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Growth Performance of the Seedlings of Four *Acacia* Species Raised in Compost-Amended Sandy and Silty Soils*

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Abstract: The objective of this study was to determine the effects of compost on growth of *Acacia nilotica*, *A. seyal*, *A. senegal* and *A. tortilis* seedlings. It was conducted in Khartoum University Farm, during December 1999- January 2002. Compost was prepared in a pit from forest litter and poultry manure. Four quantities of compost were added to a sandy soil and a silty soil (% volume): zero, 25%, 50% and 75%. The blends were packed in polythene bags prior to transplanting. The compost was slightly acidic, non-saline, and rich in nutrients and had high water holding capacity. The compost negatively affected acacia seed germination percentage by 1.5 to 5.3 folds compared to the mineral soils. Shoot height in the compost-sand mixes increased significantly as compared to the unamended sandy soil by 1.4 to 2 folds. Root length was generally lower in the compost treatments. Shoot and root biomass in the compost media was significantly higher than in the sandy soil and increased by 3 to 7 and 1.5 to 3.0 folds, respectively. In the silt-compost mixes, seedlings' shoot heights were significantly greater than in the unamended silty soil. Root lengths in the silt-compost mixes were not significantly different from those in the silty soil. Shoot and root biomass in the silt-compost mixes was not significantly different from that in the unamended silty soil. Compost effects on seedlings' growth occurred in

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prorata to amounts of rates applied. Compost use in nurseries is advantageous to mineral soils and produces sturdy and healthy seedlings much solicited for multiple purposes.

Key words: Sand; silt; compost; acacias; seedlings

INTRODUCTION

Compost is the product of deliberate transformation of organic matter into humus through biological and chemical decomposition. The process takes place under controlled conditions in heaps or pits. The decomposition process takes place naturally by mixed population of organisms in a warm moist environment. To accelerate the decomposition process, a number of factors should be carefully monitored (Miller and Jones 1995; Stofella and Kahn 2001; Misra *et al*. 2003); these include C/N ratio of the organic input (25/1 to 35/1), particle size (≈10 mm), moisture content (50% – 60%), air flow (0.6 – 1.8 m^3 air/day/kg), temperature (55°C – 60°C held for 3 days) and heap size (1.5 m high and 2.5 m wide). Compost maturation can generally take few weeks to years, depending on the manipulation and monitoring of the above mentioned factors (Miller and Jones 1995; Brinton 2000; Stofella and Kahn 2001).

Compost attributes, such as soil ameliorator and crop fertilizer, are widely recognized in agricultural and forestry practices. In forest and horticulture nurseries, use of mature compost is preferred to other growing media, because it is light, has high cation exchange capacity and nutrients, high water holding capacity, favourably low C/N ratio and is weed and pathogen free (Evans 1982; Landis 1990; Jaenicke 1999; Diver and Greer 2001). Seedlings grown in organic potting mixtures develop fibrous root systems and effectively bind the media within the container, which is essential to minimize negative effects on plants during transporting or transplanting (Dalzell *et al*. 1987; Miller and Jones 1995). Negative effects of compost on seedlings are very rare, and if there are any they might come from weeds, disease and pest infestation and harmful polyphenols in case of sensitive crops (Miller and Jones 1995; Stofella and Kahn 2001; Gonzalez and Cooperband 2003).

In the Sudan nurseries, container seedling substrates usually consist of mineral soil such as sand, silt, clay and mixtures (Waheed Khan 1989). Use of organic matter in the nursery potting mixtures is rare in the Sudan. Limited and transient experience in this respect was gained from foreign aid organizations, like FINNIDA (Finish International Development Agency, in 1980s), which used peat, brought from abroad, in nursery potting mixtures to raise forest tree seedlings. Recently, a number of nursery owners in the capital and other main towns are beginning to use organic matter in their nursery potting mixtures. However, information concerned with form, quality and proportions of organic additions to nursery media are lacking. Research is needed to determine the appropriate forms, quality and rates of organic matter that suit tree species and prevailing conditions in the Sudan.

The study aimed at preparing a compost product and testing it in a mixture with sand and silt on seed germination and seedling growth of *Acacia nilotica* (L.) Willd. ex Del., *A. seyal* Del. var. *fistula* (Schweinf.) Oliv., *A. senegal* (L.) Willd. and *A. tortilis* (Forssk.) Hayne.

MATERIALS AND METHODS

Materials and experimentation: The study was conducted in the nursery of Khartoum University Farm. Compost was produced from tree litter (200 kg from Elsunt forest, Khartoum State) and poultry manure (50 kg from a poultry farm adjacent to the study site); it was prepared in a pit according to a method described by Miller and Jones (1995), between 28 December 1999 and 12 March 2000. Sand and silt soils were brought from Nile River bank. Seeds of acacia trees (*A. nilotica*, *A. seyal*, *A. senegal* and *A. tortilis*) were procured from the National Tree Seed Center (Forest Research Center, Khartoum). Black polythene bags (20 x 10 cm, flat) were obtained from the local market.

The growing media were prepared by blending the compost with the sand and silt soils in the following proportions (% volume) zero, 25%, 50% and 75%. Hence, the resulting treatments were SC0, SC25, SC50 and SC75 for the sand mixtures and LC0, LC25, LC50 and LC75 for the silt mixtures. The blends were then filled in the polythene bags. The bags were arranged in seedbeds to avoid leakage of compost between the treatments during irrigation; this was achieved by building brick-cemented walls between the seedbeds. Each species was replicated four times from each substrate category and randomly arranged in three blocks (totalling 192 bags).

Seeds were sown in trays filled with sand (On 28 April 2000) for procurement of sufficient seedling stock. On 12 May 2000, the seedlings were transplanted into the polythene bags filled with the respective growing media. Seed germination test in the nursery was carried out in a separate set of the prepared treatments. Three seeds were directly sown in each respective treatment and replicated ten times. Seed germination was monitored for two weeks and final seed germination percentage was calculated. Watering of the seedlings was done in the morning and evening during the first month and then once daily in the subsequent months. Weeding and other tending works were executed according to routine nursery operations. The parameters measured were shoot and root lengths and their biomass.

Laboratory analysis: All the physicochemical determinations were carried out according to the international procedures (Page 1982; Klute 1986; Kalra 1998). Air dry composite-samples of soils and compost (mixture of 3 samples) were used to analyse particle size distribution, bulk density, water holding capacity, pH, electrical conductivity (Ec.), soluble cations (Ca, Mg, Na and K), Nitrogen, Phosphorous and organic carbon.

The physicochemical properties of these soils and compost showed that: The sandy soil was predominantly composed of sand fraction and with very little silt and some clay (Table 1). Its bulk density was medium, has a neutral pH and non-saline. It was very poor in nutrient elements including nitrogen, available phosphorus and organic carbon. The silty soil had a medium magnitude bulk density and neutral pH, and was non-saline. It was amply supplied with Ca, Mg and P but had low N and C contents. The compost had a very low bulk density, high water holding capacity, slightly acidic reaction and was non-saline.

Statistical analysis: The data were subjected to analyses of variance by a SAS program package (SAS 2004) and mean separations were obtained by Duncan's multiple range test.

Table 1. Some physicochemical properties of sand, silt and compost

Property*	Sand	Silt	Compost
Sand (%)	84.6	17.1	-
Silt (%)	2.5	50	1.0
Clay (%)	12.9	32.9	5.0
Bulk density (g/cm^3)	1.41	1.07	0.76
Water holding capacity (%)	27.7	55.7	85.5
pH	7.4	7.4	6.8
EC (dS/m)	0.04	0.8	1.3
Bulk density (g/cm^3)	1.41	1.07	0.76
Ca‡ (meq/l)	4	2.4	37
Mg‡ (meq/l)	2.5	1.5	16
K‡ (meq/l)	0.09	0.05	0.24
Na‡ (meq/l)	0.86	0.21	3.41
Total N (%)	0.01	0.03	0.58
Organic carbon (%)	0.46	1.12	21
C/N ratio	46	37	36
Available P (ppm)	0.66	1.06	6.04

*Property values were obtained from analysis of compost samples (mixtures of 3 samples before analysis).
‡Soluble concentration.

RESULTS

Seed germination: Seed germination, conducted in the sand-compost mixtures, showed that *A. nilotica* had the highest germination percentage in the unamended sandy soil (SC0), which was significantly different ($P<0.05$) from the other media, while the lowest germination of the species was in the SC25 medium (Table 2). Among the compost-amended treatments, SC75 recorded significantly ($P<0.05$) higher germination rate than the other two treatments. *A. seyal* seed germination rate was significantly lowest in SC0 and highest in SC25. *A. senegal* seed germination rate was significantly higher in SC0 than in the three compost-amended media. Meanwhile, *A. tortilis* seed germination rate was highest in SC75 and lowest in SC25, and showed significant differences between all the media.

Table 2. Seed germination (%) of four *Acacia* species in sand and silt compost mixtures

Growing media[®]	*Acacia nilotica*	*Acacia seyal*	*Acacia senegal*	*Acacia tortilis*
SC0	45a	32.5a	72.5a	35a
SC25	12.5c	62.5b	45b	15b
SC50	17.5bc	42.5a	42.5b	25c
SC75	25b	42.5a	45b	52.5d
LC0	25b	63a	85a	53a
LC25	18bc	20b	80a	23c
LC50	15c	23b	55c	33b
LC75	40a	20b	67b	10d

[®]SC0: sand without compost; SC25: sand with 25% compost; SC50: sand with 50% compost; SC75: sand with 75% compost. LC0: silt without compost; LC25: silt with 25% compost; LC50: silt with 50% compost; LC75: silt with 75% compost.

Values in the same column with different letters are significant at $P<0.05$.

A. nilotica had significantly higher germination percentage in the LC75 medium than in the other media (Table 2). Seed germination in the LC0 was significantly higher than in LC0. *A. seyal* seed germination percentage was significantly higher in the silty soil compared to the compost-amended media, in which the germination rate had similar values. *A. senegal* seed germination percentages were significantly higher in the silt and LC25 media than in LC50 and LC75 treatments. Meanwhile, *A. tortilis* seed germination percentage was significantly higher in LC0 in comparison with other media; and the lowest seed germination percent was recorded in LC75 medium, which was significantly different from the rest of the other media.

Seedlings' growth parameters in the sand and sand-compost media

A. *Acacia nilotica*: Seedlings' shoot heights of the species in the sand-compost media were significantly ($P<0.05$) higher than in SC0 (Table 3). Root lengths showed no significant differences between the treatments, even though they were slightly higher in SC0 and SC25. The shoot/root ratio values were above unity and increased in proportion to the amount of compost rates; values in SC75 and SC50 were significantly different from those in SC25 and SC0. Seedling biomass in the compost-amended treatments was greater than that in the sand medium by 3 to 4 folds, and showed significant differences. Similarly, the root biomass in compost treatments exceeded that in SC0 by 1.5 to 2 folds and showed significant differences. The shoot/root biomass ratios gave similar results for the shoot and root length ratios.

Table 3. seedling growth parameters of four *Acacia species* in sand compost mixture

Treatment	Shoot height (cm)	Root length (cm)	Shoot/root length ratio	Shoot biomass (g)	Root biomass (g)	Shoot/root biomass ratio
Acacia nilotica						
SC0	41.5a	30.8a	1.4a	3.0a	1.1a	2.9a
SC25	80.3b	35.3a	2.3a	10.8b	2.0b	5.3b
SC50	91.8b	21.0a	4.4b	12.7b	1.6ab	8.1c
SC75	90.3b	29.3a	3.5b	12.5b	2.3b	5.6b
Acacia seyal						
SC0	30.5a	24.5a	1.3a	1.1a	1.7a	0.7a
SC25	79.0b	39.3a	2.2a	6.4b	5.3b	1.3ab
SC50	71.3b	32.0a	2.2a	6.6b	5.0b	1.3ab
SC75	75.5b	34.8a	2.4a	7.1b	5.3b	1.4b
Acacia senegal						
SC0	35.0a	31.3a	1.1a	1.1a	1.7a	0.7a
SC25	44.0ab	27.0ab	1.8ab	2.8b	2.8a	1.0a
SC50	45.0ab	22.8bc	2.0bc	6.2c	5.6b	1.1a
SC75	48.0b	19.3c	2.5c	4.5d	4.9b	1.0a
Acacia tortilis						
SC0	37.8a	34.0a	1.0a	1.9a	1.3a	1.5a
SC25	88.5b	27.0a	3.3b	5.9b	1.8a	3.5b
SC50	83.5b	32.0a	2.6bc	8.1b	3.4b	2.4c
SC75	74.3b	33.0a	2.4c	5.9b	2.5ab	2.5c

® SC0: sand without compost; SC25: sand with 25% compost; SC50: sand with 50% compost; SC75: sand with 75% compost.

Values of different species in the column with different letters are significant at $P < 0.05$.

B. ***Acacia seyal*****:** Seedlings' shoot heights of this species in the compost-amended media grew to more than twice of that in sand medium and were significantly ($P<0.05$) different. Root lengths were higher in all compost treatments but showed no significant differences. Shoot/root length ratio values were above unity in all the treatments; values in compost-amended media were higher than that in unamended sandy soil by 1.7 folds. Shoot and root biomass in the compost-amended treatments was significantly higher than in SC0. Shoot/root biomass ratio was less than unity in the SC0 treatment, while values in the compost treatments were all above unity, however significant differences were restricted between SC0 and SC75 treatments.

C. ***Acacia senegal*****:** Shoot heights of seedlings of this species in the compost-amended treatments were significantly higher than in SC0; among compost treatments, shoot heights increased in prorata to compost application rates. Root in SC0 treatment was significantly longer than those in the compost treatments. The shortest root length value was found in the treatment with the highest compost application. Shoot/root length ratio values were all above unity in all the treatments and they significantly increased in the compost media compared to SC0. Shoot and root biomass in the compost media was significantly higher than in SC0 medium. Shoot/root biomass ratios in the compost media were above unity but the average ratio in SC0 was less than one.

D. ***Acacia tortilis*****:** Seedlings' shoot heights of this species in the compost media were significantly higher than in the unamende sand, more than twice higher. Root lengths had similar values in all the treatments. Shoot/root length ratios were all above unity in all the media and increased with increasing compost rates. Shoot and root biomass in the compost media was significantly higher than in SC0 medium. The shoot/root biomass ratios in all the treatments were greater than unity and those in the compost media had significantly higher values than in the unamende sandy soil.

Seedlings' growth parameters in the silt and silt-compost media

A. *Acacia nilotica*: Shoot heights of this species in the compost-amended media were significantly ($P<0.05$) taller than in LC0 (Table 4). Root lengths did not show significant differences between the silt and compost amended treatments. The shoot/root ratios were all above unity in all the treatments; significant differences were found only between the highest compost rate and the rest of the treatments. Shoot biomass increased in proportion to the amount of compost added; only the two higher compost dose treatments showed significant differences from the LC0 treatment. Root biomass also increased in proportion to amounts of compost applied, but no significant differences were detected between the treatments. The shoot/root biomass ratios were all above unity, and did show significant differences between the treatments.

Table 4. Seedling growth parameters of four *Acacia species* in silt compost mixture

Treatment	Shoot height (cm)	Root length (cm)	Shoot/root length ratio	Shoot biomass (g)	Root biomass (g)	Shoot/root biomass ratio
Acacia nilotica						
SC0	77a	28.5ab	2.8ab	8.0a	1.6a	5.2a
SC25	83.8b	31.3ab	2.7b	10.4ab	1.8a	6.0a
SC50	89.3b	35.3a	2.9ab	13.2bc	2.8a	5.3a
SC75	92b	23.5b	3.9a	14.0c	2.7a	5.4a
Acacia seyal						
SC0	63.8a	34.8a	1.9a	4.9a	4.6a	1.1a
SC25	74.7b	39.8a	1.9a	6.5ab	4.8a	1.4a
SC50	76.0b	44.3a	1.7a	5.5a	4.5a	1.5a
SC75	77.3b	35.6a	2.2a	7.9b	5.8a	1.4a
Acacia senegal						
SC0	45.3a	21.5a	2.1a	2.6a	2.8a	0.9a
SC25	47.5ab	21.8ab	2.2a	4.6b	3.8ab	1.3a
SC50	49.5b	24.3ab	2.1a	4.9b	4.4ab	1.1a
SC75	53.8c	24.8b	2.2a	5.7b	4.9b	1.2a
Acacia tortilis						
SC0	67.5a	26.3a	2.6a	5.5a	2.1a	2.9a
SC25	74.3a	29.3ab	2.6a	5.6a	2.5a	2.4a
SC50	75.5a	31.8ab	2.4a	5.7a	2.6a	2.2a
SC75	81.0a	35.8b	2.3a	7.4a	2.9a	2.5a

® LC0: silt without compost; LC25: silt with 25% compost; LC50: silt with 50% compost; LC75: silt with 75% compost.

Values in the column for each species with different letters are significant at $P < 0.05$.

B. ***Acacia seyal*****:** Shoot heights of this species in compost-amended media were significantly higher than the LC0 medium (Table 4). Values of shoot heights among the compost-amended media were very close to each other and were not significantly different at $P<0.05$. Root lengths development did not show a definite pattern between the treatments and the values were not significantly different either. Shoot/root length ratio values were more than unity in all the treatments. Shoot biomass in the compost-amended treatments was greater than in the LC0 medium, but only the highest compost dose treatment was significantly different from the LC0 treatment. Root biomass values were very similar in all the treatment and did not show significant differences. Shoot/root biomass ratios were all above unity, very close to each other and were not significantly different among all the treatments.

C. ***Acacia senegal*****:** Shoot heights of this species in the compost amended treatments were very close to each other, except those in the highest compost treatment which were significantly greater than those in the rest of the treatments (Table 4). Root lengths increased in proportion to the amount of compost rates, but only the LC75 was significantly different from the LC0 treatment. Shoot/root length ratio values were all above unity and very close to each other in all the treatments. Shoot and root biomass increased with the increase of compost added and was significantly different from those in LC0 medium. Shoot/root biomass ratio values were approximately a unity in all the treatments and did not show significant differences.

D. ***Acacia tortilis*****:** Shoot heights of this species increased with the ascending amounts of compost applied, but did show significant differences between the treatments (Table 4). Root lengths also increased with the increase in compost added, but only the highest compost treatment showed significant differences from the silt medium. Shoot/root length ratio values were above unity and were very close to each other in all the treatments. Shoot and root biomasses increased with increasing compost doses, but were not significantly different from the silt medium. Shoot/root biomass ratios were above unity and with very close values in all the treatments.

DISCUSSION

The sandy soil used in this study was very poor in nutrients in comparison to the same soil enriched with compost material. However, the silty soil was relatively richer than the sandy soil but not to the level of the compost. It was expected that blending of compost with the mineral soil would enrich the growing media in prorata to the amounts of compost added. The physical and chemical properties of the compost produced were comparable with those reported in the literature (Stofella and Kahn 2001; Szmidt *et al*. 2003), and it was among the richest materials described.

Seed germination of the tested tree species, in the nursery conditions, did not show a definite trend in all the different media, although significant differences were found between the media. Generally, compost has significantly reduced seed germination percent. The most affected species were *A. tortilis*, *A. seyal* and *A. nilotica*. This might be attributed to the organic matter effects by either creating water logged conditions in the containers and thereby reducing the oxygen supply or releasing deleterious acids that damage the seed viability (Hall *et al*. 1982; Sanker and Rai 1993; Fitzpatrick *et al*. 1998; Fenner and Thompson 2005). It is worth to mention that, organic matter in the natural habitats of these acacias is very scanty and seeds of these species do not encode any signals of conditions created in the containers; and hence poor germination capacity could be perceived in these conditions.

Seedlings of the tested tree species raised in the unamended sandy soil were generally stunted and exhibited poor growth and development compared to media enriched by compost mixtures. They developed small pale coloured foliage (that was continuously defoliating) with spots on the leaflets, probably from malnutrition and/or fungus attack. Contrastingly, seedlings grown in the compost mixture media were healthier with dark green leaflets and ramification of numerous lateral branches. In addition, the shoot height and seedling biomass growth have positively responded to compost amendments of the sandy soil. The major exception from this trend was that of the root, which was poor in the compost treatments for most mixes and tree species tested. This phenomenon is directly linked to the fertility of the growing substrate. In poorly fertile medium, much of the photosynthates produced by the seedling are being allocated to the growth and development of the root system in search for water and nutrients. Meanwhile in media with higher fertility, seedlings expend less energy on root growth and most of the photosynthates produced are directed to vegetative growth (Marschner 1986; Kraske and Fernandez 1990).

Qualitatively, seedlings raised in the silty soil or silt-compost-fractions developed densely green foliage and numerous lateral shoots. Seedlings' shoot heights in these substrates grew at similar patterns and with very close lengths all along the monitoring period. Towards the end of the monitoring period, seedlings' shoot heights growth in the silty soil medium slowed down and deflected from the parallels of compost media. Growth of root lengths developed in the same pattern as described for the shoot heights. Shoot heights for most of the species were more than double the root lengths except for *A. seyal*, which generally gave identical lengths. This indicates that seedlings did not expend much energy on root development because the substrates in which they grew were rich in nutrients (Marschner 1986; Kraske and Fernandez 1990). Seedlings biomass (shoot and root) was invariably higher in the compost media and proportionate to the amount of compost doses added. The shoot/root biomass ratios revealed that *A. nilotica* and to some extend *A. tortilis* shoots responded to compost application better than the roots, with these ratios figuring to more than five and two folds, respectively.

Results from this study confirm the numerous assertions outlined in the literature about the positive effects of compost on the growing media characteristics, in terms of probably ameliorating their physical (bulk density, porosity, water holding capacity) and chemical (reactivity, conductivity, CEC, nutrient content, C/N) conditions (Mexal and Fisher 1987; Fitzpatrick 2001; Stofella and Kahn 2001). Hence, the good growth performance of the acacia seedlings recorded here is directly linked to the improvements of the growing media induced by the application of the compost product. However, the silty soil, as a relatively rich medium, will support the seedlings' growth, for a certain time, better than the sandy soil but less vigour than the compost-amended media. Even though, at long term, the compost will continue to release nutrients (Alexander, 2001; Chaney *et al*. 2001; He *et al*. 2001; Sikora and Szmidt 2001) when their stocks in the silty soil would have been depleted or used up by the seedlings.

In conclusion, compost tends to suppress the germination capacity of the acacia seeds, probably as a result of noxious solutes released by this material. Seedlings' growth performance is directly pertinent to the media fertility (both physical and chemical). Compost amendments to the poorer mineral soil (sand) induce spectacular seedlings' growth than applications to the relatively richer medium, e.g. silty soil. Therefore, compost qualities as good growing medium and fertilizer, and light mass that facilitate its easy handling outweigh benefits that could be gained from using the mineral soil.

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أداء شتول أربعة أنواع من الأكاسيا في أوساط تربة رملية و سلتية محسنة بسماد بلدي (الكمبوست)*

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المستخلص: هدفت هذه الدراسة إلى تحديد تأثير سماد بلدي (Compost) علي نمو شتول أربعة أنواع من أشجار الأكاسيا (*Acacia nilotica*, *A. seyal*, *A. senegal* and *A. tortilis*). أجريت الدراسة في مزرعة جامعة الخرطوم في الفترة من ديسمبر 1999 إلى يناير 2002م . حُضر السماد البلدي من نثار الأشجار وروث الدجاج في حفرة . أضيفت أربع كميات من السماد البلدي إلى الرمل والطمي (% حجم) وهي: صفر و 25% و 50% و75 % سماد . عُبأت الخلطات في أكياس من البوليثين قبل غرس الشتول فيها . كان السماد ذي حموضة قليلة وغير ملحي وغني بالعناصر الغذائية وله سعة عالية لحفظ الماء . أثر السماد سلبياً على نسبة إنبات البذور بـ 1.5 إلى 5.3 مرة عن التربة الشاهد. زادت أطوال الشتول معنوياً في خلطات السماد والرمل ، مقارنةً بالرمل الصافي وذلك بنمو 1.4 إلى 2 مرة . أما أطوال الجذور فقد كانت عموماً أعلى في معاملات السماد . زادت الكتلة الحيوية للجذوع والجذور معنوياً في السماد مقارنةً بالرمل الصافي وذلك بـ 3 إلى 7 و 1.5 إلى 3.0 مرات على التوالي . في أوساط خلطات الطمي بالسماد ، زادت أطوال الشتول معنوياً مقارنةً بالطمي الصافي ، لكن أطوال الجذور لم تزد معنوياً في هذه الخلطـات ، وكذلك لم تزد الكتلة الحيوية للجذوع والجذور معنوياً في خلطات السماد . تأثيرات السماد العضوي

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على نمو الشتول حدث في تناسب طردي مع الكميات المضافة . إستعمال السماد العضوي له أفضلية على التربة المعدنية ويؤدي إلى إنتاج شتول قوية وسليمه مطلوبة للإستعمالات المتعددة .