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Growth of *Racosperma mangium* Willd during nursery phase irrigated with waste waters

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Abstract

An experiment was carried in order to evaluate the effect of waste waters irrigation on *Racosperma mangium* Willd growth under nursery conditions in the Waters Research Center of La Universidad del Zulia, Venezuela. The treatments were five different levels of waste waters (0, 25, 50, 75 y 100%) which were applied daily. Aerial (AL) and root length (RL), aerial (ADW) and root dry weight (RDW), number of leaf (NL) and total leaf area (LA) were evaluated weekly during 12 weeks. The results showed a highly significant effect ($P<0.01$) of the treatments on all evaluated variables except RL. The highest AL value (29.28 cm), ADW and RDW (5.16 and 3.00 g), NL and LA (17.77 and 325.43 cm^2) were obtained with 100% of waste waters. The irrigation with waste waters is an effective alternative to promote high growth of *R. mangium* in nursery phase.
Key words: *Racosperma mangium*, nursery, waste waters, growth, development.

Introduction

The use of forage tree legumes might be the consequence of the tropical agricultural exploitation systems to the challenge of the environment protection. The introduction of this use on agroforestry systems is getting importance because these systems offer a foliage with a high content of essential proteins and minerals, among with a high digestibility. Other advantages of the use of these plants might be the fact that these nourish the soil, because they fix atmospheric nitrogen, and protect against erosion, besides of having other uses as shadow on the paddock, wind-breaker barriers, wood and sticks. All these aspects have named these plants as multipurpose tree (19).

Inside these species is established the evaluation of

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Racosperma mangium Willd, legume (*Mimosoideae* subfamily) that adapts to environments with high temperatures and soils with nutrients deficit and acidity problems (3), native of the northeast of Australia, southeast of New Guinea and east of Indonesia (10; 16), it has been demonstrated the potential for the incorporation on the agroforestry systems in Dry Tropical Forest conditions and acid soils on the Occident of Venezuela (12, 14). However, this specie requires nursery care that would guarantee an adequate initial phase of growth for the obtaining of optimum plants for the establishment in the field, which mainly requires of activities that guarantee a good supply of water and nutrients, and the application of residual waters has proved to accomplish all these conditions (10).

The aim of this work was to evaluate *R. mangium*, submitted to irrigation with different concentrations of residual waters during nursery phase, as a choice to minimize the use of drinking water used for irrigation, and therefore to increase the exploitation of the recycled water from urban areas.

Materials and methods

The experiment was done on the Water Research Center (CIA) of the Engineering Faculty of La Universidad del Zulia, Venezuela. The area is located on the coordinates 10º41'12" north latitude and 71º38'05" west longitude, with an approximate high of 20 msnm. This region is classified as very dry tropical forest (7), with an average temperature of 30ºC and an annual precipitation of 600 mm.

The evaluated treatments were five different levels of residual water on the irrigation water (0, 25, 50, 75 and 100 %), which was coming from the C series of the lagoons treatment system of CIA, which is constituted by a facultative lagoon and two lagoons of maturation. On the first, the removal process of organic matter happens by aerobic oxidation next to the surface, and by anaerobic fermentation at the bottom, and on the seconds the removal of microorganisms is done by sun exposure, depredation, aggregation and sedimentation among other mechanisms (15). The chemical composition of treatments is shown on table 1.

Plants were previously germinated on nursery conditions in germinator trays on an inert substrate prepared with a base of peat and vegetal fiber in 2:1 proportion. During this phase, seedlings were irrigated with drinking water for a period of more than 30 days until complete the germination, thus there is not effect of treatments in this phase (13). Afterwards, plants were transplanted to the field on pots of 15 kg of capacity, filled with a vegetal cover coming from the area.

Each treatment was represented by a smallholding of 25 pots with a plant each, which,

Table 1. Chemical composition of the applied treatments

Residual water	N	P	K	Fe	Pb
%			mg^{-1}		
0	2.10	4.66	1.76	0.28	0.11
25	5.39	6.33	4.62	0.33	0.11
50	13.23	11.06	7.58	0.42	0.12
75	19.04	15.90	10.27	0.55	0.14
100	26.32	21.08	17.54	0.64	0.16

Average of four samples during the essay.

previous to the application of the treatment these were left for 14 days to allow an adequate recovery and, subsequently were evaluated for 12 weeks with the irrigation treatment, applying individually and daily to each pot a volume of 350 ml of irrigation solution.

It was weekly sampled on a destructive way a plant by treatment and repetition, in order to evaluate: longitude and dry weight of the aerial and radical part, leaves number, and the total foliar area with the use of the silhouette Digitizer Delta-T Devices LTD.

A randomized block design with treatment arrangement on split-plot and 5 replications was used. On the results analysis the statistical SAS software was used (18). The applied procedures were PROC GLM for the variance analysis and means were compared with the Tukey test.

Results and discussion

Longitude of the aerial and radical area: As it is observed in table 2, the growth of the aerial part of the plant was significantly affected ($P<0.01$) by treatments with residual waters, while for the root longitude there was not detected any effect of the treatments.

The longitude of the aerial part increased at the same time that increased the residual water content in the treatments. The highest values for this variable were obtained when plants were irrigated with 75 and 100% of residual water (26.70 and 29.28 cm, respectively). The increment was of 25 and 37% in plants treated with 75 and 100% of residual water respectively, compare to those that did not receive residual water.

This behavior is predictable considering the benefits of essential mineral elements as N and P that had the residual water, as well as was observed on the analysis made to the water (table 1). This minerals contribution on the irrigation with fertilization aspect favored a fast initial vegetative growth.

The application effect of P and

Table 2. Longitude of the aerial and radical area of R. mangium plants, submitted to different treatments with residual water.

Residual water	Aerial area	Radical area
%	cm	
0	21.36[c]	31.39
25	23.77[bc]	29.39
50	23.91[bc]	28.72
75	26.70[ab]	29.14
100	29.28[a]	30.77

Values with different letters in the same column differ statistically (P<0.01), according to the Tukey test.

in a lower aspect of K, on the growth of *R. mangium* has been previously reported. On this matter, the application of 30 to 60 kg of P/ha produces a percentage increment of 64% in the plant's height compared to the non fertilized plants.

Aerial and radical dry weight: The yield of the dry matter of the aerial and radial part was favored with the application of residual waters. In table 3 is observed how the significantly highest values (P<0.01) for both variables (6.16 and 3.00 g/plant for the aerial and radical part respectively) were obtained when plants received 100% of residual water, representing and increment of 80.4% for the aerial biomass, and 105.5% for the radical biomass compared to the plants that did not receive residual water.

The contributions of nutrients contained on the residual water stimulate the biomass production of plants even more than the

Table 3. Yield of aerial and radical dry matter of *R. mangium* plants submitted to different treatments of residual water

Residual water	Aerial area	Radical area
%	g/plant	
0	2.86[c]	1.46[c]
25	2.83[c]	1.72[bc]
50	3.23[c]	2.11[bc]
75	4.34[b]	2.33[ab]
100	5.16[a]	3.00[a]

Values with different letters on the same column differ statistically (P<0.01), according to the Tukey test.

fertilization treatments. A comparison of some irrigation with fertilizer treatments, that included irrigation with water to which was added N, P and K, on equivalent quantities of the present on residual waters, and irrigation with residual waters on the forage yield and oat and wheat grain showed that with the use of these last are obtained better or same results in yields than the reported in treatments with water with added nutrients (4). Therefore, this suggests that nutrients provided by residual water are rapidly advantaged by plants, this statement has been reported by others authors (8, 11) and agrees to the observed in this experiment, due to, at the same time that increases the quantity of residual waters in the treatment increases the production of aerial and radical biomass.

Similar behaviors have been reported when evaluating irrigation treatments with or without fertilization, and different applications of residual waters, obtaining increments in the rank from 0 to 356% on corn grain, from 5 to 130% on forage, form 85 to 191% on red clover and from 79 to 139% in alfalfa (17). Likewise, yields on the biomass production of *Paspalum notatum Flugge* have been reported, with applications of residual waters and the solids residues as fertilization.

The observed results in this essay show that the use of these residual waters significantly stimulate the biomass production of *R. mangium* in this phase, however, this response depends on the own characteristics of the used water. Some authors suggest that the composition of the residual waters is related to the origin and proportion of industrials and/or domestics residues that this water has (20). Research done with residual waters of petrochemical activities only obtained increments in total biomass of *Leucaena leucocephala* until reached levels of 50% of residual waters on the irrigation water. Probably, the urban origin of the residual waters used on this research have better conditions for the usage with irrigation purpose compare to the effluent waters of industrial processes.

Leaves number and total foliar area: table 4 shows the significant effect ($P<0.01$) of treatments with residual water on the total foliar area, and the total number of leaves by plant. It is observed how the highest values for foliar area were obtained with treatments 75 and 100% residual water (280.61 and 325.43 cm^2, respectively). These plants showed an increment in the total foliar area of 48.5 and 75.3% with treatments of 75 and 100% of residual water respectively, compare to those that only received drinking water.

Likewise, the highest number of leaves by plant (17.77) was obtained with the treatment of 100% of residual water, which represents a difference of 30.8% in relation to those that did not receive residual water.

The applied treatments on this research guaranteed an adequate

Table 4. Foliar area and leaves number of *R. mangium* plants submitted to different treatments of residual water.

Residual water	Total foliar area	Leaves number
%	cm^2	
0	188.89[b]	13.59[b]
25	208.19[b]	14.61[b]
50	227.29[b]	13.82[b]
75	280.61[a]	14.96[ab]
100	325.43[a]	17.77[a]

Values with different letters in the same column differ statistically (P<0.01), according to the Tukey test.

supply of water and nutrients, and both conditions are necessary for a fast increase of the foliar area (6, 9). Treatments improved the efficiency in the capture of light of plants of *R. mangium*, due to these stimulated and increment on the photosynthetically active foliar surface, and this is related to the response on the obtained biomass production.

Conclusions and recommendations

The obtained results allow to conclude that there exits a highly significant effect of the application of residual waters on the behavior of *Racosperma mangium* during nursery phase.

The use of this water on this initial phase represents an alternative to accelerate the plants' development, and allows a faster establishment. Likewise, it is a manner of adequate use for the recycle water, minimizing the environmental impact of this, and reducing the use of drinking water with irrigation purpose.

However, it is convenient to make further research with more time using this water because it can induce the accumulation of heavy elements. Though in this essay was not observed an adverse effect of these elements on the plants' development, it is very important to carefully evaluate their dynamic, due to these can reach the man through the trophic chain plant-animal-man.

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Literature cited

1. Adjei, M. and J. Rechcigl. 2002. Bahiagrass production and nutritive value as affected by domestic wastewater residuals. *Agron. J.* 94:1400-1410.

2. Angulo, R., Y. Montilla, M. Rivas, T. Clavero, R. Razz and C. Castro. 1997. Efecto de diferentes niveles de aguas residuales sobre el crecimiento de la *Leucaena leucocephala* en condiciones de vivero. Interciencia. 22: 28-30.

3. Blair, G., M. Panjaitan, D. Ivory, B. Palmer and M. Subjadi. 1988. An evaluation of tree legumes on an acid ultisol in South Sumatra, Indonesia. J. Agric. Sci. 111: 435-441.

4. Bouwer, H. and R. Chaney. 1974. Land treatment of waste waters. Advances in Agronomy. 26: 133-174.

5. Dart, P. and A. Almendras. 1991. Role of symbiotic association in nutrition of tropical Acacias. In: Turnbull, J. (Ed.): Advances in tropical Acacia Research: International workshop. Proceedings Nº 35: 13-19.

6. Elias, F. and F. Castellvi. 1996. Agrometeorología. Ediciones Mundi-Prensa. Madrid, España. pp. 517.

7. Ewel, J. and Madriz, A. 1968. Zonas de vida de Venezuela. Dirección de Investigación. Ministerio de Agricultura y Cría. Venezuela. p.65.

8. Hernan, E. and E. Hilliboe. 1990. Manual de tratamiento de aguas negras. 4ª Edición. Editorial Limaza. México D.F. pp 129-140.

9. Lambers, H., F. Stuart and L. Pons. 1998. Plant physiological ecology. Springer Verlag. New York. pp 540.

10. Latif M., S. Khan and M. Bhuiyan. 1985. Prospects of *Acacia mangium* for afforestation in Bangladesh. The Pakistan J. of Forestry. 8: 7-12.

11. Metcalf, E. 1995. Vertidos y reutilización. Ingeniería de aguas residuales. 3ª Edición. Editorial Labor S.A. Barcelona, España. pp. 893-1022.

12. Rodríguez-Petit, A., T. Clavero, R. Razz. 2001. Efecto de la altura y la frecuencia de poda en la producción de materia seca de *Acacia mangium* Willd. Revista Forestal Centroamericana. 35(3): 38-40.

13. Rodríguez-Petit A., T. Clavero, R. Razz and C. Cárdenas. 2000. Efecto del riego con aguas residuales sobre la germinación temprana de *Acacia mangium* Willd. Memorias IV Taller Internacional «Los árboles y arbustos en la ganadería tropical». EEPF «Indio Hatuey». Varadero, Cuba. p. 58.

14. Rodríguez-Petit, A., T. Clavero and R. Razz. 1997. Regrowth of *Acacia mangium* Willd under defoliation.

Willd. J. Anim. Sci. 75 (Supl. 1): 206.

15. Romero, J. 1988. Acuitratamiento por lagunas de estabilización. 2ª Edición. Editorial Romor. Santa Fe de Bogota. p 145.

16. Sedgley M., J. Harbard, R. Smith, A. Wickeneswari and A. Griffin. 1992. Reproductive biology and interspesific hybrisation for *Acacia mangium* and *Acacia auriculiformis*. Aust. J. of Bot. 40: 37-48.

17. Sopper, W. and L. Kardos. 1973. Recycling treated municipal waste waters and sludge through forest and crop land. Pennsylvania Estate Univ. Press. Univesrisity Park, Pennsylvania. p. 271.

18. Statistical Analysis System (SAS). 1990. SAS/STAT User's guide Version 6. 4th edition. SAS Institute Inc. Cary, NC.

19. Van Den Beldt, R. 1995. The future role of leguminous multi-purpose trees in tropical farming systems. In: Shelton, H. M., Piggin, C. M. and Brewbaker, J. L. (Eds.). Leucaena: Opportunities and Limitations. ACIAR Proceedings Nº 57: 241.

20. Wild, A. 1992. Condiciones del suelo y desarrollo de las plantas según Russel. Ediciones Mundi-Prensa. Madrid, España. pp. 1045.