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Effects of Soil Types and Mango (*Mangifera indica* L.) Humus on Growth and Survival of some Tree Seedlings in the Nursery

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Abstract: This study aimed to assess the effects of various soil types and organic growing media on the growth of some tree seedlings. It was conducted in the nursery of the Faculty of Forestry, University of Khartoum, Shambat, during March-November 2006. Soil growing growth media consisted of sand, silt and clay, while the organic matter consisted of decomposed mango humus. Seeds of *Tamarindus indica* L., *Albizia lebbeck* (L.) Benth. and *Acacia senegal* (L.) Wild. were directly sown in polyethylene bags (10x20 cm). Seedlings shoot height, diameter, shoot and root biomasses of all the species were positively significantly affected by clay and silt media. Root growth was significantly greater in sand than other media. Mango humus had negatively ($P < 0.05$) affected seedlings' growth of all the tested species. Nonetheless, seedlings' survival rate was far better in the sand than in the other media. Silt and clay can be used as suitable growing media; pure sand may be used if production of seedlings with well developed root system is envisaged. However, type and source of organic matter should be cautiously chosen before it can be confidently used as a suitable growing medium.

Key words: Sand, clay, silt, mango humus, growth media, tree seedlings, Nursery.

INTRODUCTION

In forest tree nurseries, a prime concern is laid on the choice and usage of growing media and containers, because they profoundly affect the vigour and quality of the seedlings produced. Growing media include various soil and organic matter types. Their main function is to improve water

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holding capacity, air, nutrients and physical support to seedlings (Evans, 1982; Landis *et al.*, 1990; Jaenicke, 1999). The main worry from growing media as nursery mixes is to be free from weeds, pests and pathogens; thus, they are often sterilized to eliminate the detrimental sources to seedling health (Miller and Jones, 1995; Landis *et al*., 1990; Jaenicke, 1999). Locally available materials of growing media are utilized preferentially as there is no need to import and handle any material universally for such purpose. In Sudan forest nurseries, Waheed Khan (1989) recommended the use of river silt or either use of clay-sand mixture in fifty-fifty proportion by volume. Exploitation of organic growing media is not widely spread; yet, phytolith from under big trees is used in some places as seedling growing medium.

This study aimed to examine the effects of different soil textures (sand, silt and clay) and organic matter from under mango trees on the growth of some tree seedlings in the nursery.

MATERIALS AND METHODS

The study was conducted in the nursery of the Faculty of Forestry, University of Khartoum, Shambat. The nursery is located on the eastern bank of the River and it is surrounded by farms and wood lots, which render the surrounding microclimatic conditions of the area much cooler than the drier inlands.

Seeds of selected tree species (*Tamarindus indica* L., *Albizia lebbeck* (L.) Benth., *Acacia senegal* (L.) Wild.) for the study were obtained from the Tree Seed Centre, at the Forestry Research Centre, Khartoum. Seeds were delivered pre-treated with conc. H_2SO_4 for 30 minutes to break seed-coat dormancy and to facilitate germination. The growing substrates consisted of three soil types and organic matter: the sandy and silty soils were brought from the Nile River bank deposits, the clay soils was collected from adjacent field to nursery location and the organic matter was collected from under mango tree (*Mangifera indica* L.) garden located at the premises of the Faculty of Forestry. The containers consisted of black cylindrical ethylene bags (10x20 cm), sealed at one end, and perforated up to its third height

The ethylene bags were filled with the respective growing media and three seeds of each tree species were directly sown in the bags on 8 March 2006. Each growing medium for each tree species was replicated twenty five times. The polyethylene bags were arranged in the nursery beds in randomized blocks which were separated by septa in order to prevent leakage of material during irrigation. Watering by River Nile water, from an in-coming ditch, was applied twice daily in the first month and then once daily thereafter. Other silvicultural operations (singling, weeding, lifting and root cutting) were executed as routinely run in the Sudanese nurseries.

Monitoring of the experiment lasted for nine months. The parameters measured included; Shoot height (cm), root length (cm), seedlings' diameter (mm), seedlings' shoots and roots biomasses (g), and seedlings' survival percentage. Laboratory determination of the physicochemical properties of the growing media was carried out according to standard methodologies (Pansu and Gautheyrou, 2006; Kalra, 1998). Data were statistically analyzed by SAS program package (2004).

RESULTS

Characterization of the growing media

All the growing media (sand, clay, silt and Mango humus) had neutral pH and free from salts, except the clay medium which is slightly saline (Table 1). These media are poorly garnished in nutrient elements particularly in N and P, only the clay medium is relatively richer in Ca and Mg.

Effect of growing media on seedlings growth

Shoot heights of *T. indica* seedlings were highest in clay and silt media, which differed significantly ($P < 0.05$) from that in sand and humus media (Table 2). Root length was highest in the sand and silt media, which were significantly different from clay and humus media. Average seedling diameter was larger in clay and showed significant differences from the rest of the media. Shoot biomass in the clay was greater than the other media and showed a significant difference. Meanwhile, root biomass in humus was less than that in the other media by a factor higher than 3 folds

and was evidently significantly different. Seedling survival was hundred percent in sand and 75% in the rest of the media.

Albizia lebbek shoot height was highest in silt medium, which was significantly different from the other media; and the shortest average seedling height was recorded in the sand medium (Table 3). Silt medium produced the longest root length, which was significantly different from the other media. The shortest root length was observed in the humus medium, it was shorter by factors ranging from 1.7 to 5 folds from the rest of media. Seedling diameters in clay and silt media had similar values, which were significantly different from sand and humus media. Silt and clay media produced the highest seedling shoot and root biomasses, which were significantly different form that in sand and humus media; the lowest values of shoot and root biomasses, were measured in the humus medium. Seedling survival rate was highest in sand medium and lowest in clay, while the values in other media fell midway between these extremes.

Acacia senegal shoot height was longer ($P < 0.05$) in clay than in the other media; shoot heights in sand and humus were shorter than in clay and silt (Table 4). The shortest root length was recorded in the humus medium which was significantly different from the other media. Seedling diameter was largest in clay which was significantly different from that in the other media. Clay medium gave the greatest values for shoot and root biomasses, which were significantly different from the other media. Seedlings' survival rates in silt and sand were higher than that in clay and humus, which had identical values.

Table 1: Some physical and chemical properties of used growing media

Growing media	Sand (%)	Silt (%)	Clay (%)	pH	EC (dS/m)	Ca‡	Mg‡	Na‡	OM† (%)	N (%)	P (ppm)
Sand	84.7	10.1	5.2	6.7	0.4	2.0	0.5	2.5	0.1	0.01	2.7
Silt	36.5	52.8	10.7	7.2	1.0	3.0	1.5	5.5	0.52	0.01	6.1
Clay	11.2	23.1	65.7	7.8	5.0	15.0	9.0	26.0	1.66	0.01	4.6
Mango Humus*	-	-	5.0	7.2	0.6	1.25	0.9	0.4	21	0.15	0.4

‡Value units are in mmol/l. †OM: organic matter. *Humus values' units are in percentage.

Table 2: Effects of growing media on growth of *Tamarindus indica* tree seedlings

Growing media	Shoot height (cm)	Root length (cm)	Diameter (mm)	Shoot dry biomass (g)	Root dry biomass (g)	Survival (%)
Sand	25.4b	62.4a	3.9b	1.3b	2.0a	100
Clay	53.9a	31.6b	6.3a	6.7a	3.4a	75
Silt	54.5a	54.1a	4.8b	3.5b	2.6a	75
Mango Humus	34.6b	18.4b	3.7b	1.5b	0.6b	75

Values in the column with different letter (s) are significantly different at $p < 0.05$.

Table 3: Effects of growing media on growth of *Albizia lebbek* tree seedlings

Growing media	Shoot height (cm)	Root length (cm)	Diameter (mm)	Shoot dry biomass (g)	Root dry biomass (g)	Survival (%)
Sand	38.6b	53.0b	6.3b	6.2b	7.0b	90
Clay	54.1ab	30.6bc	8.5a	12.2a	11.5a	60
Silt	69.9a	95.5a	9.3a	17.0a	15.5a	80
Mango Humus	41.1b	18.0c	6.3b	4.9b	3.4b	75

Values in the column with different letter (s) are significantly different at $p < 0.05$.

Table 4: Effects of growing media on growth of *Acacia senegal* tree seedlings

Growing media	Shoot height (cm)	Root length (cm)	Diameter (mm)	Shoot dry biomass (g)	Root dry biomass (g)	Survival (%)
Sand	36.9b	44.0a	4.6b	1.4b	2.0b	85
Clay	54.5a	34.4a	7.5a	4.2a	3.5a	75
Silt	44.0b	31.8a	4.0b	1.3b	1.0b	90
Mango Humus	37.4b	15.9b	4.3b	1.3b	1.1b	75

Values in the column with different letter (s) are significantly different at $p < 0.05$.

DISCUSSION

From the results of this study, it was obvious that the seedlings growth parameters of the studied species were best in the clay and silt media and very poor in the sand and humus media. Observed exception from this trend, was the good root length growth and better seedlings survival in the sand medium.

The good response of the seedlings growth to clay and silt media is directly linked to the adequate physicochemical growth conditions offered by these media, particularly nutrients and water (Kozlowski, 1971; Landis *et al*., 1990). However, clay is known to have bad physical properties that might lead to create water perched medium and devoid container seedlings from necessary oxygen supplies for appropriate root proliferation (Feeley, 2005). This drawback was offset, in this study, by ample perforations of the polyethylene bags, which drain excess water and avoid creating water logging within the bag.

Root length growth was better in sand than in the other media. Root growth is maximal in soils having high sand percentage as roots have to explore more volume in search of water, and nutrients helped by easy penetration into the sand (Funk *et al*., 1980; Grant *et al*., 2012; Hattori *et al*., 2013). It was also observed by several authors that seedlings devote more energy in developing their root system in poor media in search for water and nutrients. While in rich media, most of the photosynthates are directed to growing and developing the above ground seedling organs (Marschner, 1986; Kraske and Fernandez, 1990). On the other hand, calculated shoot/root length and biomass ratios discerned that magnitude values of these ratios are all below unity in sand medium depicting better root growth. While in humus, values of these ratios are two units or above, in most cases, which shows that root growth in this medium is at a very serious stake. The good balance of these ratios is a matter of genuine concern for nursery container stock raising agencies (Leskovar, 1990; NeSmith and Duval, 1998; Richard, 2006).

All the seedlings of the studied tree species had mediocre growth performance in Mango humus. This might be attributed to the fact that Mango leaves contain chemical compounds like polyphenols and flavonoids (Musvoto *et al*., 2000; Kanwali *et al*., 2009; Severi *et al*., 2009) that are detrimental to seedling root and hence to the health of the whole plants. Also, the Mango humus, as unstable organic matter, is subject to decomposition during usage in which case it can release acid that lowers pH and create noxious conditions to the root zone in the bags. This is contrasted by the very good performance of various tree seedlings in stable organic matter like compost that is observed by many authors (Miller and Jones, 1995; Stofella and Kahn, 2001; Ameri, 2002; Kung'u *et al*., 2008).

The high seedlings' survival rate in sand medium can be due to the less infestation of this nutritionally poor medium by pests and diseases; and as long as the seedlings are continuously kept wet they can thrive for long periods. Meanwhile, humus, clay and silt to some extent as rich media are infested by myriad of biota, particularly, lethal micro-fauna and flora that can cause death to the seedlings. In this regard, Landis *et al*. (1990) prescribes the use of less fertile substrates or sterilization of the growing media in such circumstances.

In conclusion, use of silt and clay are recommended as suitable growing media in forestry nurseries; for the clay medium, care must be taken to provide it with thorough drainage in order to avoid creating water perched conditions in the container. Sand may be used if production of seedlings with developed root system is intended. It has the merit of being relatively free from damaging agents and lessening the rate of seedling mortality; but seedlings should not be kept for long in the containers as their nutrient stock may be exhausted. Organic matter has many advantages over the mineral soil; nevertheless, utmost care should be taken to select an appropriate material that is not potentially harmful to seedlings, like Mango humus.

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تأثير أنواع الترب و دبال المانجو علي نمو و بقاء شتلات بعض عينات أشجار الغابات في المشتل

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المستخلص: هدفت هذه الدراسة الي تقييم تأثير وسائط النمو من الترب و المادة العضوية علي نمو شتول بعض الأشجار الغابية. أجريت الدراسة في مشتل كلية الغابات ، جامعة الخرطوم ، شمبات ، في الفترة من مارس الي نوفمبر 2006م. وسائط النمو من الترب شملت الرمل و الطمي و الطين بينما يتمثل وسيط المادة العضوية في دبال متحلل من أشجار المانجو (*Mangifera indica* L.). و قد زرعت بذور أشجار العرديب (*Tamarindus indica* L.)، دقن الباشا (*Albizia lebbeck* (L.) Benth.) و الهشاب (*Acacia senegal* (L.) Wild.) مباشرةً في أكياس من البولي إيثلين (20x10 سم). تأثر إرتفاع الشتول و القطر و الوزن الجاف للجذوع و الجذور إيجابياً و معنوياً في وسائط الطين و الطمي. بينما كان نمو الجذور أفضل في الرمل مما هو في الوسائط الأخري. أما دبال المانجو فقد أثر سلبياً و معنوياً علي نمو شتول كل أنواع الأشجار التي تم إختبارها. علي الرغم من ذلك ، فإن معدل بقاء شتول جميع الأشجار كان أفضل في الرمل عن بقية الوسائط. إجمالاً ، فإن الطمي و الطين يمكن إستعمالهما كوسائط نمو مناسبة ؛ أما الرمل فربما يكون إستعماله مناسباً عندما يراد إنتاج شتول ذات نظام جذري فاعل. من ناحية أخري ، ينبغي توخي الحيطة و الحذر في إختيار نوع و مصدر المادة العضوية قبل إستعمالها كوسيط نمو للشتول.

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