Urban Forestry & Urban Greening 21 (2017) 175–182

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Original article

Foliar iron sulphate-organic acids sprays improve the performance of oriental plane tree in calcareous soil better than soil treatments

Bijan Salahi[a], Ebrahim Hadavi[a,*], Seyed Mahmood Samar[b]

[a] Horticulture Department, Karaj Branch, Islamic Azad University, Karaj, Iran
[b] Soil and Water Research Institute of Iran, Karaj, Iran

ARTICLE INFO

Article history:
Received 23 April 2016
Received in revised form 23 October 2016
Accepted 5 December 2016
Available online 9 December 2016

Keywords:
Calcareous soil
Fe Deficiency
Foliar biostimulation
Organic acids

ABSTRACT

Oriental plane tree (*Platanus orientalis*) is among the much-used elements of urban decoration in Iran. Many thousands-of-years-old plane trees are still viable in different cities. In recent years, because of the changes in management practices of urban areas, like widespread use of asphalt for streets pavement and use of concrete in water canals together with the polluted water and air, the growing condition is worsened causing a widespread occurrence of chlorosis symptoms. In this study, we assessed the effect of foliar sprays (3000 ppm or 6000 ppm humic acid, 4 or 8 mM of malic acid, citric acid or L-glutamine and a control blank treatment) in comparison to soil treatments (a localized placement method in which a mixture of sulfur, FeSO4 and decomposed manure is placed under the topsoil and a standard sequestrene Fe 138 application), for improving the performance of plane trees. All the sprays contained 0.7% FeSO4 as Iron source. The leaf area, leaf SPAD value, leaf thickness and trichome presence on leaves, the color of the newly emerged leaf and the current season shoot growth were recorded. The concentration of key leaf elements were also determined. Glutamine treated plants showed elevated acquisition of boron, manganese, zinc and copper. In all treatments, the leaf chlorophyll index (SPAD) significantly increased compared to the control treatment. Glutamine, citric acid, and sequestrene treatments were superior in improving the color of the young leaves. Treatments containing glutamine and citric acid had more trichomes on the leaf surface compared to the control and the leaf necrosis index was reduced by all applied treatments. Sequential Equations Modeling (SEM) is used to examine the path of noted responses to applied treatments.

1. Introduction

More than half the world's population are living in urban areas. This share reaches to three-quarters of the total population in developed countries. Meanwhile, a mass conversion of land from rural to urban use has taken place. However, the role of trees as the basic element of rural and urban decoration remains unchanged. On the other side, the situation for trees is unsustainable; the rise in fossil fuels use and the global warming has altered the microclimate of trees in recent years. As a result, while plane tree grew well in main cities of Iran in the past, but nowadays syndromes of misadaptation like chlorotic leaves and premature shedding of leaves have become widespread. Obviously, the situation for the plant is not as safe as it used to be for a long time. For instance, the pavement of urban areas creates large-scale soil sealing that already has been shown to affect on plane trees (Morgenroth and Visser, 2010). Spatial changes in wind, temperature extremes and means and rainfall and irrigation patterns are among other changing factors to which the pollution of soil and air should be added.

Plane trees provide timber, are highly decorative and exert a valuable influence on urban pollution while being prone to calcareous chlorosis (Ake et al., 1991). In a study on plane trees in an urban area in china, Wang et al. (2012) showed that foliar N content varied from 1.5% to 5.3%, with an annual average of 3.4% (2012). In a search for proper indicators of calcareous chlorosis in plane tree, the activity of glutathione peroxidase (GP) enzyme and concentration of carotenoids and chlorophyll were determined as promising physiological indices of active Fe, while the total Fe concentration in leaves was considered misleading (Khoshgoftarmanesh et al., 2013). In another study, the mean concentrations of nitrogen, phosphorus, potassium, sodium, iron, zinc, manganese and copper in green plane trees were determined; they suggested that the chlorosis could be attributed to deficiency of nitrogen, iron, zinc and manganese (Lakzian et al., 2012).

---

* Corresponding author.
E-mail address: hadavi@kiau.ac.ir (E. Hadavi).

http://dx.doi.org/10.1016/j.ufug.2016.12.001
1618-8667/

Currently, there is an interest in the use of humic substances (HS) in improving plant performance. Recently, a wide range of HS effects is reviewed as a subcategory of biostimulants by Calvo et al. (2014) who concluded that HS affects various aspects of plant physiology and growth. It has been shown that HS in soils affects the plant growth indirectly via changes in composition and function of the rhizosphere microorganisms (Varanini and Pinton, 2000). By a survey of a wide range of published studies, Rose et al. (2014) found that HS generally increase shoot and root growth by 15–25%, but there is a high variation, which increases the risk for farmers. Around half of the studies on Shoot DW response and one-third of Root DW studies failed to significantly increase growth; thus, there is a strong need to improve the consistency and predictability of the growth responses. Likewise, Quilty and Cattle (2011) concluded that while HS are becoming increasingly available as commercial supplements for crop improvement, but growth effects can be either positive or negative and hard to predict.

Eidyan et al. (2014) noted a synergism between foliar application of iron sulfate+citric acid in prolonging the vase-life in tuberose. Darandeh and Hadavi (2012) noted a rise in chlorophyll content of lilium by spraying iron sulfate+malic acid; a change in the carbohydrate partitioning in favor of the underground sinks was also observed by applied treatments. Root-exudated organic acids are the main carbon source for rhizobacteria (Ohwaki and Sugahara, 1997). An elevation in the citrate and malate exudates from roots of calcicole plants (plants growing in alkaline soils) enables them to extract P and Fe from such soils (Lopez-Bucio et al., 2000). Jafari and Hadavi (2012), suggested that foliar organic acids could lead to augmented plant mineral acquisition by an increase in exudation of organic acids as part of the responsible mechanism for improved growth performance. The proposed increase in organic acid exudation in response to foliar organic acids was confirmed later by An et al. (2014), and the mediation of these exudates in mineral absorption from the soil medium is well known (Marschner, 1996; Bais et al., 2006; Arcand and Schneider, 2006).

Soil fertilization is a costly procedure for urban trees while foliar sprays are much easier to conduct. Therefore, we planned this research to evaluate some promising alternative foliar treatments in comparison with prevalent soil-applied treatments and watched for possible signs of improvement in the adaptability of the plane trees to the harsher urban environment that they are facing nowadays.

2. Material and methods

This study was conducted in an urban park in the district 5 of Tehran municipality. Eleven treatments were compared in seven replications in a completely randomized design experiment. Replications consisted of single trees, which were selected to be in a similar group of size and other visual features. Foliar sprays were applied in late June when trees developed chlorotic leaves and replicated three times in a two weeks interval. The Iron chelate treatment (Sequestrene Fe 138 6%; EDDHA) and the localized placement method (known locally as 'Chal-kood') were carried out at the same time. The treatments were selected based on the results of a pre-experiment with foliar treatments that was carried out during the previous year.

Based on the preliminary tests, we used 10 l of foliar solution for each tree, which was considered sufficient to wet the trees up to start of the dripping stage from the leaves. The foliar treatments were 3000 ppm or 6000 ppm humic acid based biostimulant (HA; Zuk, Iran), 4 or 8 mM of DL-malic acid (MA; Merck, Germany), citric acid (CA; Monohydrate, Daejung Chemical, Korea) or L-glutamine (Gln; Karen, Iran) and a control blank treatment (water+surfactant). All the nine applied foliar treatments contained 0.7% FeSO4, 0.2% urea and 0.4 ml l^{-1} of a commercial surfactant (Citowett, BASF, Germany). For the remaining two soil treatments, we dug four 30–50 cm deep holes in four sides of each tree. In the localized placement treatment, 1 kg of sulfur and 300 g FeSO4 were added to 15 kg of decomposed manure and placed in the holes, which were finally refilled with the same soil. In the sequestrene treatment, we dissolved 100 g of sequestrene Fe 138 (Syngenta, Spain) in 10 l of water and poured into the prepared holes. The holes were refilled with the same soil. A total of 11 foliar and soil treatments were applied.

The leaf samples collected one month after the last spray, during early morning hours. The middle one-third of each branch used for leaf collection. The leaves were collected from four sides of each tree and the middle part. Total of 50 leaves per replicate collected. To measure the leaf area, we divided the collected leaves to small and large groups and then 3 out of each category were picked by random for measurement. The corresponding leaf area is reported as the mean of larger leaf area (LLA) or smaller leaf area (SLA). The collected leaves were further used for mean fresh weight estimation. After drying and determination of mean dry weight, the concentration of Nitrogen (N), Phosphorus (P), Potassium (K), Iron (Fe), Manganese (Mn), Boron (B), Copper (Cu), and Zinc (Zn) were determined by an independent reference laboratory.

To find out the current-season shoot growth (CSSG), we collected four branches from each tree and measured the current year growth. Measurement of chlorophyll index was carried out using a SPAD reader (SPAD-502, Minolta Camera Co. Ltd., Japan).

Other features like leaf thickness estimation, trichome density of leaves, seed production, and the leaf color were estimated by scoring.

Data analysis conducted using SPSS (Ver 20, IBM Inc.) and the means compared using Duncan**'s** test at 5% significance level. Preliminary analyses (examination of normal probability plots and scatterplots) were performed to ensure no violation of assumptions of normality and homoscedasticity. Structural equations modeling (SEM) analysis was carried out using AMOS extension of the same statistical software package.

3. Results

3.1. Leaf area

As could be seen in Table 1, the large leaves reached their maximum area by spraying of 6000 ppm HA, which was significantly larger than all other treatments. Other treatments including 3000 ppm HA, 4 mM CA, 8 mM Gln, 4 mM MA and 8 mM CA, showed significant superiority compared to control as well. On the other side was the 8 mM MA treatment, which reduced LLA compared to the control treatment.

The increase in SLA did not follow the same pattern. Gln treatments significantly increased the SLA compared to all other treatments, including the control.

3.2. Current season shoot growth (CSSG)

The shoots grew more in trees treated with both 4 and 8 mM Gln. HA treatments were also effective, followed by 4 mM MA, localized placement and both of CA treatments, which were still considered superior to the control treatment. On the other side, by application of 8 mM MA the CSSG fell below the control (Table 1).

3.3. Leaf chlorophyll index (SPAD)

The highest amount of chlorophyll index was noted in localized placement treatment with a twofold increase compared with the