WEED MANAGEMENT AND ITS INFLUENCE ON THE LOAD BEARING CAPACITY OF RED-YELLOW LATOSOL UNDER THE CROWN PROJECTION IN COFFEE CULTURE [1]

Gislene Aparecida dos Santos[2], Moacir de Souza Dias Junior[3], Paulo Tácito Gontijo Guimarães[4], Cezar Francisco Araújo Junior[5], Paula Sant'Anna Moreira Pais[6]

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ABSTRACT: Weed management is identified as a major cause of soil compaction in coffee plantations, because of its necessary frequent undertaking. The objectives of this study were: a) to develop bearing capacity models, for a Red-Yellow Latosol cultivated with coffee (*Coffea arabica*, L.), as a function of the associated weed management methods, preconsolidation pressure and moisture; b) to identify, through the use of these models, the weed management more resistant and more susceptible to soil compaction, under the coffee crown projection. This study was carried out in an experiment installed in the Experimental Farm of EPAMIG in Patrocínio MG, using the Rubi cultivar 1192. The weed control methods were: Hand hoe, Post-emergence herbicide, Pre-emergence herbicide and Brush Trimmer (Roçacarpa – commercial name), associated with the rotary tiller, disk harrow, were mower and no weed control between plant rows. For each weed management, 15 samples were collected at depths of 0-3, 10-13 and 25-28 cm, to generate the capacity bearing model, totaling 720 undisturbed soil samples. To obtain the capacity bearing models, the undisturbed soil samples with different moisture content were submitted to the uniaxial compression tests according to Bowles (1986) modified by Dias Junior (1994). The pre-emergence herbicide associated to no weed control condition and were mower and the hand hoe associated to no weed control presented higher resistance to soil compaction. The Brush Trimmer (Roçacarpa) methods, associated to were mower; the Pre-emergence herbicide, associated to rotary tillers; and Pre-emergence herbicide and Brush Trimmer, associated to disk harrow between rows, presented higher susceptibility to soil compaction.

Key words: Susceptibility to soil compaction, weed, coffee**.**

CAPACIDADE DE SUPORTE DE CARGA DE UM LATOSSOLO INFLUENCIADA PELO MANEJO DE PLANTAS INVASORAS EM LAVOURA CAFEEIRA

RESUMO: *O manejo de plantas invasoras é apontado como um dos principais causadores de compactação do solo em lavouras cafeeiras, em razão da necessidade e frequência com que é realizada essa prática. Objetivou-se neste trabalho: a) desenvolver modelos de capacidade de suporte de carga (CSC), para um LVA cultivado com cafeeiro (*Coffea arabica*, L.), em função dos métodos associados de controle de plantas invasoras, pressão de preconsolidação e umidade do solo. b) identificar, pelo uso desses modelos, o método de controle mais resistente e mais suscetível à compactação, na Projeção da Copa do cafeeiro. O estudo foi conduzido na Fazenda Experimental da Epamig de Patrocínio MG. Os métodos de controle de plantas invasoras utilizados foram: Capina Manual, Herbicida de Pós-emergência, Herbicida de Pré-emergência e Roçacarpa (nome comercial), associados à Enxada Rotativa, Grade de Disco, Roçadora e Sem Capina (testemunha) nas entrelinhas. Para cada condição de manejo, foram coletadas, nas profundidades 0-3, 10-13 e 25-28 cm, 15 amostras para gerar o modelo de CSC, totalizando 720 amostras inderformadas. Para a obtenção dos modelos, as amostras com diferentes umidades do solo foram submetidas ao ensaio de compressão uniaxial de acordo com Bowles (1986), modificado por Dias Junior (1994). Os métodos de controle, Herbicida de Pré-emergência; associados à condição sem capina e à roçadora; a Capina Manual, associada à sem capina, nas entrelinhas, apresentaram maior resistência à compactação. Os métodos Roçacarpa, associados à roçadora; o Herbicida de Pré-emergência, associado à enxada rotativa; e o Herbicida de Pré-emergência e Roçacarpa, associados à Grade de Discos nas entrelinhas, apresentaram maior suscetibilidade à compactação do solo.*

Palavras-chave: Suscetibilidade à compactação, plantas daninhas, café.

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[2]Agricultural Engineer, Post-doctorate grant through FAPEMIG, Soil Science Departament, Federal University of Lavras – UFLA. P.O. Box 3037, CEP 37200-000 Lavras (MG) CNPq grant holder – gisantosolos@yahoo.com.br
[3]Agricultural Engineer, PhD in Crop and Soil Science. Professor Associated with the Soil Science Departament, Federal University of Lavras – P.O. Box 3037 – 37200-000 Lavras,MG – CNPq grant holder – msouzadj@ufla.br
[4]Agronomist, Researcher, Doctor, Centro Tecnológico Sul Minas/EPAMIG – Federal University of Lavras, MG – paulotgg@epamig.br
[5]Agronomist, Doctoral candidate in Soil Science, Soil Science Departament, Federal University of Lavras – P.O. Box 3037 – 37200-000 Lavras, MG – cfaj@bol.com.br
[6]Agronomist, Researcher from Embrapa/Café, Soil Science Departament, Federal University of Lavras, P.O. Box 3037 – 37200-000 Lavras, MG – paulaufla.yahoo.com.br

1 INTRODUCTION

The coffee culture has allowed great technological exploration progress for the improve its final product, mainly when observing the number of countries that have entered the market in the last decades, which has also forced the Brazilian producer to have a quality final product, although still with a very high final cost (MARINO, 2002).

Coffee is the second most marketed product in the world, only behind petroleum. Brazil has lead world coffee production for two centuries, and its political, economical and social history were always linked to the product price cycles. The national production corresponds, on average, to 33% of the world production, with a production in the harvest of 2005/2006 of around 33.3 million bags of coffee. Minas Gerais is the highest national producer, with production around 15.6 million bags, which corresponds to approximately 47% of the national production (AGRIANUAL, 2006).

The development of coffee cultivation is related to the use of agricultural machines, that can cause soil compaction (ARAÚJO-JUNIOR et al., 2008; DIAS JUNIOR, 2000; DIAS JUNIOR & PIERCE, 1996; LARSON & GUPTA, 1980; SANTOS, 2006), altering the medium where the root system develops (GYSI, 2001). Therefore, the traffic under inadequate soil humidity conditions, in areas cultivated with coffee plants, has become a concern due to the compaction caused by the machines along the years, which can lead to productivity reduction.

Soil compaction has been defined as the compression of the non-saturated soil, during which a density increase occurs as a consequence of the its volume reduction, which is a result of the expulsion of the air of the soil pores due to inadequate management (DIAS JUNIOR, 2000; GUPTA & ALLMARAS, 1987; GUPTA et al., 1989). Soil compaction is identified as one of the main problems causing soil degradation (DIAS JUNIOR et al., 2007; PAGLIAI et al., 2004).

Coffee producers have been interested in the identification, quantification and minimization of the effects on the environment caused by coffee culture management, in such a way possible, through research, to adapt those activities in a way consistent with the development of sustainable coffee activity (ARAÚJO JÚNIOR et al., 2008).

Weed control management is pointed out as one of the main causes of coffee field soil compaction, due to its high frequency of occurrence. The mechanical operations recommended for the elimination of the weeds can be done by mechanical weeding, with disc harrow, rotary tiller and were mower associated to the use of herbicides or not (ALCÂNTARA, 1997). In several works found in the literature, only the problem that the automated operations can cause to the soils is identified (ANJOS et al., 1994; MIRANDA, 2001; MIRANDA et al., 2003), without, however, quantifying the pressures induced to the soils by the machine traffic that can, as a consequence, cause soil compaction.

The behavior observed by Alcântara & Ferreira (2000) reveals that, on average, the management of weeds using pre-emergence herbicide (PrEH) promotes an increase in the potential acidity, exchangeable aluminum and aluminum saturation values, while the no weeding treatment (NW), reduces the soil acidity components and the other management systems used (were mower; harrow; rotary tiller; post-emergence herbicide and manual weeding) present intermediate behavior between the management system without weeding and pre-emergence herbicide. Theodoro et al. (2003), on comparing the changes occurring in the attributes of a dystrophic Red Latosol Red (LVd) cultivated with coffee plant, in organic systems, under conversion and conventional in relation to the soil under native forest, verified pH increase in the organic systems and in conversion, due to the liming practices, organic manuring and permanent vegetation covering of the soil.

In this study, therefore, the objective was to to develop a soil structure sustainability model for soils under coffee cultivation in function of the preconsolidation pressure and humidity of the soil and to determine, by the use of that model, the susceptibility to compaction under different systems of weed control.

2 MATERIAL AND METHODS

This study was conducted on the Epamig Experimental Farm (Minas Gerais Agricultural Research Company) located Patrocínio - MG, Alto Paranaíba region that is geographically located at 18°57’00’’S latitude, and 47°00’00’’W longitude and an altitude of 934 meters.

The relief is gently undulating over a great range and the predominant soil class is that of Latosols. The soil of the area study was classified as dystrophic Red-yellow Latosol (EMBRAPA, 2006) of clayey texture (340g kgÉ¹ silt, 250 g kgÉ¹ sand and 410 g kg^{-1} clay) (DAY, 1986), and with a particle density of 2.63 g cm^{-3} (BLANKE & HARTGE, 1986).

The study was conducted on a Ruby 1192 cultivar coffee crop (*Coffea Arabic* L.), previously installed in 1999, planted at a spacing 3.80 x 0.70 m. The design used in the installation of the experiment was random block, with subdivided parcels and three repetitions, containing four treatments in the sub parcels (Crown Projection): Manual Weeding; Post-emergence Herbicide; Pre-emergence Herbicide and Brush Trimmer (Roçacarpa – commercial n).

The undisturbed samples were collected using an Uhland sampler, with a volumetric ring 6.40 cm in diameter by 2.54 cm high. The sampling points were located at the Crown Projection of the coffee plant.

For each management condition, 15 samples were randomly collected at different depths to obtain the load bearing capacity model (LBC), under the Crown Projection, totaling 720 samples (Table 1).

For the obtaining of the load bearing capacity models of the structure, the undisturbed samples with different soil moisture were submitted to the uniaxial compression test, according to Bowles (1986), modified by Dias Junior (1994). To determine the different soil moisture, the undisturbed samples were initially saturated and then air-dried in the laboratory. Only after that procedure were those samples submitted to the uniaxial compression test, using a Boart Longyear pneumatic consolidometer. The pressures applied to each sample were in the following order: 25, 50, 100, 200, 400, 800 and 1.600 kPa, each being applied until reaching 90% of the maximum deformation, and only then, applying a new pressure (TAYLOR, 1948).

Through the compression curves, the preconsolidation pressures (s_p) were obtained, acquired using an electronic spreadsheet proposed by Dias Junior & Pierce (1995). As the preconsolidation pressures obtained were then, represented on the vertical axis (Y) and the soil moisture, estimated gravimetrically, represented on the abscissa axis (X), obtaining the load bearing

Table 1 – Methods, collection site, depth and number of samples collected at the Experimental Farm in Patrocínio-MG.

Weed Control Methods							
Between Rows (BR)	Depth (cm)	Crown Projection (CP)				Number of samples for each method	
						Smp/Depth.	Total
		MW	PsEH	PrEH	Roç		
Rotary Tiller	0-3	15	15	15	15	60	
	10-13	15	15	15	15	60	180
	25-28	15	15	15	15	60	
		MW	PsEH	PrEH	Roç		
Disc Harrow	0-3	15	15	15	15	60	
	10-13	15	15	15	15	60	180
	25-28	15	15	15	15	60	
		MW	PsEH	PrEH	Roç		
Were mower	0-3	15	15	15	15	60	
	10-13	15	15	15	15	60	180
	25-28	15	15	15	15	60	
		MW	PsEH	PrEH	Roç		
No Weeding (Control)	0-3	15	15	15	15	60	
	10-13	15	15	15	15	60	180
	25-28	15	15	15	15	60	

Where: Smp/Depth = number of samples per depth; Roç = Brush Trimmer (Roçacarpa - commercial name); PrEH = Pre-emergence Herbicide; MW = Manual Weeding; PsEH = Post-emergence Herbicide capacity models in function of the preconsolidation pressure and the humidity, as proposed by Dias Junior (1994), expressed by the model $s_p = 10^{(a + b U)}$, where s_p is the preconsolidation pressure; U is the soil gravimetric moisture; and "a" and "b" are regression adjustment parameters.

3 RESULTS AND DISCUSSION

• Load bearing capacity of an RYL, under the crown projection of coffee plant using different weed control methods, associated to the NO WEEDING method between rows:

The LBC models of the Crown Projection where the control of weeds was done by Manual Weeding, at the depths of 0-3 and 10-13 cm, were not statistically different (Table 2). As a result, a new model was also adjusted using all the values of s_p and U, obtaining a new model that was different from the model of the 25-28 cm depth (Table 2 and Figure 1a). For the soil moisture less than 0.25 kg kg^{-1}, the depths 0-3 and 10-13 cm are more susceptible to compaction than the 25-28 cm depth. For moisture higher than 0.25 kg kg^{-1}, there occurs an inversion of that behavior, the depth of 25-28 cm becoming more susceptible to compaction.

The LBC models of the Crown Projection where the control of weeds was done with Post-emergence Herbicide did not present significant difference at the depths 10-13 and 25-28 (Table 2). Therefore, a new model was adjusted using all the values of s_p and U, obtaining a new model that was different from the model of the 0-3 cm depth (Table 2 and Figure 1b). The 0-3 cm depth is more susceptible to compaction than the depths of 10-13 and 25-28 cm (Figure 1b). That higher compaction susceptibility can be justified by the fact that, when the weed control is carried out with Post-emergence Herbicide, a vegetation covering remains on the surface, providing an improvement of the soil structure by the root system.

Table 2 – Significance test according to Snedecor & Cochran (1989) among the load bearing capacity models [$\sigma_p = 10^{(a + bU)}$] in an RYL at depths, for different weed control methods under the coffee Crown Projection for the No Weeding method.

Weed Control Methods Crown Projection			
Depths (cm)	F	F: Angular Coefficient, b	F: Linear Coefficient, a
Manual Weeding			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	**	ns
Post-emergence Herbicide			
0-3 vs 10-13	H	ns	**
0-3 vs 25-28	H	ns	**
10-13 vs 25-28	H	ns	ns
0-3 vs 10-13 and 25-28	H	ns	**
Pre-emergence Herbicide			
0-3 vs 10-13	H	ns	ns
0-3 and10-13 vs 25-28	H	ns	*
Brush Trimmer			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	ns	ns

(F) – tests the data homogeneity; (H) - homogeneous; (NH) not homogeneous (ns) – not significant; (*) significant to 5% probability; (**) significant to 1% probability.

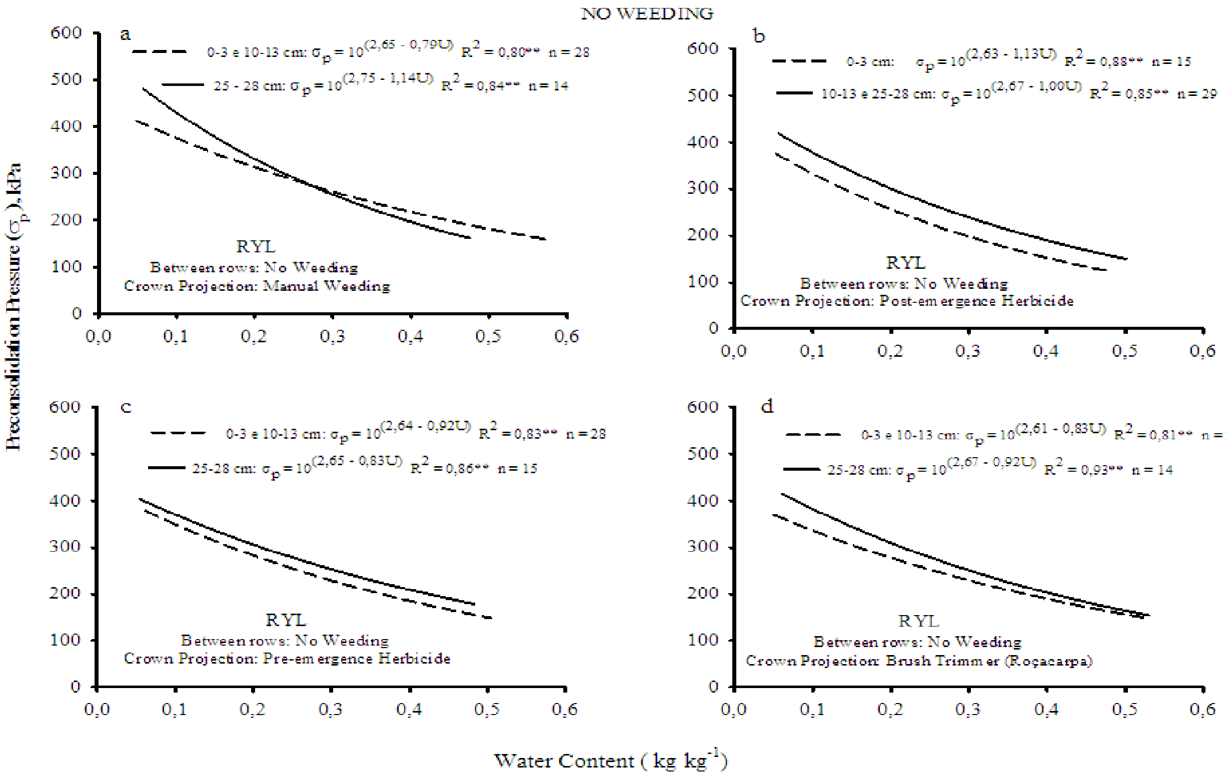

Figure 1 – Load Bearing Capacity Models of a RYL, among depths, when using under the Crown Projection: Manual Weeding; Post-emergence Herbicide; Pre-emergence Herbicide and Brush Trimmer, associated to the No Weeding method between rows.

The LBC models of the Crown Projection where the weed control was done with Pre-emergence Herbicide were not different statistically at the depths 0-3 and 10-13 cm (Table 2). Thus, a new model was adjusted using all the values of s_p and U, obtaining a new model that was different from the model of the 25-28 cm depth (Table 2 and Figure 1c). The models suggest that the soil at the 0-3 and 10-13 cm depths is more susceptible to compaction, when compared with the 25-28 cm depth (Figure 1c). The formation of the surface sealing in areas constantly managed with PrEH was observed by Faria et al. (1998) and, in coffee crops, by Alcântara & Ferreira (2000).

Anther aspect that is worth pointing out is that, because of the pore blockage caused by the surface sealing in the 0–3 cm layer, the deepest layers constantly remain humid and less subject to the wetting and drying cycles, thus diminishing the natural mechanical resistance of the soil.

The LBC models of the Crown projection of the coffee plant, where the weed control was conducted with Brush Trimmer (Roçacarpa) were not different statistically at the depths 0-3 and 10-13 cm (Table 2). So, a new model was adjusted using all the values of s_p and U, obtaining a new model that was different from the model of the 25-28 cm depth (Table 2 and Figure 1d). As such, the model suggests that the soil at the 0-3 and 10-13 cm depths is more susceptible to compaction, compared to the 25-28 cm depth (Figure 1d).

In general, when the weed control methods were used under the Crown Projection of the coffee plant, associated to No Weeding, between rows, the LBC models, at the depths of 0-3 and 10-13 cm, presented as being the more susceptible to compaction, and the 25-28 cm depth, as the most resistant.

• Load bearing capacity of a RYL, under the crown projection of the coffee plant using different weed control methods, associated to the ROTARY TILLER method between rows:

The LBC model under the Crown projection of the coffee plant where Manual Weeding was used as weed control, at the depths of 0-3 and 10-13 cm, were not different statistically (Table 3). As a result, a new model was adjusted using all the values of s_p and U, obtaining a new model that was different from the model of the 25-28 cm depth (Table 3 and Figure 2a). The soil at the 25-28 cm depth was the most susceptible to compaction, by the fact of there not being traffic under the crown projection, while the 0-3 and 10-13 cm depths were those that presented higher resistance to the compaction.

The LBC models of the Crown Projection where the weed control was done with Post-emergence Herbicide were not different at the depths 0-3, 10-13 and 25-28 (Table 3). Therefore, a new model was adjusted using all the values of s_p and U, obtaining a single model for the three depths (Table 3 and Figure 2b). Those results indicate that the application of Post-emergence Herbicide favors the organic matter incorporation in the soil, conditioning the structure.

The LBC models of the Crown Projection of the coffee plant where the weed control was accomplished with Pre-emergence Herbicide were not significantly different at the depths 0-3 and 10-13 cm (Table 3), a new model being fitting using all the values of s_p and U, these being different from the model of the 25-28 cm depth (Table 3 and Figure 2c). At the 0-3 and 10-13 cm depths, the soil showed more susceptible to compaction than at the 25-28 cm depth, for moisture inferior to 0.35 kg kg^{-1} (Figure 2c).

The management system with the pre-emergence herbicide exposes the soil, making it more susceptible to the erosive agents; consequently, the destructuring and loss of the water absorption capacity resulting from the pore blockage provokes higher surface runoff, which in turn, intensifies the erosion (ALCÂNTARA & FERREIRA, 2000; FARIA et al., 1998). The direct impact of rain drops

Table 3 – Test according to Snedecor & Cochran (1989) among the load bearing capacity models [$\sigma_p = 10^{(a + bU)}$] in an RYL at depths, for different weed control methods under the coffee Crown Projection of the coffee plant, accociated to the Rotary Tiller method.

Weed Control Methods Crown Projection			
Depths (cm)	F	F: Angular Coefficient, b	F: Linear Coefficient, a
Manual Weeding			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	ns	*
Post-emergence Herbicide			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	ns	ns
Pre-emergence Herbicide			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	**	ns
Brush Trimmer			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	ns	ns

(F) – tests the data homogeneity; (H) - homogeneous; (NH) not homogeneous (ns) – not significant; (*) significant to 5% probability; (**) significant to 1% probability.

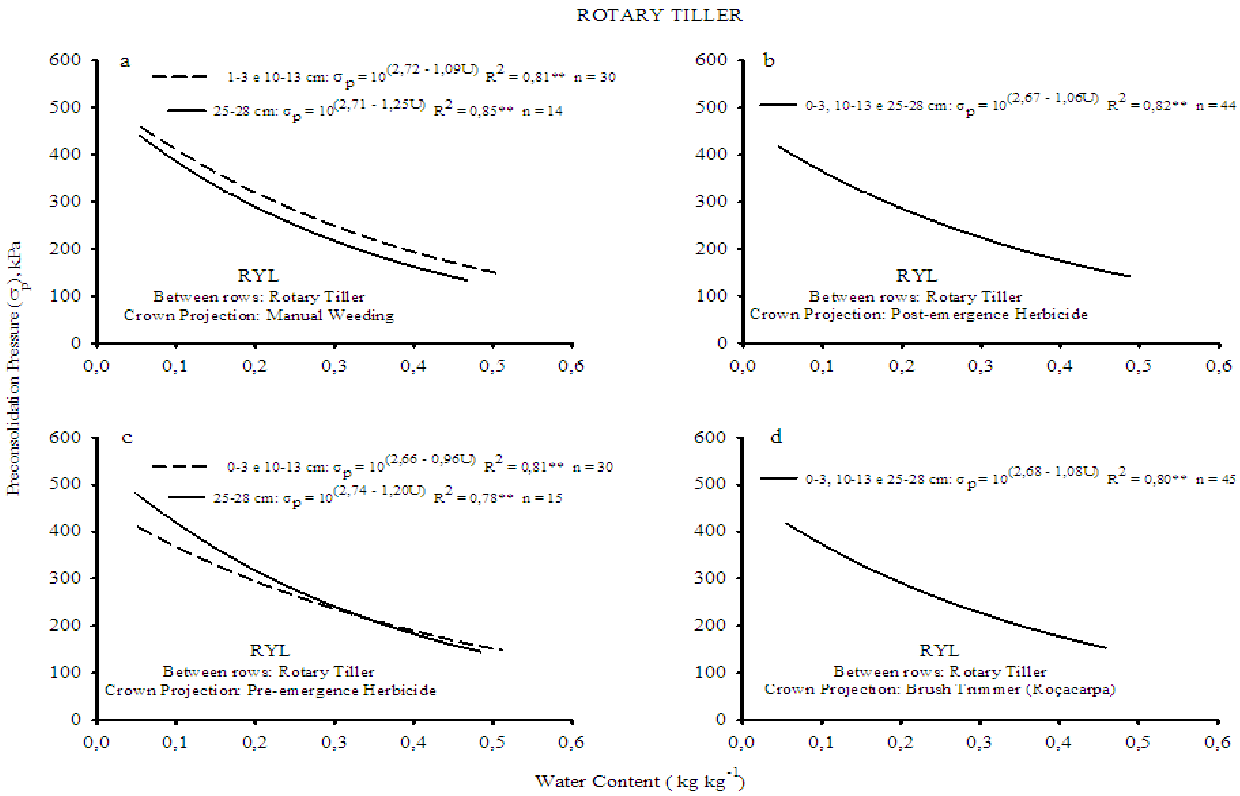

Figure 2 – Load Bearing Capacity Models of a RYL, among depths, when using under the Crown Projection: Manual Weeding; Post-emergence Herbicide; Pre-emergence Herbicide and Brush Trimmer, associated to the Rotary Tiller method between rows.

and the wetting and drying cycles, as well as the action of the herbicide as a structure disorganizing agent, provokes rearrangement of the particles, providing the emergence of layers impermeable to water, due to the migration of the clay particles which obstructed the pores.

The LBC models of the Crown Projection where the weed control was conducted with Brush Trimmer were not significantly different (Table 3), a new model being fitted using all the values of s_p and U of the three depths, obtaining a single model for that depth (Table 3 and Figure 2d).

• Load bearing capacity of a RYL, under the crown projection of the coffee plant using different weed control methods, associated to the DISC HARROW method between rows:

The LBC models of the Crown Projection for the Manual Weeding, at the soil depths of 0-3 and 25-28 cm, were not different statistically (Table 4). Thus, a new model was adjusted using all the values of s_p and U, propitiating the obtaining of a new model that was different from the model obtain for the soil depth of 10-13 cm (Table 4 and Figure 3a). For the soil moisture less than 0.30 kg kg^{-1}, the soil at the depth of 10-13 cm is more susceptible to compaction, compared to the depths of 0-3 and 25-28 cm. For moisture higher than 30 kg kg^{-1}, an inversion of that behavior occurs, causing the depths of 0-3 and 25-28 cm to become more susceptible to the compaction.

The LBC models of the Crown Projection where the weed control of was done with Post-emergence Herbicide were not statistically different at the depths 10-13 and 25-28 cm (Table 4). As a result, a new model was adjusted using all the values of s_p and U, obtaining a new model, which was different from the model of the 0-3 cm depth (Table 4 and Figure 3b). The soil depth of 0-3 cm was more

Table 4 – Test according to Snedecor & Cochran (1989) among the load bearing capacity models [$\sigma_p = 10^{(a + bU)}$] in an RYL at depths, for different weed control methods under the coffee Crown Projection for the Disc Harrow method.

Weed Control Methods Crown Projection			
Depths (cm)	F	F: Angular Coefficient, b	F: Linear Coefficient, a
Manual Weeding			
0-3 vs 10-13	H	**	ns
0-3 vs 25-28	H	ns	ns
0-3 and 25-28 vs 10-13	H	**	ns
Post-emergence Herbicide			
0-3 vs 10-13	H	ns	**
0-3 vs 25-28	H	*	**
10-13 vs 25-28	H	ns	ns
0-3 vs 10-13 and 25-28	H	*	**
Pre-emergence Herbicide			
0-3 vs 10-13	H	ns	ns
0-3 and10-13 vs 25-28	H	ns	ns
Brush Trimmer			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	ns	ns

(F) – tests the data homogeneity; (H) - homogeneous; (NH) not homogeneous (ns) – not significant; (*) significant to 5% probability; (**) significant to 1% probability.

susceptible to the compaction than the depths of 10-13 and 25-28 cm (Figure 3b). The highest susceptibility of the soil to the compaction at the depth 0-3 cm can be due to the preservation and improvement of the structure in the surface layer, conditioned by the roots of the dead plants and vegetable residues on the surface.

The LBC models of the Crown Projection where the weed control was carried out with Pre-emergence Herbicide were not statistically different at the depths of 0-3, 10-13 and 25-28 cm, (Table 4). So, a new model was adjusted using all the values of s_p and U, obtaining a new model for the three depths under study (Table 4 and Figure 3c). That is justified by the fact that the Pre-emergence Herbicide to leaves the soil surface free from vegetation; therefore, it does not provide any improvement on surface, presenting a structural uniformity in depth.

The LBC models of the Crown Projection of the coffee plant where the control of weedswas accomplished with Brush Trimmer were not statistically different at the depths of 0-3, 10-13 and 25-28 cm (Table 4). Due to this, a new model was adjusted using all the values of s_p and U and obtaining a new model for all of the depths (Table 4 and Figure 3d). This demonstrates that that method affects the three depths, promoting the same structural behavior.

• Load Bearing Capacity of a RYL, among depths, when using under the Crown Projection: Manual Weeding; Post-emergence Herbicide; Pre-emergence Herbicide and Brush Trimmer, associated to the WERE MOWER method between rows:

The LBC models of the Crown Projection where the weed control was conducted by Manual Weeding, for the depths of 0-3, 10-13 and 25-28 cm, were not significantly different (Table 5) and a new model was adjusted (Table 5 and Figure 4a).

For The LBC models of the Crown Projection where the weed control was done with Post-emergence Herbicide, there was no significant difference for the depths 0-3, 10-13 and 25-28 cm, (Table 5) and a new model was obtained (Figure 4b).

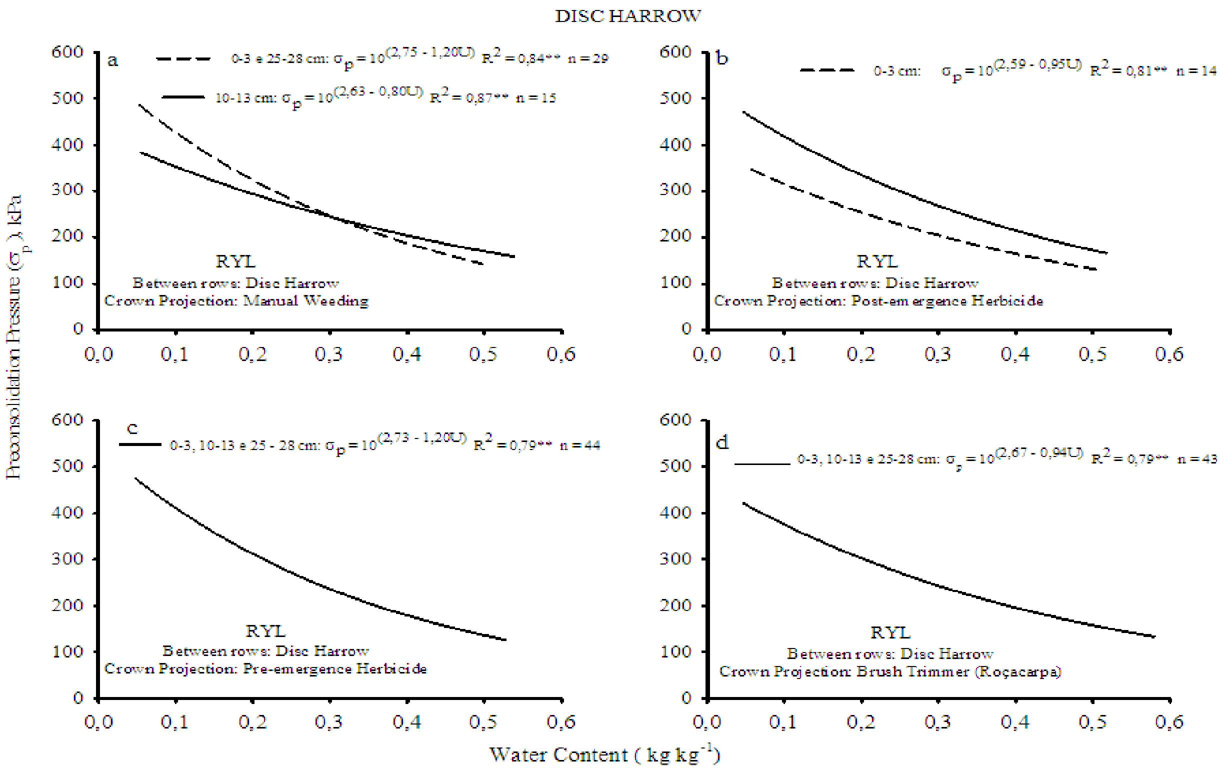

Figure 3 – Load Bearing Capacity Models of a RYL, among depths, when using under the Crown Projection: Manual Weeding; Post-emergence Herbicide; Pre-emergence Herbicide and Brush Trimmer, associated to the Disc Harrow method between rows.

For the Crown Projection where the weed control was accomplished with Pre- emergence Herbicide, the models were statistically different at the depths of 0-3, 13-13 and 25-28 cm (Table 5).

The 0-3 and 10-13 cm depths are more susceptible to compaction than the 25-28 cm depth for the soil with moisture less than 0.22 kg kg^{-1}. For moisture higher than 0.22 kg kg^{-1}, an inversion of behavior occurs, the surface becoming more resistant to the compaction than the 10-14 cm depth (Figure 4c). The constant use of the pre-emergence herbicide and, consequently, the exposure of the soil to rain drop impacts enhances the surface sealing of the soil (ALCÂNTARA & FERREIRA, 2000; BERTONI & LOMBARDI NETO, 1999; FARIA et al., 1998). The surface sealing was characterized by high soil density, low porosity and low hydraulic conductivity, factors that interfere in the compressive behavior of the soil and, consequently, in the preconsolidation pressure, resulting in a higher LBC.

The LBC models of the Crown Projection where the weed control was carried out with Brush Trimmer were not different at the depths of 0-3 and 25-28 cm (Table 5). Therefore, a new model was adjusted, using all the values of s_p and U and a new model obtained, that was significantly different from the 10-13 cm depth (Figure 4d). The 0-3 and 25-28 cm depths, for moisture less than 0.20 kg kg^{-1}, are more susceptible to the compaction of the soil; however, for moisture higher than that value, an inversion occurs and the 10-13 cm depth comes to have a higher susceptibility.

Table 5 – Test according to Snedecor & Cochran (1989) among the load bearing capacity models [$\sigma_p = 10^{(a + bU)}$] in an RYL at depths, for different weed control methods under the coffee Crown Projection, associated to the Were mower method.

Depths (cm)	F	F: Angular Coefficient, b	F: Linear Coefficient, a
Weed Control Methods – Crown Projection			
Manual Weeding			
0-3 vs 10-13	H	ns	ns
0-3 and10-13 vs 25-28	H	ns	ns
Post-emergence Herbicide			
0-3 vs 10-13	H	ns	ns
0-3 and 10-13 vs 25-28	H	ns	ns
Pre-emergence Herbicide			
0-3 vs 10-13	H	**	ns
0-3 vs 25-28	H	**	ns
10-13 vs 25-28	H	*	ns
Brush Trimmer			
0-3 vs 10-13	H	**	ns
0-3 vs 25-28	H	ns	ns
0-3 and 25-28 vs 10-13	H	**	ns

(F) – tests the data homogeneity; (H) - homogeneous; (NH) not homogeneous (ns) – not significant; (*) significant to 5% probability; (**) significant to 1% probability.

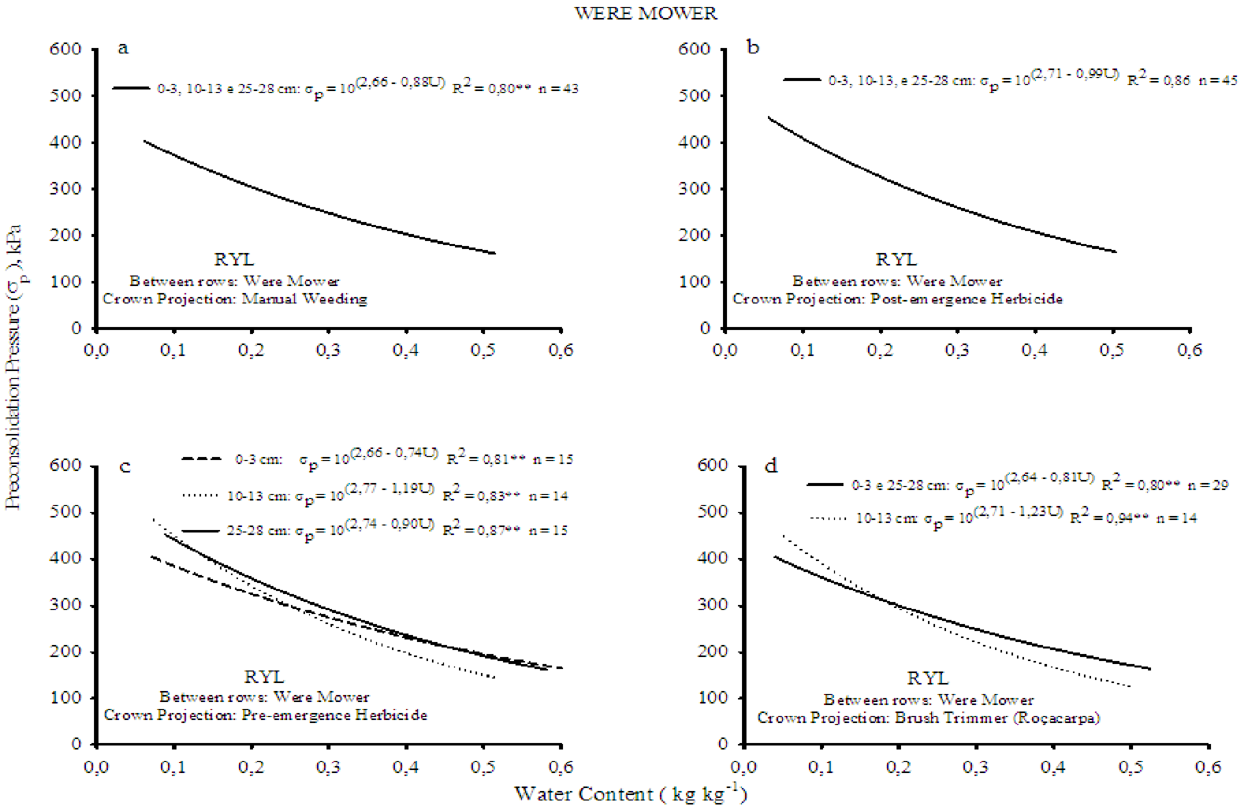

Figure 4 – Load Bearing Capacity Models of a RYL, among depths, when using under the Crown Projection: Manual Weeding; Post-emergence Herbicide; Pre-emergence Herbicide and Brush Trimmer, associated to the Were mower method between rows.

4 CONCLUSIONS

a) Under the canopy, the Pre-emergence Herbicide, Disc harrow, Were mower and the No Weeding condition, made the soil more resistant to compaction in the soils with the lowest moisture, and the most susceptible to compaction was the Post-emergence Herbicide.

b) The Pre-emergence Herbicide, when associated to the No Weeding condition, made the soil more resistant to compaction, for moisture inferior to 0.30 kg kg^{-1} and, above that, Brush Trimmer (Roçacarpa) presented higher susceptibility.

c) In depth, the Pre-emergence Herbicide, associated to Were mower, was the most resistant to the compaction, and when associated to the Rotary Tiller, was more susceptible to compaction, for the soil moisture less than 0.22 kg kg^{-1}. For soil moisture above 0.22 kg kg^{-1}, the highest susceptibility to compaction occurred when using the Pre-emergence Herbicide under the Crown Projection, with the Disc Harrow between rows.

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6 BIBLIOGRAFIC REFERENCES

AGRIANUAL. **Anuário da agricultura brasileira**. São Paulo: FNP Consultoria e Comércio, 2006. 504 p.

ALCANTARA, E. N. **Efeito de diferentes métodos de controle de plantas daninhas na cultura do cafeeiro (coffea arabica L.) sobre a qualidade de um Latossolo Roxo distrófico**. 1997. 133 f. Tese (Doutorado em Fitotecnia) – Universidade Federal de Lavras, Lavras, 1997.

ALCÂNTARA, E. N.; FERREIRA, M. M. Efeito de métodos de controle de plantas invasoras na cultura do cafeeiro (Coffea arabica L.) sobre a qualidade física do solo. **Revista Brasileira de Ciência do Solo**, Campinas, v. 24, p. 711-721, 2000.

ANJOS, J. A.; UBERTI, A. A. A.; VIZZOTTO, V. J.; LEITE, G. G.; KRIEGER, M. Propriedades físicas em solos sob: diferentes sistemas de uso e manejo. **Revista Brasileira de Ciência do Solo**, Campinas, v. 18, n. 1, p. 139-145, 1994.

ARAUJO-JUNIOR, C. F.; DIAS JUNIOR, M. S. de; GUIMARÃES, P. T. G.; PIRES, B. S. Resistência à compactação de um Latossolo cultivado com cafeeiro, sob diferentes sistemas de manejos de plantas invasoras. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 32, n. 1, p. 1-9, jan./fev. 2008.

BERTONI, J.; LOMBARDI NETO, F. **Conservação do solo**. 4. ed. São Paulo: Ícone, 1999. 355 p.

BLAKE, G. R.; HARTGE, K. H. Particle density. In: KLUTE, C. (Ed.). **Methods of soil analysis**: part 1, physical and mineralogical methods. 2. ed. Madison: American Society Agronomy, 1986. p. 377-382. (Agronomy Monograph, 9).

BOWLES, J. E. **Engineering properties of soils and their measurements**. 3. ed. New York: McGraw-Hill, 1986.

DAY, P. R. Particle fraction and particle size analysis. In: KLUTE, C. A. (Ed.). **Methods of soil analysis**: part 1, physical and mineralogical methods. 2. ed. Madison: American Society Agronomy, 1986. p. 545-567. (Agronomy Monography, 9).

DIAS JUNIOR, M. S. **Compression of the soils under long-term tillage and Wheel traffic**. 1994. 114 f. Tese (Doutorado) - Michigan State University, East Lansing, 1994.

DIAS JUNIOR, M. S. Compactação do solo. In: NOVAIS, R. F.; ARYLREZ, V. H. V.; SCHAEFER, C. E. G. R. **Tópicos em ciência do solo**. Viçosa, MG: Sociedade Brasileira de Ciência do Solo, 2000. v. 1, p. 55-94.

DIAS JUNIOR, M. S.; FONSECA, S.; ARAUJO JUNIOR, C. F.; SIRYL, A. R. Soil compaction due to forest harvest operations. **Pesquisa Agropecuária Brasileira**, Brasília, v. 42, p. 257-264, 2007.

DIAS JUNIOR, M. S.; PIERCE, F. J. A simple procedure for estimating preconsolidation pressure from soil compression curves. **Soil Technology**, Amsterdam, v. 8, p. 139-151, 1995.

DIAS JUNIOR, M. S.; PIERCE, F. J. Revisão de literatura: o processo de compactação do solo e sua modelagem. **Revista Brasileira de Ciência do Solo**, Campinas, v. 20, p. 175-182, 1996.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. Centro Nacional de Pesquisas de Solos. **Sistema brasileiro de classificação de solos**. 2. ed. Rio de Janeiro: Embrapa Solos; Brasília: Sistema de Produção de Informação, 2006. 306 p.

FARIA, J. C.; SHAEFER, C. E. R.; RUIZ, H. A.; COSTA, L. M. Effects of weed control n physical and micropedological properties of Brazilian Ultisol. **Revista Brasileira de Ciência do Solo**, Campinas, v. 22, p. 731-741, 1998.

GUPTA, S. C.; ALLMARAS, R. R. Models to access the susceptibility of siol to excessive compaction. **Advances in Soil Science**, New York, v. 6, p. 65-100, 1987.

GUPTA, S. C.; HADAS, A.; SCHAFER, R. L. Modeling soil mechanical behavior during compaction. In: LARSON, W. E.; BLAKE, G. R.; ALLMARAS, R. R.; VOORHEES, W. B.; GUPTA, S. C. (Eds.). **Mechanics and related process in structured agricultural soils**. Dordrecht: Kluwer Academic, 1989. p. 137-152.

GYSI, M. Compaction of a Eutric Cambisol under heavy wheel traffic in Switzerland: field data and a critical state soil mechanics model approach. **Soil Tillage Research**, Amsterdam, v. 61, p. 133-142, 2001.

LARSON, W. E.; GUPTA, S. C. Estimating critical stress in unsaturated soils from changes in pore water pressure during confined compression. **Soil Science Society of America Journal**, Madison, v. 44, p. 1127-1132, 1980.

MARINO, L. K. Expansão desordenada da cultura cafeeira. In: AGRIANUAL. **Anuário da agricultura brasileira**. São Paulo: Consultoria & Comércio, 2002. p. 210-214.

MIRANDA, E. E. V. **Avaliação da sustentabilidade da estrutura de um Latossolo sob cultivo de cafeeiro na região dos Cerrados**. 2001. 57 p. Dissertação (Mestrado) - Universidade Federal de Lavras, Lavras, 2001.

MIRANDA, E. E. V.; DIAS JUNIOR, M. S.; GUIMARÃES, P. T. G.; PINTO, J. A. O.; ARAUJO JUNIOR, C. F.; LASMAR JUNIOR, E. Efeito do manejo e do tráfego nos modelos de sustentabilidade da estrutura de um Latossolo Vermelho cultivado com cafeeiros. **Ciência e Agrotecnologia**, Lavras, p. 1506-1515, 2003. Edição especial.

PAGLIAI, M.; VIGNOZZI, N.; PELLEGRINI, S. Soil structure and the effect of management practices. **Soil & Tillage Research**, Amsterdam, v. 4, p. 433-444, 2004.

SANTOS, G. A. **load bearing capacity de um Latossolo cultivado com cafeeiros sob métodos associados de controle de plantas invasoras**. 2006. 103 p. Tese (Doutorado) - Universidade Federal de Lavras, Lavras, 2006.

SNEDECOR, G. W.; COCHRAN, W. G. **Statical methods**. 8. ed. Ames: State University, 1989. 503 p.

TAYLOR, D. W. **Fundamentals of soil mechanics**. New York: Wiley, 1948. 700 p.

THEODORO, V. C. A.; ARYLRENGA, M. I. N.; GUIMARÃES, R. J. Chemical changes of a soil under different management forms of coffee plantation. **Revista Brasileira de Ciência do Solo**, Campinas, v. 27, n. 6, p. 1039-1047, nov./dez. 2003.