Acer*, *Prunus*, *Crataegus*, *Malus*, *Abies*, *Pinus*, etc. (Barberaki and Kintzios 2002, Zuber 2004, Tsopelas *et al.* 2004).

V. album is a mostly globose perennial evergreen shrub with persistent haustoria in the host. This phanerophyte hemi-parasite, contains chlorophyll *a* and *b* and is able to conduct the photosynthesis. It takes water and nutrients from the host and produces its own metabolites whenever it has access to light and carbon dioxide (Watson 2001, Briggs 2003, Zuber 2004).

In this study, the amount of some primary nutrients like N, P, K, Ca, Zn and Mn in the leaves taken from the branches infested and non-infested with *Viscum album* was compared with the leaves of completely healthy trees growing near – by (control trees). The aim of the study was to study whether *V. album* may cause the decrease of these elements in its two prevalent host species (i.e. *Carpinus betulus* L. and ironwood *Parrotia persica* Meyer.) in Hyrcanian Forests. Also the mistletoe effect on foliar area and weight of *Parrotia persica* Meyer. individuals was assessed.

The Caspian zone forests which is also called the Hyrcanian forests are the most valuable forests in Iran. They cover the northern slopes and foothills of Alborz mountains. Location of Alborz mountains between the Caspian Sea and Iran plateau results in mild climate and distinct vegetation cover. Forests of these zone stretch out from sea level up to an altitude of 2800 m and encompass different forest type thanks to 80 woody species i.e. trees and shrubs (Hosseini 2003, Sagheb-Talebi *et al.* 2005). The most common trees are *Fagus orientalis* Lipsky, *Quercus castanifolia* C. A. M., *Carpinus betulus* L., *Zelkova carpinifolia* (Pall.) Dipp., *Diospyros lotus* L., *Buxus hyrcanus* Pojark, *Taxus baccata* L., *Castanea sativa* Mill., *Acer velutinum* Boiss, *Sorbus torminalis* (L.) Crantz. (Hosseini 2003).

For this study, two forest communities were selected in Hyrcanian forests, being the most dominant hosts of *Viscum album* L. These are : the *Parrotio-Carpinetum* community in Nour Forest Park (36°34´N, 51°41´E, at 10 m a.s.l.) and *Querco-Carpinetum* in Educational-Research Forest of Kheiroud kenar-Noshahr (36°34´N, 51°50´E; at 640 m a.s.l.), both located in Northern Part of Iran in Mazandaran province. The mean annual precipitation of two regions are respectively 1040 mm and 1345 mm and mean annual temperature – 17°C and 15.9°C.

Five severely infested ironwood individuals and five completely health trees (a control tree found near each infected one) were selected in Nour Forest Park in August 2004. The sample trees had approximately the same value of breast-height-diameter, height and crown shape. The infested and non-infested branches, as well as branches from control trees, had similar diameter, length and sun light direction. Eleven largest leaves per branch were selected, and their area and weight were measured. To compare the content of nutrients, leaf samples were picked from non-infested and infested branches of parasitized trees and healthy tree branches; the leaves were located in external middle part of the crown with same position towards sun light direction.

About 100 leaves (including petioles) were picked and placed into tightly sealed

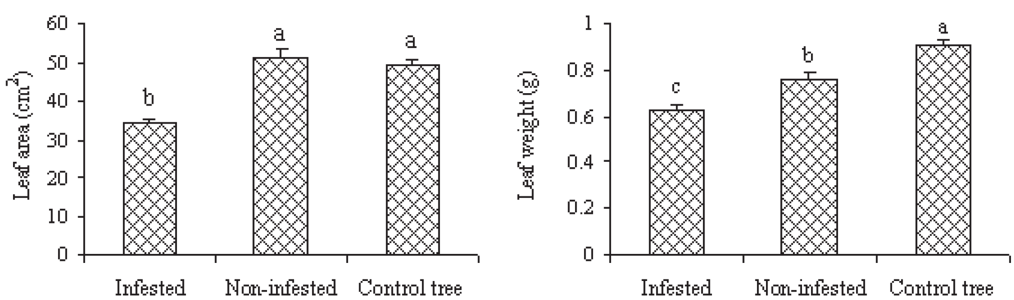

Fig. 1. Mean leaf area (left) and weight(right) in infested and non-infested branches and in control trees of *Parrotia persica* (Dunnert T3 and Tukey HSD test).

nylon bags and immediately transferred to the laboratory with minimum delay. Then plant material was oven dried at 65°C for 48 h, ground to a fine powder using a Willey mill and then digested (Wet digestion technique) with H_2SO_4, salicylic acid, H_2O_2 and Selenium powder. The digest was filtered with Whatman paper no. 42.

Contents of the elements were determined using following techniques: total nitrogen with Titration procedure after distillation using KJELTEC Auto Analyzer (model Tecator 1030), the potassium content by flame photometry with Flame Emission Spectrometer (model JENWAY Clinical PFP7), phosphorus by vanadium-molybdate method using Spectrophotometer (model JENWAY 6505) and Ca, Zn and Mn with Atomic Absorption Spectrophotometer (model Shimatsu 6550). Finally all data were analyzed by one-way analysis of variance (ANOVA) and Tukey HSD and Dunnett T3 tests using SPSS 12.0 for windows software.

The results of Dunnett T3 test, showed that the leaf area as well as leaf weight of ironwood are lower in infested branches compared to non-infested and control tree branches of this species (Fig. 1) (P = 0.000). Only in case of ironwood the differences in nitrogen content in leaves were statistically significant. The content of this element in leaves of infested branches was lower than in the leaves of control trees; in non-infested branches of parasitized trees the relevant values were intermediate (Table 2). The amount of potassium in leaves of infested branches was higher than in leaves of control trees in both species (Tables 1 and 2). The amount of zinc as well, was higher in infested than in control trees of both species. The amount of manganese in infested ironwood trees was higher than in control

Table 1. The nutrients content (mean values ± S.E.) of host and control trees of hornbeam (*Carpinus betulus)* based on *post-hoc* comparison (Tukey HSD test, P <0.01). The same letters denote that the difference among groups (at 95% confidence level) is not significant.

Nutrients	Infested branches	Non-infested branches	Control tree branches
nitrogen (%)	a 0.12 ± 1.94	a 0.11 ± 1.90	a 0.11 ± 2.02
phosphorus (%)	a 0.03 ± 0.17	a 0.02 ± 0.16	a 0.02± 0.19
potassium (%)	a 0.29 ± 5.33	ab 0.23 ± 5.10	b 0.23± 4.32
calcium (%)	a 0.51± 3.81	a 0.54 ± 4.42	a 0.99 ± 5.09
zinc (ppm)	a 1.08 ± 9.20	a 0.77 ± 9.09	b 0.55 ± 5.39
manganese (ppm)	a 0.98 ± 6.61	a 0.64 ± 5.80	a 0.40 ± 6.69

Table 2. Nutrients content (mean ± S.E.) of host and control trees of Ironwood (*Parrotia persica)* based on *post-hoc* comparison (Tukey HSD test, P <0.01). The same letters denote that the difference among groups (at 95% confidence level) is not significant.

Nutrients	Infested branches	Non-infested branches	Control tree branches
nitrogen (%)	b 0.04 ± 1.30	ab 0.07 ± 1.47	a 0.03 ± 1.59
phosphorus (%)	a 0.01 ± 0.17	a 0.01 ± 0.16	a 0.01± 0.15
potassium (%)	a 0.15 ± 4.81	ab 0.21 ± 4.45	b 0.16± 3.82
calcium (%)	a 0.53± 5.15	a 0.14 ± 6.03	a 0.60 ± 5.60
zinc (ppm)	a 1.01 ± 5.04	ab 0.76 ± 2.70	b 0.50 ± 1.43
manganese (ppm)	a 4.63 ± 36.44	a 2.62 ± 25.28	b 0.65 ± 17.30

group. The contents of other nutrients like phosphorus and calcium do not show any significant differences between analyzed groups of leaves (Tables 1 and 2).

Viscum album, like many other mistletoes, is a hemi parasitic plant, absorbing water and nutrients from the host xylem, but able to produce its own assimilates in the process of photosynthesis (Tennakoon and Pate 1996, Heide-Jørgensen 2004, Zuber 2004).

V. album has a high transpiration rate, similar to many other parasitic plants and a low photosynthetic rate. The study of the nutrient contents of the xylem and seasonal measurements of the biomass and tissue nutrient contents of *Viscum* and *Pinus* have led to the hypothesis that the high rate of transpiration may be necessary for the parasites to take up sufficient nitrogen from the xylem of the host. Nitrogen is important for the production of biomass (Zuber 2004). Other studies of growth rate and accumulation of nutrients like N, P, K and Ca as well as values for carbon isotope ratios of mistletoe tissue further support the hypothesis that the higher transpiration rates of mistletoes represent a nitrogen uptake mechanism. Nitrogen is the nutrient potentially the most limiting the mistletoe growth. Generally the solutes in the xylem sap of the host reach the mistletoe through the transpiration stream and according to this, the amount of nutrients like N, K, P, Ca and Mg are considerably higher in *Viscum* than in the host, specially when compared to infected host branches (Zuber 2004). The reason is that the hydrostatic pressure in the cells of the two parts of haustorial connection (between host and parasite) is in favor of the parasite and hence water with dissolved nutrients will always flow from the host to the parasite and not in the opposite direction (Heide-Jørgensen 2004).

When the mistletoe infects host branches, the changes in host leaf area, leaf number, growth rate and biomass reflect the physiological and metabolic perturbation induced by the parasite (Karunaichamy *et al.* 1999). Competition for water, inorganic ions and metabolites is the simplest explanation for loss in host production and consequently a decrease in leaf area and leaf weight (see Fig. 1). According to Marschner (1995), high nitrogen supply increases the severity of infection by parasites and it is why a positive correlation between nitrogen application and pest attack is often observed. This relationship can be explained by the important role played by nitrogen; the mistletoes have no real root in soil and can not absorb mineral nitrogen directly from soil they take it up through the haustoria in host xylem (Zuber 2004, Watson 2001). The host plant also is not able to absorb and compensate nitrogen supply quickly; consequently we perceive the decreasing in amount of nitrogen in infested branches of *Parrotia persica*.

In contrast to nitrogen, high concentration of potassium increases the resistance of host plants to both parasites attack and difficult environmental conditions (Marschner 1995). It seems that confronting with the parasite, the host plant uptakes higher amount of potassium from the soil; the result is the higher concentration of this element in infested branches of both host species (Tables 1 and 2). According to Marschner (1995) micronutrients can also indirectly affect plants resistance. In case of deficiency, not only the defense mechanism of the plant could be impaired but often plants become a more suitable feeding substrate. On the whole, micronutrient-deficient plants suffered much more pest attacks than plants well-supplied with micronutrients (Marschner 1995). It seems that the similar mechanism functions in case of zinc and manganese as well as in case of potassium. The host plants being attacked by parasites change their metabolism and try to absorb more micronutrients from the soil.

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