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Francisco S. R. Holanda^{1,4}

Renisson N. Araújo Filho^{2,5}

Julio C. B. Lima¹

Igor P. Rocha³

1 Universidade Federal de Sergipe, Centro de Ciências Biológicas e da Saúde, Departamento de Engenharia Agrônômica, Cidade Universitária Prof. José Aloísio de Campos, Avenida Marechal Rondon s/n, Jardim Rosa Elze, CEP 49100-000, São Cristóvão-SE, Brasil. Fone: (79) 2105-6929. Fax: (79) 2105-6494. E-mail: fholanda@infonet.com.br; lima@ufs.br

2 Universidade Federal Rural de Pernambuco. Departamento de Agronomia, Centro de Pesquisa de Solos, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, CEP 52171-900, Recife-PE, Brasil. Fone: (81) 3320-6242. E-mail: nepoaraujo@hotmail.com; rochaigor@hotmail.com

3 Universidade Federal Rural de Pernambuco. Programa de Pós-graduação em Engenharia Agrícola, Departamento de Tecnologia Rural, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, CEP 52171-900, Recife-PE, Brasil. Fone: (81) 3320-6279. E-mail: rochaigor@hotmail.com

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Comparison of different containers in the production of seedlings of vetiver grass for erosion control

ABSTRACT

Vetiver grass (*Vetiveria zizanioides* L. Nash) is a perennial grass used in the recovery of degraded areas, mainly to control erosion. The use of containers in the production of seedlings of many species, including vetiver grass, has been employed to reach a faster root system formation and better nutritional and plant health control. The objective of this study was to compare the seedling development of vetiver grass in different containers in order to be later used in riverbank erosion control. An assay was carried out at the campus of Universidade Federal de Sergipe, located in the municipality of São Cristóvão from February to April of 2010. Containers of plastic bags and plastic tubes were tested with volumes of 700 cm³ and 280 cm³, respectively, in a completely randomized design (CRD). The specie development was evaluated at intervals of fifteen days over two months. The plastic tubes treatment showed the highest means data for root density (RD), root length density (RLD), root numbers (N), and external root surface (S). The suitable period for the best root system development, under the experimental conditions, was from 30 to 45 days.

Key words: root system, soil bioengineering, *Vetiveria zizanioides*

Comparação de diferentes recipientes na produção de mudas de capim vetiver, para controle de erosão

RESUMO

O capim vetiver (*Vetiveria zizanioides* L. Nash) é uma gramínea perene muito utilizada na recuperação de áreas degradadas, sobretudo no controle de erosão. Com o uso de recipientes na produção de mudas de inúmeras espécies vegetais, incluindo o capim vetiver, pode-se obter maior rapidez na formação do sistema radicular e melhor controle nutricional e fitossanitário. Com o objetivo de comparar o desenvolvimento morfológico de mudas de capim vetiver produzidas em diferentes recipientes para serem utilizadas no controle de erosão em taludes marginais, realizou-se um experimento no Campus da Universidade Federal de Sergipe, São Cristóvão, SE, no período de fevereiro a abril de 2010. Na produção de mudas foram testados recipientes de sacos plásticos de polietileno e tubetes com capacidade volumétrica de 1.413,72 cm³ e 280 cm³, respectivamente, em delineamento experimental inteiramente casualizado (DIC). O desenvolvimento da espécie foi avaliado em intervalos quinzenais, durante dois meses. As maiores médias de densidade de raízes (RD), densidade do comprimento de raízes (RLD), número de raízes (N) e superfície externa de raízes (S) foram identificadas no tratamento com tubete. O período adequado para o melhor desenvolvimento do sistema radicular é de 30-45 dias.

Palavras-chave: Sistema radicular, bioengenharia de solos, *Vetiveria zizanioides*

INTRODUCTION

Among the various techniques used to control erosion on the river banks, soil bioengineering is the most cost effective alternative that allows the recovery of riparian vegetation, especially when compared to civil engineering works. This biotechnique consists in the use of vegetation in soil and sediment stabilization works, combined or not with inert elements such as rock or geotextile materials (Wu & Feng, 2006).

Soil cover with grass or herbaceous vegetation provides an efficient protection against surface erosion by reducing the impact of rainfall on bare soil (Davide et al., 2000), besides increased percolation of water, soil cohesion, and resistance on the banks, are provided by the root system (Burylo et al., 2009). Grasses such as vetiver grass (*Vetiveria zizanioides* L. Nash) have been used in erosion control practices and slope stabilization (Mickovski et al., 2005; Mickovski & Van Beek, 2009), promoting a reduction by 50% and 70% of surface runoff and eroded soil (Phien & Tam, 2007). The reproduction of vetiver Grass occurs in the sexual and asexual ways, although the propagation by seedlings is indeed the most common, when tillers are taken from the stock plant and brought directly to the field or replicates in pots in order to be multiplied (Cazzuffi et al., 2006; Chong & Chu, 2007).

The use of containers for the production of seedlings of many plant species, including vetiver grass, has been employed to obtain faster formation of the root system and greater practicality in the multiplication of seedlings (Chomchalow, 2000). The production of seedlings can be performed in tubes or plastic bags, but the tubes seem to have some advantages such as: reduction in spending on the substrate, less nursery area needed, and easy transportation and handling of seedlings (Ribeiro et al., 2005; Vallone et al., 2010a). The objective of this study was to compare the morphological development of seedlings of vetiver grass (*Vetiveria zizanioides*) grown in different containers for use in erosion control on riverbanks.

MATERIAL AND METHODS

The test was conducted at the Nursery of the Universidade Federal de Sergipe (UFS), located in São Cristóvão, SE (37° 06' 20" W and 10° 55' 51" S), during the period of February to April 2010. The climatic classification of the region, according to Köppen, is type A, wet tropical climate with dry summer, with average annual rainfall of 1,400 mm and average annual temperature of 26 °C.

The seedlings of vetiver grass were produced from tillers extracted from offshoots (stock plant), with each tiller size standardized to approximately 15 cm height of the above ground parts of plants and presenting few roots. The substrate used in the containers was composed of black soil, coconut coir, and lime in the proportion of 30:60:0.06 kg, and 73 g of fertilizer NPK (3-12-6) per m³ of substrate. The seedlings grew in plastic bags or in plastic tubes and irrigation was done twice daily, in the early morning and late afternoon, until saturation of the substrate.

The experiment was in completely randomized design, with the following treatments: T₁ - plastic tubes, conical shape and volume capacity 280 cm³, and T₂ -polyethylene plastic bag with volume capacity 754 cm³ (dimensions 15 cm height and diameter 8) and holes at the bottom for drainage of excess water, with each treatment being replicated three times. The duration of the experiment was 08 (eight) weeks and assessments were carried out at 15 day intervals. Nine (09) individuals from each treatment were selected and evaluated, destructively, totaling 18 plants for each 15 day evaluation, for the following parameters: root numbers (N), external root surface (S), which is the area of root in contact with the soil, root density (RD), root length density (RLD), root wet mass (RWM), root dry mass (RDM), shoot wet mass (SWM), and shoot dry mass (SDM). The results were submitted to analysis of variance (ANOVA) and the means compared by the Tukey test at significance of 5% probability, using SISVAR software.

A ruler graduated in centimeters was used in determining root length, with reference to the distance from the neck to the apex of the root. The values of external surface (S) were determined through the product of mean diameters (upper, middle, and lower) by their length. The weight of the wet material (RWM and SWM) was obtained by separately weighing the shoot and root system on an analytical balance with precision to 0.01 g. Then the material was taken to an oven with constant temperature of 60°C, for 72 hours until constant weight in order to obtain the dry mass (RDM and SDM).

RESULTS AND DISCUSSION

Root system characteristics as the root numbers (N), external root surface (S), root density (RD), and root length density (RLD) may influence the stability of soils and consequently the control of erosion, and presented differentiated behavior when it came to the assessment of seedling development in the containers tested.

Root density and root length density

The highest means for root density (RD) and root length density (RLD) were identified in the treatment with the tube (P ≤ 0.05), which is a container with less volume available for root development (Table 1) while it allowed less folding, presenting greater initial growth after planting, agreeing with the findings of Santos et al. (2000). Roots with non-uniform diameters and greater folding were observed in the plastic bag.

Seedlings with higher root length density (RLD) will possibly show higher initial resistance to floods and landslides

Table 1. Mean values of root density (RD) and root length density (RLD) for seedlings of vetiver grass, results for the 60 days of evaluation

Tabela 1. Valores médios de densidade de raízes (RD) e densidade do comprimento de Raízes (RLD) de mudas de capim vetiver, resultado para 60 dias de avaliação

Treatment	Root density (RD) (g cm ⁻³)	Root length density (RLD) (cm cm ²)
Tube	0.0979 a	1.299 a
Plastic Bag	0.0014 b	0.207 b

* Means followed by same lowercase letters in the columns do not differ significantly by the Tukey test (P ≤ 0.05)

by permitting a greater soil structure due to the increased contribution of carbon and higher concentration of fulvic acids and humin in soils cultivated with grasses, as reported by Barreto et al. (2008). Besides this, they also can promote a greater absorption of water in subsurface layers of soil (Stokes et al., 2009), directly influencing the stability of these layers and, consequently, the resistance of the roots to breakage at critical moments, seeing that the roots will resist landslides until their disruption.

As these parameters (RD and RLD) express the live root dry mass per volume of soil and the total root length per volume of soil, respectively, the identified differences are possibly explained more in function of the volumes of the containers than in function of the effect of those in development of seedlings. According to Danner et al. (2007), Leles et al. (2000) and Queiroz & Melém Júnior (2001) the containers with greater volume provide better development of some morphological seedling characteristics, possibly due to the greater space and greater availability of nutrients. However, it is noteworthy that the results found by the authors cited above were obtained in research with tree species, since works comparing containers in the seedling production of Poaceae are rare.

Root numbers and external root surface

A tendency for better results was observed for the parameters root numbers (N) and external root surface (S) for the tube (Table 2), although no statistical difference was verified for these parameters in the development of the roots of vetiver grass in the two containers. Gyssels et al. (2005) and Reubens et al. (2007) stressed that the external surface, especially of roots less than 3 mm, is a very important parameter in erosion control, as the greater the external surface, the greater will be the contact area with soil. This way, it is expected that the root system of vetiver grass seedlings, produced in tubes, will possibly provide a greater contact with constituents of the solid fraction of the soil due to the greater root numbers (N) and greater external root surface (S).

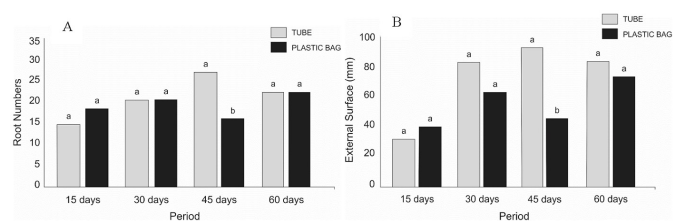
Table 2. Mean values of root numbers (N) and external root surface (S) for seedlings of vetiver grass, results for the evaluation of 60 days

Tabela 2. Valores médios de número de raízes (N) e superfície externa de raízes (S) de mudas de capim vetiver, resultados para 60 dias de avaliação

Treatment	Root numbers (N)	External root surface (S) in mm
Tube	23.17 a	71.89 a
Plastic Bag	21.08 a	55.10 a

* Means followed by same lowercase letters in the columns do not differ significantly by the Tukey test ($P \leq 0.05$)

The external root surface (S) was influenced by the root numbers and by the lengths and diameters of the same. It was noticed that increase in the number of roots, in both containers, was reflected in the increase of external surface (Figure 1). With a decrease in diameter of the roots there may occur a decrease in external surface, reducing their contact area with the soil. Therefore, it is desirable that the root system of a vetiver grass seedling has lots of fine roots ($> 3\text{mm}$) and small numbers of thick roots ($< 3\text{mm}$). According to Mickovski & Van Beek (2009) and Truong & Loch (2004), the roots of



* Means followed by same lowercase letters in the columns do not differ significantly by the Tukey test ($P \leq 0.05$)

Figure 1. Mean values of external root surface (S), (A) - root numbers (N) and (B) from seedlings of vetiver grass

Figura 1. Médias dos valores de superfície externa de raízes (S) (A) e número de raízes (B) de mudas de capim vetiver

vetiver grass have greater tensile strength with the decrease of their diameter.

When comparing the values observed at each assessment (Figure 1), it is possible to state that the seedlings grown in tubes reached the highest means at 45 days of the experiment for the parameters root numbers (N) and external root surface (S), suggesting that this is the best time to use these seedlings, since from this period on there is a decrease. Chomchalow (2000) notes that vetiver grass seedlings should remain in the containers approximately 45 days before planting in the field. It is noteworthy that for the plastic bag container the increase was gradual, reaching peak values for the parameters root numbers (N) and external root surface (S) only at 60 days.

Root wet mass, root dry mass, shoot wet mass, and shoot dry mass

The highest means for root wet mass (RWM) and root dry mass (RDM) were identified in the treatment with the tube, the container with the smaller volume, but with no significant difference ($P \leq 0.05$) for these parameters (Table 3). This result is consistent with the observations by Vallone et al. (2010a) on the root dry mass (RDM), but disagrees with Brachtvogel & Malavasi (2010), where increase in the container volume produced better seedling development, showing higher means of root dry mass (RDM), when compared to the means obtained in containers of smaller volume.

Table 3. Mean values of root wet mass (RWM), root dry mass (RDM), shoot wet mass (SWM), and shoot dry mass (SDM) for seedlings of vetiver grass, results for the evaluation of 60 days

Tabela 3. Valores médios de massa úmida de raízes (MUR), massa seca de raízes (MSR), massa úmida da parte aérea (MUPA) e massa seca da parte aérea (MSPA) de mudas de capim vetiver, resultados para 60 dias de avaliação

Treatment	RWM	RDM	SWM	SDM
	(g)			
Tube	3.17 a	0.88 a	4.91 a	1.57 a
Plastic Bag	2.74 a	0.71 a	5.61 a	1.70 a

* Means followed by same lowercase letters in the columns do not differ significantly by the Tukey test ($P \leq 0.05$)

The results related to root dry mass (RDM) possibly occurred due to a greater allocation of photoassimilates for the roots when the root system is in limiting conditions, as also observed by Samôr et al. (2002). This behavior seems to occur around 45 days, when the data from the external

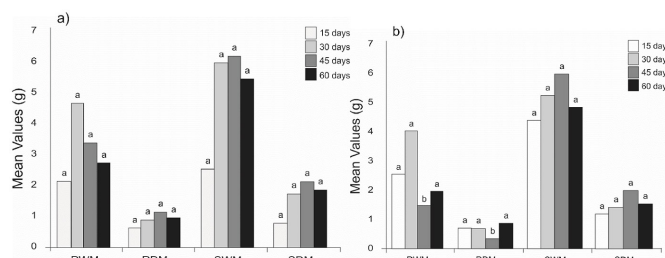
surface reaches its maximum, decreasing at 60 days (Figure 1). This result can also be explained by the better root system formation for seedlings grown in tubes, with less folding. In the plastic bags there was a greater formation of thin roots and an accentuated folding of the roots (Table 1).

The highest means for shoot wet mass (SWM) and shoot dry mass (SDM) were observed in the treatment with the plastic bag (Table 3). Gomes et al. (2003), Malavasi & Malavasi (2006), Sodr  et al. (2007) and Vallone et al. (2010b), working with seedlings of eucalyptus (*Eucalyptus grandis*), louro (*Cordia trichotoma* (Vell.) Arrab. ex Steud), jacaranda (*Jacaranda micrantha* Cham.), cocoa (*Theobroma cacao*) and coffee (*Coffea arabica* L.), respectively, found the highest accumulation of shoot dry mass in plastic bags, containers that have a greater volume, allowing better root development when compared to the values identified for the tubes. It is noteworthy that the species mentioned possess an axial type root system, with quite different architecture from the fasciculate root system of vetiver grass.

The parameters shoot wet mass (SWM) and shoot dry mass (SDM) may have been influenced by the volume of available container providing the best root development. The lower volume of substrate in the tubes may explain the poor development of the seedling stem due to depletion of nutrients present in the substrate, which agrees with the findings of Jos  et al. (2005) and Ribeiro et al. (2005). Another relevant factor is the lesser amount of water stored in containers of smaller dimensions, directly influencing the availability of nutrients and water (Brachtvogel & Malavasi, 2010). Chong & Chu (2007), working with vetiver grass seedlings under different irrigation regimes, noted that the volume of the container influenced positively the total biomass production, due to the increased provision of water and nutrients to the plant.

When the parameters RWM, RDM, SWM, and SDM for each treatment were analyzed within each evaluation period, the highest RWM means were identified at 30 days and at 45 days for RDM, when a significant difference occurred ($P \leq 0.05$) (Figure 2).

This behavior reinforces the occurrence of decreasing development of seedling growth by nutrient depletion over time



* Means followed by same lowercase letters in the columns do not differ significantly by the Tukey test ($P \leq 0.05$)

Figure 2. Mean values of root wet mass (RWM), root dry mass (RDM), shoot wet mass (SWM), and shoot dry mass (SDM) for seedlings of vetiver grass observed in the unfolded treatment (Tube) - (A) - and Plastic Bag - (B) within each evaluated period

Figura 2. Valores m dios de massa  mida (RWM), massa seca de ra zes (MSR), massa  mida (SWM) e massa seca (SDM) para mudas de capim vetiver observado no desdobramento do tratamento (Tube) - (A) - e saco de pl stico - (B) dentro de cada per odo avaliado

and lower water reserves. The lesser volume in the tubes may limit the growth and number of tubers over the course of time, which negatively influences the process of nutrient absorption (Novaes et al., 2001). At 15 days the highest means were found in treatment with the plastic bag, but no significant difference was observed for the seedlings in tubes. For the parameters SWM and SDM the highest means varied according to treatment and the collection period, disagreeing with Serrano et al. (2006), who identified the highest values of SDM in treatment with containers of greater volume. Brachtvogel & Malavasi (2010) observed that larger volumes of substrate provided better root development, allowing greater absorption of nutrients and consequently a greater development of the plant stem.

CONCLUSIONS

The parameters of root density, root length density, root numbers, and external root surface showed better performance in smaller tube when compared with plastic bag;

The appropriate period for the best root system development is from 30 to 45 days in tubes, and at 60 days in plastic bags;

The tubes may limit root system growth beyond 45 days, and over time negatively influence the process of nutrient absorption, implicating a lower development of shoot wet mass and shoot dry mass.

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