Research Article

Use of bagasse, leaf compost and cow dung as sources of organic media for potting and mixing ratio on the growth of mango and lemon rootstock seedlings

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Abstract: Bagasse, leaf compost and cow dung are readily available to most nursery men in the lowveld of Zimbabwe. The objective of this experiment was to determine the effect of three sources of organic matter namely bagasse, leaf compost and cow dung and the effect of four mixing ratios 1 : 1 : 2, 2 : 1 : 2, 3 :1 : 2 and 3 : 2 : 1 (sand: organic media: soil) for potting on the growth of mango and lemon seedlings. There were no significant differences in plant height, number of leaves and stem diameter for seedlings grown in media containing bagasse and leaf compost for mango seedlings. Lemon seedling in media containing leaf compost had a significantly bigger stem diameter (0.61 cm) compared to those in media containing bagasse (0.49 cm) and cow dung (0.47 cm). Mango and lemon seedlings in media with cow dung had a significantly high mortality and slow growth due to high electrical conductivity. Mixing ratio 1 : 1 : 2 and 3 : 2 : 1 had significantly bigger seedlings for both mango and lemon. Mango seedlings in media containing leaf compost had significantly high root (25.8 g) and shoot (63.0 g) dry weight. Bagasse and leaf compost were better sources of organic matter for mango seedlings while leaf compost was better for lemon seedlings.

Keywords: Mango; lemon; rootstock seedlings; organic matter; mixing ratio

1. Introduction

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Poor growth of mango and citrus seedlings in the nursery can be due to poor choice of the source of organic matter. Organic matter is important in the formulation of growing media. It improves the quality of the potting media (Khater 2015). The mixing ratio of the amendments is also a determining factor for the growth of seedling (Arce and Rivera 2018); (Parasana et al., 2013). The ideal potting media has good structure, texture, water holding capacity, aeration and good sanitation for seedlings (Robbins 2018); (Jacobs et al., 2009).

Most nurseries in Zimbabwe use organic matter that is readily available and cheap to them. In Manicaland pine bark is commonly used because of its availability in the province. Triangle nurseries and other nurseries in the lowveld of Zimbabwe use bagasse. Many nurseries around the country use compost or animal manure mixed with forest top soil (Matenda et al., 2010). Organic materials from agriculture, forestry, green areas, and livestock farming as well as residues from municipal and industrial waste are used to prepare compost (Mehmood et al., 2013). Sources of organic matter like bagasse (sugar cane filter), compost and cow dung could be commercially exploited (Zhang et al., 2013); (Campititeli et al., 2018).

The main benefit of organic matter application is the positive effect on soil organic matter and soil structure. Different sources of organic media have different physical and chemical characteristics (Khater 2015). The chemical and physical properties as well as nitrogen, phosphorus and potassium concentration of potting media are the dominant factors affecting the use of media. The availability of nutrients to plants, mobility of water into or through media and penetration of roots in the potting media are also very important (Khan et al., 2006). Organic matter acts as a rich source of nutrients for the growth of microorganisms. Adding it to growing media significantly impacts their populations (Adoma et al., 2013); (Tanwar et al., 2013). This in turn affects the media composition in terms of the C, N and P mineralization (Pupin and Nahas 2011). Cow dung is traditionally used since it is abundant in some areas. The main disadvantages of cow dung include possible high salts, fine particle size and weeds. The major advantage is that it contributes many nutrients and has the potential to improve media physical properties (Mahmuddin Nur et al., 2019); Rahma Harti et al., 2020).

Bagasse has high levels of organic matter. It can increase organic matter content of growing media and improve the water holding capacity. Bagasse contains significant amounts of iron, manganese, calcium, magnesium, silicon and phosphorous and this enhances its suitability as an alternative source of organic matter (Dotaniya et al., 2016); (Chand et al., 2011). Rusul et al., (1999)

and Trochoulias et al., (1990) observed that bagasse has a high water holding capacity and can produce high quality containerized plants. Forest top soil is rich in organic matter from decaying leaves. Leaf compost can be generated by composting leaf sweepings.

The mixing ratio of the media amendments affects the growth of seedlings. Mixing ratio determines the availability of nutrients to plants, mobility of water into or through the media and penetration of roots in potting media. The general recommendation is 1 : 1 : 2 (sand: compost: forest soil) or 2 : 1 (forest soil : bagasse). Very high organic matter in the poly bag media can cause over wetting and encourage moss growth which is unsuitable for the seedlings (Rikayah and Zabedah 1992). It is generally recommended to include 25% of organic matter in growing media (Charlie et al., 2019). Local nurseries mix organic matter with inorganic amendments like sand and soil. Sand improves the drainage of the media.

Citrus thrives well in pH slightly below the neutral point. Mango also prefers slightly acidic soils (pH 5.5 to 7.5). Mango and lemon rootstock seedling are ideal for grafting and budding from 9 to 12 months after sowing in the nursery. Vigorous rootstock seedlings have a fast take off rate and success rate is high. This is vital since the growth success in the nursery facilitates later growth in the field (Malip and Yusof 1996).

The objectives of this experiment were to determine the effect of different sources of organic matter on the growth of mango and citrus seedlings and the effect of mixing ratios (sand: sources of organic matter: soil) for potting on the growth of mango and citrus rootstock seedlings.

2. Materials and Methods

The experiment was conducted at Chiredzi Research Station located in the Southeast lowveld of Zimbabwe. Three sources of organic media were used i.e. bagasse, leaf compost and cow dung. One year old bagasse and well decomposed cow dung were used. Leaf compost was made from leaf litter. The three sources of organic media were each mixed with soil and river sand in four different ratios to make 12 different media shown in Table 1.

Table 1. Mixing ratios for potting media

Potting mixtures	Source of organic matter (SOM)	Mixing ratio (sand : organic media: soil)	Percentage of organic media	Percentage of sand
A	Leaf compost (LC)	1 : 1 : 2	25	25
B	Cow dung (CD)	1 : 1 : 2	25	25
C	Bagasse (B)	1 : 1 : 2	25	25
D	Leaf compost	2 : 1 : 2	20	40
E	Cow dung	2 : 1 : 2	20	40
F	Bagasse	2 : 1 : 2	20	40
G	Leaf compost	3 : 1 : 2	16	50
H	Cow dung	3 : 1 : 2	16	50
I	Bagasse	3 : 1 : 2	16	50
J	Leaf compost	3 : 2 : 1	33	50
K	Cow dung	3 : 2 : 1	33	50
L	Bagasse	3 : 2 : 1	33	50

The fertility status of the 12 media was quantified. Mango seedlings of the variety Sabre were sown in sand media under 50% shade. Uniform mango seedlings were transplanted at three leaf stage into polybags (150 mm x 250 mm X 90 microns) containing the 12 prepared media. Lemon seed from variety Volkermeriana were planted in sand and uniform seedlings were transplanted at three leaf stage.

A two factorial design was used in a randomised complete block design. The treatments were replicated three times. Each treatment had a sample of 10 potted plants. The two factors were source of organic matter (SOM) and mixing ratios (sand: organic media: soil). Sources of organic matter were bagasse (B), Leaf compost (LC) and Cow dung (CD). River sand and soil below the top soil were used to prepare the mixtures.

Physical characteristics

The core method was used for the determination of bulk density. Bulk density was calculated by the formula derived by the American Society of Agronomy as follows:

Bulk density (d) = Weight of oven dry core soil /volume of the sample (g cm^{-3}). Moisture Percentage = loss in weight on oven drying / weight of oven dry soil X 100.

Chemical characteristics

The potting media were analysed at the Zimbabwe Sugar Association Experiment Station (ZSAES) chemistry and Soils Laboratory using standard soil analysis methods. The pH of the samples was measured in 1 : 5 (soil : 0.01 M $CaCl_2$ solution) using inolab WTW pH/ ION/ COND 750 pH meter (WTW GmbH, Weilheim, Germany). Soil conductivity was measured in a 1 : 5 (soil

: deionized water) using the same instrument. Available phosphorus (P) was extracted by the Resin method using Dowex 21 KCl anion exchange resin beads (Sigma Aldrich, USA). The Concentration of P was reads at wavelength 420nm on a Libra Biochrom SP80 UV Vis (Biochrom Ltd, UK) after adding equal amounts of ammonium vanadate and ammonium molybdate to the leachate. Available potassium (K) was extracted using neutral ammonium acetate and concentrations were determined using the appropriate cathode Lamp of a Varian Spectra AA50 (Varian Australia) atomic absorption spectrophotometer. Sodium (Na), calcium (Ca) and magnesium (Mg) were measured using Atomic Absorption Spectroscopy.

The data for plant growth characteristics (plant height, stem diameter and number of mature leaves) were recorded every month for 6 months and at 12 months after transplanting lemon seedlings. Growth parameters for mango seedlings were taken every month for 5 months and at 12 months after transplanting. Mortality in each media composition was also recorded. The investigation was done over three seasons and the mean was used for analysis. All the data was subjected to analysis of variance using GenStat 14th edition. Means were separated by the fishers protected at $p<0.05$, $p<0.01$ and $p<0.001$ level.

3. Results

3.1 Physical and Chemical Characteristics of the Potting Mixtures

Table 2 shows the physical and chemical properties of the different types of potting mixtures prepared. Media with cow dung had the highest EC 602 us/cm and media with leaf compost had the lowest value 262 uS/cm. The pH values of the media ranged from 6.63 to 7.22.

Table 2. Chemical characteristics for potting media evaluated

Mixing ratio	SOM	pH Cacl2	EC uS/cm	SAR	P_2O_5 Ppm	K Ppm	Ca Ppm	Mg Ppm	Na Ppm	BD g cm^{-3}
1:1:2	LC	6.68	247	0.567	236	495	2058	602	20.7	1.21
	CD	6.86	449	3.322	630	1195.2	2139	923	130	1.11
	B	6.94	270	0.029	584	717.7	1713	718	1	1.23
2:1:2	LC	6.96	262	0.030	530	572	2556	553	1.2	1.31
	CD	7.08	602	4.071	598	1418.5	1976	827	167.7	1.27
	B	7.17	446	0.363	660	1507.3	2112	866	14	1.19
3:1:2	LC	7.09	346	0.676	293	859	2587	599	2.7	1.25
	CD	7.22	593	3.857	680	1382	2257	743	149.4	1.19
	B	7.22	388	0.285	612	1273	2072	889	11	1.31
3:2:1	LC	7.14	272	0.073	279	617.8	2048	458	2.6	1.13
	CD	7.14	489	3.072	332	1050.2	1622	644	103.4	1.19
	B	7.02	283	0.023	336	609.6	1666	617	0.8	1.25

*NB SAR sodium adsorption ratio SOM source of organic media

3.2 Mango

3.2.1 Source of organic matter

Plant height, number of leaves and stem diameter for mango seedlings grown in potting mixtures containing bagasse and leaf compost were significantly higher. They were higher than those of the seedlings grown in media with cow dung at 12 months after transplanting (Table 3). Fig 1, Fig 2 and Fig 3 show the similar growth trend of the mango seedlings in mixtures that contain bagasse and leaf compost from transplanting to 6 months after transplanting. At 12 months after transplanting the stem diameter was ideal for grafting for mango seedlings growing in media with bagasse (0.96 cm) and leaf compost (0.89 cm). While the stem diameter of the seedlings in media with cow dung (0.55 cm) was significantly small. Mango seedlings grown in media containing leaf compost had significantly high root dry weight (25.8 g) and shoot dry weight (63.0 g). The root dry weight and shoot dry weight for seedlings raised media with bagasse was (17.2 g and 49.5 g) and cow dung (9.5 g and 34.0 g) respectively (Table 4).

Mortality rate was significantly higher (58%) in potting media with cow dung compared to media with bagasse (20.8%) and leaf compost (15%).

Table 3: Number of leaves (NL), plant height (PH), stem diameter (SD) and mortality (M) for mango and lemon seedlings at 12 months after transplanting

	Mango				Lemon			
Mixing ratio	NL	PH (cm)	SD (cm)	M %	NL	PH (cm)	SD (cm)	M %
1:1:2 (Sand: OM: Soil)	35.6 a	43.5 a	0.83 ab	33.3	26.7 ab	56.1	0.54	8.9
2:1:2 (Sand: OM: Soil)	28.7 bc	40.2 ab	0.73 b	33.3	24.8 b	55.9	0.50	10.0
3:1:2 (Sand: OM: Soil)	27.5 c	34.4 b	0.77 b	32.2	24.9 b	55.0	0.53	8.9
3:2:1 (Sand: OM: Soil)	34.3 ab	44.4 a	0.88 a	27.8	28.4 a	59.9	0.53	10.1
Significance	*	*	*	NS	*	NS	NS	NS
Source of organic matter								
Leaf compost	39.1 a	54.6 a	0.89 a	15.0 a	31.1 a	67.0 a	0.61 a	0.8 b
Cow dung	15 b	15 b	0.55 b	58.3 b	22.6 b	48.9 b	0.47 b	21.7 a
Bagasse	40.5 a	52.3 a	0.96 a	20.8 a	24.8 b	54.9 b	0.49 b	5.8 b
Significance	***	***	***	***	***	***	***	***
Potting mixtures								
A 1:1:2 (Sand: LC: soil)	42.7	60.4 a	0.98	13.3	34.1	72.0	0.69 a	0
B 1:1:2 (Sand: CD: soil)	19.9	12.6 c	0.55	63.3	22.4	46.7	0.43 d	20.0
C 1:1:2 (Sand: B: soil)	44.3	57.6 a	0.97	25.3	23.6	51.0	0.49 cd	6.7
D 2:1:2 (Sand: LC: soil)	38.5	55.4 a	0.84	13.3	30.5	67.7	0.61 ab	0
E 2:1:2 (Sand: CD: soil)	8.3	7.3 c	0.42	73.3	20.2	46.0	0.43 d	26.7
F 2:1:2 (Sand: B: soil)	39.4	58.0 a	0.93	13.3	23.7	55.0	0.47 cd	3.3
G 3:1:2 (Sand: LC: soil)	32.6	39.2 b	0.79	23.3	28.0	62.3	0.55 bc	0
H 3:1:2 (Sand: CD: soil)	12	22.0 c	0.58	43.3	22.1	51.0	0.53 bc	16.7
I 3:1:2 (Sand: B: soil)	37.8	42.1 b	0.93	30.0	24.4	53.5	0.50 c	10.0
J 3:2:1 (Sand: LC: soil)	42.6	63.3 a	0.96	13.3	31.8	67.3	0.60 ab	3.3
K 3:2:1 (Sand: CD: soil)	19.9	18.1 c	0.65	53.3	25.7	53.0	0.48 cd	23.3
L 3:2:1 (Sand: B: soil)	40.4	51.7 a	1.02	16.7	27.6	59.3	0.52 bc	3.3
Mean	31.5	40.0	0.8	31.7	26.2	56.7	0.52	9.4
Significance	NS	**	NS	NS	NS	NS	*	NS

Means in the same column followed by a common letter are not significantly different ($p<0.05$) *, ($P<0.01$) ** and ($P< 0.001$) ***

3.2.2 Mixing ratio

Significant differences in the growth of the mango seedlings were observed in the different mixing ratios. Seedlings in mixing ratios 1 : 1 : 2 and 3 : 2 : 1 (sand: organic media: soil) had taller seedlings 43.5 cm and 44.4 cm, more number of leaves 35.6 and 34.3 and bigger stem diameter 0.83 cm and 0.89 cm respectively at 12 months. These mixing ratios had a higher percentage of organic matter.

Table 4. Mango and lemon root dry weight, shoot dry weight and root: shoot ratio at 12 months

	Mango			**Lemon**		
Mixing ratio	Root dry weight (g)	Shoot dry weight (g)	Root: shoot ratio	Root dry weight (g)	Shoot dry weight (g)	Root: Shoot ratio
1:1:2 (Sand: OM: Soil)	20.7	54.7	0.37	13.2	18.8	0.71 a
2:1:2 (Sand: OM: Soil)	13.1	34.4	0.44	15.6	24.3	0.65 b
3:1:2 (Sand: OM: Soil)	20.0	56.2	0.32	12.0	19.4	0.60 b
3:2:1 (Sand: OM: Soil)	16.2	50.0	0.32	15.9	24.8	0.64 b
Significance	NS	NS	NS	NS	NS	**
Source of organic matter						

Leaf compost	25.8 a	63.0 a	0.46	16.1 a	22.0 ab	0.74 a
cow dung	9.5 c	34.0 b	0.34	9.17 b	16.5 b	0.55 c
Bagasse	17.2 b	49.5 a	0.35	17.17 a	27.0 a	0.65 b
Significance	***	**	NS	***	**	***
Potting mixtures						
A 1:1:2 (Sand: LC: sand)	31.3	70.0	0.44	18.0	22.3	0.82
B 1:1:2 (Sand: CD: sand)	10.8	38.7	0.27	10.0	17.0	0.6
C 1:1:2 (Sand: B: sand)	20.7	55.0	0.39	11.7	17.0	0.72
D 2:1:2 (Sand: LC: sand)	18.7	98.0	0.41	13.0	17.7	0.76
E 2:1:2 (Sand: CD: sand)	9.3	22.7	0.57	10.3	17.7	0.59
F 2:1:2 (Sand: B: sand)	11.3	32.1	0.35	23.3	37.7	0.61
G 3:1:2 (Sand: LC: sand)	36.0	80.7	0.45	16.7	23.7	0.71
H 3:1:2 (Sand: CD: sand)	8.0	32.0	0.26	6.0	12.3	0.50
I 3:1:2 (Sand: B: sand)	16.0	56.0	0.27	13.3	22.3	0.60
J 3:2:1 (Sand: LC: sand)	17.3	53.3	0.32	17.0	24.3	0.70
K 3:2:1 (Sand: CD: sand)	10.7	42.7	0.24	10.3	19.0	0.54
L 3:2:1 (Sand: B: sand)	20.7	54.0	0.38	20.3	31.0	0.67
Mean	17.5	48.8	0.36	14.17	21.8	0.65

Means in the same column followed by a common letter are not significantly different ($p<0.05$) *, ($P<0.01$) ** and ($P< 0.001$) ***

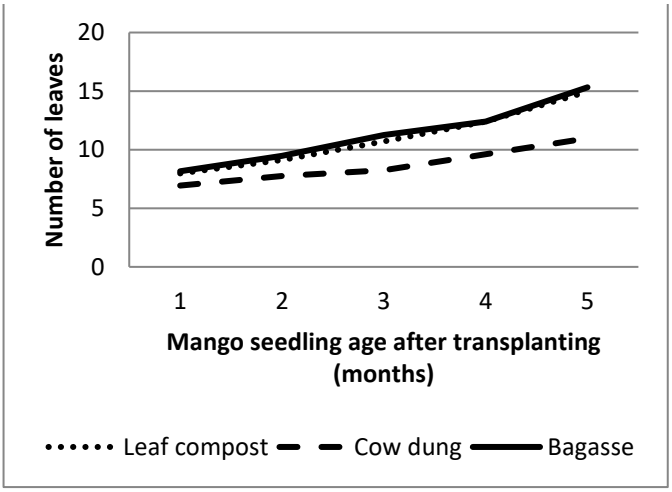

Fig.1 Changes in number of leaves during the growth of mango seedlings in three types of organic media

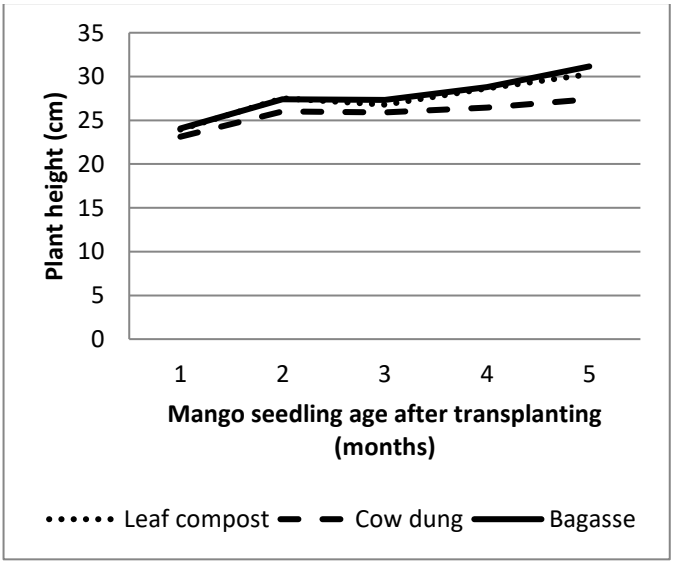

Fig.2 Changes in plant height during the growth of mango seedlings in three types of organic media

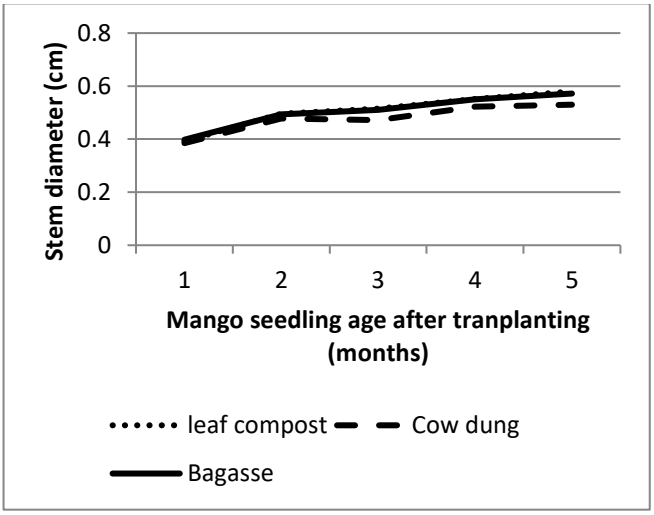

Fig.3 : Changes in stem diameter during the growth of mango seedlings in three types of organic media

3.3 Lemon

3.3.1 Source of organic mater

Significant differences in plant height, number of leaves and stem diameter were observed among all the sources of organic matter at 12 months after transplanting the lemon seedlings Table 3. Potting media with leaf compost outperformed bagasse and cow dung .The tallest seedlings were the ones in the mixtures containing leaf compost (67 cm) followed by bagasse (54.9 cm) and lastly cow dung (48.8 cm). The stem diameter of seedlings in leaf compost (0.61 cm) was significantly bigger than the stem diameter of seedlings grown in media containing bagasse (0.49 cm) and cow dung (0.47 cm). The number of leaves for the seedlings in media containing leaf compost (32.1) was significantly higher than the number of leaves for seedlings grown in media with bagasse (24.8) and cow dung (22.6).

A significantly high mortality was observed in seedlings grown on media with cow dung (21.7%) compared to leaf compost (0.8%) and bagasse (5.8%). The results indicate that electrical conductivity of media with cow dung was very high.

Fig 4, Fig 5 and Fig 6 show that lemon seedlings grown in potting media containing bagasse grew faster compared to those grown in media with leaf compost and cow dung from transplanting to 6 months after transplanting. At 12 after transplanting the seedlings in leaf compost were significantly bigger than the seedlings grown in media with bagasse Table 3.

The root dry weight and shoot dry weight for lemon seedlings grown in media containing bagasse and leaf compost were not significantly different. The root : shoot ratio for lemon seedlings grown in media with leaf compost (0.74) was significantly higher than bagasse (0.65) and cow dung (0.55).

3.3.2 Mixing ratio

Lemon seedlings grown in the 3 : 2 : 1 and 1 : 1 : 2 (sand: organic matter: soil) mixing ratio had a significantly higher number of leaves 28 and 27 respectively than mixing ration of 2 : 1 : 2 (24.8) and 3 : 1 : 2 (24.9). Mixing ratio of 1 : 1 : 2 (sand: organic media: soil) had a significantly high root shoot ration (0.71).

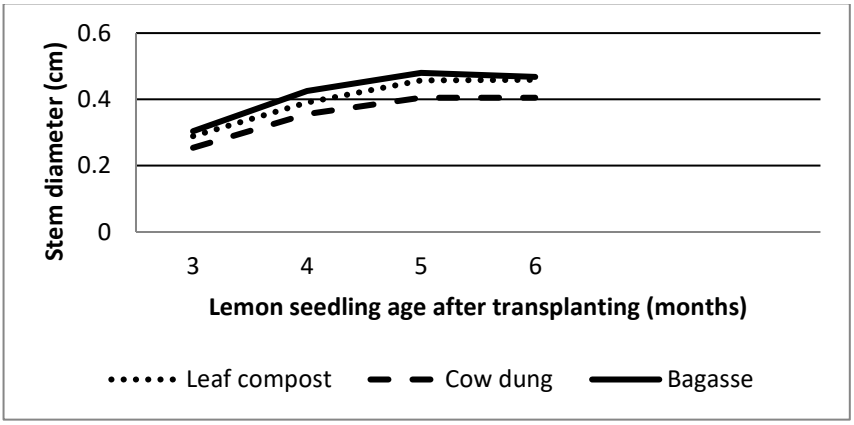

Fig.4: Changes in stem diameter during the growth of lemon seedlings in three types of organic media

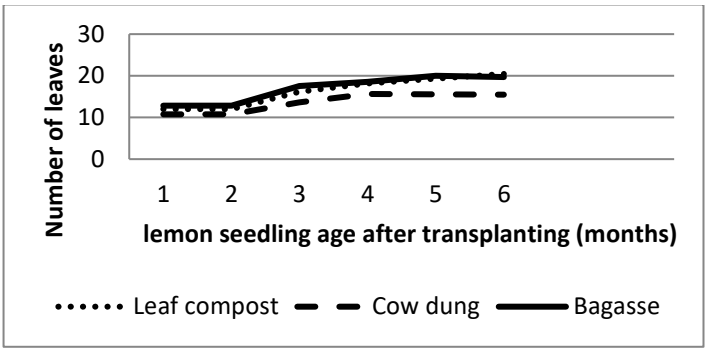

Fig. 5: Changes in number of leaves during the growth of lemon seedlings in three types of organic media

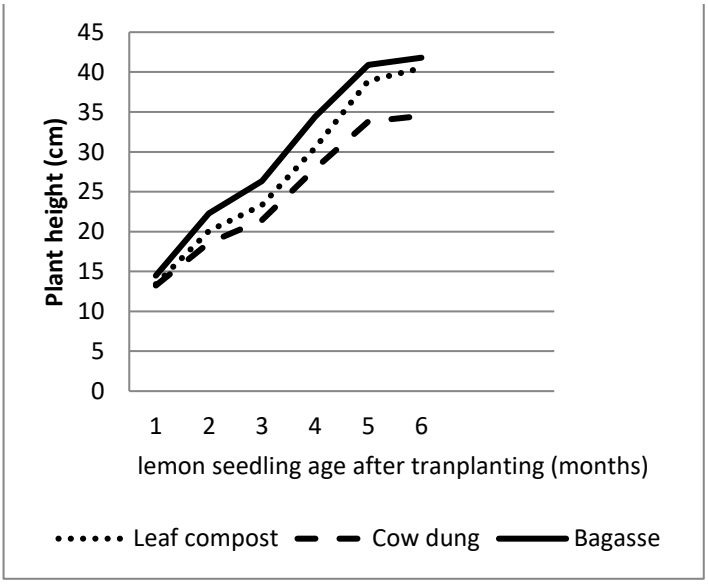

Fig.6: Changes in plant height during the growth of lemon seedlings in three types of organic media

4. Discussion

The high EC for media with cow dung was a result of the high levels of sodium relative to the other media containing bagasse and leaf compost. Cattle in the lowveld feed on the sweet velds which usually have a high nutritive value but with high level of salt because the soils are very fertile. These salts may inhibit biological activity because salinity represents the main factor limiting plant growth (Bustamante et al., 2008). The recommended EC level for growing media is <550 uS/cm (Robbins and Evans 2013). The results indicate that electrical conductivity of media with cow dung was very high (Khan et al., 2006) also observed poor plant growth in media combinations that had high values of EC in lemon seedlings. Robbins and Evan (2013) also stated that manure has the disadvantage of possible high salts although it is rich in other nutrients.

Most of the pH values for the potting mixture were within the desirable range 5.5 to 7.0 recommend for general nursery plant media (Chong 2005). Haq et al., (2017) also observed that bagasse was a good source of organic matter for growing mango rootstock seedlings.

The best mixing ratios for both mango and lemon seedling had a higher percentage of organic media. Mixing ratio of 1 : 1 : 2 (top soil: organic media: sand) with 25% organic media and 3 : 2 : 1 33% organic media.

More leaf number for the mango and lemon seedlings implies larger total leaf surface area with higher stomatal density for efficient photosynthesis. This promotes production of a greater biomass hence the growth of the seedlings. The ideal stem diameter for grafting mango seedlings is pencil thickness about 0.7 cm and long internodes. Tall seedlings have longer internodes and have a better success when grafting and budding. The mango seedling growing in media containing bagasse and leaf compost were ready for grafting at the same time. Citrus seedlings growing in media with leaf compost were ready for budding earlier than those growing in media with bagasse or cow dung.

5. Conclusions

Source of organic matter affects the growth of mango and citrus seedlings. Bagasse and leaf compost encourage fast growth of mango seedlings. Citrus seedlings grow faster in media with leaf compost than in media with bagasse or cow dung. Cow dung had high levels of salts which led to a high mortality rate for both mango and citrus seedlings. The salts also caused slow growth of both mango and citrus seedlings. Mango seedlings are more sensitive to high levels of salts compare to citrus seedlings. Lemon rootstock seedlings grow better in media with a mixing ratio of 1 : 1 : 2 (sand : organic matter : soil). Mango rootstock seedlings grow well when the mixing ratio is either 1 : 1 : 2 or 3 : 2 : 1.

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