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Effect of Sewage Effluent Irrigation Regimes on Wood Quality of *Prosopis juliflora* Grown in Riyadh Region

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ABSTRACT. The effect of sewage effluent water supply regimes on wood quality was investigated in *Prosopis juliflora* (Sw) DC. The tree plantation was established for four years on a sandy loam soil in the Agricultural Experiments Station of King Saud University at Deirab near Riyadh. Felled trees were sampled for wood density, ring width, earlywood percent, fiber length, and chemical composition.

Trees grown on sites receiving irrigation at 70% of the available soil moisture (ASM) formed wider annual rings with higher earlywood percent, produced higher density wood and longer earlywood fibers than trees grown on 30% ASM site.

Average holocellulose, alpha-cellulose and pentosans contents were higher in wetter sites at 70% ASM than in drier sites (88.36% *vs.* 84.9%, 48.10% *vs.* 41.50%, and 20% *vs.* 17.5%, respectively). Alcohol-benzene solubles wood extractives were higher in the trees grown on dry sites than in those grown on wet sites (7.8% *vs.* 4.9%).

Results of this study should be of value in planning afforestation programs using *Prosopis juliflora* in similar regions.

The particular potential of the genus *Prosopis* for arid zones is well established (Leakey and Last 1980, and Pedersen 1980). *Prosopis* produces an excellent firewood, durable posts and abundant pods which are eagerly sought by cattle (Wiley and Manwiller 1982). Rosende *et al.* (1984) found that tamarugo (*Prosopis tamarugo*) of 22-year-old consisted of ash content 1.41 and 1.15%, 1% NaOH solubles 6.93 and 8.82%, total extractives of 18.04 and 28.67%, lignin content of 21.72 and 22.67%, holocellulose 79.30 and 76.15%, and alpha-cellulose 38.90 and 36.55% for sapwood and heartwood, respectively. Also, they noted that in *Prosopis alba* the ash contents were 1.72 and 2.07% while 1% NaOH solubility were 8.67 and 12.87% with total extractives of 29.92 and 32.76%; lignin content

21.05 and 21.30%, holocellulose 79.05 and 79.7%, alpha-cellulose 41.90 and 43.04% for sapwood and heartwood, respectively. The harvestable pods of *Prosopis* spp. have crude protein of 19-21%, due to high protein content, mesquite pods mostly used for animal feeding (Earl 1985 and Talpada *et al.*, 1979). Ground *Prosopis juliflora* (Sw.) Dc. pods were also used in a concentrated feeds to cattle as a cheap replacement of wheat bran (Rao and Reddy 1983). *Prosopis juliflora* is considered a multi-purpose tree under arid zones conditions. Thus, more information on anatomical characteristics and chemical composition of this species is desirable.

Due to the scarcity of water in arid regions, several countries have used sewage effluent irrigation systems for tree plantations (Kandeel and Kherallah 1981). This is done successfully in Deirab area of the Central Saudi Arabia zone near Riyadh. Hence, the objectives of the current study were: i) to determine the potential value of *Prosopis juliflora* to Saudi Arabia through investigating its growth and wood characteristics under sewage effluent water stress, and ii) to study the possibility of using this tree species in afforestation projects under arid zones conditions such as those of the Riyadh area in Saudi Arabia.

Materials and Methods

Six 4-year-old *Prosopis juliflora* trees (propagated by seeds) were sampled from a randomly designed experimental with two water regime treatments. Tree plantations were irrigated for four years by sewage effluent (Appendix I) according to the following irrigation (regimes: 1) dry treatment, which was watered when the available soil moisture (ASM) fell to 30%, 2) wet treatment, in which the watering was carried out when the ASM fell to 70%. At the end of the experiment, the number of waterings was 126 and 197 for the dry and the wet treatments, respectively. The amounts of consumed water were 226.8 and 354.6 m^3 for the dry and wet treatments, respectively.

After felling the trees (in 1985) total tree height and diameter at 20 cm above ground level for each tree were measured. Sample logs of one meter length above the ground level were taken from each tree of both two treatments. The proportions of sapwood and heartwood (as indicated by color differences), growth ring width, and the proportion of earlywood as an average for all rings were determined. Figure 1 shows the sampling method in which each log taken from each tree provided three 20 cm-thick matched discs for the determinations of anatomical characteristics, specific gravity, and chemical constituents, respectively. Specific gravity specimens were taken from the middle matched disc and were carried out according to the maximum moisture content method reported by Smith (1961). Fiber length specimens were removed from the upper matched disc. A

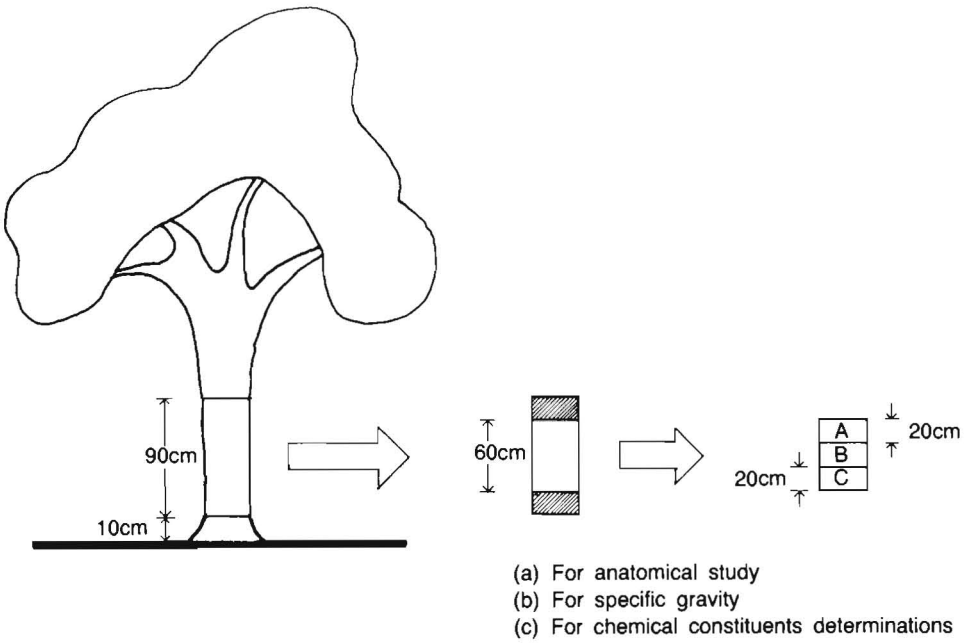

Fig. 1. Sampling procedure for anatomical, specific gravity and chemical constituents determinations in *Prosopis juliflora* wood.

debarked 0.3 cm wide slicers from the pith to the bark every 2 cm were taken from each tree. These samples were macerated in 1:1 solution of 30% hydrogen peroxide and glacial acetic acid at 60°C for three days, and stained with Safranin, temporarily mounted in glycerin, and measured using a microprojector. The number of fibers (sample size) needed for a reliable estimate was calculated using a double sampling (Stein 1945 and Kandeel *et al.*, 1977).

For chemical analysis, the lower matched disc from each tree was subsequently separated into heartwood and sapwood. The sapwood and heartwood of mesquite (*Prosopis juliflora*) are easily differentiated by color, the sapwood being yellowish and the heartwood red-brown. Sapwood and heartwood for each sampled tree were converted to thin-longitudinal shavings, air-dried, then ground in a Wiley mill to pass through 40-mesh screen and be retained on 60-mesh screen. The amounts of extractives (benzene-ethanol, ethanol, and water-solubles) were determined by TAPPI Standard method (1968). The holocellulose in wood was determined

according to the acid-chlorite method (Browning 1967). The amount of alpha-cellulose in holocellulose was determined in accordance to ASTM (1960). The determination of pentosan content in wood was carried out according to TAPPI Standard method (1978).

To investigate differences between irrigation regimes, data were statistically analyzed. Mean values of the studied wood properties were compared statistically using the t-test in pairs (Steel and Torrie 1960).

Results and Discussion

Table 1 illustrates the differences between sapwood of dry-treatment and sapwood of wet-treatment (70% ASM) in both two irrigation regimes, as well as between heartwood of dry-treatment (30% ASM) and heartwood of wet-treatment (70% ASM).

There was a significant differences (5% level) in specific gravity of sapwood between the two irrigation regimes. No significant differences were noted within heartwood under the two regimes. Fiber length of wood from the wet-treatment significantly longer than that of wood from dry-treatment. The annual growth ring thickness, early-wood percentage, and the heartwood percentage were significantly higher (1% level) in the wet-treatment than in dry treatment. No significant differences were found in total tree height and tree diameter (at 20 cm height above ground level) between the two irrigation regimes.

Results of chemical studies are summarized in Table 2. Benzene-ethanol extractives and total extractives of the sapwood of *Prosopis juliflora* in the wet treatment were significantly lower (5% level), whereas holocellulose content and alpha-cellulose content were significantly higher (5% and 1% levels, respectively) than in the dry treatment. No significant differences were found in pentosan contents of sapwood between the wet-and dry-treatments.

There was no significant difference in benzene-ethanol solubles and holocellulose content of the heartwood between the two irrigation regimes. However, pentosan content, and alpha-cellulose were significantly higher in the wet-treatment than in the dry one.

Generally, the percentage of holocellulose and alpha-cellulose are higher in the sapwood than in the heartwood. Heartwood contains a higher percentage of pentosan and extractives proportions than the sapwood. These results agree with Goldstein and Villarreal (1972) who studied the chemical composition of *Prosopis juliflora* wood and found that holocellulose was 70.6 and 54.2%, Xylans 19.8 and

Table 1. Average height, diameter, specific gravity, and characteristics of the wood of *Prosopis juliflora*.

Irrigation regimes		Tree height, (m)	Tree diameter, (cm)	Specific gravity	Fiber length (mm)	Annual growth thickness (mm)	Early-wood (%)	Heart-wood (%)
1	SW			0.66 a		12.4 b	82 b	
	HW	7.0	11.6	0.55	0.81 a			42 b
2	SW			0.59 a		6.8 b	51 b	
	HW	6.9	11.3	0.53	0.69 a			47 b

SW – sapwood, and HW-heartwood.
1 = 70% of the available soil moisture (ASM).
2 = 30% of the available soil moisture (ASM).
a = significant at 5% probability level.
b = significant at 1% probability level.

Table 2. The chemical constituents of *Prosopis juliflora* wood as affected by irrigation regimes.

Irrigation regimes		Benzene-ethanol, solubles (%)	Total extractives (%)	Carbohydrates*		
				Pentosan (%)	Holocellulose (%)	Alpha-cellulose (%)
1	SW	3.07 a	10.14 a	19	90.28 a	51.38 aa
	HW	6.83	11.37 b	21 a	86.44	44.90 bb
2	SW	6.10 a	12.86 a	17	85.09 a	43.45 aa
	HW	9.15	13.93 b	18 a	84.78	40.30 bb

SW – sapwood, and HW-heartwood.
1 = 70% of the available soil moisture (ASM).
2 = 30% of the available soil moisture (ASM).
Values with same letter are significantly different at 5% level, while values with same double letters are significantly different at 1% level.
* Based on extractive-free oven-dry weight of wood.

23.0%, and benzene-ethanol extractives 4.4 and 12.2% for sapwood and heartwood, respectively. Rosende *et al.* (1984) however, found different results when working with *Prosopis tamarugo* (F. Phil.). The results are expected to be different specially due to the high salts tolerant of *Prosopis tamarugo* than the *Prosopis juliflora* which is the study material. Also the current study investigated the effect of sewage water stress on the magnitude of chemical constituents rather than the actual constituents only.

Conclusions

From the previous results the following conclusions can be drown:

1. Trees grown in the 70% ASM (available soil moisture) sites gave wood with higher specific gravity and longer fibers than trees grown in the 30% ASM (available soil moisture) sites.

2. The wood produced by the trees grown under 70% ASM irrigation regime had significantly higher earlywood percentage, heartwood percentage, and annual growth thickness than those grown at sites receiving irrigation at 30% ASM.

3. There was no significant difference between the two irrigation regimes in the total height of the trees and tree diameter averages at height of 20 cm above ground level.

4. Trees irrigated at 70% ASM, gave wood which was significantly higher in the holocellulose, alpha-cellulose, and pentosans than trees irrigated at 30% ASM.

5. Trees irrigated at 30% ASM, produced wood which was higher in the extractives content, specially benzene-ethanol solubles than those irrigated at 70% ASM.

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Appendix I

Chemical analysis of irrigation water at the Experiment Station in Deirab

Property	Well water	Sewage water
ph	7.5	7.1
EC	2.1	2.1
T.S.S.	1300 ppm	—
Soluble cations (mg/l)		
Na	9.7	1.13
Ca	5.0	9.24*
Mg	5.8	
K	0.4	0.63
Soluble anions (mg/l)		
CO_3	nil	—
HO_3	2.6	4.2
Cl	10.5	7.0
SO_4	9.0	7.20

* This value is a total of Ca & Mg.

تأثيرات معدلات الري على نوعية الخشب في أشجار البروسوبس [*Prosopis juliflora*] النامية في منطقة الرياض

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درست تأثيرات الري على ثوابت نوعية الخشب في أشجار البروسوبس *Prosopis juliflora* ولقد استمرت الأشجار منزرعة لمدة أربع سنوات في تربة رملية طمية بمحطة الأبحاث التابعة لجامعة الملك سعود بديراب قرب الرياض. هذا وقد ظهر تأثير الإجهاد المائي بوضوح على سُمك الحلقة السنوية وكثافة الخشب المتكون وأن الأشجار النامية في المواقع التي تتلقي ري عند ٧٠٪ من الرطوبة المتاحة بالتربة قد كونت حلقات نموية أوسع وأعطت نسبة أعلى من الخشب المبكر وكونت أخشاب ذات كثافة أعلى من الأشجار النامية في مواقع أخرى جافة، هذا وقد أظهر طول الألياف نفس النمط. وكانت محتويات الخشب من الهولوسيلولوز والألفاسيلولوز والبنتوزان (كربوهيدرات) أعلى في المواقع الرطبة عنها في المواقع الجافة بالقيم التالية: ٣٦, ٨٨٪ و ٩, ٨٤٪ هولوسيلولوز و ١, ٤٨٪ و ٥, ٤١٪ الفاسيلولوز و ٢٠٪ و ٥, ١٧٪ بنتوزان في المواقع الرطبة والجافة على التوالي. هذا وفي الجانب الاخر كانت المستخلصات الذائبة في الكحول والبنزين أعلى في الأشجارالنامية في المواقع الجافة عنها في الأشجار النامية في المواقع الرطبة (٨, ٧٪ و ٩, ٤٪). ويناقش البحث الحالي تأثير الإجهاد المائي على نوعية الخشب في أشجار هذا الجنس، كما أنه يقدم معلومات ذات أهمية كبيرة لمشروعات التشجير بالمناطق الجافة التي تستخدم أشجار البروسوبس.