GROWTH AND NUTRITIONAL ANALYSIS OF TREE SPECIES IN CONTAMINATED SUBSTRATE BY LEACHABLE HERBICIDES[1]

Rebecca de Araújo Fiore[2*], José Barbosa Dos Santos[3], Evander Alves Ferreira[4], Cássia Michelle Cabral[5] and Israel Marinho Pereira[6]

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[2] Universidade Federal dos Vales do Jequitinhonha e Mucuri - Campus JK, Programa de Pós-Graduação em Ciência Florestal, Diamantina, MG - Brasil. E-mail: <rebecca.floresta@gmail.com>.
[3] Universidade Federal dos Vales do Jequitinhonha e Mucuri - Campus JK, Centro de Ciências Agrárias, Diamantina, MG - Brasil. E-mail: <jbarbosasantos@yahoo.com.br>.
[4] Universidade Federal dos Vales do Jequitinhonha e Mucuri - Campus JK, Diamantina, MG - Brasil. E-mail: <evanderalves@gmail.com>.
[5] Universidade Federal dos Vales do Jequitinhonha e Mucuri - Campus JK, Departamento de Ciências Biológicas, Diamantina, MG - Brasil. E-mail: <mtchells@yahoo.com.br>.
[6] Universidade Federal dos Vales do Jequitinhonha e Mucuri - Campus JK, Departamento de Engenharia Florestal, Diamantina, MG - Brasil. E-mail:<imarinhopereira@gmail.com>.
*Corresponding author.

ABSTRACT – Ecosystems contamination by residues of pesticides requires special attention to the herbicides subject to leaching. The objective was to select tree species to rhizodegradation contaminated by residues of 2,4-D and atrazine and to recompose riparian areas to agricultural fields, then reducing the risk of contamination of water courses. A total of 36 treatments consisted of the combinations of forest species were evaluated [*Inga marginata* (Inga), *Schizolobium parahyba* (guapuruvu), *Handroanthus serratifolius* (ipê amarelo), *Jacaranda puberula* (carobinha), *Cedrela fissilis* (cedro), *Calophyllum brasiliensis* (landin), *Psidium mirsinoides* (goiabinha), *Tibouchina glandulosa* (quaresmeira), *Caesalpinia férrea* (pau-ferro), *Caesalpinia pluviosa* (sibipiruna), *Terminalia argêntea* (capitão) and *Schinopsis brasiliensis* (braúna)] and three solutions simulating leachate compound (atrazine, 2,4-D and water - control), with four replicates each. The characteristics measured were plant height, stem diameter, number of leaves, leaf area and dry biomass, and foliar nutrition. Forest species survived the herbicide application, and most showed an increase in macronutrients even under an herbicide application, and the Inga had the highest tolerance regarding growth analysis. It is recommended to use species that are more tolerant to Atrazine and 2,4-D in field experiments to confirm previous results of this simulation.

Keywords: Inga marginata; Tolerance; Phytoremediation.

CRESCIMENTO E ANÁLISE NUTRICIONAL DE ESPÉCIES ARBÓREAS EM SUBSTRATO CONTAMINADO POR HERBICIDAS LIXIVIÁVEIS

RESUMO – A contaminação de ecossistemas por resíduos de defensivos agrícolas, especial atenção deve ser dada para os herbicidas passíveis de lixiviação. O objetivo foi selecionar espécies arbóreas para a rizodegradação de ambientes contaminados por resíduos de 2,4-D e atrazine, e para recomposição de mata ciliar aos campos agrícolas e, consequentemente, diminuir riscos de contaminação de cursos hídricos. Foram avaliados 36 tratamentos compostos pela combinação de 12 espécies florestais: [inga- ***Inga marginata*** *Willd, guapuruvu -* ***Schizolobium parahyba*** *(Vell), ipê amarelo-* ***Handroanthus serratifolius*** *(A.H.Gentry) S.Grose, carobinha -* ***Jacaranda puberula*** *Chan, cedro-* ***Cedrela fissilis*** *Vell, landin -****Calophyllum brasiliense*** *Camb, goiabinha-* ***Psidium myrsinoides*** *Berg, quaresmeira-****Tibouchina granulosa*** *Cogn, pau-ferro -* ***Caesalpinia ferrea*** *Mart, sibipiruna -* ***Caesalpinia pluviosa*** *DC, capitão –****Terminalia argentea*** *Mart & Zucc e braúna-* ***Schinopsis brasiliensis*** *Enge S.F.Blacke] e três soluções simulando o composto lixiviado (atrazine, 2,4-D e água – controle), com quatro repetições cada. Foram mensuradas a altura da planta, o diâmetro do caule, o número de folhas, a área foliar e o acúmulo de biomassa seca e a nutrição foliar. A maioria das espécies apresentou increaseo*

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em macronutrientes mesmo submetidas à aplicação dos herbicidas, sendo que o inga apresentou maior tolerância em relação as análise de crescimento. Assim, recomenda-se a utilização das espécies mais tolerantes aos herbicidas Atrazine e 2,4-D em experimentos de campo para confirmar os resultados preliminares desta simulação.

Palavras-chave: ***Inga marginata****; Tolerância; Fitorremediação.*

1. INTRODUCTION

Leachable herbicide has been the subject of researches and discussions around the world, since their molecules movement on soil may reach superficial zones or the water table (LAVORENTI; REGITANO, 2003). The more time the product is in a soil without being absorbed, degraded or mineralized, the higher is the possibility of leaching (PIRES et al., 2003), this way the intensity depends on physical-chemical characteristics of compounds as type of soil, organic matter content, saturation, rain, irrigation, besides plants presence (PIRES et al., 2003; BICALHO, 2007).

Among herbicides with high potential of groundwater contamination and persistent on environment, they are the triazines, group from which atrazine (6-cloro-N-etil-N'-(1-metiletil)-1, 3,5-triazina-2,4-diamina) takes part. It is found in superficial and ground water in North America, and in some European countries, (STRUTHERS et al., 1998), and its aquatic ecological effects cause preoccupation on regulatory communities. Auxinic herbicides also shows leaching potential, highlighting 2,4-D (acid 2,4 dichlorophenoxyacetic), that is highly used in this country, being detected in water courses mainly in the South. (PRIMEL et al., 2005).

Following this sense, it becomes priority in the area of environmental sustainability to develop researches on alternatives of herbicide use together techniques to accelerate degradation. One of the alternatives is the phytoremediation that consists in using plants and their microbiota, on removing or immobilize metabolites, or turning them inoffensive to ecosystem (PIRES et al., 2003).

As regards leachable herbicides, a potential proposal would be the use of tree species developed downstream from agricultural areas, preferable at near barriers or in riparian areas, in which, phytoremediation mechanisms as rhizofiltration would be used, on adsorption or precipitation of the contaminate in the aqueous media.(GRATÃO et al.,2005). In this case, choosing the tree species is important. Relevant factors to this study include area characterization, estimates of time to phytoremediation basing on the characteristics of the area and of the vegetal specie and the destination of the contaminant and its metabolites on the plant (MARQUES et al., 2011).

Under this hypothesis, species that are tolerant to those products and with capacity to decrease their residue could avoid or at least reduce the effective quantity of the compounds on water courses.

This study objective was to evaluate the potential of Forest species to remediate substrates contaminated with atrazine and 2,4-D, simulating contamination conditions of groundwater.

2. MATERIALAND METHODS

The experiment was conducted in a protected environment at Universidade Federal dos Vales do Jequitinhonha e Mucuri, in Diamantina-MG. Native vegetal species used were acquired at Horto do Instituto Estadual de Florestas (IEF) de Diamantina-MG, being around six or eight months old, at initial growth stage, standardized height and approximated number of leaves.

They were evaluated 36 treatments compounded by the combination of 12 forest species [*Inga marginata* (inga), *Schizolobium parahyba* (guapuruvu), *Handroanthus serratifolius* (ipê amarelo), *Jacaranda puberula* (carobinha), *Cedrela fissilis* (cedro), *Calophyllum brasiliensis* (landin), *Psidium mirsinoides* (goiabinha), *Tibouchina glandulosa* (quaresmeira), *Caesalpinia férrea* (pau-ferro), *Caesalpinia pluviosa* (sibipiruna), *Terminalia argêntea* (capitão) and *Schinopsis brasiliensis* (braúna)] and three solutions that simulated the leachate compound (atrazine, 2,4-D and water – control), with four replicates, arranged in a randomized block design.

Plants of native vegetal species were sowed under appropriate conditions and developed for eight months at Horto do Instituto Estadual de Florestas (IEF) de Diamantina-MG. Later, they were selected bu height and leaves number aiming the standardization. Then, they were planted in pots of polietilene with capacity of 8 dm^3 and an area of 0.0314 m^2. Pots had as substrate samples of Red yellow latosol, of Sandy-clay texture from UFVJM, collected at 0-20 cm depth, in areas that were not cultivated nor had history of herbicide contamination. Fertilization was done according to soil necessity, observed through chemical analysis that consisted of applying 8.0 kg/m³ of P_2O_5 as simple superphosphate, 0.8 kg/m³ of N as ammonium sulphate and 0.4 kg/m² of K_2O with potassium chloride (CANTARUTTI et al, 2007).

The proposed total rate of the herbicide was divided into three applications at each 20 days (60, 80 and 100 days seedlings planting), being each application equivalent to half commercial rate of Primóleo® (1.25 kg ha^{-1} of atrazine), and half of commercial rate of DMA 806 BR® (0.4 kg ha^{-1} de 2,4-D). This division was in order to simulate these herbicide leaching (CERDEIRA et al., 2005; D'ANTONINO et al., 2009) downstream application area. Applications were done by using a manual micropipette guiding aliquot directly in plates that catch water under de pots in order to simulate contaminated water absorption by roots. Also to the irrigation during the experiment water was catch in the plates, up to field capacity.

After 60 days of third herbicide application (14th month after sowing), growth characteristics were evaluated: plant height (PH) (measured with a ruler from the plant base to the last leaf insertion); stem diameter (SD) (measured with a caliper at 2cm from the soil); leaves number (LN) and foliar area (FA). Vegetal matter was collected separately and later dehydrated in a forced air green house at 65º C, up to have constant matter to determine dry matter. To measure dry weight it was used a semi analytical balance. To determine foliar area the blades were scanned and analyzed by using a software of image processing and advanced measurement ANATI QUANTI 2.0.

Data about growth was turned into percentage in relation to the control, once they were different species, so with different development characteristics. Later, variance was analyzed, being the significant mea ns grouped according to Scott-Knott, at 5% of probabilty of error.

Samples were submitted to sulphuric digestion followed by distillation and titulation in order to quantify nitrogen content and nitro-perchloric digestion, being phosphorus determined by colorimetry with spectrophometer through the method of vitamin C (BRAGA & DEFELIPO, 1974), and potassium by flame photometric method according to Malavolta (1980). Results were understood by calculating content, total content and relative content of nutrients in the shoot part of the plant. It was done analysis of variance and the significant means among species grouped according to Scott-Knott at 5% of probabilty of error and the means among herbicide compared according to Tukey at 5% of probabilty of error.

3. RESULTS

After analyzing atrazine effects on plant behavior, mean showed that most plants height was 15% smaller when compared to the controls. However, inga, ipê amarelo, carobinha, landin and pau-ferro showed significant increase ($p< 0,05$) of 9%, (Table 1). The effect of 2,4-D in, inga (22,15%) and carobinha (14,75%) was significant. The other species showed smaller PH, mean of 14% (Table 1).

For SD there were no significant differences when compared to each specie behavior after herbicide application (Table 1). For the treatment with atrazine, most plants showed smaller SD, mean of 18. 4% when compared to the controls. Guapuruvu, carobinha, pau-ferro and sibipiruna showed increase in SD, mean of 9%. Under 2,4-D effect braúna, pau--ferro, goiabinha, landin, cedro and ipê amarelo showed smaller SD, around 18% (Table 1). Some species also showed significant increase as guapuruvu (9.6%), carobinha (4.97%), quaresmeira (6.48%) and sibipiruna (25.01 %).

Number of leaves varied among plants under herbicide action. Under effect of atrazine 50% of the species showed increase on leaf number, mainly for carobinha and pau-ferro that showed an increase superior to 100% in relation to the controls. Other species showed smaller values, mean of 49%. The smaller FA was remarkable in almost all species submitted to atrazine, varying from 18% to 78% less.

Most of the species showed low values of LN when under 2,4-D effect, with mean of 6% for the less affected and 95% to the most affected. Cedro, goiabinha, quaresmeira and sibipiruna had a mean increase of 22% for LN (Table 2) and carobinha around 260% in relation to the control. As LN, the parameter FA was also significantly smaller for almost all species when submitted to 2,4-D, except for guapuruvu that showed 56% superior to the control.

Table 1 – Plant height (PH %) and stem diameter (SD %) of forest species under the application of atrazine and 2.4-D compared to their respective control (100%).
Tabela 1 – *Altura de planta (AP %) e diâmetro do caule (DC %) de espécies florestais submetidas à aplicação dos herbicidas atrazine e 2,4-D comparadas a sua respectiva testemunha (100%).*

Specie	PH (%)		SD (%)	
	Atrazine	2,4-D	Atrazine	2,4-D
Inga	102.18 aA	122.15 aA	98.00 aA	98.13 aA
Guapuruvu	87.07 bA	84.91 bA	109.25 aA	109.67 aA
Capitão	67.71 bA	7.88 bA	94.54 bA	96.66 aA
Quaresmeira	91.76 bA	98.62 bA	80.90 bA	106.48 aA
Carobinha	120.23 aA	114.75 aA	109.66 aA	104.97 aA
Cedro	80.36 bA	85.05 bA	80.63 bA	78.30 bA
Landim	100.89 aA	100.75 bA	70.36 bA	86.16 bA
Goiabinha	92.94 bA	83.97 bA	76.59 bA	91.55 bA
Pau-Ferro	108.35 aA	93.54 bA	111.00 aA	87.61 bA
Sibipiruna	92.33 bA	95.25 bA	106.67 aA	125.01 aA
Ipê amarelo	112.65 aA	83.18 bB	82.37 bA	80.14 bA
Braúna	82.65 bA	75.96 bA	89.73 bA	70.26 bA
CV (%)	**20.52**		**21.19**	

* Means followed by de same lower case letter on the columns do not differ among themselves according to Scott Knott at 5%. On lines for each variable, means with the same capital letter do not differ among themselves according to F test at 5% of probability of error.

Table 2 – Number of leaves (LN %) and foliar area (FA %) of forest species submitted to the application of atrazine and 2,4-D compared to their respective control (100%).
Tabela 2 – *Número de folhas (NF %) e área foliar (AF %) de espécies florestais submetidas à aplicação dos herbicidas atrazine e 2.4-D comparadas a sua respectiva testemunha (100%).*

Specie	LN (%)		FA (%)	
	Atrazine	2.4D	Atrazine	2.4D
Inga	127.64 cA	69.92 cB	81.54 bA	90.15 bA
Guapuruvu	66.66 dA	58.33 cA	132.36 aA	156.02 aA
Capitão	48.78 dA	69.51 cA	97.49 bA	87.14 bA
Quaresmeira	80.00 cA	111.37 bA	77.57 bA	91.76 bA
Carobinha	216.67 aB	366.66 aA	101.00 bA	47.18 cB
Cedro	32.00 dB	144.00 bA	80.66 bA	69.96 bA
Landim	54.07 dA	61.63 cA	31.11 cA	30.33 cA
Goiabinha	145.09 bA	120.65 bA	65.83 bA	72.63 bA
Pau-Ferro	237.43 aA	5.02 dB	90.89 bA	90.89 bA
Sibipiruna	108.69 cA	115.22 bA	19.04 cA	9.77 cA
Ipê amarelo	28.57 dA	60.71 cA	16.98 cA	41.21 cA
Braúna	107.09 cA	9.65 dB	82.03 bA	104.14 bA
CV (%)	**38.30**		**32.96**	

* Means followed by de same lower case letter on the columns do not differ among themselves according to Scott Knott at 5%. On lines for each variable, means with the same capital letter do not differ among themselves according to F test at 5% of probability of error.

Species showed smaller values of leaves dry biomass when under atrazine action, being ipê amarelo (92%) and cedro (78%) the most affected. Under 2,4-D action, braúna was the most affected losing every single leaf (Table 3). Species that were negatively affected showed smaller values of biomass of the shoot area, varying from 33 to 70%.

Stem dry matter (SDM) showed significant differences between the two herbicides to the species: landim, quaresmeira, pau-ferro and sibipiruna (Table 3). Under atrazine action it was observed value 75% smaller for cedro. Inga, guapuruvu and pau-ferro showed significant increase ($p<0,05$) 19%, 21% and 32%, respectively. 2,4-D did not allowed accumulation of SDM on cedro, with a value 75% smaller. Inga and guapuruvu showed increases of 11 and 7 %, respectively which indicates their potential to tolerate the two herbicides.

Table 3 – Dry matter of leaves (LDM). stem dry weight (SDW). dry weight of root (RDM) and total dry matter (TDM) of forest species tested submitted to application of atrazine and 2,4-D compared to their respective control (100%).

Tabela 3 – *Massa seca de folhas (MSF). Massa seca de caule (MSC). Massa seca de raiz (MSR) e Massa seca total (MST) de espécies florestais submetidas à aplicação dos herbicidas atrazine e 2.4-D comparadas a sua respectiva testemunha (100%).*

Specie	LDM (%)		SDW (%)	
	Atrazine	2,4-D	Atrazine	2,4-D
Inga	82.13 aA	94.60 aA	119.76 aA	111.80 aA
Guapuruvu	49.12 bA	72.51 bA	121.97 aA	107.11 aA
Capitão	81.46 aB	117.41 aA	56.15 cA	67.56 bA
Quaresmeira	66.90 aB	101.74 aA	51.46 cB	119.13 aA
Carobinha	89.43 aA	62.90 bA	90.47 bA	77.77 bA
Cedro	22.10 cA	33.67 cA	25.55 cA	25.55 bA
Landim	72.16 aA	92.16 aA	45.43 cB	82.65 aA
Goiabinha	42.40 bA	65.66 bA	54.78 cA	53.31 bA
Pau-Ferro	54.43 bA	12.53 dB	132.32 aA	55.61 bB
Sibipiruna	81.31 aA	92.44 aA	59.95 cB	95.28 aA
Ipê amarelo	8.77 cB	44.68 cA	57.69 cA	61.53 bA
Braúna	82.05 aA	00.00 dB	91.73 bA	62.32 bA
CV (%)	**37.40**		**31.25**	

Specie	RDM (%)		TDM (%)	
	Atrazine	2,4-D	Atrazine	2,4-D
Inga	108.95 bA	111.87 aA	103.61 aA	106.09 aA
Guapuruvu	98.74 bA	89.46 aA	81.61 aA	89.69 aA
Capitão	89.24 bB	135.88 aA	75.62 aA	90.28 aA
Quaresmeira	53.30 cB	110.98 aA	57.22 bB	110.62 aA
Carobinha	142.24 aA	124.49 aA	107.38 aA	88.39 aA
Cedro	46.55 cA	48.27 bA	31.40 cA	35.83 bA
Landim	45.53 cA	79.41 bA	54.37 bA	84.74 aA
Goiabinha	63.00 cA	65.41 bA	53.39 bA	61.46 bA
Pau-Ferro	148.18 aA	42.05 bB	111.64 aA	36.73 bB
Sibipiruna	68.85 cA	104.93 aA	70.04 bA	97.55 aA
Ipê amarelo	23.06 cA	59.10 bA	29.84 cA	55.11 bA
Braúna	104.56 bA	50.10 bB	92.78 aA	46.88 bB
CV (%)	**32.68**		**29.44**	

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Regarding roots dry matter (RDM) it was observed that the species showed a diversified behavior under herbicides action (Table 3). Inga and carobinha had increased in both treatments. Quaresmeira and capitão showed smaller value of RDM under atrazine action, however, under 2,4-D action the values increased. Results for pau-ferro and braúna were exact the opposite. The other species showed smaller RDM values in a similar way under both herbicide action.

Inga, carobinha and pau-ferro increased values of total dry matter (TDM) around 7.54% when under atrazine action and inga and quaresmeira around 8% under 2,4-D action (Table 3). To the other species values of TDM were smaller in 52% under atrazine action and 32% under 2,4-D action.

Total N (Table 4) had significant differences among treatments. Herbicide application caused decrease on N accumulation in carobinha, sibipiruna while capitão showed higher N accumulation under both atrazine and 2,4D.

Carobinha and brauna showed smaller P accumulation on treatments submitted to herbicides action (Table 4). Capitão showed higher P accumulation on treatments with herbicide while to the other species there were no differences.

Carobinha, sibipiruna and brauna had smaller K accumulation on treatments with herbicide (Table 4). For Ipê amarelo K accumulation was smaller when submitted to atrazine, while to capitão this accumulation was higher for treatments with herbicides. To the other species there were no significant differences.

The relative content of macronutrients (Table 5) showed that in most species N, P and K increased in relation to their controls.

Table 4 – Total Content (mg / plant) of macronutrients shoots of forest species grown in pots under the effect of absorption of atrazine and 24-D herbicides, and without the effect (Control).

Tabela 4 – *Conteúdo Total (mg/ planta) de macronutrientes da parte aérea de espécies florestais, cultivadas em vasos, sob o efeito da absorção dos herbicidas atrazine e 2,4-D, e sem o efeito (Controle).*

Species	Total content of N (mg/plant)		
	Control	**atrazine**	**2,4-D**
Inga	130.0 aA	120.0 aA	150.0 aA
Guapuruvu	60.0 bA	40.0 bA	40.0 bA
Capitão	10.0 cB	40.0 bA	30.0 bB
Quaresmeira	10.0 cA	10.0 cA	10.0 bA
Carobinha	60.0 bA	30.0 bB	20.0 bB
Cedro	40.0 cA	30.0 bA	20.0 bA
Landim	10.0 cA	30.0 bA	20.0 bA
Goiabinha	10.0 cA	10.0cA	10.0 bA
Pau-Ferro	20.0 cA	10.0 cA	20.0 bA
Sibipiruna	60.0 bA	20.0 bB	20.0 bB
Ipê amarelo	30.0 cA	10.0 cA	20.0 bA
Braúna	20.0 cA	10.0 cA	10.0 bA
CV(%)	**64.62**		
Species	Total contento f P (mg/plant)		
	Control	**atrazine**	**2,4-D**
Inga	80.0 aA	80.0 bA	130.0 bA
Guapuruvu	40.0 bA	80.0 bA	40.0 cA
Capitão	30.0 bB	240.0 aA	220.0 aA
Quaresmeira	10.0 bA	20.0 cA	10.0 cA
Carobinha	80.0 aA	20.0 cB	10.0 cB
Cedro	70.0 aA	50.0 bA	40.0 cA
Landim	10.0 bA	40.0 bA	20.0 cA
Goiabinha	20.0 bA	20.0 cA	40.0 cA
Pau-Ferro	20.0 bA	10.0 cA	0.00 cA
Sibipiruna	10.0 aA	50.0 bA	50.0 cA
Ipê amarelo	40.0 bA	10.0 cA	30.0 cA
Braúna	80.0 aA	10.0 cB	10.0 cB
CV(%)	**75.72**		
Species	Total Content of K (mg/plant)		
	Control	**atrazine**	**2,4-D**
Inga	590.0 aA	430.0 aA	440.0 aA
Guapuruvu	320.0 bA	400.0 aA	220.0 bA
Capitão	50.0 cB	300.0 aA	270.0 aA
Quaresmeira	90.0 cA	110.0 bA	110.0 bA
Carobinha	410.0 bA	180.0 bB	170.0 bB
Cedro	360.0 bA	250.0 aA	170.0 bA
Landim	120.0 cA	310.0 aA	160.0 bA
Goiabinha	130.0 cA	120.0 bA	160.0 bA
Pau-Ferro	140.0 cA	40.0 bA	90.0 bA
Sibipiruna	440.0 bA	220.0 aB	200.0 bB
Ipê amarelo	360.0 bA	20.0 bB	230.0 bA
Braúna	310.0 bA	40.0 bB	10.0 bB
CV(%)	**55.15**		

* Means followed by de same lower case letter on the columns do not differ among themselves according to Scott Knott at 5%. On lines for each variable, means with the same capital letter do not differ among themselves according to F test at 5% of probability of error.

Table 5 – Relative Content of macronutrients shoots of forest species grown in pots under the effect of absorption of atrazine and 2,4-D compared to control.
Tabela 5 *– Conteúdo Relativo de macronutrientes da parte aérea de espécies florestais, cultivadas em vasos, sob o efeito da absorção dos herbicidas atrazine e 2.4-D, em relação ao controle.*

Specie	Relative content of N		Relative content of P		Relative content of K	
	Atrazine	2,4-D	Atrazine	2,4-D	Atrazine	2,4-D
Inga	1.03 bA	1.20 bA	1.23 bA	1.70 aA	0.87 cA	0.84 aA
Guapuruvu	1.59 bA	1.07 bA	3.69 aA	1.52 aB	2.55 aA	1.14 aB
Capitão	1.22 bA	0.86 bA	1.18 bA	1.18 bA	1.19 cA	1.07 aA
Quaresmeira	1.34 bA	1.08 bA	1.66 bA	1.03 bA	1.52 bA	0.98 aA
Carobinha	1.17 bA	1.15 bA	0.58 cA	0.66 bA	0.83 cA	1.14 aA
Cedro	1.44 bA	0.73 bA	1.51 bA	1.22 bA	1.03 cA	0.83 aA
Landim	2.52 aA	1.26 bA	2.88 aA	0.98 bB	2.41 aA	1.00 aB
Goiabinha	2.84 aA	2.07 bA	1.95 bA	2.30 aA	1.67 bA	1.56 bA
Pau-Ferro	1.14 bB	4.06 aA	1.45 bA	0.78 bA	1.04 cB	2.28 aA
Sibipiruna	1.36 bA	1.02 bA	1.81 bA	1.74 aA	1.70 bA	1.31 aA
Ipê amarelo	1.60 bA	1.16 bA	0.33 cA	0.98 bA	0.27 dA	0.74 aA
Braúna	2.11 aA	0.63 bB	1.58 bA	0.14 bB	1.03 cA	0.32 aB
CV (%)	**59.02**		**46.74**		**34.38**	

* Means followed by de same lower case letter on the columns do not differ among themselves according to Scott Knott at 5%. On lines for each variable, means with the same capital letter do not differ among themselves according to F test at 5% of probability of error.

4. DISCUSSION

Analyzing height and diameter some species were more tolerant than others. The factor ecological group may not justify the effects observed because even pioneer and secondary species showed increase for PH and SD with both atrazine and 2,4-D herbicide.

Regarding leaf number, the production is determined by an allocation of resources involved in a relation of compensation (LONNIE, 2012). This relation can be observed even in the treatments with atrazine as the ones with 2,4-D. Both herbicides action provided adverse situations what makes some species to invest more in leaf number than in area, or vice verse, in order to have a better use of resources. Among species considered pioneers with higher tolerance to direct radiation, inga showed an increasing only under atrazine action and the guapuruvu showed lower increase of LN in both treatments. On the other hand, plants from the group initial secondary, as goiabinha and carobinha, and from the group later secondary sibipiruna showed more leaves then the other with both herbicides. It indicates that the ecological group can not relate with the observed results.

Reduction of foliar dry matter showed by all species with atrazine can be related to the inhibition or the reduction of the photosynthetic apparatus on photosystem II of the seedlings (ALADESANWA et al., 2001), cause of this herbicide action.

Brauna phenology, the most negatively affected in leaves dry matter with 2,4-D, may explain the total lost of leaves because it is a deciduous facultative specie and it can also lost leaves during dry period or because of other physiological disturbance (BARBOSA et al., 1989).

Inga and carobinha showed increase of roots under both herbicide actions what may be favored by the ecological group which they take part, according to Budowski classification (1965), cause studies have confirmed that pioneers have radicular system more developed (GONÇALVES et al.,1992). The increase of roots showed under 2,4-D action can be explained by a disorganized cells growth promoted by it, so roots are shorter and thicker (AMARANTE JUNIOR et al., 2002). Assuming that the mechanism of action comes from increasing the production of enzymes and proteins, probable positive effect to plants can come when in tolerant rates.

After analyzing growth parameters, it was observed that the specie inga excelled. Analyzing species development in soil with mining residue, some authors (CORRÊA, 2006; SILVA and CORRÊA, 2008; STARR, 2009) observed that inga grew up more and it is a specie with ability to develop under adverse conditions. This observation together its high use in projects of riparian recovery praises the interest in studying this specie as a potential of phytoremediation in studies of environmental decontamination.

Regarding N accumulation increase in plants treated with herbicides from the group triazine, this effect has been noticed in some studies that had used subrates of atrazine (MOHANADAS et al., 1978; KLEPPER, 1979). One way for plants acquiring nitrogen is by absorbing nitrate through the roots. Nitrate is reduced to nitrite, and then into ammonia, cause of nitrate and nitrite reducing enzymes (DÉLU-FILHO et al., 1998). Fleck et al. (2001) when analyzing atrazine effect on nitrogen utilization by corn plants observed that the herbicide, depending on nitrogen source, favors N content on phytomass, being that because metabolism action of plant is associated to energy supply to nitrate and nitrite enzymes.

Capitão specie showed higher P content and it confirms the synthesis that Pioneer species have more nutritional efficiency to P than the ones with more advance successional stages (DUBOC, 2005). Santos et al. (2008) evaluated both Pioneer and secondary species behavior on P absorption and they also verified that, in general, the tendency is pioneers showing higher capacity of P absorption.

Most species showed increases on N, P and K comparing to the controls, as observed on values of relative content of macronutrients. It is interesting because those seedlings were submitted to herbicides action and they still obtained a better nutritional use.

In general it is observed that species on initial successional stages have higher capacity of absorbing nutrients than on other stages, characteristic that is related to growth potential, higher development and thin roots density, and higher potential in the rate of biomass synthesis (GONÇALVES et al., 1992; FURTINI NETO et al., 2000).

Ipê amarelo and cedro were more susceptible to products. Both belong to the ecological group of secondary (BUDOWSKI, 1965; CARVALHO, 2003), what could be one of the reasons of low tolerance, because they are plants of later growth and spend more time to establishing themselves (GOMIDE, 1997). On the other hand, inga and carobinha had positive answer to herbicides application, which can be explained by the fact that they belong to the Pioneer group and have a faster growth, radicular system more developed and higher potential of absorbing nutrients than the ones from secondary group (POGGIANI; SCHUMACHER, 2004), what ensured better performance in the first months.

5. CONCLUSION

1. Inga showed higher tolerance to herbicide in relation to growth analyzes, mainly because of the increase on roots dry matter.

2. Ipê amarelo and cedro were the most sensitive species to herbicide application.

3. It was observed an increase of macronutrients for most species, even submitted to herbicide application.

4. It is recommended using species that are more tolerant to the herbicides atrazine and 2,4-D in filed experiments to confirm the previous results of this simulation. Other factors need to be included as evaluation of rhizosphere right after herbicide application and also some months later when species have radicular system more developed, and also evaluating residue effects.

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