RESEARCH PAPER

The physiological and growth response of *Acacia caven* under water stress and the application of different levels of biosolids

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Abstract

S. Donoso, K. Peña-Rojas, C. Pacheco, S. Durán, R. Santelices, and C. Mascaró. 2015. The physiological and growth response of *Acacia caven* under water stress and the application of different levels of biosolid. Cien. Inv. Agr. 42(2):273-283. *Acacia caven* (Mol.) Mol. (Leguminosae), generally known as "espino," is one of the most common tree species in the Mediterranean region of Chile. This species grows in nutritionally poor soils with low water availability during the summer, so it is very difficult for new seedlings to become established. To investigate the effects of water restriction and the potential benefit of the application of biosolids (sludge bio-dried to 25% moisture) on the growth of the plant, a completely random, two x three factorial design was carried out in controlled nursery conditions under two irrigation regimes (well-watered plants and controlled water restriction) and three biosolid application rates (0:100, 10:90 and 20:80) in a clay substrate. Physiological evaluations (predawn water potential, photosynthesis and gas exchange) were performed at representative times along the water restriction gradients and supplemented with measurements of growth and biomass distribution. Once plants entered the water restriction phase, those in the biosolid-treated substrate exhibited better hydration compared to plants in the untreated substrate. This was attributed to the increased organic matter content as well as to changes in the textural characteristics of the original substrate that increased its capacity to deliver water to the plants. Additionally, the application of biosolids promoted shoot and leaf growth in well-watered plants, increasing the shoot:root ratio, which could be a disadvantage under water stress.

Key words: Biomass, predawn water potential, photosynthesis, shoot:root ratio, water restriction.

Introduction

The growing worldwide interest in improving the quality of wastewater has progressively increased

the amount being treated. Biosolids are a byproduct of water treatment, and they are mainly composed of organic matter, macro- and micronutrients, and some trace elements. In Chile, the production of biosolids has significantly increased over the last decade, making disposal a prominent environmental issue. Currently, there are several alternatives for the

disposal of biosolids: landfill deposits, incineration and increasing crop production (Paz *et al*., 2007), and several studies have shown that biosolids have a positive effect on the growth of plants (Pascual *et al*., 2004; Antolin *et al*., 2010; Valdecantos *et al*., 2011). Therefore, one potential solution to the environmental problem of biosolids is their application as fertilizer in forest plantations to increase the amount of organic matter and improve the capacity of the soil to store water (Cogger *et al*., 2000).

These benefits might be crucial to reforestation efforts in Mediterranean areas because one of the main problems affecting seedlings during their establishment phase is high mortality, which occurs as a result of water deficit, one of the most critical environmental stress factors for Mediterranean species (Villar-Salvador *et al*., 2004; Pardos *et al*., 2005). Water deficit significantly affects plant photosynthetic and water performance and eventually negatively impacts biomass growth and accumulation. Biosolids are a source of readily available organic matter (Fuentes *et al*., 2007a) that can be used to improve plant establishment (Henry *et al*., 1994; Larcheveque *et al*., 2006). This is of special interest to the use of *Acacia caven* (Mol.) ("espino") for reforestation in central Chile as this process is generally performed on nutritionally poor soils with reduced water availability, which makes plant establishment very difficult. To date, few studies have examined the effects of biosolid application on the physiological response of forest species under restricted water conditions; most have instead focused on the nutritional effects. The objective of this study was to describe the physiological and growth responses in espino plants subjected to water stress under different levels of biosolid application.

Materials and methods

Study site and experimental design

The trial was conducted at the University of Chile's experimental nursery, Antumapu (33° 34' S and 70° 37' W, altitude 420 m.), during the summer of 2011. At this time of the year, the monthly average maximum temperature ranges from 28.7 to 20.7 °C, and the minimum monthly temperature averages 15.0 to 7.9 °C. Total rainfall during the study period was 0 mm.

One month before the start of the experiment, 105 two-year-old espino plants were selected based on their height (average of 34 cm) and root collar diameter (average of 4.5 mm) and placed in 10-L pots. Thirty-five plants were assigned to each of three substrate treatments: a control group without added biosolids (T-0); 90% soil with 10% of the biosolid treated substrate (T-10), and 80% soil with 20% of the biosolid treated substrate (T-20). The soil (Rungue series, Vertic Haploxerolls (Mollisols), CIREN, 1996) (Table 1) was collected from El Rutal farm, which is located 60 km north of Santiago. The source of the biosolids was sludge bio-dried to 25% moisture from the El Trebal plant in Santiago, which treats 57% of the city's wastewater. Both substrates were transferred to the nursery and air dried before being mixed to form a homogeneous substrate. The physicochemical properties of the different substrates are presented in Table 1; the main characteristics of the biosolids were as follows: 47.4% organic matter, pH of 6.4, electrical conductivity of 8.09 dS m^{-1}, and 79% total solids. Plants were kept under constant irrigation for 30 days to homogenize the water and physiological conditions.

Throughout the study, periodic monitoring of the water content in the substrate (WCS) was conducted as follows:

$$WCS(\%) = \frac{Fsw - Dsw}{Hsw - Dsw} \times 100$$

where WCS is the percentage of the water content in the substrate; *Fsw* is the fresh weight of the substrate (in kg) taken when the control weight was measured; *Hsw* is the hydrated substrate weight (in kg) obtained once the gravitational water was drained, and *Dsw* corresponds to the

Table 1. Compositions of the experimental substrates.

Analysis	Control	10% biosolids	20% biosolids
Texture	Clay	Clay	Clay loam
Clay (%)	45.0	45.0	39.0
Loam (%)	31.0	33.0	37.0
Sand (%)	24.0	22.0	24.0
pH susp.	7.9	7.7	7.6
CE susp. (mS cm^{-1})	0.5	0.5	0.7
O.M. (%)	2.0	2.8	3.1
N available (mg kg^{-1})	40.0	38.0	76.0
P available Olsen (mg kg^{-1})	16.0	70.0	85.0
K available (mg kg^{-1})	510.0	543.0	553.0

O.M.: Organic matter.

estimate of the dry weight of the substrate in kg, which is obtained after drying multiple substrate samples in a forced air lab oven at 105 °C for 48 h. WCS was monitored in a random sample of 10 individuals from each treatment.

For each substrate combination (3 levels), two irrigation regimes were applied. a) Well-watered plants (C: Control) were irrigated every two days, and WCS values over 50% were maintained throughout the experiment. b) Plants under controlled water restriction (R: Restriction) were subjected to a gradual decrease in WCS, and this restriction was maintained until day 44 when the plants reached stable WCS levels (10% in treatments T-10 and T-20; 30% in T-0). After 23 days under these stable levels, the plants were

rehydrated (day 69) to reach WCS values similar to those of the well-watered plants. To do this, 14 plants were kept well-watered, and 21 plants were subjected to water stress (Figure 1, Table 2) in each substrate combination. Therefore, the experimental design generated a gradient with two levels of water restriction and three substrates.

Evaluation of specific water variables

Assessments of predawn leaf water potential (Ψa) and predawn leaf relative water content (RWCa) were performed based on the WCS gradients obtained during the experiment. Ψa was determined with a pressure chamber (model 1000, PMS Instruments, Corvallis, OR), and the RWCa was estimated from the ratio of the fresh tissue weight to the turgid tissue weight following the procedures described by Galmés *et al.* (2007). Measurements were carried out based on a random sample of six individuals from each treatment. Each measurement was taken from buds located on the upper third of each plant, which had similar characteristics in terms of the number, maturity, size and health of the leaves.

Evaluation of photosynthesis and gas exchange

When plants reached the lowest WCS level (at noon on day 61) during the experiment, net
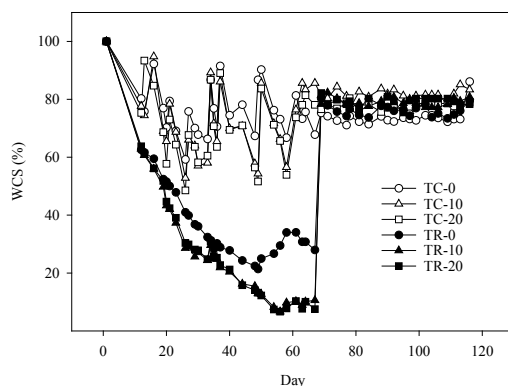
Figure 1. Substrate water content (WCS) by treatment during the experiment expressed as mean values (n = 10).

Table 2. Predawn water potential (Ψa), predawn leaf relative water content (RWCa) and substrate water content (WCS) by evaluation day and treatment.

Day	Treatment	Ψa (MPa)	RWCa (%)	WCS (%)
1	TC-0	-0.5 ± 0.0 a	85.0 ± 5.0 a	100.0 ± 0.0 a
	TC-10	-0.5 ± 0.1 a	91.0 ± 2.7 ab	97.0 ± 3.0 a
	TC-20	-0.5 ± 0.0 a	95.4 ± 0.7 b	100.0 ± 0.0 a
	TR-0	-0.5 ± 0.0 a	85.0 ± 5.0 a	100.0 ± 0.0 a
	TR-10	-0.5 ± 0.1 a	91.0 ± 2.7 ab	97.0 ± 3.0 a
	TR-20	-0.5 ± 0.0 a	95.4 ± 0.7 b	100.0 ± 0.0 a
20	TC-0	-0.3 ± 0.0 b	92.0 ± 1.4 a	80.0 ± 2.0 c
	TC-10	-0.3 ± 0.0 b	88.5 ± 2.0 a	78.0 ± 2.0 c
	TC-20	-0.4 ± 0.0 b	92.4 ± 1.2 a	75.0 ± 2.0 c
	TR-0	-0.6 ± 0.1 a	91.0 ± 1.2 a	51.0 ± 3.0 b
	TR-10	-0.6 ± 0.0 a	92.2 ± 0.7 a	45.0 ± 2.0 a
	TR-20	-0.6 ± 0.0 a	90.8 ± 1.8 a	41.0 ± 1.0 a
40	TC-0	-0.3 ± 0.0 d	94.6 ± 1.0 ab	86.0 ± 6.0 b
	TC-10	-0.4 ± 0.0 d	95.6 ± 0.8 ab	79.0 ± 6.0 b
	TC-20	-0.3 ± 0.0 d	98.4 ± 4.0 ab	80.0 ± 4.0 b
	TR-0	-3.8 ± 0.4 a	64.6 ± 10.2 a	27.0 ± 2.0 a
	TR-10	-1.9 ± 0.2 b	89.0 ± 25.9 b	19.0 ± 2.0 a
	TR-20	-1.4 ± 0.1 c	88.8 ± 1.0 ab	20.0 ± 0.0 a
61	TC-0	-0.3 ± 0.0 d	92.5 ± 2.5 b	88.0 ± 2.0 c
	TC-10	-0.3 ± 0.0 d	93.4 ± 1.5 b	90.0 ± 2.0 c
	TC-20	-0.3 ± 0.0 d	92.4 ± 1.4 b	93.0 ± 3.0 c
	TR-0	-4.8 ± 0.4 b	77.8 ± 3.6 a	30.0 ± 2.0 b
	TR-10	-5.6 ± 0.2 a	81.9 ± 2.9 a	9.0 ± 1.0 a
	TR-20	-3.9 ± 0.1 c	75.7 ± 2.9 a	10.0 ± 1.0 a
117	TC-0	-0.3 ± 0.0 a	95.1 ± 0.7 a	100.0 ± 2.0 c
	TC-10	-0.3 ± 0.0 a	97.0 ± 1.1 a	90.0 ± 3.0 ab
	TC-20	-0.3 ± 0.0 a	95.6 ± 1.1 a	90.0 ± 2.0 ab
	TR-0	-0.3 ± 0.0 a	95.5 ± 1.1 a	96.0 ± 3.0 bc
	TR-10	-0.3 ± 0.0 a	95.6 ± 0.9 a	89.0 ± 2.0 a
	TR-20	-0.3 ± 0.0 a	97.6 ± 0.6 a	85.0 ± 2.0 a

Values expressed as means ± standard errors (n=6). Different letters indicate significant differences among treatments for each evaluation day (Duncan's test, P≤0.05).

photosynthesis (An), stomatal conductance (gs), transpiration (E) and internal CO_2 concentration (Ci) were calculated using an ADC Bioscientific LCpro+ system. Measurements were taken on five of the leaves on the upper third of the plants per treatment (two levels of irrigation and three levels of substrate) for a total of 30 measurements.

Evaluation of growth traits and biomass distribution

Root collar diameter (RCD) and total height were periodically monitored throughout the study.

At the beginning of the experiment, all of the plants were marked on the lower section of their main stem (root collar) to track the development in both traits. The main stem of each plant was used for the height measurement, and the distance between the mark and the apex of the stem was measured at each opportunity using a 1 mm precision measuring tape. A Vernier caliper with a 0.1 mm resolution was used to calculate RCD.

The biomass of the plant components (leaves, shoots and roots) was determined at the beginning and end of the water restriction period. In each

evaluation, a random sample of five individuals per treatment was analyzed, and for each selected plant, the root system was separated from the aerial part, which in turn was separated into leaves and woody material. Samples were dried at 65 °C in a forced air oven until they reached a stable weight, and the total biomass per component and the shoot:root biomass ratio were obtained.

Statistical analysis

Differences in the biomass, photosynthesis, and gas exchange measurements were tested with analysis of variance using a completely random two x three factorial design (irrigation regime and biosolid doses). Plant growth was analyzed by repeated measures ANOVA, which evaluated the statistical significance of the differences among the mean values of each treatment using Duncan's test (P≤0.05).

Results

Plant water status during the study

The WCS values of the well-watered plants were maintained above 50% for the entire experiment (Figure 1). Under these conditions, the predawn Ψa and predawn leaf RWCa showed no significant differences as a result of the application of biosolids with Ψa values around -0.3 MPa and RWCa values above 85% (Table 2). However, from the beginning of the experiment, the WCS values of the plants under water restriction progressively decreased (from 27 to 19%), which resulted in a decrease in the average Ψa and RWCa values at day 40. During this period, statistically significant differences (P=0.01) among the water-restricted treatments were observed. For example, the treatment without biosolids presented the lowest Ψa (-3.8 MPa) and RWCa (64.6%) values, which were significantly different from the treatments with biosolids (TR-10: -1.9 MPa for Ψa and 89.0% for RWCa; TR-20: -1.4 MPa for Ψa and 88.8% for RWCa). On day

61, the plants in the water restriction treatment registered the lowest WCS levels (TR-0: 30.0%; TR-10: 9.0%; TR-20: 10.0%) and the lowest Ψa and RWCa values. The substrate treated with 20% biosolids exhibited reduced water stress (Ψa of -3.9 MPa), but a different situation occurred in the 10% biosolids treatment, which presented an average Ψa value of -5.6 MPa. However, the treatment without biosolids exhibited moderate water stress (Ψa of -4.8 MPa) as well as a significantly higher WCS value than the other treatments under water restriction. Additionally, the water available to the plant, evaluated through the relationship between Ψa and WCS (trend lines), was greater in the treatments with biosolid additions (Figure 2), which presented higher organic matter contents and changes in their textural properties (Table 1). After day 61, the water restriction treatments were returned to the Ψa and RWCa values observed at the beginning of the experiment, and the WCS values increased.
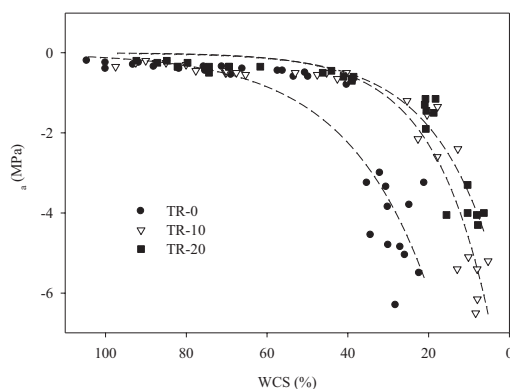
Figure 2. Predawn water potential (Ψa) according to the substrate water content values (WCS) in the water restriction treatments and the trend lines for each treatment. Values represent the Ψa and WCS measurements taken throughout the experiment.

Photosynthesis and gas exchange

During the evaluation of gas exchange at the end of the water stress period (day 61), the well-watered treatments showed average net photosynthesis

(An) values of over 18 mol m^{-2}s^{-1}, mean values of stomatal conductance (gs) over 420 mmol m^{-2}s^{-1} and average E values over 16 mmol m^{-2}s^{-1} while the Ci levels were approximately 270 mol m^{-2}s^{-1} (Figure 3). Within this group, the application of biosolids resulted in a proportional increase in An, but it was not significantly different (P=0.04) from the value observed in the treatment without biosolids. Furthermore, the An, gs and E values in the group under water restriction during this period were significantly lower (P≤0.01) than those observed in the well-watered treatments, but no significant differences were observed as a result of the application of biosolids.

Biomass growth and distribution

At the beginning of the experiment, espino plants had RCD values between 4.3 and 5.1 mm, and the well-watered plants maintained positive growth throughout the study (Figure 4A). Within these plants, the 20% biosolids treatment (TC-20) registered a significantly greater (48%) RCD value at the end of the trial than those obtained from the treatments without biosolids, whereas the 10% biosolids treatment presented a significant increase of only 27%. The plants subject to the water restriction treatments also maintained positive increases, but they were smaller than those obtained in the well-watered treatments. Therefore, the 20% biosolids treatment showed a 36% greater RCD value at the end of the trial than that obtained without biosolids while in the 10% biosolids treatment, this difference was 26%.

The total height response was similar to that observed for RCD. At the beginning of the experiment, the espino plants were between 30 and 35 cm tall, and at the end of the study, the well-watered plants subject to the 20% and 10% biosolids treatments presented significantly (P=0.005) greater heights (35 and 40%) than the treatment without biosolids (Figure 4B). Under water restriction, the observed increases were of lower magnitude than those in the well-watered treatments. Unlike what happened with RCD, the application of biosolids had no significant effect on the increase in total height.

At end of the experiment, the well-watered plants exhibited a significant increase (P=0.001) in all biomass components (Table 3). The biosolid applications had a significant effect on the increase in biomass (more than 70%) of the aerial parts (leaves and shoot), and the plants under water restriction yielded lower values (50%) than those obtained in the well-watered plants, especially for total biomass. The shoot:root biomass ratio significantly decreased (P=0.03) in the treatments without biosolid applications under both levels of irrigation.

Discussion

The observed response in the predawn Ψa and predawn RWCa values in well-watered and water-stressed plants is consistent with that observed in several studies of Mediterranean species under stress conditions (Pardos *et al.*, 2005; Galmés *et al.*, 2007; Gallé *et al.*, 2007; Donoso *et al*, 2011). The application of biosolids to the substrate exerted a positive effect on the response of the plants to water stress; during the period when plants entered the water restriction phase (day 40), the biosolid application treatments resulted in greater predawn water potential than that observed in the treatment without biosolids. Later, when the water restriction was more severe (day 61), this result was also observed in the TR-20 but not in the TR-10 treatment, which presented more severe water restriction conditions indicated by the low WCS values of the plants (9%). However, the results suggest that the application of biosolids to the substrate promotes improved plant hydration under conditions of water stress, and this may be attributed to changes in the physical properties of the substrate, mainly increased organic matter content and modified texture, that improved its ability to deliver water to the plants. Such substrate conditions can be crucial to reforesta-
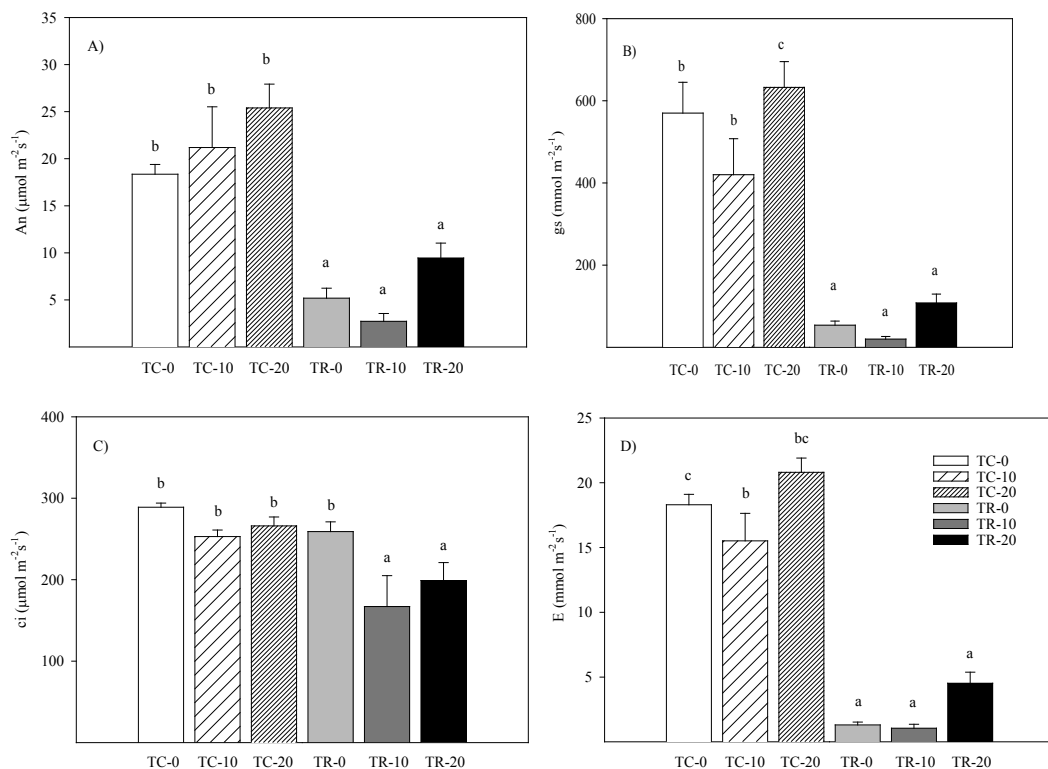
Figure 3. Gas exchange trials on day 61 of the evaluation. A) Net photosynthesis = An; B) stomatal conductance = gs; C) internal CO_2 concentration = Ci; D) Transpiration = E. Values are expressed as means ± standard errors (n = 5), and different letters indicate significant differences among treatments (Duncan's test, P≤0.05).
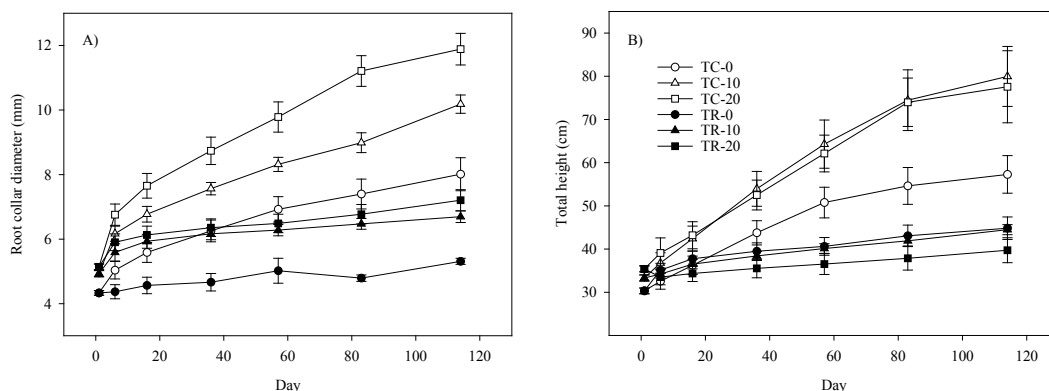
Figure 4. Plant development by treatment during the experiment. A) Growth in root collar diameter (RCD) and B) total height. Values are expressed as means ± standard errors (n=10).

Table 3. Plant biomass by component, evaluation period and treatment (two irrigation regimes: well-watered (TC) and water restriction (TR); three levels of biosolid application: 0%, 10% and 20%).

Component	Treatment	Day 1	Day 70
Leaves (g plant^{-1})	TC-0	1.0 ± 0.1 a	3.7 ± 0.3 b
	TC-10	1.1 ± 0.2 a	7.8 ± 1.3 c
	TC-20	1.2 ± 0.2 a	7.2 ± 1.0 c
	TR-0	1.0 ± 0.1 a	0.7 ± 0.1 a
	TR-10	1.1 ± 0.2 a	1.6 ± 0.3 ab
	TR-20	1.2 ± 0.2 a	2.9 ± 0.3 b
Shoots (g plant^{-1})	TC-0	1.8 ± 0.2 a	6.0 ± 0.7 ab
	TC-10	1.9 ± 0.6 a	11.6 ± 3.0 c
	TC-20	2.0 ± 0.3 a	9.6 ± 1.0 bc
	TR-0	1.8 ± 0.2 a	4.2 ± 0.3 a
	TR-10	1.9 ± 0.6 a	4.6 ± 0.6 a
	TR-20	2.0 ± 0.3 a	4.8 ± 0.5 a
Root (g plant^{-1})	TC-0	2.1 ± 0.2 a	17.1 ± 1.5 b
	TC-10	2.9 ± 0.9 a	15.3 ± 2.2 b
	TC-20	2.4 ± 0.4 a	9.8 ± 0.5 a
	TR-0	2.1 ± 0.2 a	6.8 ± 0.2 a
	TR-10	2.9 ± 0.9 a	7.4 ± 0.9 a
	TR-20	2.4 ± 0.4 a	7.2 ± 0.4 a
Total (g plant^{-1})	TC-0	5.0 ± 0.3 a	26.8 ± 2.2 b
	TC-10	6.0 ± 1.1 a	34.8 ± 6.4 b
	TC-20	5.6 ± 0.5 a	26.6 ± 2.2 b
	TR-0	5.0 ± 0.3 a	11.7 ± 0.4 a
	TR-10	6.0 ± 1.1 a	13.5 ± 1.0 a
	TR-20	5.6 ± 0.5 a	15.0 ± 0.8 a
Shoot:root ratio	TC-0	1.3 ± 0.1 a	0.6 ± 0.0 a
	TC-10	1.0 ± 0.1 a	1.3 ± 0.1 c
	TC-20	1.3 ± 0.1 a	1.7 ± 0.1 d
	TR-0	1.3 ± 0.1 a	0.7 ± 0.1 a
	TR-10	1.0 ± 0.1 a	0.8 ± 0.2 abc
	TR-20	1.3 ± 0.1 a	1.1 ± 0.1 bc

Values expressed as means ± standard errors (n=5). Different letters indicate significant differences among treatments for each component (Duncan's test, P≤0.05).

tion in areas with clay soils, such as those in the northern part of Santiago, as these soils present low permeability, low organic matter content and tend toward compaction. The application of organic matter through biosolids helps address the most important limitation to plant growth, the lack of available water, as it promotes the renovation of the physical soil characteristics and improves the chemical properties (Henry *et al.*, 1994; Valdecantos *et al.*, 2011). This soil moisture response differs from that obtained by Fuentes *et al.* (2007b), who observed that higher biosolid application rates resulted in a reduced Ψa values in *Quercus ilex* plants compared to those observed in untreated plants. This behavior was related to decreased osmotic potential in the soil as a result of an increased concentration of salts in the roots.

In terms of the gas exchange parameters obtained from the evaluation on day 61, significantly higher An, gs and E rates were observed in the well-watered treatments than in the water restriction treatments, and the application of biosolids in the well-hydrated substrate led to a proportional increase in An. This response was associated with a significant increase in foliar biomass that ultimately resulted in an increase in the carbon balance, which promoted greater growth and biomass accumulation in the aerial components. In contrast, a decrease in WCS and Ψa values in the treatments under water restriction caused a reduction in An, gs and E, which ultimately reduced growth and the average values of almost all of the biomass components. According to Flexas *et al.* (2006), limited growth and biomass accumulation due to water stress are mainly caused by a reduced carbon balance in the plant; a condition that might be caused by a decrease in An as a result of a decrease in gs. This is consistent with the results obtained in this study for the water-restricted treatments.

The most important results from the biosolid applications were increased growth and aerial biomass accumulation, which have already been observed in other species (Pascual *et al.*, 2004; Antolin *et al.*, 2005; Antolin *et al.*, 2010; Valdecantos *et al.*, 2011). This response, in which biosolids stimulate plant growth, is primarily related to an increase in nutrient levels in the substrate (Pascual *et al.*, 2004; Antolin *et al.*, 2010). In this study, the biosolid applications positively affected RCD and total plant height, and under well-watered conditions, both variables significantly increased.

Finally, these results suggest that the natural behavior of espino is to first promote investment in the root followed by the aerial portion because the shoot:root biomass ratio decreased significantly under both irrigation conditions (in the absence of biosolids in the substrate), resulting in an important advantage during episodes of water restriction. However, this ability to cope with stress can be significantly modified by the application of biosolids as, under both irrigation conditions, the biosolids produced a proportional increase in the shoot:root ratio, mainly due to an increase in the biomass of leaves and shoots. Valdecantos *et al.* (2011) also observed a significant increase in the aerial biomass of *Pinus halepensis* seedlings amended with biosolids in liquid form, a response that was accompanied by an increase in leaf biomass and a decrease in the root portion that ultimately resulted in a significant increase in the stem:root ratio. This behavior has been observed in numerous studies, which have reported increases in the shoot:root ratio together with an improvement in the nutritional status of the soil or growing media (Proe and Millard, 1994; Colpaert *et al.*, 1996). This can mean increased susceptibility of seedlings to water stress due to an increase in the evapotranspiration surface area, so to prevent this situation, further research into the application of biosolids combined with other treatments should be performed to ultimately correct the increase in the shoot:root ratio. Alternatively, it is possible that biosolids should be just applied to the surface to minimize their contact with the roots.

In conclusion, the application of biosolids to clay substrates improves water delivery to plants, which promotes better hydration during episodes of water restriction. Additionally, the application of biosolids stimulates aerial plant growth and increases the shoot:root biomass ratio, which may compromise the ability of a plant to cope in water-restricted environments. Therefore, it is necessary to delve deeper into the dynamics of biosolid application and the possible consequences for biomass distribution under field conditions.

Acknowledgements

Resumen

S. Donoso, K. Peña-Rojas, C. Pacheco, S. Durán, R. Santelices y C. Mascaró. 2015. Respuesta fisiológica y de crecimiento en plantas de *Acacia caven* (Mol.) bajo diferentes niveles de aplicación de biosólido y restricción hídrica. Cien. Inv. Agr. **42(2):273-283.** *Acacia caven* (Mol.) Mol. (Leguminosae), generalmente conocido como "espino", es una de las especies arbóreas más comunes en la región mediterránea de Chile. Esta especie crece en suelos nutricionalmente pobres y con una baja disponibilidad hídrica estival, que dificulta el proceso de establecimiento de nuevas plántulas. Para investigar los efectos de la restricción hídrica y el potencial benéfico de la aplicación de biosólidos (biosolido-seco a 25% de humedad) en el crecimiento de la planta, se estableció un ensayo con un diseño bifactorial completamente al azar en vivero bajo condiciones controladas. Se aplicaron dos tipos de riego (plantas bien regadas y restricción hídrica controlada) y tres dosis de aplicación de biosólidos en un sustrato arcilloso (0:100, 10:90 y 20:80). La evaluación fisiológica (potencial hídrico a pre-alba, fotosíntesis e intercambio gaseoso) fue realizada en momentos representativos del gradiente de restricción hídrica, y fue complementada con mediciones de crecimiento y distribución de biomasa. Cuando las plantas entraron en la fase de restricción hídrica, aquellas que se crecieron en un sustrato con biosólido, presentaron una mejor condición hídrica en comparación con las plantas sin biosólido. Esto se debe a un aumento en el contenido de materia orgánica y a un cambio en las características texturales del sustrato original, incrementando la capacidad para suministrar agua a las plantas. Adicionalmente, la aplicación de biosólidos promovió el crecimiento de hojas y tallos en plantas bien regadas, e incremento la relación tallo: raíz, que es una desventaja para la tolerancia al estrés hídrico.

Palabras clave: Biomasa, potencial hídrico a pre-alba, fotosíntesis, relación raíz tallo, restricción hídrica.

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