ORIGINAL ARTICLE

EFFECTS OF MULCHING AND WATERING FREQUENCY ON THE GROWTH AND DEVELOPMENT IN NURSERIES OF COFFEE (*Coffea canephora* P. var Robusta) PLANTS PRODUCED BY DIRECT CUTTING UNDER PLASTIC-TUNNEL

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ABSTRACT

Background: In Cameroon, coffee is one of the most important cash crops. Overall, these crops currently represent 17% of the Gross Domestic Product. However, the quantity of coffee produced is currently below government expectations due to, among other things, the ageing of coffee orchards. Yet, increasing the yield of this crop may be possible by rehabilitating and extending these orchards with quality seeds. However, climate change and land pressure can negatively impact on the availability of water resources needed to produce these plants. Therefore, mulching seems to be an alternative to relieve coffee farmers during the maintenance of their nurseries in dry seasons or in areas where water is difficult to access. **Objective**: To find methods of producing coffee plants that can use straw to provide the lowest possible watering frequency for optimal growth and development. **Methods**: This work was carried out at the Nkoemvone Agricultural Research Station in southern Cameroon. A total of 360 Robusta coffee cuttings were tested in three replicates, each with six experimental units (treatments) of 20 plants each, in a completely randomized design. Agronomic parameters were measured at a monthly frequency. In addition, the fresh and dry weights of the different organs of the coffee plants were determined in the laboratory to calculate their dry matter content. **Results**: At the end of the experiment, the best treatments were T_3 which presented the average values of 10.71 cm plant height, 2.72 mm stem diameter, 6.28 leaves, 3.26 nodes, 44.35±6.51% stem dry matter content and 32.58±2.73% leaf dry matter content at the end of the trial. Then T_4 followed with 10.60 cm, 2.83 mm, 6.28, 3.27, 49.15±1.47% and 38.17±4.23% respectively. Finally, T_0 (controls) showed 9.57 cm, 2.72 mm, 5.87, 3.27, 50.58±1.99% and 39.34±2.24% respectively. On the other hand, the T_2 treatment was the least successful since all these parameters were null at six months after cutting. **Conclusion**: As the objective is to seek the lowest watering frequency, coffee growers can opt for the T_4 treatment which allows reducing by half the watering frequency currently recommended to growers.

Keywords: *Robusta coffee, direct cuttings, mulching, watering frequency, growth, development.*

RESUME

Contexte: Au Cameroun, le café fait partie des cultures de rente les plus importantes. Globalement, ces cultures représentent actuellement 17 % du Produit Intérieur Brute. Cependant, la quantité de café produite actuellement est en deçà des attentes du gouvernement à cause entre autres du vieillissement des vergers de caféiers. Pourtant, l'augmentation du rendement de cette culture peut être boostée par la réhabilitation et l'extension de ces vergers avec des semences de qualité. Mais, les changements climatiques et la pression foncière peuvent impacter négativement sur la disponibilité des ressources en eau nécessaire pour produire ces plants. Alors, le paillage semble être une alternative pour soulager les caféiculteurs pendant l'entretien de leurs pépinières en saisons sèches ou dans les zones où l'eau est difficilement accessible. **Objectifs:** Trouver des méthodes de production des plants de café susceptibles d'utiliser par le biais de la paille, les plus faibles fréquences d'arrosage permettant une croissance et un développement optimal de ces plants. **Méthodes:** Ces travaux ont été réalisés à la Station de Recherche Agricole de Nkoemvone au Sud-Cameroun. Au total, 360 plants bouturés de café robusta répartis dans 03 répétitions ayant chacune 6 unités expérimentales (traitements) de 20 plants chacune ont été testés dans un dispositif complètement randomisé. Les paramètres agronomiques ont été mesurés à une fréquence mensuelle. Par ailleurs, les poids frais et secs des différents organes des plants de café ont été déterminés en laboratoire pour calculer leurs teneurs en matière sèche. **Résultats:** A la fin de l'expérimentation, les meilleures traitements étaient T_3 qui a présenté les valeurs moyennes de 10,71 cm de hauteur des plants, 2,72 mm de diamètre des tiges, 6,28 feuilles, 3,26 nœuds, 44,35±6,51% de teneur en matière sèche des tiges et 32,58±2,73% de teneur en matière sèche des feuilles à la fin de l'essai. Ensuite, T_4 suivait avec 10,60 cm, 2,83 mm, 6,28, 3,27, 49,15±1,47% et 38,17±4,23% respectivement. En fin, T_0 (témoins) a présenté 9,57 cm, 2,72 mm, 5,87, 3,27, 50,58±1,99% et 39,34±2,24% respectivement. Par contre, le traitement T_2 a été le moins performant puisque tous ces paramètres ont été nuls à six mois après le bouturage. **Conclusion:** L'objectif étant de rechercher la plus faible fréquence d'arrosage, les producteurs de café peuvent opter pour le traitement T_4 qui permet de diminuer de moitié la fréquence d'arrosage actuellement recommandée aux producteurs.

Mots clés: *Café Robusta, bouturage direct, paillage, fréquence d'arrosage, croissance, développement.*

1. INTRODUCTION

Coffee trees are native to Africa, and more precisely to Ethiopia [1]. They belong to the Rubiaceae family, which has more than 6000 species. Only two types of coffee (Robusta and Arabica) are cultivated for their seeds which, after roasting, are used to prepare a drink with stimulating properties due to the presence of an alkaloid called caffeine. This drink contains manganese, potassium, magnesium, vitamins B2, B3, B5 and reduces the risk of type 2 diabetes [2]. Also, coffee is in fact the second most traded commodity after oil [3-4]. In Cameroon, the coffee sector directly or indirectly employs 423,000 households, or an estimated 3,000,000 people [5]. It is among the most important cash crops in the country and overall, these crops currently account for 17% of Cameroon's Gross Domestic Product [6]. Robusta coffee accounts for 90% of national production and is grown mainly in forest areas [7]. According to the [8], Cameroon planned to produce 220,000 tonnes of coffee in 2020. However, this objective is far from being achieved, given the gap between the quantity of coffee produced now and that which was expected; since current production is only estimated at around 25,000 tonnes for both varieties [8]. This low production can be explained in part by constraints related to damage caused by diseases such as orange coffee rust [9], and damage caused by insects such as the coffee berry borer [10]. In addition, the ageing of coffee orchards, which is not compensated for by a rehabilitation process, is one of the factors regularly cited in the drop in yield. In this regard, the government, through the 2014 plan for the recovery and development of the cocoa and coffee sectors, had undertaken actions relating to, among other things: the rejuvenation of orchards, more than half of which are already over thirty years old; the extension of cultivated areas by another four hundred thousand hectares and the use of high-yielding plant material. In order to achieve these objectives, which are still difficult to attain, knowledge of good plant material multiplication practices is one of the conditions to be fulfilled by producers, who constitute the important link in the coffee chain. Thus, it is often advisable to produce these seeds in the nursery, since the successful creation of a robusta coffee plantation in Cameroon often requires vegetative propagation, which has the advantage of reducing the length of time the plants stay in the nursery and of obtaining plants that are genetically similar to the parent tree from which they are derived. It is a privileged place on which the success or failure of the future plantation will depend [11]. This nursery must be located near a watering point that does not dry up in the dry season, in order to facilitate watering, which is a very important factor for its success [12]. Especially since the recommended period for the creation of a coffee nursery is from September to March of the following year, and this always forces the nurseryman to go through a long period of drought, during which he must necessarily water the young plants to ensure their optimal development. Thus, after the removal of the rooted seedlings from the propagator called plastic-tunnel, where they spend 03 months, these seedlings must be followed in the nursery for 03 months as well before being planted in the field. The rooting phase of the cuttings is not very demanding in terms of water since the tunnel considerably reduces evapotranspiration by keeping the substrate permanently moist, whereas in the nursery phase the maintenance of these plants requires a more considerable supply of water. However, in a context marked by climate change, the dry seasons have become more or less prolonged in recent years, causing at times the drying up of water points that were previously considered to be inexhaustible during the dry season. In addition, the pressure of land tenure leads many coffee farmers to establish their fields and nurseries on sites far from permanent water points, and these farmers, who are mostly poor, generally do not have enough money to build a water point next to their nursery. All these constraints make it difficult to access water resources in the dry season, while nursery monitoring activities during this period depend heavily on it. Mulching is an agricultural practice that conserves moisture, limits evapotranspiration, adds organic matter and limits soil erosion [13-14]. This practice is generally observed in the field, but hardly practiced in the nursery. However, it seems to be an alternative that could more or less reduce the frequency of watering during nursery maintenance. It could relieve coffee growers of the burden of monitoring their nurseries during periods when water is less available, or in agricultural areas. Thus, the objective of this study is to find a method of maintaining Robusta coffee cuttings nurseries that uses straw to ensure the lowest possible watering frequency for acceptable growth and development of the plants.

2. MATERIALS AND METHODS

2.1 Sample sites

This experiment was carried out at Nkoemvone Agricultural Research Station, located in the Ebolowa 2nd District, Mvila Department, and South Cameroon Region. This station is located at an altitude of 580 m, between 2°49'54.1''N and 11°08'12.4''E. This trial was conducted in a large shed with sufficient light and ventilation to avoid uncontrolled watering and wilting of the coffee plants.

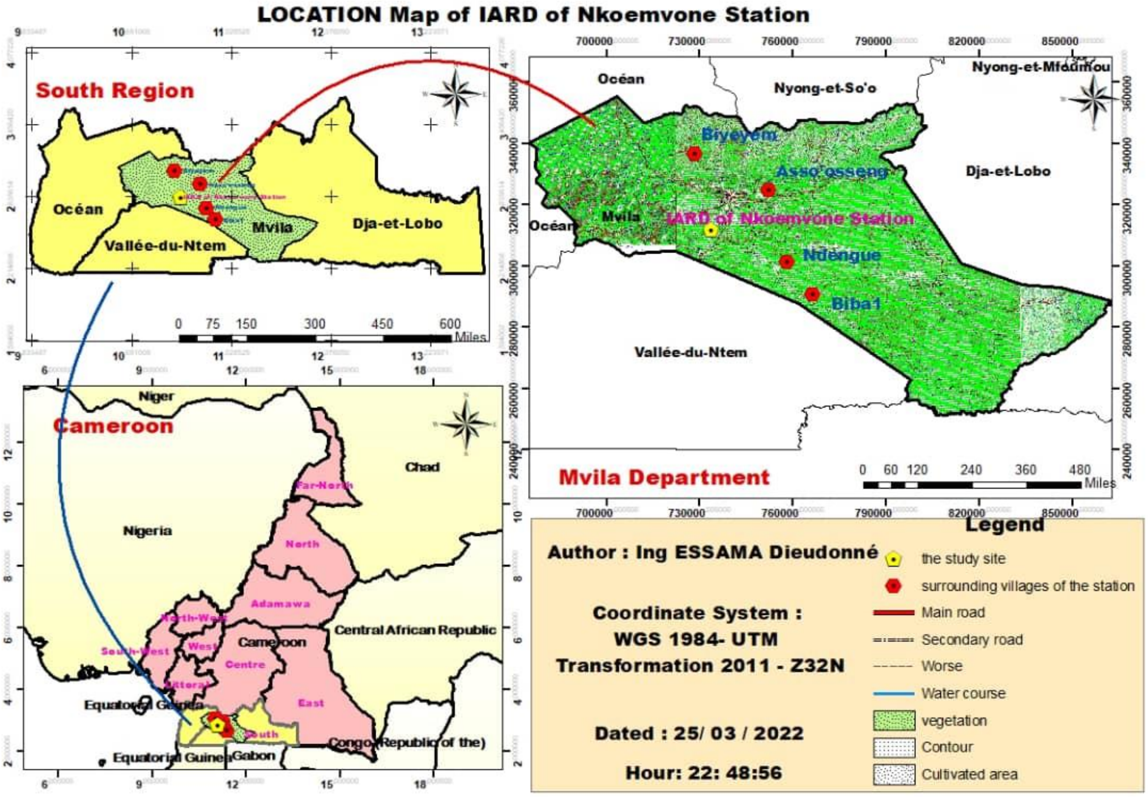

Figure 1: the mape presents the study site (Nkoemvone Agricultural Research Station).

2.1.1 Rainfall and temperature

In the southern region, the climate is equatorial with two rainy seasons and two dry seasons. Rainfall varies from 1,500 to 2,000 mm [15-16] and the least rainy months are between December and mid-March. Average annual temperatures are around 25°C. However, the highest temperatures are generally recorded in the months of February to April and can rise to 30°C [17].

2.1.2 Pedology

The southern region is covered by ferralitic soils of the lateritic domain, which were formed by erosion due to high temperatures and heavy rainfall. On the other hand, they are rich soils with a high nutrient retention capacity [18]. Table 1 presents the physico-chemical properties of the soil sampling site used for this experiment.

Table 1: The following table shows the physico-chemical properties of the initial substrate [17]

Physicochemical parameters	Parameter values
Depth (Cm)	0-20
Clay	37.4
Silt	16.8
Sand	45.8
Textural class	SC
pH-water	5.5
pH-KCl	4.5
Δ pH	-1
CO (%)	2.31
MO (%)	3.98
N tot, (%)	0.19
C/N	12
Calcium	4.00
Magnesium	0.64
Potassium	0.07
Sodium	0.28
Sum of bases	4.99
CEC pH7	9
Saturation (%)	55
Bray II (mg/Kg)	7.96

SC = Sandy Clay; **SCL** = Sandy Clay Loam. (Source: Soil Analysis and Environmental Chemistry, Research Unit, FASA, Uds, 2021).

2.2 Materials

The material consisted of rooted plants of the Robusta coffee clone M5. This clone is native to Madagascar [19]. However, the cuttings (Figure 2A) from which these rooted plants (Figure 2B) were obtained came from a coffee woodlot at the IRAD station in Nkoemvone.
In addition, a camera, a sensitive balance, a transparent tarpaulin, polythene bags, a machete, a file, a pruning shears, a decameter, a calliper, a ruler and data collection sheets were used.

Figure 2: The figure showed the plant material used. **A**: Plastic sub-tunnel cuttings; **B**: Rooted coffee plants.

2.3 Methods

2.3.1 Experimental design

The experimental design was a randomised complete block design [20]. This trial had eighteen elementary plots. It had six treatments repeated three times each. In each elementary plot, there were twenty coffee plants planted in twenty different bags. There were a total of three hundred and sixty plants in the trial. The spacing between treatments was 0.5 m, and 1 m between replications. These treatments were: Unmulched with a Watering Frequency of once every two days (T_0) (control treatment); Unmulched with a Watering Frequency of once every four days (T_1); Unmulched with a Watering Frequency of once every six days (T_2); Mulched with a Watering Frequency of once every two days (T_3); Mulched with a Watering Frequency of once every four days (T_4) and Mulched with a Watering Frequency of once every six days (T_5).

2.3.2 Production of rooted coffee plants and application of treatments

This trial was carried out in the period from September 2021 to March 2022 and lasted six months. It was carried out in two phases. Firstly, the rooted coffee plants were produced by the direct plastic sub-tunnel cutting method (Figure 2B). This plant production technique consisted of planting the coffee cuttings in polyethylene pots of dimensions 15 x 20 cm previously filled with humus soil. These bags were then carefully placed in a tunnel (the advantage of using plastic tunnels is that they are easy to make and less expensive than conventional propagation trays, which are more expensive for farmers), which had been built beforehand using local materials and transparent tarpaulins in such a way as to create a microclimate conducive to the budding of the cuttings [21], but also to ensure that the seedlings were well-lit in order to prevent them from withering away. These pots were watered at a rate of one sprout per day for the first two weeks. After the start of budding, the seedlings were watered at a frequency of one watering every three days. Thus, this phase lasted three months and rooted seedlings were obtained. Then, after acclimatising these seedlings outside the tunnel for a week, the experimental set-up was set up in a shed with sufficient ventilation and light. Subsequently, the treatments were applied from three months after cutting.

For the mulched treatments, 20 g of straw was applied to the surface of the pots so as to completely cover the collar of the seedling inside. This straw was made of dry grass (*Pennisetum* sp.). The choice of grass as straw in this work is due to the fact that the dry leaves of this genus of the Poacea family allow a better coverage of the pot surface. It is available everywhere in the coffee growing areas and can be easily handled. Another advantage is that the leaves of other species belonging to this family can be used, in case grass is not available. On the other hand, tree leaves are less suitable, since they are difficult to handle and are usually not available in sufficient quantities [22].

Then, the plants were watered regularly according to the watering frequency corresponding to each treatment and the amount of water applied per pot during a watering was the same. The work of [23] shows that when monitoring cocoa plants in the nursery, it is advisable to use 05 litres of water to water a bed of 1 m^2 in area. For this purpose, the volume of water received by each plant during one watering was 57 ml. This volume was determined using the formula for the area (S) of the circle, since the area (s) of the pots used had a circular shape: $s = \pi r^2$, where s = area of the pot and r = radius of the pot area [17].

2.3.3 Assessment of agronomic parameters

Agronomic parameters of growth (stem length and crown diameter) and development (number of leaves and stem nodes) were collected at a frequency of once a month over a six-month period. These data were collected on twenty coffee plants previously labelled in different treatments. At the end of the work, the plants that had resisted the different treatments applied were pulled out. Then, the length of the longest root of each plant was measured (growth parameter) and the secondary roots were counted (development parameter). These roots were separated from the stems with the help of a pruning shears and placed in envelopes labelled according to the treatments. In addition, the stems were also collected by treatment and the different batches were labelled. In the laboratory, data were collected on the fresh weight of stems, leaves and roots using a sensitive balance. The dry matter weight was determined after drying the fresh organs in an oven for 48 hours at a temperature of 60°C [24]. The dry matter content (DMC) was obtained using the following formula: DMC (%) = (DW / FW) X 100; where DW = dry weight; FW = fresh weight; DMC = dry matter content [25].

2.3.4 Data recording

Data was suggested to one-way analysis of variance (ANOVA) with R software version 3.5.1. The data tested followed a normal law (Shapiro-Wilk test; $P>0.05$) and the comparisons of means were determined on data using Tukey HSD test when the analysis of variance was significant.

3. RESULTS

3.1. Effect of treatments on coffee plant growth and development

The height of the coffee plants increased significantly ($P>0.05$) in treatments T_0, T_3 and T_4 from the beginning of the application of the treatments until the sixth month, except for the other three treatments in which this height rather decreased with time from the fourth month (Figure 3). The highest average heights were observed in treatments T_3 (10.71 cm) and T_4 (10.60 cm), while T_2 (0.00 cm) recorded the lowest value, since it was cancelled out by the fifth month. That is, two months after the beginning of the treatments.

On the other hand, the stem collar diameter of the coffee plants increased slightly in treatments T_0, T_3 and T_4 from the beginning of the application of the treatments (3 months after the cuttings) until the sixth month, except for the other three treatments in which the average values of the diameter rather decreased with time (Figure 4). Thus, it can be observed that at the beginning of the application of the treatments, the value of the diameter at the neck of the stems of all the treatments is very close to 2 mm and none of the treatments could reach 3 mm of diameter. The highest average diameter was obtained in treatment T_4 (2.83 mm). On the other hand, T_2 (0.00 mm) recorded the lowest average diameter, as it also cancelled in the fifth month.

The average number of leaves was significantly influenced by the treatments (Figure 5). For treatments T_0, T_3 and T_4, the number of leaves increased significantly ($P>0.05$) from the fourth to the sixth month. In contrast, in the other three treatments, the value of the average number of leaves rather decreased in the same time interval. This value was again cancelled out in the fifth month for treatment T_2 (0.00).

In relation to the number of nodes, the behaviour of the curves was almost similar to those observed in the case of the number of leaves. In treatments T_0, T_3 and T_4 the number of nodes increased significantly ($P>0.05$) from the beginning of the application of the treatments and these treatments presented approximately the same average values of the number of nodes (3.30; 3.26 and 3.26 respectively). However, the other three treatments showed decreasing node numbers as in the other organs.

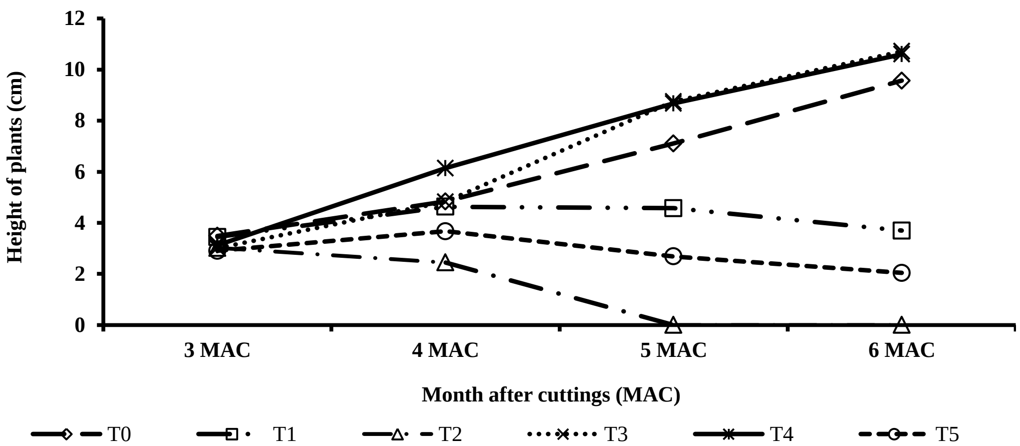

Figure 3: Effect of treatments on coffee plant height.

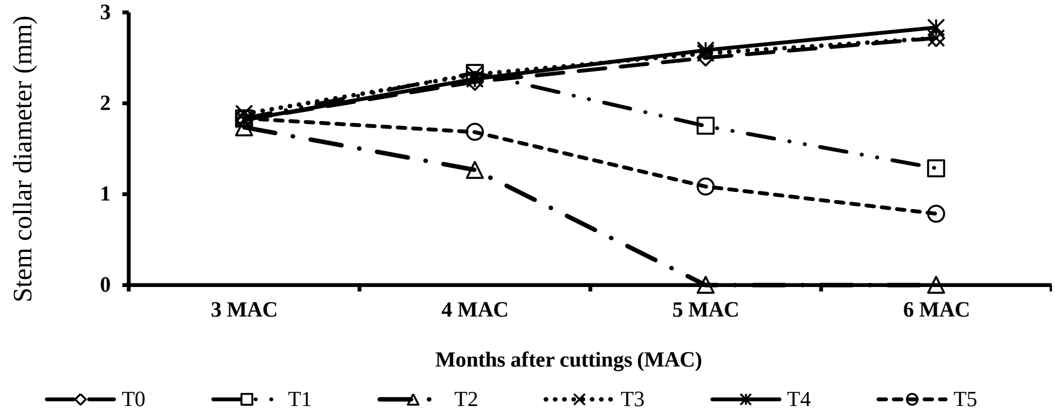

Figure 4: Effect of treatments on the collar diameter of coffee plants

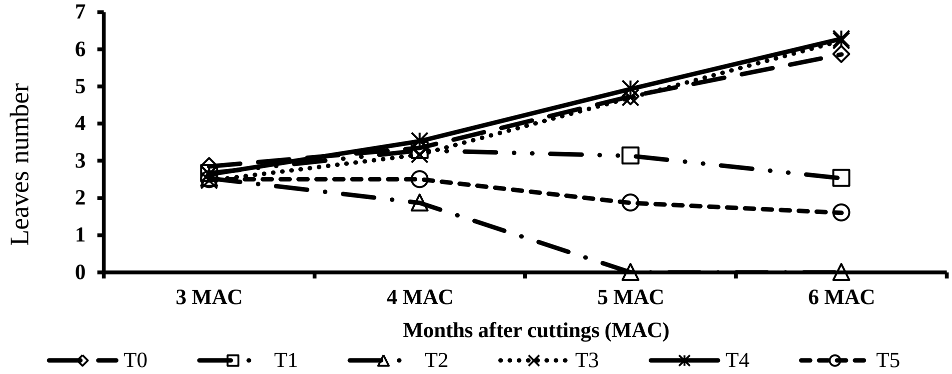

Figure 5: Effect of treatments on the number of leaves of coffee plants.

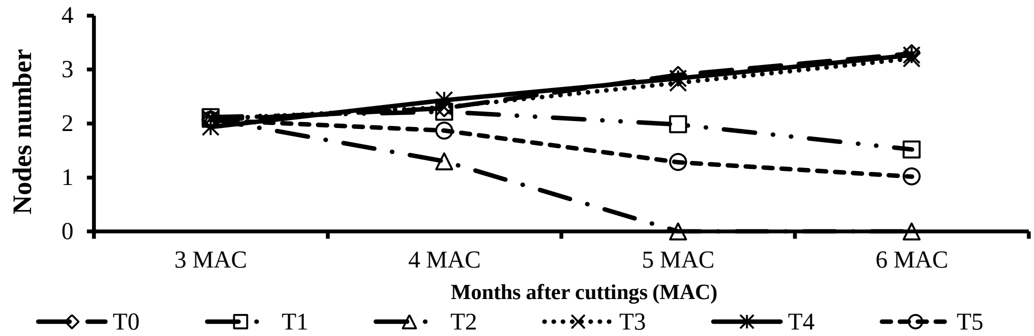

Figure 6: Effect of treatments on the number of nodes of coffee plants

3.2 Effect of treatments on longest root size and number of secondary roots.

Six months after cutting, the average size of the longest roots and the average number of secondary roots of coffee plants increased significantly (P>0.001) in the different treatments (Table 2). Overall, this length and number did not vary significantly with the exception of T_4 (11.33 ± 1.24 cm and 14.25 ± 1.98 respectively) which showed a significantly (P>0.001) high mean secondary root size. However, the lowest mean values were observed in treatments T_2 (0.00 ± 0.00 cm and 0.00 ± 0.00) and T_5 (1.48 ± 0.51 cm and 2.35 ± 0.87 respectively).

Table 2: The table presents the average length of longest roots and number of secondary roots.

Treatments	Average longest root length (cm)	Average secondary roots number
T_0	10.26 ± 1.94a	11.37 ± 1.81b
T_1	10.46 ± 1.25a	12.27 ± 1.60b
T_2	0.00 ± 0.00b	0.00 ± 0.00c
T_3	10.71 ± 0.94a	13.25 ± 1.32a
T_4	11.33 ± 1.24a	14.25 ± 1.98ab
T_5	1.48 ± 0.51b	2.35 ± 0.87 c
F-value	120.1	114.2
Pr(>F)	<0.001***	<0.001***

3.3 Effect of treatments on the dry matter content of coffee plant organs

In the different organs, the dry matter contents obtained differed significantly (P>0.001) between some treatments (Table 3). Overall, the mean dry matter content of the stems was higher than that of the roots and leaves, and the dry matter content of the leaves was lowest. Treatments T_1 (60.77 ± 2.50 %) and T_5 (57.94 ± 8.36 %) had the highest dry matter content in the stems, while T_2 (00.00 ± 0.00 %) had the lowest. At leaf level, T_1 (46.97 ± 9.46 %) and T_5 (49.05 ± 8.6 %) were also better than the others. Similarly, T_1 (55.11 ± 8.51 %) and T_5 (51.48 ± 7.88 %) had the highest dry matter content in the roots. T_2 (00.00 ± 0.00 %) also had the lowest dry matter content in the latter two organs, as did the stems.

Table 3: The table presents the influence of treaments on dry matter content (%) of coffee plants.

Treatments	Stems (%)	Leaves (%)	Roots (%)
T_0	50.58 ± 1.99ab	39.34 ± 2.24ab	40.58 ± 2.05bc
T_1	60.77 ± 2.50a	46.97 ± 9.46ab	55.11 ± 8.51a
T_2	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00d
T_3	44.35 ± 6.51b	32.58 ± 2.73b	31.49 ± 2.55c
T_4	49.15 ± 1.47ab	38.17 ± 4.23ab	45.52 ± 1.81ab
T_5	57.94 ± 8.36a	49.05 ± 8.61a	51.48 ± 7.88ab
F-Value	71.61	29.65	48.98
Pr(>F)	<0.001***	<0.001***	<0.001***

3.1 Correlation

The analysis of the correspondence table between the measured parameters showed that almost all of them are significantly (P>0.001) positively correlated with each other (Table 4). Only Root Dry Weight (DRW) and Average Plant Height (APH) (r = 0.898*) were significantly correlated at the P>0.05 threshold and positive with each other respectively.

Table 4: The table presents the correlation matrix of the measured variables of coffee plants**.**

	ADM	APH	ALN	ANN	ALRL	ASRN	FSW	FLW	FRW	DSW	DLW	DRW
ADM	1											
APH	0,985**	1										
ALN	0,996**	0,992**	1									
ANN	0,998**	0,981**	0,996**	1								
ALRL	0,932**	0,900**	0,916**	0,914**	1							
ASRN	0,937**	0,918**	0,923**	0,917**	0,992**	1						
FSW	0,998**	0,989**	0,996**	0,997**	0,914**	0,925**	1					
FLW	0,994**	0,969**	0,988**	0,993**	0,944**	0,937**	0,987**	1				
FRW	0,996**	0,980**	0,993**	0,998**	0,905**	0,907**	0,997**	0,992**	1			
DSW	0,985**	0,950**	0,975**	0,986**	0,934**	0,938**	0,980**	0,980**	0,977**	1		
DLW	0,956**	0,900**	0,942**	0,958**	0,944**	0,928**	0,941**	0,968**	0,946**	0,984**	1	
DRW	0,944**	0,898*	0,934**	0,946**	0,917**	0,920**	0,934**	0,938**	0,927**	0,984**	0,982**	1

** Correlation is significant at the 0.01 level (two-tailed); * The correlation is significant at the 0.05 level (two-tailed). **ASD**: Average stem diameter; **APH**: Average plant height; **ALN**: Average leaves number; **ANN**: Average node number; **ALRL**: Average longest root length; **ASRN**: Average secondary root number; **FSW**: Fresh stem weight; **FLW**: Fresh leaves weight; **FRW**: Fresh root weight; **DSW**: Dry stem weight; **DLW**: Dry leaves weight; **DRW**: Dry root weight.

4. DISCUSSION

The applied treatments significantly (P>0.05) influenced the growth and development of the coffee plants during their nursery follow-up. Overall, the agronomic parameters of the seedlings in the mulched treatments performed better than those that were not mulched. This is because straw conserves soil moisture and reduces evapotranspiration [13-14]. Whereas in the unmulched treatments, watering water evaporates more quickly and therefore requires a higher watering frequency. The T_0 treatment is the one whose watering frequency is often recommended to growers. But at six months after cutting, when the plants are already ready to be planted in the field, the results show that the mulched treatments T_3 and T_4 showed better growth and development of the different agronomic parameters measured (stem height, crown diameter, number of leaves and nodes) than this treatment (T_0). This result can be explained by the fact that these treatments benefited from the addition of straw, which favoured the permanent maintenance of the humidity of the substrate, but also from a probable addition of organic matter, which would have been responsible for the agronomic performances obtained. On the other hand, the different values of these agronomic parameters started to decrease one month after the beginning of the application of the three other treatments and these values were cancelled out two months after the beginning of the treatments (5th month after cutting) for the T_5 treatment (0.00 ± 0.00 unit). This can be explained by the fact that this time interval falls within the period of the year when certain climatic parameters are often harsher (February - mid-March), since at this time it usually does not rain anymore and temperatures are often the highest [17]. Thus, these climate elements would probably have contributed to a decrease in air humidity and an increase in evapotranspiration. They would thus have gradually caused the drying out of the various substrates, followed by the early death of the coffee plants due to water stress and depending on the treatments applied.

On the other hand, the average length of the longest root and the average number of secondary roots decreased with increasing watering frequency (Table 2). This result could be explained by the higher or lower number of dead plants recorded in some treatments, which would have strongly contributed to reduce the average length of the longest root and the average number of secondary roots, in those treatments with low watering frequencies such as T_5 and especially T_2. These results are similar to those obtained by [17] when they studied the effect of mulching and watering frequency on some agronomic parameters of nursery grown cocoa plants. An observation of these values also shows that the number of secondary roots increases with the size of the longest root. The explanation of this result seems complex since in cut coffee plants, the insertion point of all these types of roots is almost the same on the stem collar, contrary to the root architecture of plants produced by direct sowing of coffee seeds in which the secondary roots are rather distributed along the main root. Therefore, studies on this type of root architecture are still needed to explain this relationship between the size of the longest root and the number of secondary roots.

With regard to dry matter content, it can be seen from Table 3 that in the different organs of the coffee plants, the dry matter content increases when the watering frequency decreases. This result can be explained by the fact that the plant tissues are richer in water when the watering frequency is appropriate. On the other hand, these tissues dehydrate as the watering frequency decreases and there is a higher dry matter content in the organs of plants of this treatment type. However, despite T_2 having one of the lowest watering frequencies, it had zero organic matter content. This may be due to the fact that all the plants in this treatment died around the fifth month, so that at the end of the experiment there were no more living coffee plants and for this reason all the agronomic parameters of this treatment were zero at the sixth month after cutting.

A correlation study revealed that all the different agronomic parameters were significantly and positively correlated to the parameters they were compared to. The different correlation coefficients obtained were almost all close to 1. Thus, this means that there is a strong linear relationship between these different measured variables [26].

5. CONCLUSION

This study aimed to help coffee growers to facilitate the maintenance of their nurseries during periods of the year or in areas where water is less available. The objective was to find methods of maintaining Robusta coffee seedling nurseries that would use straw to ensure the lowest possible watering frequency for optimal growth and development of the plants. It appears from this experiment that out of the six treatments applied, three treatments, namely T_3, T_4 and T_0 (controls), respectively allowed to obtain satisfactory agronomic performances (stem height, collar diameter, number of leaves, number of stem nodes, number of secondary roots and length of the longest roots) of the cuttings followed in the nursery for up to six months. In contrast, treatments T_2 and T_5 showed the worst performance overall. However, the objective is to find the lowest watering frequency that would alleviate the difficulties of watering the plants. We therefore recommend that farmers opt for the T_4 treatment, which allows the currently recommended watering frequency to be halved. In the future, it would be desirable for future work to evaluate the probable contribution of organic matter due to the degradation of grass straw applied during the trial and to establish the link with the performance obtained in the different treatments.

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