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Quality levels of organic coffee seedlings in black and white nonwoven fabric (NWF) containers of various sizes

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The introduction of organic production in coffee growing has demanded an increase for information on seedling production with standard of quality. Hence, the purpose of the present work was to evaluate how the amount of organic substrate in black and white nonwoven fabric (NWF) bags in four different sizes influences the quality index of *Coffea arabica* L. seedling produced in an organic system. The quality parameters evaluated were leaf area; number of leaves; plant height; collar diameter; dry matter of leaves, stalk, root and total. Whereas the parameters of quantity were the relation between shoot dry matter and root dry matter (RSR); the relation between shoot height and stem diameter (RHD) and the Dickson Quality Index (DQI). Seedlings produced in 1200 mL black containers presented the best results in most of the evaluated parameters. Seedlings produced in 410 mL containers presented Dickson Quality Index of 0.2, which is the index described by other authors as the adequate standard of quality for seedlings.

Key words: *Coffea arabica* L., Dickson quality index, Agropote®, organic composite.

INTRODUCTION

Brazil is the greatest grower, exporter and the second greatest consumer of coffee in the world (USDA, 2014). Coffee growing in Brazil has economic and social relevance. In 2013, Brazil exported around 32 million bags of coffee for U$5.27 billion, generating an estimate number of eight million jobs. Coffee cultivated area in the country is 2.311 million hectares with 6.69 billion coffee plants (CONAB, 2014; BRASIL, 2014).

In this context, coffee production without the use of chemical pesticides and fertilizers in Brazil – that is organic coffee – (Figueira and Lima-Filho, 2012) has increased each year (Della-Lucia et al., 2007), and it continues with high levels of increase (Caixeta and Pedini, 2002).

In order for the production chain of organic coffee to work properly, it is necessary that crops be healthy and economically viable. One of the basic items for the success of coffee crops is the use of good quality seedlings (Favarin et al., 2003). Villar-Salvador et al. (2004) state that the influence of this quality is

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determined by the growth rate of a specific genotype, which determines how adapted it is to the environmental conditions, at transplanting and stress resistance.

During production of organic seedlings, Ministry of Agriculture, Fishing and Supply (MAPA) Normative Instruction n. 007, of 17 May 1999, and Law 10831/03 determine that seeds and seedlings must come from organic systems and, in the absence of those, the grower may use products existing in the market as long as they have been previously evaluated by the certifying institution and do not include genetically modified organisms – GMO/transgenics (BRASIL, 1999; 2003).

However, due to the shortage of seeds and registered nurseries, the normative instruction still allows for the use of seeds and seedlings obtained from conventional growing methods (Moura et al., 2007), as long as the period necessary for the conversion of conventional to organic crop be waited. This way, the introduction of organic production in coffee growing demanded an increase for information on seedling production.

There are various factors that may influence the initial development of coffee growing in the field, such as the seedlings production process and, specially, the container and substrate used (Vallone et al., 2009). Amongst the containers used in conventional coffee seedling production in Brazil, one can first list black polyethylene bags and black hard plastic tubes (Vallone et al., 2010). Both types of containers present a few disadvantages, such as the contamination of the environment by the plastic bags when they are not properly discarded and, in the case of the tubes, the need for returning them to the nursery personnel.

Recently, growers started using bags made of white nonwoven fabric (NWF) called Agropote® as an alternative for the production of seedlings with standard of quality for they present favorable morphological and physiological characteristics responsible for the fast growth of seedlings.

The NWF is a material made from polypropylene and viscose based fabric (standard NBR-13370) (ABINT, 2013). Amongst its main characteristics are the facts that it is non-toxic and semipermeable, besides being classified as a biodegradable product due to be made with polypropylene in which the additive was added oxybiodegradable PDQ-H®, which degrade in a much shorter time than ordinary plastics. Its degradation time in the environment runs from six months to one year (ABINT, 2013).

Previous studies have been published by Matiello et al. (2008) and evaluated the formation and direct planting of coffee seedlings in NWF containers. Nasser et al. (2010) studied the development and quality of coffee seedlings (C*offea arabica* L.) produced in conventional plastic bacs, tubes and NWF bags.

Regarding the substrate, the most common mixture in the production of coffee seedlings using conventional polyethylene bags was formed by soil (70%) and cattle manure (30%), enriched with chemical fertilizers (Dias et al., 2009). Cunha et al. (2006) state that the substrate used must contain biological, physical, and chemical characteristics that fulfill the plant's needs. Besides, the individual cost of the seedling must be considered in relation to its final cost (Dias et al., 2009).

Figueira and Lima-Filho (2012) state that, in organic agriculture, chemical products are substituted by byproducts that come from recycled vegetal and animal organic materials. Hence, the use of cattle, sheep and poultry manure has the potential for composing substrates to be used when preparing coffee seedlings for they are one of the most common sources of essential micro and macronutrients needed for the good development of seedlings. In one of the first technical standards adopted for coffee growing, Souza (1996) already stated that the substrate used in the formation of seedlings should be composed of soil (50%) and manure (50%).

For the organic production of coffee seedlings, the requirements for organic growing imposed by MAPA must be fulfilled. Besides, preventive measures regarding the construction and maintenance of the nurseries must be adopted so that one can get healthy and good quality seedlings (Moura et al., 2005).

The objective of the present work was to evaluate how the volume of organic substrate in white and black NWF bags influence the development and quality index of *C. arabica* L. seedlings produced in an organic system.

The Dickson Quality Index (DQI) is considered a good indicator amongst the parameters of quality of seedlings, especially when it takes into account the robustness and the balance in the distribution of phytomass in the seedlings. Therefore, the DQI results are important parameters to be used when evaluating the quality of seedlings (Fonseca et al., 2002).

MATERIALS AND METHODS

The experiment was carried out from December 2012 to June 2013, in the seedling production sector in the Agrarian Sciences Center at the State University of Londrina (UEL), in Londrina-PR. The region is located at 23° 23'S latitude, 51° 11'W longitude and altitude of 566 m. According to the classification of Köppen, the environment is humid subtropical (Cfa).

Pre-sowing was carried out in December 2012 with seedlings of cultivar 'Iapar 98' at the cotyledonary-leaf stage, known as '*orelha-de-onça'* (ear of Brazilian jaguar), which had been sown in sand beds. The seedlings were placed in raised beds in a nursery covered with shade cloths with shade percentage of 50% and equipped with an automated irrigation system of micro sprinklers of flow rate of 75 L h-1 that were run six times a day for 10 min.

The containers were made with NWF of two colors: 1) black and 2) white; of four different sizes: T1) 8 cm x 15 cm (220 mL); T2) 10 cm x 18 cm (410 mL); T3) 12 cm x 21 cm (750 mL) and T4) 14 cm x 24 cm (1200 mL). The substrate used was a mixture of 50% soil a+ 50% organic composite (mixture of cattle, poultry and sheep manure), both taken from the Farm School of UEL. Soil testing is shown in Table 1.

The experimental design was completely randomized in a factorial scheme with four sizes of NWF bags in two colors, with 4 repetitions and 30 plants per plot. Seedlings growth and quality

Table 1. Soil analysis and the organic compound. Londrina, 2013.

Parameter	Soil	Organic composite
P (mg/dm^{-3})	1,87	847,85
K ($cmol_c\ dm^{-3}$)	0,09	10,98
Ca ($cmol_c\ dm^{-3}$)	3,80	16,49
Mg ($cmol_c\ dm^{-3}$)	1,32	4,48
Ca/Mg ($cmol_c\ dm^{-3}$)	5,12	20,97
Al ($cmol_c\ dm^{-3}$)	0,05	0
C (g/kg^{-1})	0,54	5,22
OM (g/kg^{-1})	0,94	9,00
BS ($cmol_c\ dm^{-3}$)	5,21	31,95
CEC ($cmol_c\ dm^{-3}$)	9,82	34,49
PBS %	53,05	92,63
pH CaCl	5,00	7,10
pH SMP	4,61	2,54
pH	5,30	7,10

OM = organic matter; BS = base saturation; CEC = cation exchange capacity; V = percentage base saturation; pH SMP = potential acidity.

$$DQI = \frac{TDM(g)}{\frac{HGT(cm)}{DIAM(mm)} + \frac{ShootDM(g)}{RootDM(g)}}$$

Figure 1. Dickson Quality Index Formula (DQI).

evaluations started 94 days after transplanting (DAT). The following characteristics were determined: leaf area (LA) expressed in cm^2, estimated with leaf area measurer LI-COR model LI 3000; b) number of leaves (NL); c) shoot height (HGT), expressed in cm, measured with a millimetric ruler, from the collar to the terminal bud; d) collar diameter (DIAM), expressed in mm, measured using a 0.01 mm precision digital caliper; e) leaves dry mass (LDM), stalk dry mass (SDM) and roots dry mass (RDM), expressed in grams, determined inside a greenhouse with forced air circulation at 75°C; f) total dry mass (TDM), expressed in grams, obtained by the sum of the dry masses of leaves, stalk and root; g) relation between shoot dry matter and root dry matter (RSR); h) relation between shoot height and stem diameter (RHD); i) Dickson Quality Index (DQI)(Figure 1), obtained through the formula of Figure 2 (Dickson et al., 1960).

The data was subject to analysis of variance by the F test and the averages were compared by the Tukey range test at 5% probability. For evaluated characteristics in each category of container color and volume, polynomial models were tested for the effect of time in days after transplanting (DAT) by means of regression analysis. The criteria for the choice of the model were the relevance by the F test at 5% probability of error that presented higher value of the coefficient of determination (R^2).

RESULTS AND DISCUSSION

The results of the analysis of variance regarding the evaluated parameters can be found in Table 2, where the relevant effect of volume and color of the containers can be observed in most of the evaluated characteristics.

Only RHD did not present relevant effect for the size of the NWF seedling heat mat, whereas for the color of the mats, parameters HGT, DIAM, RootDM, RHD and DQI did not present relevant effect. Hence, every other characteristic presented relevant interaction with the sizes and colors at 5% probability level by F test. Marana et al. (2008) when evaluating quality and growth index for coffee seedling in tubes also observed that RSR did not present relevant interaction amongst the studied substrates and doses of slow release fertilizers.

Table 3 presents the averages of the variables analyzed in seedlings considering the volume of the containers by the Tukey range test. Amongst all the evaluated characteristics, only RHD did not show relevant difference for the different volumes of NWF containers. The same was observed by Pereira et al. (2013) when RHD did not preset statistical difference on its numbers. The foresaid authors reached the average value of 7.36 for RHD and characterize such value as excessive growth for seedlings of coffee canephora in height. In the present work, RHD values vary from 6.21 to 6.46.

As a result, while observing the time in T, considering all variables in relation to the volumes of the containers, test F was carried out to determine the level of the equations. A positive linear effect was observed for characteristics DIAM and LDM, whereas for all other characteristics, the effect was quadratic positive (Figure 2 and Table 2).

The 1200 mL container presented the highest statistical difference for all characteristics, and only with DIAM, RoodDM and RSR there were no differences considering volumes 750 and 1200 mL (Tables 3, 4 and Figure 2).

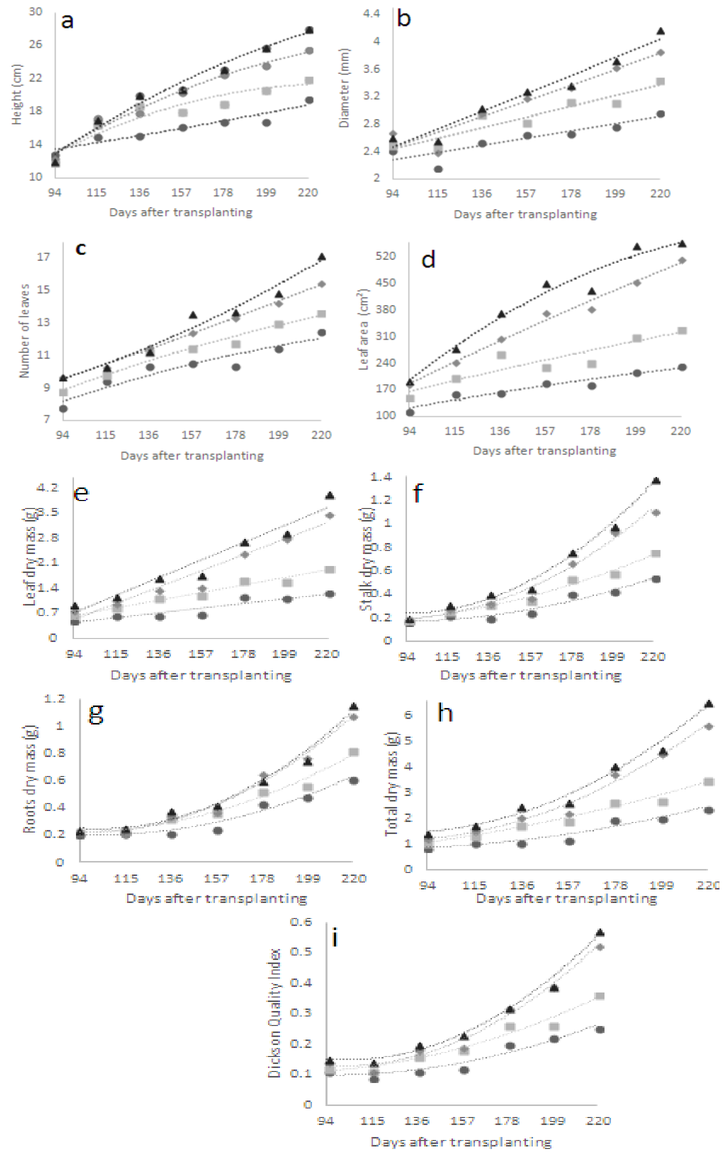

Figure 2. Variation of HGT (a), DIAM (b), NL(c), LA (d), LDM (e), SDM (f), RootDM (g), TDM (h) and DQI (i) of *C. arabica* L. seedlings considering the volumes of the NWF containers in the seven conducted evaluations. Key: ● 220 mL ■ 410 mL ◆ 750 mL ▲ 1200 mL, HGT: height; DIAM: collar diameter; NL: number of leaves; LA: leaf area; LDM: leaf dry mass; SDM: stalk dry mass; RDM: roots dry mass; TDM: total dry mass; DQI: Dickson Quality Index.

In general, all parameters showed an increase in values with the increase of the volume of the containers, the color being irrelevant. Vallone et al. (2010) evaluated different containers and substrates in the production of coffee seedlings and concluded that larger containers provide for more developed seedlings.

Gülcü et al. (2010) evaluated morphological characteristics, such as height, collar diameter, fresh and dry weight of shoot and root, and the shoot/root relations in seedlings of *Juniperus excelsa* Bieb. in polyethylene containers with variation in length and substrate composition. The best results indicated that the greater the length of the container, the better the quality of the seedlings. Therefore, the authors concluded that the best seedlings were produces in 11 cm x 30 cm containers, and the best substrate was formed by forest soil.

The quality of the seedlings is necessary for the success of cultures that demand a growing stage in nurseries. The influence of such quality has been studied considering the performance of such seedlings in the field

Table 2. Analysis of variance of variables HGT, DIAM, NL, LA, LDM, SDM, RootDM, TDM, RSR, RHD e DQI of *C. arabica* L. seedlings in NWF seedling heat mats (Londrina, 2013).

F test	DF	HGT (cm)	DIAM (mm)	NL	LA (cm²)	LDM (g)
V	3	**	**	**	**	**
C	1	NR	NR	**	**	**
T	7	(R^2=0.95)	(R^2=0.92)	(R^2=0.98)	(R^2=0.98)	(R^2=0.95)
VxC	3	NR	NR	NR	NR	NR
VxT	21	**	**	**	**	**
CxT	7	NR	*	NR	NR	*

Teste F	GL	SDM (g)	RootDM (g)	TDM (g)	RSR	HAD	DQI
V	3	**	**	**	**	NR	**
C	1	**	NR	**	**	NR	NR
T	7	(R^2=0.98)	(R^2=0.96)	(R^2=0.96)	(R^2=0.56)	(R^2=0.38)	(R^2=0.96)
VxC	3	NR	NR	NR	NR	NR	NR
VxT	21	**	**	**	NR	NR	**
CxT	7	*	NR	*	NR	NR	NR

** ($p<0.01$) e * ($p<0.05$), NR = non-relevant, V: volume; C: color; T: time; DF: degree of freedom; HGT: height; DIAM: collar diameter; NL: number of leaves; LA: leaf area; LDM: leaf dry mass; SDM: stalk dry mass; RDM: roots dry mass; TDM: total dry mass; RSR: relation between shoot dry matter and root dry matter; RHD: relation between shoot height and stem diameter; DQI: Dickson Quality Index.

Table 3. Averages of variables HGT, DIAM, NL, LA, LDM, SDM, RootDM, TDM, RSR, RHD e DQI of *C. arabica* L. seedlings in NWF seedling heat mats (Londrina, 2013).

Averages	HGT (cm)	DIAM (mm)	NL	LA (cm²)	LDM (g)
8 × 15 cm	16.02^{d}	2.59^{c}	10.30^{d}	178.10^{d}	0.84^{d}
10 × 18 cm	18.11^{c}	2.90^{b}	11.33^{c}	246.48^{c}	1.27^{c}
12 × 21 cm	19.96^{b}	3.14^{a}	12.40^{b}	349.60^{b}	1.88^{b}
14 × 24 cm	21.00^{a}	3.25^{a}	12.95^{a}	404.44^{a}	2.20^{a}
Black	18.93^{a}	3.00^{a}	11.90^{a}	301.62^{a}	1.64^{a}
White	18.63^{a}	2.94^{a}	11.59^{b}	287.69^{b}	1.45^{b}
CV (%)	6.70	8.01	7.82	10.54	20.60

Averages	SDM (g)	RootDM (g)	TDM (g)	RSR	RHD	DQI
8 × 15 cm	0.30^{d}	0.35^{c}	1.50^{d}	3.43^{c}	6.21^{a}	0.15^{d}
10 × 18 cm	0.41^{c}	0.43^{b}	2.12^{c}	4.17^{b}	6.24^{a}	0.20^{c}
12 × 21 cm	0.54^{b}	0.52^{a}	2.95^{b}	4.90^{a}	6.34^{a}	0.26^{b}
14 × 24 cm	0.64^{a}	0.54^{a}	3.39^{a}	5.39^{a}	6.46^{a}	0.28^{a}
Black	0.49^{a}	0.45^{a}	2.59^{a}	4.81^{a}	6.29^{a}	0.23^{a}
White	0.46^{b}	0.47^{a}	2.39^{b}	4.14^{b}	6.33^{a}	0.22^{a}
CV (%)	18.64	21.11	18.30	27.55	15.63	19.49

Averages followed by different letters in the same column differ from one another being relevant by the Tukey range test at 5%. CV: coefficient of variation; HGT: height; DIAM: collar diameter; NL: number of leaves; LA: leaf area; LDM: leaf dry mass; SDM: stalk dry mass; RDM: roots dry mass; TDM: total dry mass; RSR: relation between shoot dry matter and root dry matter; RHD: relation between shoot height and stem diameter; DQI: Dickson Quality Index.

and is a consequence of the time the seedlings have lived from nursery until planting (Del Campo; Navarro; Ceacero, 2010). In this context, the concept of 'target seedlings', which present a minimum standard of quality in order to be planted in the field, has been discussed and applied to the eucalyptus culture (Close, 2012). There is lack of studies applied to coffee seedlings, even though coffee growing presents high importance due to the fact it is a perennial culture.

In order to evaluate the DQI considering the size of the

Table 4. Equations of regression of the parameters studied in the quality of *C. arabica* L. seedlings in NWF seedling heat mats of different volumes, in relation to the evaluation periods (Londrina, 2013).

Parameter	Volume (mL)	Equations of regression	R²
HGT	220	$y1 = -0.0004x^2 + 0.1803x + 9.3349$	0.9755
	410	$y2 = -0.0004x^2 + 0.1654x + 9.7113$	0.9705
	750	$y3 = -0.0004x^2 + 0.1329x + 10.433$	0.8881
	1200	$y4 = -5E-05x^2 + 0.0455x + 12.505$	0.876
DIAM	220	$y1 = 0.0106x + 2.2978$	0.9605
	410	$y2 = 0.0092x + 2.317$	0.9089
	750	$y3 = 0.0061x + 2.3509$	0.8637
	1200	$y4 = 0.0042x + 2.2152$	0.7839
NL	220	$y1 = -2E-05x^2 + 0.052x + 8.4309$	0.9523
	410	$y2 = -7E-05x^2 + 0.051x + 8.5003$	0.9889
	750	$y3 = -0.0001x^2 + 0.0517x + 7.8512$	0.9753
	1200	$y4 = -1E-04x^2 + 0.0445x + 7.3416$	0.8981
LA	220	$y1 = -0.0134x^2 + 4.9702x + 98.383$	0.9732
	410	$y2 = -0.0057x^2 + 3.2068x + 121.03$	0.987
	750	$y3 = -0.002x^2 + 1.4271x + 138.7$	0.859
	1200	$y4 = -0.0023x^2 + 1.1507x + 99.392$	0.9446
LDM	220	$y1 = 0.0197x + 0.4046$	0.946
	410	$y2 = 0.0182x + 0.2437$	0.9584
	750	$y3 = 0.0082x + 0.5378$	0.929
	1200	$y4 = 0.0054x + 0.3607$	0.8767
SDM	220	$y1 = 3E-05x^2 + 0.0011x + 0.18$	0.9763
	410	$y2 = 2E-05x^2 + 0.0019x + 0.1251$	0.9803
	750	$y3 = 6E-06x^2 + 0.0027x + 0.1178$	0.9607
	1200	$y4 = 8E-06x^2 + 0.001x + 0.1329$	0.9158
RootDM	220	$y1 = 3E-05x^2 + 0.0007x + 0.1785$	0.9598
	410	$y2 = 3E-05x^2 - 0.0003x + 0.231$	0.9585
	750	$y3 = 1E-05x^2 + 0.0011x + 0.1839$	0.9416
	1200	$y4 = 2E-05x^2 - 1E-17x + 0.19$	0.9333
TDM	220	$y1 = 0.0001x^2 + 0.0124x + 1.1044$	0.9623
	410	$y2 = 9E-05x^2 + 0.0133x + 0.8074$	0.9708
	750	$y3 = -3E-06x^2 + 0.0164x + 0.6816$	0.9491
	1200	$y4= 2E-05x^2 + 0.0068x + 0.67$	0.9027
DQI	220	$y1 = 2E-05x^2 - 0.0002x + 0.1419$	0.9636
	410	$y2 = 1E-05x^2 + 6E-05x + 0.1141$	0.9611
	750	$y3 = 4E-06x^2 + 0.0009x + 0.0877$	0.9193
	1200	$y4 = 4E-06x^2 + 0.0003x + 0.0862$	0.9028

HGT: height; DIAM: collar diameter; NL: number of leaves; LA: leaf area; LDM: leaf dry mass; SDM: stalk dry mass; RDM: roots dry mass; TDM: total dry mass; DQI: Dickson Quality Index.

NWF bags, the volume of 1200 mL, with greater dimensions (14 cm x 24 cm), was the one that presented the best result in relation to the index of value 0.28 (Table 3, Table 4 and Figure 2). Hunt (1990) recommended as DQI standard the minimum value of 0.20. Hence, it is interesting observing the seedlings that reached such value, with a substrate value of 410 mL.

Marana et al. (2008) reached DQI valuest hat vary

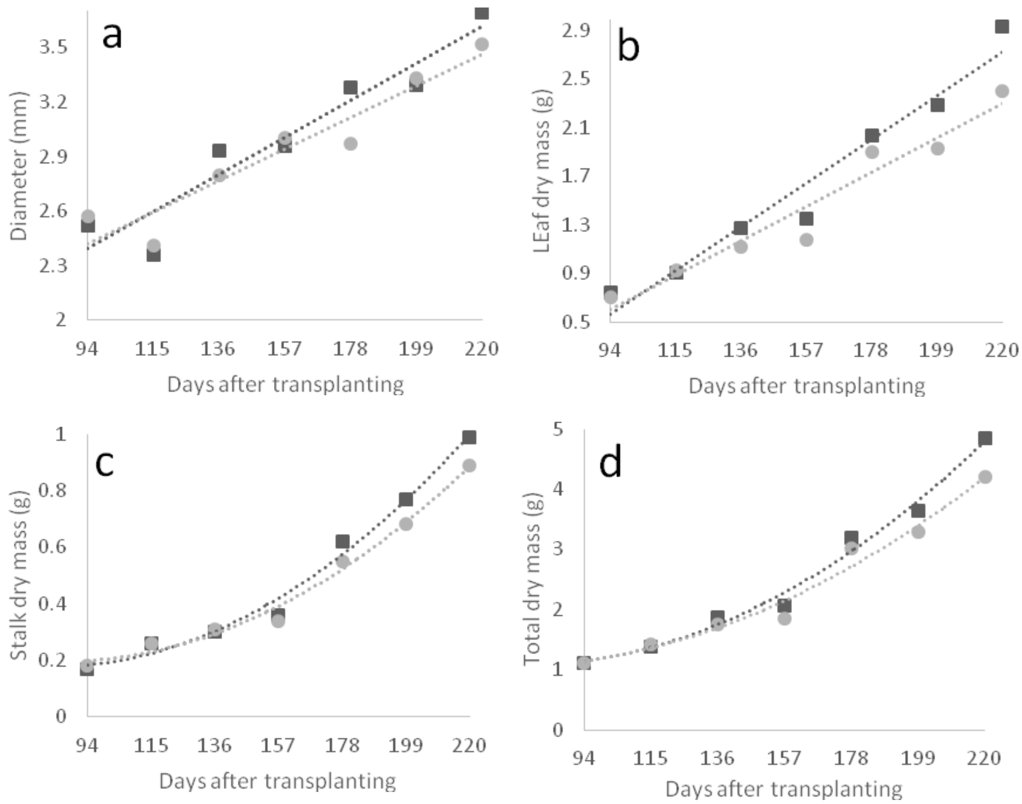

Figure 3. Variation of DIAM (a), LDM (b), SDM (c) and TDM (d) of *C. arabica* L. seedlings considering the colors of the NWF containers in the seven conducted evaluations. Key: ■ Black ● White, DIAM: collar diameter; LDM: leaf dry mass; SDM: stalk dry mass; TDM: total dry mass.

between 0.04 and 0.21 for coffee seedlings produced in tubes. Silva et al. (2012) when evaluating *Eucalyptus urophylla* × *Eucaliptus grandis* seedlings in relation to the substrates at 90 days after staking reached maximum values of DQI 0.19 with vermiculite and coconut fiber based substrate at the same proportion (1:1).

Pereira et al. (2013), when evaluating seedlings that came from four distinct nurseries located in the south of the capital of the state of Espírito Santo, reached DQI values that vary from 0.21 and 0.70. Whereas Binotto (2007), while studying the relations between growth variables and Dickson Quality Index in eucalyptus and pine seedlings reached DQI values of 0.5 for *E. grandis* 120 days after emergence and 0.25 for *Pinus elliotti* 175 days after emergence.

Regarding the colors of the NWF bags in Table 3 and Figure 3, it can be observed that black bags presented greater relevant differences for most of the parameters. Furuta (1960) was pioneer in studies relating the color of the containers with seedlings development. In his study, *Flex crenata rotundifolia* seedlings presented better results in light color containers.

For the interactions between the volume and color of the containers, none of the evaluated characteristics presented relevant effect (Table 2). For the interaction of the volume of the containers with the seven conducted evaluations, only RSR and RHD were not relevant, whereas all other characteristics presented relevant effect, demonstrating that the time factor (DAT) imposes differences to the growth of the plants in the different sizes of the bags. Regarding the interaction of the color with the seven conducted evaluations, only characteristics DIAM, LDM, SDM and TDM presented relevant effect. TDM values vary from 1.50 to 3.39. While Maranata et al. (2008) obtained values for the same parameter between 0.16 and 1.86; one can observe the superiority of the values obtained in seedlings produced in NWF seedling heat mats with organic substrate.

When analyzing the behavior of the functions in Graphs a and b in Figure 3 and Table 3, for the size of the containers, it can be observed that points for maximum growth were reached and correspondent to the evaluated days, which vary from 21 cm for HGT and 3.25 mm for DIAM. Such points did not influence the values for RHD so no relevant difference between the sizes existed. Binotto (2007) state that the variable height is only efficient to indicate the quality of seedlings when it is analyzed together with the collar of the diameter.

According to Graph b in Figure 3 and Table 5, it can be observed that the values for diameter at 115 DAT were

Table 5. Equations of regression of the parameters studied in the quality of *C. arabica* L. seedlings in NWF seedling heat mats of different colors, in relation to the evaluation periods (Londrina, 2013).

Parameter	Color	Equations of regression	R^2
DIAM	Black	y1 = 0.0081x + 2.277	0.8838
	White	y2 = 0.007x + 2.3098	0.9248
LDM	Black	y1 = 0.0145x + 0.3409	0.9624
	White	y2 = 0.0112x + 0.4398	0.9348
SDM	Black	$y1 = 2E\text{-}05x^2 + 0.002x + 0.1212$	0.9751
	White	$y2 = 2E\text{-}05x^2 + 0.0014x + 0.1515$	0.976
TDM	Black	$y1 = 7E\text{-}05x^2 + 0.0121x + 0.8109$	0.9674
	White	$y2 = 4E\text{-}05x^2 + 0.0122x + 0.8262$	0.9552

DIAM: collar diameter; LDM: leaf dry mass; SDM: stalk dry mass; TDM: total dry mass.

smaller, which can be explained due to the fact of the evaluation of the work be carried out in the destructive method, always evaluating different plants at each evaluated period. Because NWF is a material of easy degradation and presenting high porosity, at the first evaluation carried out (94 DAT), it was observed that the 220 mL and 410 mL containers already presented exposed small lateral roots.

At 157 DAT, black containers of all sizes presented exposed lateral roots, whereas this fact was not observed in white containers. In NWF 220 mL bags of both colors – black and white – intertwined roots were present amongst the bags. It was also observed the presence of *'pião-torto',* or the twisting of the main root of the coffee seedling when in contact with the bottom of the container in 220 mL and 410 mL bags.

At 199 DAT, it was observed that lateral roods in all sizes containers and independently of the color were very firm, hard and intertwined amongst the bags. At 220 DAT, only 1200 mL bags presented seedlings with the first pair of plagiotropic branches, due to its bigger volume and consequent providing the seedling with greater nutrient levels for its formation, therefore resulting in greater growth and stronger seedlings.

Due to the fact that coffee is a perennial culture, the production of healthy seedlings, well developed and with high standard of quality is a factor of extreme importance for coffee growing. Therefore, in the present work, it was observed that black 1200 mL NWF bags presented the best results for the evaluated parameters. It is important to highlight that coffee seedling in 410 mL containers presented the minimum value required by the DQI for good quality seedlings.

Conflict of Interest

The authors have not declared any conflict of interest.

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