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Effect of commercial growing media on emergence, growth and development of tomato seedlings

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Abstract

Commercial growth media were evaluated for their effect on tomato (*Lycopersicon esculentum* L.) seedling emergence, growth and development in 80% net shade house at Botswana University of Agriculture and Natural Resources from March-April 2015. Three locally available commercial growth media (germination mix, cocopeat and hygromix) were used. A completely randomized design (CRD) with four repetitions was used. Tomato seeds were sown on 200 cells styrofoam seedling trays to evaluate seedling emergence. Thereafter, the following growth and development parameter were measured; leaf number and area, plant height, fresh and dry masses. Data was subjected to analysis of variance (ANOVA). Results revealed no significant differences ($p>0.05$) in seedling emergence among the three growing media for the entire study period. However, hygromix gave superior absolute numbers compared to other two growth media. Hygromix also gave significantly ($p<0.01$) larger leaves and taller seedlings than germination mix and cocopeat whereas, no significant difference was observed on shoot fresh and dry masses. Growing media had no significant influence on seedling emergence rate although hygromix sown seeds still emerged relatively faster than the other media. Growers must pay attention to details when selecting the medium to use. Therefore, hygromix and to some extent germination mix are recommended as the most desirable growing media for raising tomato seedlings.

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Introduction

Tomato (*Lycopersicon esculentum* L.) is member of the Solanaceae family that is grown world-wide (Sharma and Singh, 2015). It originated from the Andean zone (Peru-Ecuador-Bolivian area) (Salunkhe *et al*., 1987) but its first cultivation was in Mexico (Uddain *et al*., 2009). Tomato is one of the most popular and widely grown commercial vegetable crops in the world (Sharma and Singh, 2015; Isack and Lyimo, 2015). Tomato fruits are consumed fresh or processed (Eivazi *et al*., 2013, Shereni *et al*., 2015) and are a source of minerals and vitamins (Wilcox *et al*., 2003; Perkins-Veazie *et al*., 2007; Uddain *et al*., 2009; Eivazi *et al*., 2013). The red fruit contain lycopene, a carotenoid that helps to prevent cardiovascular diseases and cancers (Giovannucci, 1999; Giovannucci *et al*., 2002; Perkins-Veazie *et al*., 2007).

Seedling production is an important step in the horticultural production system because it influences the final crop yield. Growing media is a major factor that influences seed germination, seedling emergence, seedling growth and quality of seedlings in a nursery (Corti *et al*., 1998; Wilson *et al*., 2001; Baiyeri, 2004; Sahin *et al*., 2005; Agbo and Omaliko, 2006; Baiyeri and Mbah, 2006; Bulut and Demir, 2007; Aklibasinda *et al*., 2011; Unal, 2013). The quality of the growing media used in containerized seedling production is largely influenced by physical, chemical and biological properties (Wilson *et al*., 2001; Grigatti *et al*., 2007; Herrera *et al*., 2008), the growing environment and plant management (Nwofia and Okwu, 2015). Growing media is not only a place where seeds are sown and seedlings raised, but is also a source and reservoir of plant nutrients (Indriyani *et al*., 2011). It also anchors the root system and therefore supports the plant (Abad *et al*., 2005). A good growing media should be composed of mixtures that are tender enough for seeds to easily germinate, retains moisture, drains excessive water and provide sufficient plant nutrients for seedling growth and development (Abad *et al*., 2002; Bilderback *et al*., 2005; Olle *et al*., 2012; Olaria *et al*., 2016).

Several growth media had been evaluated on various plants by previous researchers (Atiyeh *et al*., 2000; Manenoi *et al*., 2009; Indriyani *et al*., 2011; Bhardwaj, 2013; Kumar *et al*., 2016). A wide range of growth media or substrates of different origin are used in vegetable production. Some media are of natural origin while others are produced artificially in factories (Verdonck *et al*., 1982; Olle *et al*., 2012; Bhat *et al*., 2013). Growth media can include organic materials such as peat, compost, tree bark, coconut fiber, vermicompost, rice husk ash, or inorganic materials such as perlite and vermiculite (Grunert *et al*., 2008; Nair *et al*., 2011; Vaughn *et al*., 2011). The growth media from organic materials are usually used in greenhouses to produce bedding plants and vegetable transplants (Atiyeh *et al*., 2000). Mineral soil or sand is also used for growing vegetable (Olle *et al*., 2012; Mathowa *et al*., 2014a) and tree seedlings (Sekepe *et al*., 2013; Mathowa *et al*., 2014b; Mathowa *et al*., 2014c). Growth media provide aeration and water, enhance root growth and physically support the plant (Olle *et al*., 2012). Organic media such as vermicompost are recommended as the best media for enhancing seedling growth (Atiyeh *et al*., 2002; Canellas *et al*., 2002; Hashemimajd *et al*., 2004; Hidalgo *et al*., 2006; Arancon *et al*., 2008).

Studies show that a high proportion of the hydroponic industry uses inorganic growing media such as vermiculite and others (Böhme *et al*., 2001; San Bautista *et al*., 2005; Böhme *et al*., 2008), whereas approximately 12% uses organic growing media (Donnan, 1998) such as peat, bark, leaf mould, sawdust and others (Olle *et al*., 2012). Commercial mixtures are often used because they are sterilized, ready to use and may even contain some fertilizer (Hochmuth *et al*., 1996). Most of the materials that make up the commercial mixtures of growth media are usually cheap and or recycled material. However, both inorganic and organic derived media can have adverse effect on overall performance of seedlings. The aim of this study was to evaluate the effect of locally available commercial mixtures on tomato seedling emergence, growth and development.

Materials and methods

Description of study site

The study was conducted in an 80% net shade house at the Botswana University of Agriculture and Natural Resources (BUAN), Sebele campus. The campus is located between latitude 24°33'S and longitude 25°54'E and elevated 994 m above sea level.

Experimental design, sampling and planting

The study was laid out in a completely randomized design (CRD) with three treatments (commercial growth media) repeated four times. The three commercial growth media were germination mix [New Frontiers (Pty) Ltd., Lobatse, Botswana], cocopeat [Galuku Africa (Pvt) Ltd., Port Elizabeth, South Africa] and hygromix [Hygrotech (Pty) Ltd., Pretoria North, South Africa] being treatments one to three respectively. Tomato seeds of moneymaker variety [Starke Ayres (Pty) Ltd., Gauteng, South Africa], were sown one in each plug/cell into 200 cells styrofoam seedling trays [Plasgrow (Pty) Ltd., Mpumalanga, South Africa] filled with the different growth media. Seedling emergence was determined on all the 200 cells of a tray. Thereafter, growth and development parameters were measured using twenty five (25) randomly tagged seedlings from each repetition throughout the study.

Cultural practices

Seedlings were watered in the morning and afternoon throughout the duration of the study. Water soluble multifeed P ® 5:2:4 (43) fertilizer [Plaaskem (Pty) Ltd., Witfield, South Africa] was applied daily with afternoon watering after development of true leaves to boost the seedlings. Seedlings were also scouted daily for incidences of pests and diseases.

Measured parameters

Seedling emergence was determined cumulatively by counting daily after sowing. Similarly, leaf number was measured cumulatively weekly after development of true leaves whereas plant height was measured quantitatively using a 30 cm ruler from the base to the terminal leaf. At termination, ten (10) fully expanded leaves were randomly sampled from each repetition and their leaf area was measured using leaf area meter- A3 light-box (Delta-T Devices Ltd., Cambridge, England). All tagged seedlings were harvested and placed into weighing brown paper bags for determination of fresh and dry weights using an electronic balance- PGW 4502e [Adam®, Smith-Hamiltom, Inc., Miami Florida, US]. The samples were oven dried to constant weight at 80°C using a hot air oven- Scientific Series 2000 [Laval Lab, Inc., Laval (Quebec), Canada].

Data analysis

Data was subjected to analysis of variance (ANOVA) using Analytical Software (2003). Where a significant F-test was used and means comparison tests carried out using Least Significant Difference (LSD) at $p \leq 0.05$.

Results and discussion

Seedling emergence

Growing media influences seed germination and succeeding emergence and growth of seedlings in a nursery (Baiyeri and Mbah, 2006) because it is a reservoir of moisture and plant nutrients (Grower, 1987). In addition, it influences the performance of seedling before they are transplanted in the field (Adediran, 2005). In this study, seedling emergence was measured on different growing media in plug seedling trays. Results show no significant differences ($p>0.05$) in seedling emergence among the three growing media from day 4 to day 16 (Fig. 1). The non-significant difference is probably due to similarities in the physical characteristics of the media used. However, hygromix revealed superior absolute numbers compared to cocopeat and germination mix. The observed superiority exhibited by the hygromix could probably be attributed to its good physical properties and water holding capacity that supported the germination of tomato seedlings. The non-significant effect of growing media observed in the study could probably be explained by Diaz-Zorita *et al.* (2005) and Cernac *et al.* (2006) who reported that germination and seedling emergence is not only dependent of soil nutrient status, but rather totally dependent on the attachment of cotyledons to the

emerging seedling to supply food until the seedling becomes autotrophic and able to use food reserves. According to Bruckner (1997) and Nkongolo and Caron (1999), the relative balance between air and water in a growing media's pore space is critical for seed germination and plant growth which is probably a characteristic to the growing media used in this study. Studies elsewhere show that physicochemical properties of a growth media are influenced by the base materials used in their formulation (Wilson *et al*., 2001; Sahin *et al*., 2005).

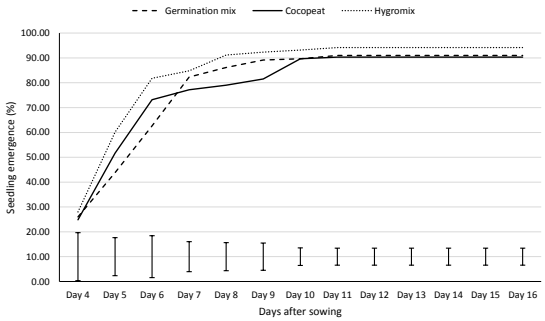

Fig. 1. Effect of commercial growing media on tomato seedling emergence.

Vertical bars are LSD values (p≤0.05). Differences between means within the LSD value are not significantly different. Where Day 4 to Day 16 are dates from 23 March to 4 April 2015.

Leaf number and area

Studies using soilless growing media have been performed on plants (Papafotiou *et al*., 2004; Grigatti *et al*., 2007; Arancon *et al*., 2008; Chavez *et al*., 2008; Nazari *et al*., 2009; Mehmood *et al*., 2013). Significant differences were revealed in the number of leaves per plant among the growing media in the first three weeks of this study (Table 1). Hygromix and germination mix produced seedlings with significantly more leaves than cocopeat. Awang *et al.* (2009) reported that cocopeat holds too much water which affects aeration and this could have choked the seedlings in the present study as evidenced by the delayed development of true leaves. This was followed by a non-significant treatment effect in week 3 among growing media. However, over time the number of leaves increased in each growing media starting from week 3. The linearity of increase in the number of leaves among the growing media could probably be due to the fact that seedlings were still in vegetative growth phase. The present findings are in agreement with studies conducted elsewhere using other plants which reported no significant effect of growing media on the number of leaves (Dolor, 2011; Khattak *et al*., 2011).

Table 1. Influence of commercial growing media on leaf number and area of tomato seedlings.

Growing media	Weeks after development of true leaves				
	Number of leaves				Leaf area (cm²)
	Week 1	Week 2	Week 3	Week 4	Week 4
Germination mix	8.15^{a}	11.80^{a}	17.93^{ab}	24.57	44.75^{b}
Cocopeat	0.00^{b}	7.75^{b}	15.65^{b}	21.65	31.70^{b}
Hygromix	8.63^{a}	12.33^{a}	21.47^{a}	25.05	62.67^{a}
Significance	**	**	*	ns	**
LSD (0.05)	2.36	2.03	4.19	ns	13.51
CV (%)	21.10	9.84	11.42	9.09	14.58

**highly significant at p<0.01, * significant at p<0.05, ^{ns} non-significant at p>0.05. Means separated by Least Significant Difference (LSD) Test at p≤0.05. Means within columns followed by the same letters are not significantly different. Where week 1 to week 4 are dates from 23 March to 19 April 2015.

At termination, seedlings grown in hygromix had highly significant larger leaves than those grown in germination mix and cocopeat (Table 1). It is most likely that hygromix provided seedlings with better physicochemical properties for growth over time.

Plant height

A good growing media anchors or supports the plant and serves as reservoir for nutrients and water, allow oxygen diffusion to the roots and gaseous exchange between the roots and atmosphere outside the root

substrate (Richards *et al*., 1986; Argo, 1998a; Argo, 1998b; Abad *et al*., 2002). Growing media significantly affected the growth of tomato seedling height in this study (Table 2). A highly significant ($p<0.01$) treatment effect was revealed for plant height from weeks 1-4. In week 1, hygromix mix produced seedlings that were significant taller that the other two growing media. However, seedlings grown in the germination mix were significantly taller than those grown in cocopeat in week 1. From weeks 2-4, seedlings grown in germination mix and hygromix were significantly ($p<0.01$) taller than cocopeat. According to Abad *et al*. (2002) and Awang *et al*. (2009) cocopeat is a good growth media with acceptable pH, electrical conductivity and other chemical attributes. However, it holds too much water which affects aeration within the growth media, thus affecting the oxygen diffusion to the roots which probably occurred in this study.

Table 2. Influence of commercial growing media on plant height of tomato seedlings.

Growing media	Plant height (cm)- weeks after development of true leaves			
	Week 1	Week 2	Week 3	Week 4
Germination mix	6.42[b]	12.35[a]	22.32[a]	24.16[a]
Cocopeat	0.00[c]	6.50[b]	13.77[b]	15.32[b]
Hygromix	8.89[a]	16.06[a]	24.61[a]	26.75[a]
Significance	**	**	**	**
LSD (0.05)	1.75	3.71	3.34	3.79
CV (%)	15.96	8.12	8.12	8.60

** Highly significant at $p<0.01$. Means separated by Least Significant Difference (LSD) Test at $p\leq0.05$**.** Means within columns followed by the same letters are not significantly different. Where week 1 to week 4 are dates from 23 March to 19 April 2015. [ns] non-significant at $p>0.05$.

Shoot weight

There were no significant differences in shoot weight among the treatments (Table 3). However, hygromix revealed superior shoot weight than the other two growing media. The fresh weight varied from 0.62 to 0.87 g for cocopeat, germination mix and hygromix respectively. Dry seedling weight ranged between 0.41 and 0.51 g. These findings are in agreement with Sekepe *et al*. (2013) who reported that *Cassia abbreviata* seedlings fresh and dry weights were not affected by growth media.

Table 3. Influence of commercial growing media on shoot weights of tomato seedlings.

Growing media	Shoot weights (g)	
	Fresh weight per 100 seedlings	Dry weight per 100 seedlings
Germination mix	0.76	0.41
Cocopeat	0.62	0.46
Hygromix	0.87	0.51
Significance	ns	ns
LSD (0.05)	ns	ns
CV (%)	15.03	20.37

Conclusion

Growing media had no significant effect on seedling emergence, however growers should select growing media which can sustain growth and development of the seedlings. Therefore, hygromix and to some extent germination mix are recommended as the most desirable growing media for raising tomato seedlings as they gave better performance.

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