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Mini Review

The Potential of the Paulownia Plant for Climate Mitigation and Environmental Protection

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Abstract

The paper contains a brief survey of climate and environment regulating effects of the Smaragdfa TM hybrid based on 26 references in this Short Communication. The investigated features are classified into two groups:

a) climate–plant interactions.

b) effects of the plant on environmental pollution.

Keywords: Paulownia tree; CO_2; climate; microclimate

Introduction

The Paulownia tree is one of the world's fastest-growing species [1]. It absorbs high amounts of carbon dioxide during its rapid growth, contributing to mitigating global warming. (Please see the first Statement in the next Section!). Another advantage of planting Paulownia for climate protection is its high tolerance to adverse environmental conditions caused by climate change, such as high temperatures and increasing drought tendencies [2]. Therefore, it can be cultivated in a wide range of climatic environments. In our previous paper [3], the role of the Smaragdfa in nutrition, health care and animal feeding was presented. The present paper comprehends regulating features of the Smaragdfa related to climate and environment.

Climate Plant Interactions

a) Its photosynthesis type C4 absorbs 100 tons of CO2/ha/year in Europe compared to Morocco's 200 tons of CO2/ha/year. The native trees process on the European continent only 13 - 13.6 tons of CO2/ha/year.

These deciduous trees, native to China, are characterized by an average height of 20-30 m (Innes, 2009). Their diameter reaches approximately two meters [4,5] by the end of their 24-30 years of life cycle. Leaves in the maturated tree reach a length of 15 – 30 cm and a width of 10-12 cm, with smooth and weaved sides [6]. The rare leaves create a cylindrical crown or an umbrella shape. Paulownia produces C4-type photosynthesis with a high level of organic matter in their leaves [7].

b) The plant actively forms and stabilizes microclimate through its crown shadow and leaves evaporation. In an Eco- Island or a carbon climate plantation, it can decrease temperature by 3-5 °C.

This Statement was proven by several articles and studies from around the world. But the most promising studies were taken in China, where more fieldwork was done over several years. They also researched intercropping effects of different Paulownia species. In these studies, several microclimate measurements were also taken, in which the data show that Smaragdfa and other Paulownia trees can effectively reduce the temperature in their environment 1-10 m distance [8-10]. Tree crown acts as a barrier against heat transfer and reduces air mixing and evaporation, increasing air temperature. Although the studies mentioned above show that in the first 4-5

years in a denser Paulownia spacing, the temperature is higher than in the control plot, it is due because the shading and the reduction in radiation are not significant in the early years of plantation. But it was also mentioned that after 40 m of distance, the temperature was higher at 0.4 °C. As the air temperature decreases in the immediate vicinity, it also affects the soil temperature and soil moisture. Due to the large foliage, the wind speed and evaporation could also decrease. These are very remarkable data and measurements. Also, due to this large foliage, Paulownia can easily influence shading and solar radiation. And these properties vary with the age of the plantation.

As in the young age, the vegetation is smaller, and the first 4 -5 years moderately affect microclimate. Nevertheless, later in an older plantation, the above effects can happen. The wind change reduction depends on the Paulownia growth stage, flowering stage, and whether the leaves are fully developed or not. The solar radiation depends on the geographical state of the plantation, its age, the season, and the distance from the tree row. Therefore, it gives a different ratio of positive effects in different regional climates. Paulownia trees can change the daytime temperature, and the night temperatures increase by 0.1-1 °C depending on the distance between the trees. Some studies also state that the relative humidity has also changed in the neighborhood of Paulownia. In the study of Yunying (1993), we found data according to 9% of rising relative humidity, which values were even higher during the night and clear days. In their study, [11] mentioned that soil moisture also reaches higher values with Paulownia trees.

c) Its evaporation during the day and its condensation at night enrich intercropping. Yield can grow up to 30% due to favorable conditions.

Around the world, several studies can be found regarding intercrop experiments. Woods (2008) published most of the results. Different studies were taken with rice, maize, peony, wheat, lettuce, sweet potato and tobacco intercrop in China and Africa. Most research mentioned that Paulownia species have several characteristics favorable to intercropping. One of them is that Paulownia species are fast-growing tree species. Although Paulownia requires a lot of light, it can be planted less densely than other tree species and has fewer leaves than other trees, making intercropping easier. As Paulownia develops its leaf late, it is favorable to wheat, maize, and summer crops, as these plants have enough time for flowering. In addition, from November to May, there are no leaves on Paulownia trees, which can be useful for other intercropped vegetation. The main conclusions were that, for example, regarding the maize growth, the impact of trees increases with the tree size, but decreases with the distance from the tree row [12,13] found that crop yield effects depended on tree density and rotation length. Furthermore, the root system groves deeply in the soil, which can be favorable for intercropping plants, as there is no competition for water in the upper part of the soil. We must mention that the early stages of intercropping are the best; as the trees grow larger, their negative impacts dominate the intercropped field. In addition, the intercropped plant yield depends on the tree spacing area, and the best numbers were getting 5x20 m.

d) Due to the tree's ability to high CO2 absorption and the smooth transformation into cellulose, oxygen production is very intense.

Woods (2008) mentioned that Paulownia could be used as a "cellulosic ethanol generator", where cellulosic ethanol is a blend of ethanol produced from biomass, including waste from urban, agricultural and forestry sources. It was cited by 2003 [14] that Paulownia has an average specific density of 0.28; this compares with values of 0.40 for Eastern Cottonwood, 0.37 for Basswood and 0.42 for Poplar. Navroodi 2013 published that the increment condition of Paulownia fortunei was better than Populus deltoids. The mean annual DBH and height increase of Paulownia was two times higher in the Guilan province of Iran. Earlier, we already mentioned studies, which showed the CO2 capacity of this tree, and the result is impressive (see above in the 1st Statement). The Paulownia tree has a high carbon sequestration coefficient [15]. The rapid growth of biomass requires a significant amount of CO2, approximately 1250 t/ha/year [16]. A single tree can absorb around 22 kg of CO2 and release 6 kg of O2 annually [17].

Impact of the Plant on Environmental Pollution

a) Leaves have a micro-adhesive surface that catches up to 30 tons of dust per year and ha, which is later recycled into the soil during the nighttime with the help of condensation. Thus, pollen, smog and other harmful components are extracted from the air, too.

Paulownia helps to clean the air polluted by harmful gases and particles, which reach high concentrations, especially in large industrial cities. All this is made possible by the big leaves of the Paulownia tree that, for this reason, can be described as the "green lung" of our cities. According to [18], each acre (i.e., 0.4 ha) of trees can absorb 13 tons of harmful gases and particles from the air each year. In other words, one ha absorbs 2.5x13 = 32.5 tons per year. The giant leaves of Paulownia can capture the small particles of pollutants in the air ten times more than any other tree species.

b) The plant's taproot reduces slope erosion, offering natural protection to the affected settlements.

Paulownia is a tree with excellent adaptability, capable of growing even in soils polluted by heavy metals and toxic substances. Therefore, absorbing these substances helps reclaim the land that would be difficult to use for other crops, purifying the soil and the water inside. Furthermore, once fallen, the large leaves fertilize the soil and enrich the soil with natural humus. The root system of Paulownia is formed by an umbrella-shaped root which usually penetrates the ground up to a maximum depth of 1-1.5 meters and a taproot which can reach depths of up to 8-9 meters; due to this root system, Paulownia is often used to settle areas at risk of erosion or landslides [19].

c) Rehabilitation of contaminated sites is an important issue all over the world. Smaragdfa® filtrates the contaminants through its taproot and could use sewage- and wastewater from garbage depots or animal breeding.

Extensive research was taken to examine the ability of remediation of Paulownia species, especially regarding the nitrates, heavy metal content and other land contaminants. [20] did their research in China, and their results were outstanding. [21] study confirm what has been said so far, Cu concentrations in roots, stems, and leaves of P. fortunei increased significantly as Cu levels increased and reached 1911, 101 and 93 µg. g-1 dry weights (D.W.) at 157 µmol l−1 Cu treatment, respectively. Tzvetkova et al. 2015 got similar results, but they also examined other elements such as Cd, Ca, Mg, K, Na, Cu, Zn and Fe) in soil, the plant root, and stems and leaves. They also calculated bioaccumulation and translocation factors to determine the potential of the plants to remove metals from the contaminated soils. They get the following results:" The B.F. for Fe, Pb, Cu and Zn in T.F. 01 line exceeded that of E.F. 02 line--5.6; 1.03; 1.20; 1.14 times, respectively. T.F. was higher in T.F. 01 line for Fe, Pb and Cd (6.0; 1.92 and 1.03, respectively) but not for Cu and Zn.

The success of phytoremediation depends on plant growth and restricted distribution of heavy metals in shoots. Their results showed that the stem length and total leaf area of Paulownia elongata x fortunei were higher than Paulownia tomentosa x fortunei. Still, B.F. for Cu and Zn and T.F. for Pb was less. B.F. for Cd was 1.7 times higher, and T.F. for Zn was 1.03 times higher in Paulownia elongata x fortunei. Selected two lines (P. tomentosa x fortunei--T.F. 01 and P elongata x fortunei--EF02) were Cu, Zn and Cd accumulators. Paulownia tomentosa x fortunei accumulated more Pb and Zn in aboveground parts, while Paulownia elongata x fortunei-accumulated Zn only" [22]. also showed that the Pb, Zn, Cu and Cd Paulownia fortunei can absorb them from the soil. [23] proved that Paulownia trees can remove N at a rate of 930 kg/ha/year, based on an average N foliar content of 2.6%. As with the growing demands of the increasing population, environmental impacts are significant issues worldwide. Therefore, the fast-growing, metal-accumulating plants can be a promising approach for remediation [24,25].

Discussion

In addition to the above-listed advantageous features of the Smaragdfa, these effects can be primarily supported by an independent addition to the agricultural soils, the device Agrooter®, which is a Hungarian patent. It is a product that, through its water retention, its tubular shape and the micro- and macro-elements, which comprise its material, can collectively and positively influence the factors that most affect plant life. In this way, it increases plants' shock tolerance, yield average, and growth rate and significantly speeds up their recovery. Made from natural materials (minerals), the product is self-degrading within three years. It can be used in both conventional manual and organic farming. Its use also significantly reduces exposure to climate change and the environmental impact (irrigation water use). Unfortunately, we could not find any descriptions in English. The homepage of the Agrooter is also in Hungarian only (https://www.gyokeritato.hu/). Note that the Hungarian name of Agrooter, 'GYÖKÉRITATÓ', means 'making the roots drink'.

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