DEVELOPMENT OF CLONAL MATRICES OF AUSTRALIAN RED CEDAR IN DIFFERENT SUBSTRATES UNDER FERTILIZER DOSES

Desenvolvimento de matrizes clonais de cedro Australiano em diferentes substratos sob doses de fertilizantes

Bruno Peres Benatti[1], Antonio Eduardo Furtini Neto[2], Bruno da Silva Moretti[3], Eduardo de Castro Stehling[4], Thaiana Marinha Almeida de Sousa[3]

ABSTRACT

In order to evaluate fertilizers doses in different substrates for growth and development of clonal matrices of Australian Red Cedar [*Toona ciliata* var. *australis* (F. Muell.) Bahadur], an experiment was conducted in a greenhouse. Five substrates were evaluate, with proportions by volume, the first consisting of 100% of Multiplant florestal®, the second of 50% vermiculite, 20% carbonized rice hulls, 20% soil and 10% coconut fiber, the third with 50% soil and 50% sand, the fourth was composed by 50% Multiplant florestal®, 10% soil and 40% coconut fiber and the fifth with 65% of Multiplant florestal®, 25% vermiculite and 10% carbonized rice hulls. The fertilizers doses applied were 0.0; 0.3; 0.6; 1.2; 2.4 of fertilization suggested by Malavolta (1980) for vases. The characteristics evaluated were: collar diameter of the matrices, production of dry mater by shoots, root system and total and accumulation of nutrients by shoot at the end of the experimental period of 150 days. The Australian Red Cedar plants have high nutritional requirements, as showed by the better development obtained with higher fertilizer doses than those suggested by Malavolta (1980). The substrate three provided the worst development to clonal matrices while the substrates 1, 4 and 5 provided the best environment for the development considering all the fertilizer doses and all variables.

Index terms: *Toona ciliata*, plant nutrition, fertilization.

RESUMO

Com o objetivo de avaliar diferentes substratos com taxas de fertilizantes para o crescimento e desenvolvimento de matrizes clonais de cedro australiano [*Toona ciliata* var. *australis* (F. Muell.) Bahadur], foi realizado um experimento em casa de vegetação. Foram avaliados cinco substratos, com as proporções em volume, sendo o primeiro composto por 100% Multiplant florestal®, o segundo de 50% Vermiculita, 20% casca de arroz carbonizada, 20% terra e 10% fibra de coco, o terceiro com 50% terra e 50% areia, o quarto com proporção de 50% Multiplant florestal®, 10% terra e 40% de fibra de coco e o quinto com 65% Multiplant florestal®, 25% vermiculita e 10% casca de arroz carbonizada. Para os níveis de fertilizantes aplicados, foram utilizadas 0.0; 0.3; 0.6; 1.2 e 2.4 da adubação sugerida por Malavolta (1980) para vasos. Foram avaliadas as características: diâmetro do colo das matrizes, produção de matéria seca de parte aérea, sistema radicular e total e o acúmulo de nutrientes na parte aérea das plantas ao final do período experimental de 150 dias. As plantas de cedro australiano apresentaram elevada exigência nutricional, visto que estimativas mostraram o melhor desenvolvimento das mesmas com doses superiores às sugeridas por Malavolta (1980). O terceiro substrato proporcionou o pior desenvolvimento para as matrizes clonais, enquanto os substratos 1, 4 e 5 proporcionaram os melhores ambientes para o desenvolvimento, considerando todas as doses de fertilizantes e todas as variáveis analisadas.

Termos para indexação: *Toona ciliata*, nutrição de planta, adubação.

(Received in march 21, 2012 and approved in may 30, 2012)

INTRODUCTION

Reforestation investments in Brazil have shown promising, because the country has adequate conditions for the development of several forest species. One specie that can be used is the Australian Red Cedar [*Toona ciliata* var. *australis* (F. Muell.) Bahadur], which has the same wood characteristics as Brazilian cedar, indicated for the manufacture of fine furniture and construction finishing , besides having rapid growth, reaching six meters tall at two years and eight months (BELA VISTA FLORESTAL, 2011).

This specie belongs to Meliaceae family, native to tropical regions of Australia and has shown good development in the southern region of Bahia and throughout the Bazilian southeast (PINHEIRO, 2003), where an average annual increase of between 20 and 30 cubic meters of wood per hectare per year can be estimated (MURAKAMI, 2008). Currently this specie is propagated

[1]Universidade Federal de Lavras/UFLA – Cx. P. 3037 – 37200-000 – Lavras – MG – Brasil – brunopbenatti@hotmail.com
[2]Universidade Federal de Lavras/UFLA – Departamento de Ciência do Solo/DCS – Lavras – MG – Brasil
[3]Universidade Federal de Lavras/UFLA – Lavras – MG – Brasil
[4]Bela Vista Florestal – Campo Belo – MG – Brasil

by seed, resulting in heterogeneous plantings that hinders the management of the area. Moreover, the seed of the Australian Red Cedar is seasonal and of short viability (SOUZA et al., 2009).

An alternative that can be used is the vegetative propagation technique, obtaining clonal plants. Therefore, quality seedling production is one of the most important stages for the culture to ensure good growth and development in the field. Considering that the nutritional status of the clonal mother plant alters the rate of development, growth intensity and specific morphological characteristics (EPSTEIN; BLOOM, 2004), the nutritional requirements of Australian Red Cedar should be known. However, studies have not been done for the Australian Red Cedar that indicate what the appropriate nutrient levels are in the substrate of the clonal matrices, to show satisfactory performance.

For an evaluation of the nutritional status of plants, the use of a plant matter analysis (MALAVOLTA, 2006) comparing the values of elements with a standard sample, allows to diagnose and correct nutritional imbalances of plants (TRANI et al., 1983). However, to obtain a standard sample, studies are necessary to determine which values are appropriate, since each species has different needs for certain nutrients.

The objective of this study was to evaluate the growth and development, content and accumulation of nutrients in clonal matrices of the Astralian Red Cedar.

MATERIAL AND METHODS

The experiment was installed in a greenhouse located at the Fazenda Bela Vista Florestal, located in the municipality of Campo Belo - MG. It consisted of five substrates (Table 1) and five doses of fertilizers (0.0; 0.3; 0.6; 1.2; 2.4), corresponding to a 5X5 factorial with 5 replications in a completely randomized design. Each experimental plot was composed of one plant in each dibble-tube with a volume of 3.5 dm³ prepared with 200 cc of No. 01 crushed stone layer covered with shade net on this substrate.

The substrate preparation was conducted in a concrete mixer with a 400 dm³ capacity for better homogenization. The percentages of each substrate was measured based on volume. On this occasion doses of macronutrient fertilizers were added. The micronutrient fertilization was by solution in dibble-tubes.

The fertilizer doses were relative to a full dose of fertilizer per vase, as suggested by Malavolta (1980). The dose corresponding to 100% consists of 300, 200, 150, 75, 50 and 15 mg.dm-3 of nitrogen, phosphorus, potassium, calcium, sulfur and magnesium, respectively, and for micronutrient doses of 5.0; 0.5; 1.5; 5.0; 0.1; 3.6 mg.dm-3 of zinc, boron, copper, iron, molybdenum and manganese, respectively.

After the treatments were installed, the transplanting of seedlings, produced by mini-cuttings from a plant with the potential to become a clonal matrice was carried out. The substrates were kept under constant humidity with daily irrigation. The plants were conducted with pruning, used in clonal matrices for higher sprouting.

Measurements of the collar diameter of plants were made at 90 and 150 days after transplanting, marking the end of the experiment. During the experiment, pruning was done to form the architecture of these matrices and stored in Kraft paper bags, identified by treatment. At the end of the experiment, plants were separated into principal stem, leaves and root system, and the material was oven-dried at 65° C until constant weight. After this, the shoot dry matter (SDM) (that is made up by leaves, stem and cut material), root system (DMRS) and compound total dry matter (TDM) were determined. The leaves and stem were analyzed chemically in the laboratories of the Soil Science Departament in Federal University of Lavras.

With the nutrient concentration values of the plants and their dry matter production, we determined the accumulation of nutrients in the aerial part. The data were subjected to variance analysis and the means subjected to regression analysis and Scott Knott test at 5%, using the Sisvar statistical software (FERREIA, 2011).

Table 1 – Percentage of components of each substrate, measured based on volume.

Substrate	Multiplant florestal®	Vermiculite	C.R.H.	Soil	Sand	C.F.
1	100	0	0	0	0	0
2	0	50	20	20	0	10
3	0	0	0	50	50	0
4	50	0	0	10	0	40
5	65	25	10	0	0	0

*C.R.H.: Carbonized Rice hulls; C.F.: coconut fiber.

RESULTS AND DISCUSSION

Collar diameter of clonal matrices

The evaluation of collar diameter of plants is one of the most important morphological factors that can be measured without the occurrence of any injury to the plants, besides being considered an important parameter in the seedling development after planting (GOMES, 2002).

All substrates showed an increase in the diameter as a function of the fertilizer dose applied (Table 2), with a posterior decrease in this variable. This behavior, as illustrated in Figure 1 can be explained by the "Mitscherlich law" that is based on the fact that with each successive increment in the fertilizer quantity, there is a lessening of production, reaching a point of maximum production and followed by a lower production, due to the toxicity caused by fertilizer (LOPES; GUILHERME, 2000).

For all fertilizer doses applied, the substrate that provided the smallest plant collar diameter was Substrate three. A similar result was obtained by Pio et al. (2004), in work with loquat, justifying the low substrate performance to excess water retention and low porosity. In order for the plant to have good development the substrate must present good aeration, drainage, retention and availability of water, the first two factors being related to macropores and the other two with micropores and specific surface of the substrate (FERREIA; DIAS- JUNIOR, 1997).

In the absence of fertilizers, independent of the clonal matrice collar diameter measurement times (90 or 150 days), Substrate 1 provided the best development to the plants, due to its favorable physical and chemical properties. Pio et al. (2005) evaluating the development of various substrates in the production of Jabuticaba seedlings concluded that a product based on pine bark (similar to Multiplant florestal®) provided better development.

With exception of Substrate 3, better development was estimated for all substrates when the fertilizer dose was above 120% of that recommended by Malavolta (1980), showing the high nutritional requirement for the specie under study. The high nutritional requirements of Australian Red Cedar is suggested by Moretti et al. (2011), more studies being recommended for an understanding of the appropriate fertilizer doses.

Dry matter production (DM)

For the SDM variable, except for Substrate 3, the plants obtained production similar to that of the collar diameter, and "Mitscherlich law" (Table 3). In Substrate 3 (50% soil, 50% sand) it was observed that the production of SDM, RSDM and TDM decreased with the increase in fertilizer doses (Figure 2). This result may be due to toxicity caused in the plant even in low doses, being progressive with dosage increase.

In the evaluation of TDM all plants presented a lower dry matter weight at the 240% rate (suggested by MALAVOLTA ,1980) compared with the 120% rate, suggesting that the 240% rate would be causing toxicity to the plant due the high fertilizer doses applied. These results show the importance of developing new experiments to define what should be the appropriate fertilizer dose for the clonal matrice of Australian Red Cedar.

Levels and accumulation of nutrients in clonal matrices.

Table 4 presents the nutrient levels and from this it was possible to quantify the nutrient accumulation in the shoot (Table 5) by the sum of the accumulation in the leaves, the pruned material of matrices and that accumulated in the stems.

Table 2 – Collar diameter of clonal matrices of Australian Red Cedar in five substrates and two time evaluations (90 and 150 days) in function of fertilizer dose percentage.

	90 days					150 days				
	Fertilizer doses									
Substrate	0	0.3	0.6	1.2	2.4	0	0.3	0.6	1.2	2.4
1	7.5a	7.3b	9.3a	9.6a	9.4a	7.6a	8.1b	9.8a	10.0a	9.9a
2	5.9b	7.0b	7.2b	8.3b	8.3b	6.3b	7.9b	7.8b	8.6b	8.6b
3	4.7c	4.6c	5.0c	4.3c	2.5c	4.8c	4.7c	5.0c	4.5c	2.5c
4	5.0c	8.4a	8.9a	9.3a	7.8a	5.3c	8.7a	9.1a	9.5a	7.8b
5	5.9b	8.9a	9.6a	9.7a	8.7a	6.4b	9.1a	9.8a	10.0a	9.2a

* Means followed by the same letter in a column do not differ at a 5% level of significance, by the Scott Knott test.

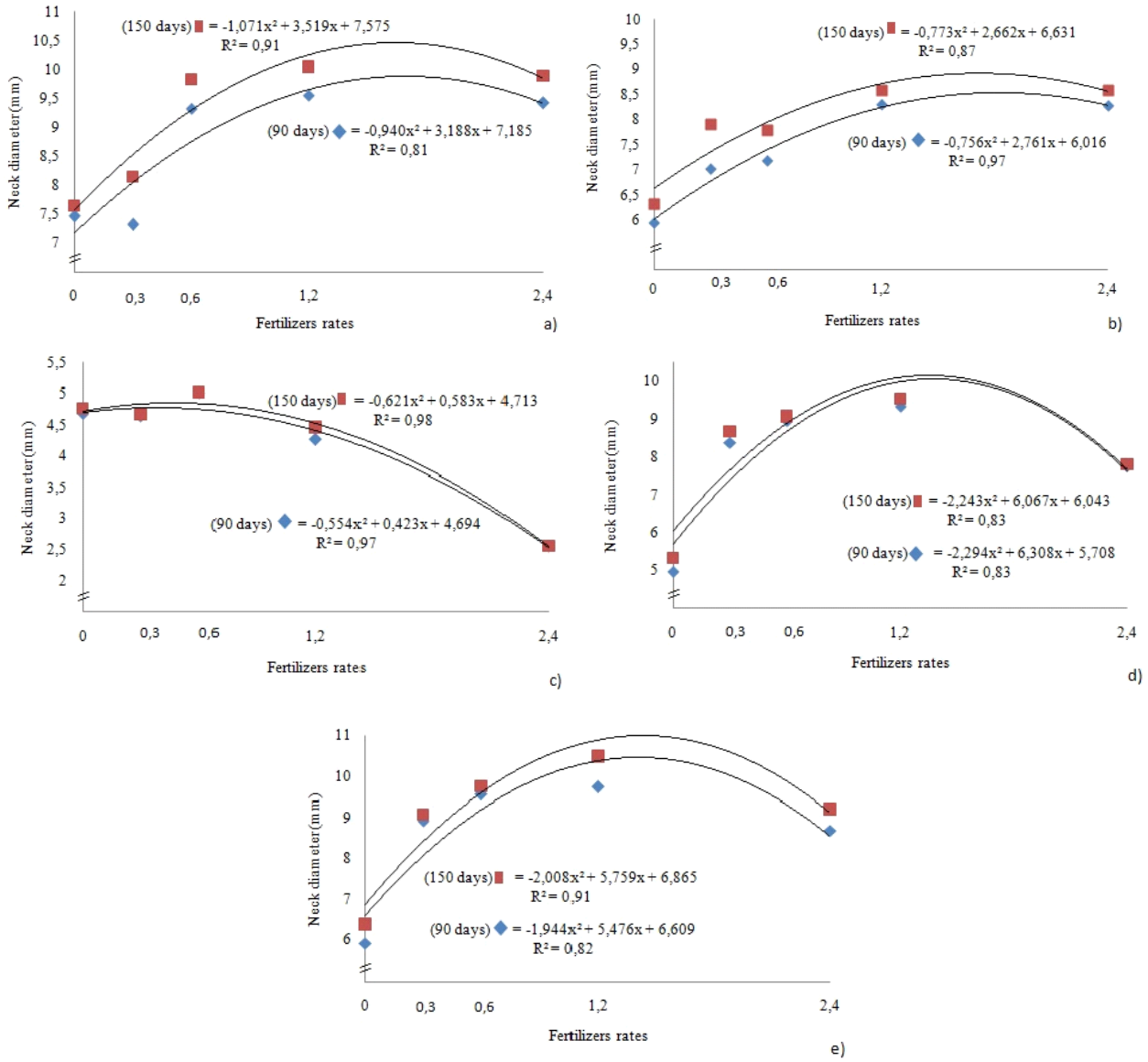

Figure 1 – a), b), c), d) and e). Collar diameter of the clonal matrice of Australian red cedar in substrates 1,2,3,4 and 5, respectively, under fertilizer doses at 90 and 150 days.

Table 3 – Production of shoot (SDM), root system (RSDM) and total (TDM) dry matter of clonal matrices in five substrates in function of fertilizer doses.

	SDM				
	Fertilizers doses				
Substrate	0	0.3	0.6	1.2	2.4
1	6.42a	13.74a	14.45a	16.5a	16.48a
2	6.84a	8.41c	9.7b	10.44c	8.63b
3	6.08a	4.71d	4.65c	4.41d	3.31c
4	4.98a	12.11b	12.74a	14.23b	9.62b
5	5.27a	10.78b	14.43a	15.94a	14.79a
	RSDM				
1	11.5a	19.71a	20.87a	17.17a	11.69a
2	9.36a	9.33b	11.93b	8.99b	6.92b
3	2.11b	2.63c	1.59c	1.66c	0.5c
4	4.32b	10.06b	10.32b	9.87b	8.62b
5	5.34b	12.07b	14.36b	12.27b	9.11b
	TDM				
1	17.92a	33.45a	35.32a	33.67a	28.17a
2	16.20a	17.74c	21.63c	19.43d	15.55c
3	8.19b	7.34d	6.24d	6.07e	3.81d
4	9.30b	22.17b	23.06c	24.1c	18.24c
5	10.61b	22.85b	28.79b	28.21b	23.9b

* Means followed by the same letter in column do not differ at a 5% level of significance, by the Skott Knott test.

It is evident by the nutrient accumulation data that with higher fertilizer doses, the accumulation of nutrients increases in the plant, but in some cases (Substrate 3) the inverse occurs, a lower accumulation with higher fertilizer doses applied, which can be explained by the low substrate aeration, providing an unfavorable environment to the root growth (PIO, 2005), resulting on a lower plant development and consequently poor nutrient accumulation.

Calcium, potassium and nitrogen are the nutrients that obtained the highest levels in the leaves of clonal matrices. The high calcium content, and consequently the high calcium requirement by Australian Red Cedar is pointed out by Souza et al. (2010), fertilizing at planting and in coverage being a necessary according to soil analysis. Potassium, in general, is the second nutrient most required by the culture (FAQUIN, 2005), and high levels of nitrogen in leaves, corroborate with the study by Moretti et al. (2011), with Australian Red Cedar plants in vases.

The nutrients that had higher accumulations were calcium, nitrogen and potassium. And the micronutrients that had the most accumulation in shoots of clonal matrices of Australian Red Cedar were iron, manganese, zinc and boron.

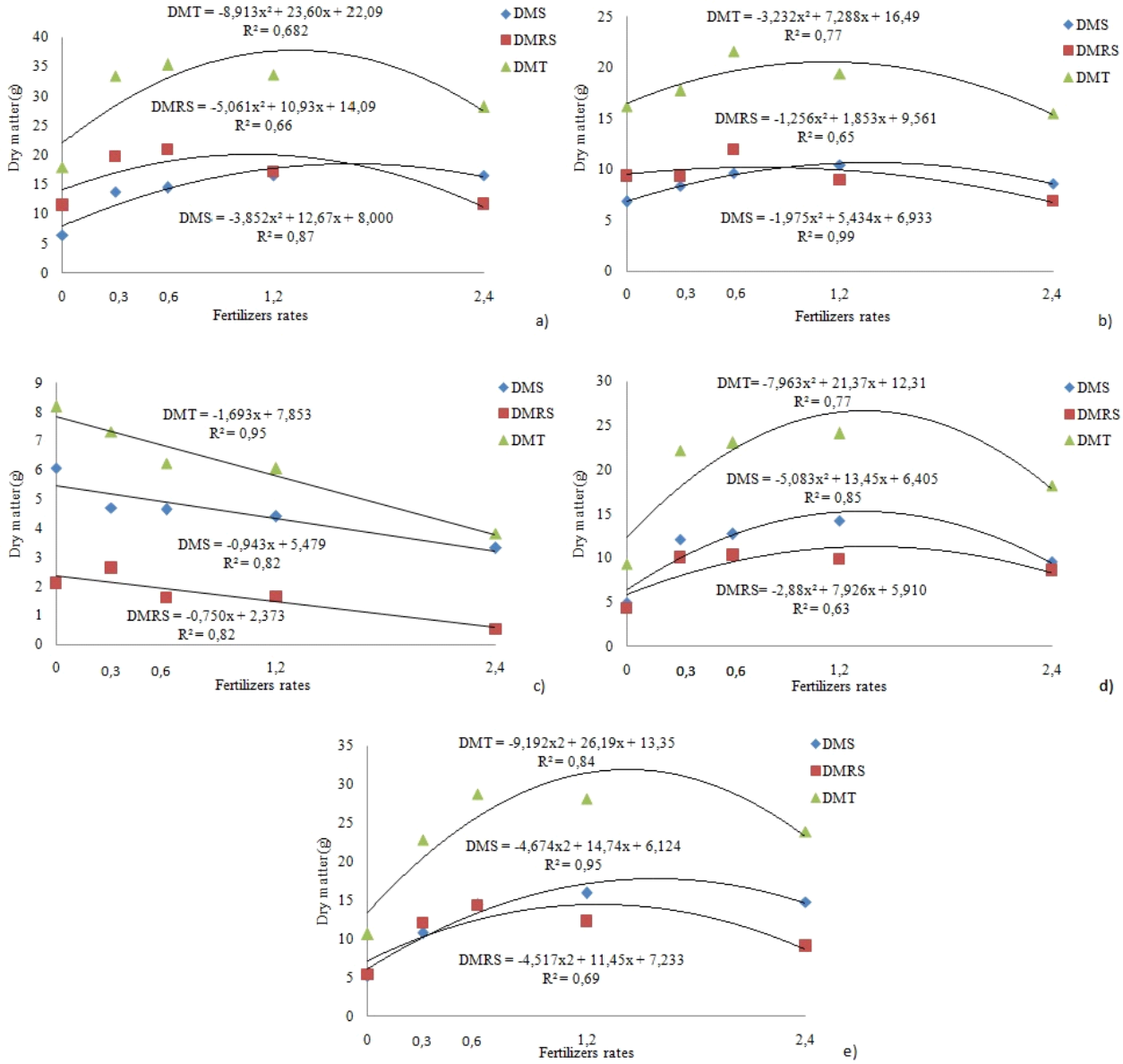

Figure 2 – a), b), c), d) and e). Production of shoot (SDM), root system (RSDM) and total (TDM) dry mater of clonal matrices of Australian Red Cedar in substrates 1,2,3,4 and 5, respectively, under fertilizer doses.

Table 4 – Nutrients contents in leaves of matrices of Australian Red Cedar in different substrates under fertilizer doses.

		N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
Subst.	Dose	g kg^{-1}						mg kg^{-1}				
1	0	15	4.77	22.21	31.58	6.37	2.26	28.97	4.18	90.02	33.12	19.19
1	0.3	21	6.44	19.51	33.1	7.17	3.05	32.88	2.95	164.53	37.57	21.6
1	0.6	25	9.22	22.81	35.85	6.96	4.37	25.31	2.87	137.04	43.36	24.71
1	1.2	29	9.54	18.01	48.29	9.17	4.52	31.88	2.66	142.92	69.62	30.64
1	2.4	29	7.88	15.3	55.92	10.41	3.73	38.18	2.37	146.01	113.32	36.24
2	0	16	5.32	23.71	19.21	10.16	2.52	34.94	3.54	152.72	100.36	30.11
2	0.3	28	5.46	20.41	13.85	11.45	2.59	30.89	4.58	134.9	98.93	28.65
2	0.6	25	5.04	16.81	18.02	12.8	2.38	37.08	3.55	141.84	118.07	26.11
2	1.2	31	2.01	18.31	20.2	16.94	2.73	50.56	2.91	151.63	139.4	24.28
2	2.4	22	2.08	9.6	16.91	5.06	1.56	17.85	4.86	84.54	61.46	26.79
3	0	32	3.71	24.61	22.98	20.01	3.73	74.25	3.31	120.49	312.37	43.42
3	0.3	35	2.49	16.51	14.76	4.92	1.52	14.82	7.08	78.13	163.59	31.23
3	0.6	38	1.03	18.91	12.8	4.12	1.66	20.23	2.82	79.22	234.19	50.55
3	1.2	51	1.1	21.61	15.84	4.07	2.2	39.31	4.39	123.77	536.82	133.4
3	2.4	50	1	22.6	13.54	3.8	2.7	27.42	4.18	119.14	427.84	127.07
4	0	19	2.84	23.11	29.39	6.03	6.23	41.62	7.87	94.14	50.19	127.07
4	0.3	25	3.21	27.01	28.69	5.21	3.23	38.18	5.28	148.84	38.02	25.37
4	0.6	24	2.93	27.61	26.01	4.87	3.05	33.9	3.09	84.87	22.85	27.24
4	1.2	30	3.11	25.51	28.36	5.37	2.81	32.88	3.01	53.51	44.87	38.39
4	2.4	38	4.9	25.51	36.84	6.85	3.52	41.62	4.16	126.13	120.89	50.12
5	0	14	2.16	19.81	39.6	9.19	2.66	32.88	2.75	104.29	57.66	20.86
5	0.3	21	3.02	18.61	32.83	8.17	2.59	37.08	0.9	154.7	52.5	22.22
5	0.6	21	3.4	23.41	37.99	9.2	3.62	28.03	2.16	119.14	41.62	23.26
5	1.2	27	3.21	13.8	46.38	11.21	2.45	42.82	3.31	180.57	101.52	27.5
5	2.4	30	3.82	14.1	51.23	13.79	2.89	51.96	17.54	231.95	155.21	37.69

Table 5 – Accumulation of nutrients in shoot of matrices of Australian Red Cedar in different substrates under fertilizer doses.

			N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
Substrate	Dose	SDM (g)	g plant^{-1}						μg planta^{-1}				
1	0	6.42	86	27	130	188	37	13	171	23	531	213	120
1	0.3	13.74	260	77	245	420	86	37	406	36	1942	550	290
1	0.6	14.45	322	112	294	467	86	55	346	36	1714	656	347
1	1.2	16.50	446	140	278	722	130	70	477	37	2165	1166	529
1	2.4	16.48	456	123	252	823	150	62	553	42	2319	1835	617
2	0	6.84	103	33	156	125	66	17	230	25	979	661	197
2	0.3	8.41	221	41	167	106	87	22	278	41	993	785	233
2	0.6	9.70	232	43	156	149	108	24	325	35	1164	1042	263
2	1.2	10.44	305	21	180	174	144	29	449	31	1336	1326	258
2	2.4	8.63	185	18	83	144	42	13	153	44	724	518	230
3	0	6.08	180	24	137	115	101	22	364	21	637	1579	273
3	0.3	4.71	160	11	75	68	22	7	71	32	363	734	147
3	0.6	4.65	171	5	84	60	18	8	94	13	364	1088	230
3	1.2	4.41	217	5	92	70	18	10	164	20	541	2290	592
3	2.4	3.31	164	3	74	45	12	9	90	14	395	1414	420
4	0	4.98	90	14	113	144	29	30	199	39	464	254	624
4	0.3	12.11	276	37	303	341	59	38	418	69	1645	480	303
4	0.6	12.74	279	38	316	308	55	36	373	45	1005	336	344
4	1.2	14.23	406	50	337	370	69	41	415	51	801	642	544
4	2.4	9.62	336	50	234	338	60	33	354	43	1192	1159	526
5	0	5.27	70	11	101	203	47	14	166	15	543	308	112
5	0.3	10.78	203	30	187	325	79	26	353	12	1461	582	226
5	0.6	14.43	275	47	298	466	111	45	355	32	1480	627	317
5	1.2	15.94	391	56	215	624	149	38	570	51	2455	1515	442
5	2.4	14.79	423	62	202	666	176	41	661	215	3034	2085	577

CONCLUSIONS

The Australian Red Cedar has high nutritional requirements, having its best development at higher fertilizers doses than those recommended for vases proposed by Malavolta (1980).

The substrate used for the development of clonal matrices of Australian Red Cedar has fundamental importance in its growth. The substrates composed of 100% Multiplant florestal® or 50% Multiplant florestal®, 10% soil and 40% coconut fiber or 65%Multiplant florestal®, 25% vermiculite and 10% carbonized rice hulls allowed the largest collar diameter of the clonal matrices.

The substrate composed of 100% Multiplant florestal® provided the highest shoot, root system and total dry matter production for the clonal matrices.

The substrate composed of 50% soil and 50% sand does not show desirable characteristics for a good development of clonal matrices of Australian Red Cedar.

ACKNOWLEDGEMENTS

The authors thank CNPq for providing scholarships and Viveiro Bela Vista Florestal for the use of the greenhouse and seedlings for this experiment.

REFERENCES

BELA VISTA FLORESTAL. Cedro australiano. Campo Belo, MG, 2011. Available in: <www.belavistaflorestal.com.br>. Access in: 12 dez. 2011.

EPSTEIN, E.; BLOOM, A. J. Mineral nutrition of plants: principles and perspectives. **Sinauer Associates**, 2004, Sunderland. 400 p.

FAQUIN, V.; **Nutrição de plantas**. Lavras: UFLA / FAEPE, 183p. 2005.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia** [online], Lavras, v. 35, n. 6, PP. 1039-1042, 2011. Available in: < http://www.editora.ufla.br/site/_adm/upload/revista/35-6-2011_01.pdf>. Access in: 02 fev 2012.

FERREIRA, M. M.; DIAS JÚNIOR, M. S. **Física do solo**. Lavras: UFLA/FAEPE, 1997. 63 p.

GOMES, J. M. et al. Parâmetros morfológicos na avaliação da qualidade de mudas de *Eucalyptus grandis*. **Revista Árvore**, Viçosa, v. 26, n. 6, p. 655-664, 2002.

LOPES, A. S.; GUILHERME, L. R. G. Uso eficiente de fertilizantes e corretivos agrícolas: aspectos agronômicos. 3. ed. São Paulo: **ANDA**, 2000. 72 p.

MALAVOLTA, E. Elementos de nutrição mineral de plantas. São Paulo, **Ceres**, 1980. 251p.

MALAVOLTA E. Manual de nutrição mineral de plantas. São Paulo: **Agronômica Ceres**, 2006. 638p.

MORETTI, B. S. et al. Crescimento e nutrição mineral de mudas de cedro australiano (*Toona ciliata*) sob omissão de nutrientes. **Cerne**, Lavras, v.17, n. 4, p. 453-463, out./dez. 2011.

MURAKAMI, C.H.G. Cedro australiano: valorização de espécies nobres. **Boletim Florestal**, São Paulo, v.7, n.2, p.1-6, fev. 2008.

PINHEIRO, A. L.; LANI, L. L.; COUTO, L. **Cedro-australiano cultivo e utilização**. Viçosa – UFV, 42p. 2003.

PIO, R. et al. Efeito de diferentes substratos no crescimento de mudas de nespereira. **Revista Brasileira de Agrociência**, Pelotas, v. 10, n. 3, p. 309-312, jul./set. 2004.

PIO, R. et al. Substratos na produção de mudas de jabuticaba. **Revista Brasileira de Agrociência**, Pelotas, v.11, p.425-427, 2005.

SOUZA, J. C. A. V. et al. Propagação vegetativa de cedo-australiano (*Toona ciliata* M. Roemer) por miniestaquia. **Revista Árvore**, Viçosa, vol.33, n.2, pp. 205-213, 2009.

SOUZA, J.C.A.V.; BARROSO, D.G.; CARNEIRO, J.G. de A. Cedro australiano: **Manual Técnico 21**. Niterói: Rio Rural, 2010. 12 p. Available in: <http://www.pesagro.rj.gov.br/downloads/riorural/manual21.pdf>. Access in: 08 dez. 2011.

TRANI, P. E.; HIROCE, R.; BATAGLIA, O.C. **Análises foliar**: amostragem e interpretação. Campinas: Foundation Cargill, 1983. 18p.