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Effect of growing media on growth and development of sweet paper (*Capsicum annum* L.) seedlings

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Abstract

This study was carried out at Botswana University of Agriculture and Natural Resources (BUAN) formerly Botswana College of Agriculture (BCA) under an 80% net shade to investigate the effect of growing media comprising cocopeat, hygromix and germination mix on growth and development of sweet pepper (*Capsicum annum* L.) seedlings. The experiment was set up in a completely randomized design (CRD) with each treatment (growing medium) replicated four times. Growth parameters measured were; seedling emergence, plant height, leaf number and area, and seedling biomasses (both fresh and dry). Seedling emergence from hygromix and germination mix was significantly (P<0.05) higher than cocopeat in the first 15 days whereas a non-significant (P>0.05) treatment response was observed from day 16 to 20 across treatments. Plant height, leaf number and area, and seedling biomasses were significantly (P<0.01) higher in hygromix and germination mix as compared to cocopeat with hygromix revealing superior performance than germination mix. Hygromix and germination mix can be used to propagate sweet pepper because they enhanced seedling emergence, growth and development. Seedlings emerged in cocopeat, but the seedlings remained stunted suggesting that the medium needs further investigation on how it can sustain seedling growth and development.

Key words: *Capsicum annum,* growing media, seedling emergence, growth and development.

Introduction

Sweet pepper (*Capsicum annum* L.) belongs to the family Solanaceae (Arancon *et al.,* 2010). It is a small shrub growing up to 2 m high, with white flowers most often one per node and short calyx teeth that rarely exceeds 0.5 mm (Torres-Quezada, 2012). Members of this family are known for their versatility as vegetable crops consumed fresh or dehydrated for spice (Arancon *et al.,* 2010). The genus Capsicum is native to the tropics of northern Latin America (Torres-Quezada, 2012). Sweet pepper is one of three important Solanaceae vegetable crops grown for their vitamin C rich fruits (El-Sayed *et al.,* 2015). The pepper crops are popular because of their colour, taste and nutritional value (Pérez-López *et al.,* 2007).

Seedling production is an important step that influences crop yield in vegetable production systems. The growing media play a critical role in the propagation of vegetable seedlings in nurseries and greenhouses because they provide water, air, nutrients and also support plants. To enhance uniform germination and seedling development in vegetable production systems, it is important to use growing medium with appropriate physical and chemical properties. A variety of growing media produced from different sources are used in the production of vegetables worldwide (Mathowa *et al.,* 2016). Some are natural in origin and others are produced artificially in factories (Verdonck *et al*., 1982; Olle *et al.*, 2012; Bhat *et al.*, 2013). Growing media used in the production of seedlings in nurseries include organic materials such as peat, tree bark, compost, coconut fiber, vermicompost, rice hush ash or inorganic materials such as perlite or vermiculite (Grunert *et al.*, 2008; Nair *et al.*, 2011; Vaughn *et al.*, 2011). These growing substrates consist of either a single component or mixtures which support plants by providing water, air and nutrients (Abad *et al.*, 2002; Bilderback *et al.,* 2005; Yilmaz *et al.,* 2014; Olaria *et al.,* 2016; Oagile *et al.,* 2016). However, different growing media vary greatly in composition, particle size, pH, aeration and ability to hold water and nutrients (Oagile *et al.*, 2016).

The demand for vegetable seedlings in recent years has led to a wider use of containers and substrates (Guzmán and Sánchez, 2003). Various studies have shown that seed germination, seedling emergence, development and quality of horticultural crops depend on the quality of the growing media (Corti *et al.*, 1998; Wilson *et al.*, 2001; Sahin *et al.*, 2005; Agbo and Omaliko, 2006; Baiyeri and Mbah, 2006; Aklibasinda *et al.*, 2011; Bhardwaj, 2014). Commercial substrates are used in raising vegetable seedlings worldwide (Rodriguez *et al.,* 2006). These substrates have advantages over soil which include, water and fertilizer use efficiency enhanced by their good water holding capacity (Jensen, 1997; Rodriguez *et al.,* 2006) and reduced populations of soil-borne pathogens (Louvet, 1982; Gullino and Garibaldi, 1994; Riviere and Caron, 2001; Rodriguez *et al.,* 2006); thus lowering costs associated with the use of soil fumigants (Rodriguez *et al.,* 2006).

Using containers to propagate vegetable seedlings is important because they improve plant growth and productivity (Leskovar *et al.,* 1990) but requires a substrate with desirable traits. Therefore, selecting a suitable growing medium is one of the most important considerations when raising containerized seedlings in a nursery (Jacobs *et al.,* 2009). The selected growing medium should have sufficient nutrient, hold water and provide good aeration to the plant root system (Biondo and Noland, 2000). The medium should be light in weight for easy handling, filling of containers by nursery workers and provide a better environment that is not offered by the soil (Bilderback *et al.,* 2005; Mastouri *et al.,* 2005). The choice of medium to use in containerized seedling production is also largely influenced by costs which may not be a suitable assessment tool (Oagile *et al.,* 2016). Information on the performance of sweet pepper seedlings propagated in some locally available commercial growing media is lacking in Botswana. Therefore, it is necessary to identify suitable growing media that enhance uniform emergence, growth and development of sweet pepper seedlings. The aim of this study was to evaluate response of sweet pepper seedlings to some locally available commercial growing media.

Materials and methods

Study site: The study was carried out at the Botswana University of Agriculture and Natural Resources (BUAN) formerly Botswana College of Agriculture (BCA), Sebele campus under 80% net shade house during March to May, 2015. The University campus is located between latitude 24°33'S and longitude 25°54'E and elevated 994 m above sea level.

Experimental layout, design and cultural practices: Sweet pepper seeds [(California wonder variety) Starke Ayres (Pty) Ltd., Mpumalanga, South Africa] were sown singly in 200 plugs styrofoam seedling trays filled with the different commercial growing media (treatments) *viz.*, hygromix [Hygrotech (Pty) Ltd., Pretoria North, South Africa; wwww.hygrotech.co.za], germination mix [New Frontiers (Pty) Ltd., Lobatse, Botswana] and cocopeat [Galuku Africa (Pvt) Ltd., Port Elizabeth, South Africa]. The experiment was laid out in a completely randomized design (CRD) with the three growing media treatments replicated four times. Seedlings were irrigated in the morning and afternoon until termination of experiment. Fertilizer, multifeed P ® 5:2:4 (43) [Plaaskem (Pty) Ltd., Witfield, South Africa] was applied daily with afternoon watering after development of true leaves. Pests and diseases were scouted daily to allow timely arrest of any outbreaks.

Data collection and analysis: Data collected comprised of seedling emergence, growth and development parameters [plant height, leaf number and area, and plant biomasses (both fresh and dry)]. Seedlings emergence was measured cumulatively on daily basis by counting any emerging seedlings from the 200 plugs per tray until a constant reading. Twenty five seedlings in the middle of each tray were tagged for growth and development parameters (plant height and leaf number) measurements which commenced after development of true leaves and continued weekly until termination of experiment (approximately seven weeks duration). Plant height was measured from base of plant to the shoot tip and leaf number determined by counting fully opened leaves. At the end of the experiment, all twenty five tagged plants were harvested and placed in brown paper bags for leaf area and plant biomass determination. Plant fresh weight was determined immediately after harvest using an electronic balance - PGW 4502e (Adam®, Smith-Hamilton, Inc., Miami Florida, US; www.adamequipment.com) and leaf area measured using leaf area meter-A3 light-box (Delta-T Devices Ltd., Cambridge, England). The same 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 collected was subjected to analysis of variance (ANOVA) using Analytical Software (2003). Where a significant *f* test was observed, separation of means was carried out using Least Significant Difference (LSD) at $P \leq 0.05$.

Results and discussion

Seedling emergence: The percent seedling emergence findings in the present study show that the seedlings emerged nine days after seed sowing (Fig. 1). There was no significant differences in seedling emergence between the germination mix and hygromix although the later exhibited superior performance from day 9 to 15, whereas, seedling emergence in coconut peat was significantly (P<0.05) lower than the other media for the same period. The non-significant differences in seedlings

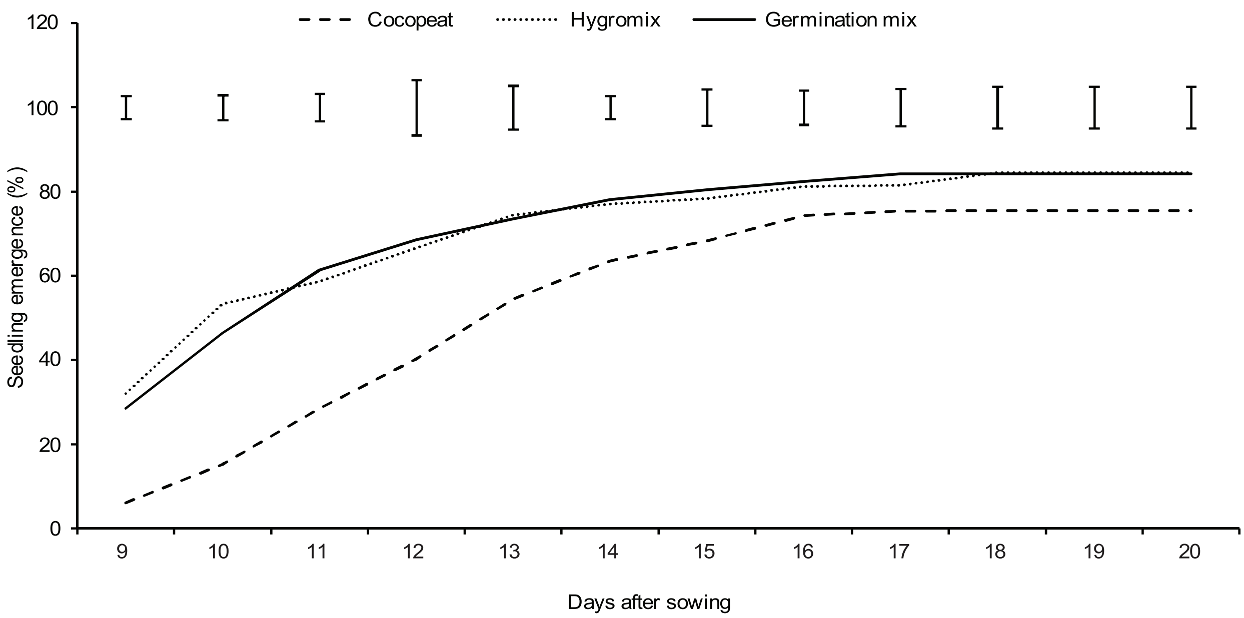

Fig. 1. Effect of growing media on sweet pepper seedling emergence. Vertical bars are LSD values ($P \leq 0.05$). Differences between means within the LSD value are not significantly different. Where day 9 to 20 are dates from 29 March to 09 April, 2015.

emergence observed between the two growing media could be due to similarities in their physical characteristics as reported in other studies (Mathowa *et al.,* 2016; Oagile *et al.,* 2016). The high seedling emergence observed in the germination mix and hygromix up to day 15 could also probably be attributed to the fact that the growing media possess good physical and chemical properties that enhanced seedlings emergence. Seed germination is influenced by different factors that include type of growing media and environmental factors such as oxygen, nutrient and water availability, temperature and light (Baiyeri and Mbah, 2006). Growing media determines seed germination, seedling emergence, growth and quality of transplanted plant. A suitable growing medium for raising seedlings should have suitable physical and chemical properties.

Overall, there were no significant differences in seedling emergence among the growing media from day 15 until at termination of the study (Fig. 1). The germination mix and hygromix reached the highest minimum prescribed 80% emergence by day 15 and 16 respectively. In agreement with the present study, Adediran (2005) recorded 95% seedling emergence with hygromix one week after sowing and attributed the performance to the slightly acidic nature of the medium. Oagile *et al.* (2016) reported 80% kale seedling emergence in the hygromix six days after seed sowing. Although no statistical differences were recorded amongst the three growing media, germination mix and hygromix had superior absolute numbers and this is attributed to their good physical and chemical properties. According to Abad *et al.* (2002) and Awang *et al.* (2009) a suitable medium should anchor or support the plant, serve as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate. The growing media's physiochemical properties such as electrical conductivity, cation exchange capacity, water retention capacity and bulk density influence plant growth and development (Bilderback *et al.,* 2005; Ghehsareh *et al.,* 2011).

Seedling height: The findings show that seedling height was significantly (P<0.01) affected by growing media (Table 1) but there were no statistical differences in sweet pepper seedling height between germination mix and hygromix from week one to two. However, from week three to four, seedlings grown in hygromix were significantly (P<0.01) taller than their germination mix counterparts. At week three, seedlings grown in hygromix had attained a height of 108.07 mm generally considered suitable for transplanting and transporting (Oagile *et al.,* 2016). At termination (week four), seedlings grown in hygromix had attained a height of 130.27 mm compared to 99.83 mm recorded in germination mix. The hygromix probably provided sufficient support to plants and allowed gaseous exchange between the rhizosphere and atmosphere as reported in other studies (Argo and Biernbaum, 1997; Oagile *et al.,* 2016). It is also possible that the vigorous and fast growth of seedlings in hygromix was enhanced by the good water holding capacity and nutrients supplied by the medium.

Table 1. Effect growing media on sweet pepper seedling height (mm, weeks after development of true leaves)

Growing media	Plant height			
	Week 1	Week 2	Week 3	Week 4
Cocopeat	0.00^b	0.00^b	0.00^c	0.00^c
Hygromix	41.00^a	74.33^a	108.07^a	130.27^a
Germination mix	35.37^a	56.77^a	77.63^b	99.83^b
Significance	**	**	**	**
LSD (0.05)	13.37	20.49	22.81	20.42
CV (%)	26.30	23.47	18.44	13.33

**Highly significant at P<0.01. Means separated by Least Significant Difference (LSD) Test at $P \leq 0.05$. Means within columns followed by the same letters are not significantly different. Where, week 1 to week 4 are dates from 11 April to 8 May, 2015.

Prior studies show that cocopeat is being used as environmentally friendly substitute for peat in soilless growing media for containerized plants in recent years (Evans and Stamps, 1996; Stamps and Evans, 1997, 1999; Offord *et al.,* 1998; Noguera *et al.,* 2000; Kumarasinghe *et al.,* 2015). Sweet pepper seedling emergence was recorded in cocopeat (Fig. 1) but the seedlings remained stunted throughout the duration of the study. A similar observation was made by Oagile *et al.* (2016) in *Brassica oleracea* var. Acephala L. Cocopeat is considered a good growing medium component with acceptable pH, electrical conductivity and other chemical attributes (Evans *et al.*, 1996; Abad *et al.,* 2002; Awang *et al.,* 2009). As a growing medium, it can be used singly or as component of medium to raise different plant species with acceptable quality (Blom, 1999; De Kreij and Leeuven, 2001; Noguera *et al.,* 1997; Yahya *et al.,* 1997 and 1999; Treder, 2008). However, cocopeat has been recognized as having relatively low levels of mineral nitrogen (N) and micronutrients such as calcium (Ca^{2+}) and Magnesium (Mg^{2+}) (Meerow, 1995; Evans *et al.*, 1996; Abad *et al.,* 2002) in addition to high water holding capacity which causes poor air-water relationship, leading to low aeration within the medium, thus affecting the oxygen diffusion to the roots (Yahya *et al.,* 2009). These attributes could have caused retarded growth in the sweet pepper seedlings grown in cocopeat.

Leaf number and area: Vegetable crops are very sensitive to saline soil, which affects leaf area, plant growth and crop yield (Chartzoulakis, 1994). The number of leaves on hygromix and germination mix were significantly (P<0.01) higher than those in cocopeat (Table 2). These findings show that cocopeat did not support seedling growth and development because there were virtually no leaves observed during the study. This is in agreement with observation made by Oagile *et al.* (2016) in *Brassica oleracea* var. Acephala L. There were statistical differences (P<0.01) in leaf number between hygromix and germination mix from week one to four. A similar observation was reported by Oagile *et al.* (2016) in *Brassica oleracea.*

Leaf area is an important parameter for agronomic studies

Table 2. Effect of growing media on sweet pepper leaf number (weeks after development of true leaves) and leaf area (cm^2)

Treatments	Leaf number				Leaf area
	Week 1	Week 2	Week 3	Week 4	Week 4
Cocopeat	0.00^b	0.00^b	0.00^b	0.00^b	0.00^c
Hygromix	1.96^a	3.19^a	4.00^a	4.29^a	7.75^a
Germination mix	1.98^a	2.62^a	3.96^a	4.32^a	4.70^b
Significance	**	**	**	**	**
LSD 0.05	0.05	0.90	0.38	0.32	1.48
CV (%)	2.03	23.19	7.12	5.71	17.85

**Highly significant at P<0.01. Means separated by Least Significant Difference (LSD) Test at $P \leq 0.05$. Means within columns followed by the same letters are not significantly different. Where, week 1 to week 4 are dates from 11 April to 8 May, 2015.

involving plant growth (Blanco and Folegatti, 2005). It is also recognized as a crucial plant index that determines the capacity of plants to trap solar radiation for photosynthesis (Mathowa *et al.,* 2014). Leaf area was significantly (P<0.01) affected by growing media. Significant difference (P<0.01) in leaf area was observed between hygromix and germination mix (Table 2). The highest leaf area was recorded in hygromix (7.75 cm^2) whereas germination mix recorded 4.70 cm^2. The highest leaf area recorded in hygromix could probably be attributed to water, nutrients and oxygen availability which continuously supported the development of sweet pepper seedlings. Cocopeat remained the poorest media used in this study because the seedlings remained stunted after emergence resulting in no leaf area values recorded. Cocopeat has variable water supply and availability, aeration and relative hydraulic conductivity caused by differences in processing methods used by different manufacturers (Abad *et al.,* 2005) which might have affected the development of sweet pepper seedlings. In addition, cocopeat has a high cation-exchange capacity which can lead to nutrient imbalance within the root zone and affect availability of nutrients (Verhagen, 1999).

Seedling biomasses: Shoot fresh and dry masses were highly significant (P<0.01) among the growing media (Table 3). Significantly higher (P<0.01) shoot fresh weight was observed in seedlings grown in hygromix mix (0.63 g) than germination mix (0.57 g) whereas cocopeat did not support any seedling growth. Mamatha and Shivananda (2012) recorded the lowest *Coleus vettiveroides* plant biomass in 100% cocopeat which they attributed to imbalance of nutrients. There was no statistical difference in dry shoot weight between hygromix mix (0.48 g) and germination mix (0.46 g). This is supported by other investigators (Sekepe *et al.,* 2013; Mathowa *et al.,* 2016; Oagile *et al.,* 2016) who reported no differences in plant dry weights.

Table 3. Effects of growing media on sweet pepper shoot fresh and dry mass (g)

Growing media	Seedling fresh weight	Seedling dry weight
Cocopeat	0.00^c	0.00^c
Hygromix	0.63^a	0.48^a
Germination mix	0.57^b	0.46^a
Significance	**	**
LSD (0.05)	0.02	0.02
CV (%)	2.72	3.00

**Highly significant at P<0.01. Means separated by Least Significant Difference (LSD) Test at $P \leq 0.05$. Means within columns followed by the same letters are not significantly different.

Germination mix and hygromix can be used to produce sweet pepper seedlings since they significantly enhanced seedlings emergence, growth and development; however, funds can be a limiting factor since the cost of hygromix is relatively higher than the germination mix. Cocopeat support sweet pepper seedling emergence but seedlings remained stunted throughout the study. Therefore, there is need to investigate ways of making cocopeat sustain the growth and development of sweet pepper seedlings.

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