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Evaluating the effects of non-soil media on emergence and growth of potato (*Solunumtuberosum* L.)

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Abstract

Two potato varieties, Bp1 and Amethyst, were grown over four weeks in various growing media. The growing media used were soil (control), saw dust, pine bark and coco peat. Parameters measured include pH, electrical conductivity (EC), cation exchange capacity (CEC), days to germination, number of stems, and plant height. Significant differences (P = 0.015) in days to emergence were observed in both varieties grown in the different media. Shortest time to emergence in both varieties was observed in potatoes grown in soil while longest days to emergence were recorded in saw dust. There were significant differences (P=0.033) in number of stems of potato varieties grown in different media. In both potato varieties coco peat had the highest number of stems while soil and saw dust had the lowest number of stems in both varieties. There were significant differences in plant height (P=0.003) of potato varieties grown in various media. Soil had the shortest plant heights in both varieties. Amethyst had the tallest plants when grown in coco peat (27.00 cm) while Bp1 had the tallest plants when grown in pine bark (29.33 cm).In conclusion Amethyst variety performed best in the coco peat growing medium while Bp1 variety performed best in pine bark growing media.

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Introduction

Potatoes (*SolanumtuberosumL.*) are ranked fourth after maize, wheat and rice (Khurana *et al.,* 2003). Commonly grown varieties in Zimbabwe include Bp1, Amethyst, Mont Claire, Opal, Emerald and Jacaranda (Makumbe, 2010). Potato seed systems are well organized, regulations exist to control the seed business and seed health and the private sector has strong participation (Gildemacher *et al.*, 2009).Diseases and pests are the major problems faced by potato farmers in Zimbabwe. These include but are not limited to;late blight (*Phytophthorainfestans*); a problematic disease that can greatly reduce yields and it is generally controlled by regular fungicide applications (Makumbe, 2010). Viral diseases include PVY, PVX, PVS, and PVM reducing yield by up to 30% (FAO, 2000). Fumigation and regular production and distribution of virus-free seed have reduced virus infection considerably, including the elimination of leaf roll virus (Joyce, 1982).Nematodes and some arthropods have been controlled by fumigation. However, Ethylene di-bromide (EDB), a major fumigant against nematodes and some arthropods, which was being used to control disease/pest persistence in the soil, has been banned. The ban was due to the fact that it resulted in ground water contamination and has carcinogenic effects in accordance to the Montreal Protocol (adopted in 1987 and amended in 2002). This has led to the need to investigate alternative potato production systems that do not require fumigants

Several techniques have been employedin the production of disease free potato tubers without the need to apply fumigants. These techniques include meristem culture, commonly employed in the regeneration of virus-free plants (Simmonds, 1997). Vigorous and disease free potato plants can be obtained in the laboratory using this method and are then transferred to hydroponic conditions for the production of seed potato tubers (Factor *et al.,* 2007). Another technique of producing disease free seed potato is hydroponics which is the culturing of plants in a nutrient solution containing balanced amounts of the essential components that are necessary for plant growth and development. There are many advantages associated with hydroponics in the culture of pre-basic potatoes as compared to conventional methods and these include; very high rates of tuber multiplication (Factor *et al.,* 2007; Correa *et al.*, 2009), absence of risks of tuber contamination by soil pathogens (Correa *et al.,* 2009) and lower incidence of physiological diseases. The main hydroponics system presently available for the cultivation of leaf vegetables and potatoes is the nutrient film technique (NFT), the deep flow technique (DFT) and aeroponics (Medeiros *et al.,* 2002).

Soilless potting media have earned much recognition because they do away or reduce the need for soil disinfestations as well as mitigating the impact of soil borne diseases, nematodes and weeds (Correa *et al.,* 2009), as well as being an affordable option for most farmers. General acceptance of soilless potting media in global food and plant production spheres has been described as the practical way out for setbacks that include root diseases, root zone oxygen deficiency, fertility management which occurs in other techniques (Albajes *et al.*, 2002). Jami-Moeini *et al.* (2001) highlighted that the advantages of container production techniques over field production techniques include more water and nutrient efficiencies, with increased food production. This study, therefore attempts to investigate the potential of using various easy to access and affordable soilless potting media on potato production as an alternative to the use of fumigants in soil.

Methods and materials

Study site

The research was carried out in a greenhouse at Midlands State University, Gweru, Zimbabwe. The area falls under Natural Region III of Zimbabwe's Agro-ecological zones, located 19.48^{o} S and 19.48^{o}W with an altitude of about 1425m above sea level. The average annual rainfall ranges from 600 mm to 750 mm and the mean temperature is around 20-25^{o}C.

Materials used were potato seed tubers of two varieties (Bp1- early-medium maturing and

Amethyst- late maturing) and different growth media (composted pine bark, coco peat, saw dust and soil). Different growth media were filled in 24 pots and tubers sown at a depth of 10cm.

Experimental design

The experiment was 2×4 factorial experiment replicated 3 times and laid out in a randomized complete block design.

Parameters measured

pH and electrical conductivity (EC)

pH and electrical conductivity (EC) of the media were determined with a potentiometer (OAKTON® pH/mV/°C meter, Series No: 43291).

Time taken to emergence

The time taken to emergence was evaluated by counting the number of days taken to emergence by the potato in each treatment.

Total number of stems

The total number of stems was determined by the number of stems that had fully emerged at four weeks after potting (WAP).

Plant height

Plant height was determined by measuring the length from just above the media to the leaf primordium of the plants with a tape measure or a ruler.

Data analysis

Analysis of Variation or variance? (ANOVA) was done using Gen stat Discovery 14th Edition (Gen Stat, 2005) and means were separated using the least significant difference (LSD) at 5% level of significance.

Results and discussion

Effects of media and variety on time taken to emergence

There were significant differences (P = 0.015) observed on days taken by BP1 and Amethyst potato varieties to emerge in different media. Amethyst grown in sawdust took the longest time (12. 00 days) to emerge. Potato variety Bp1 grown in saw dust emerged after 10.67 days while soil (control) had the least number of days to emergence for both varieties with Bp1 and Amethyst having 5.67 days and 6.33 days respectively.

Table 1. pH and electrical conductivity (EC) and of growing media.

Growing media	Week 1	Week 2	Week 3	Week 4
	pH			
Soil (control)	5.33	5.50	5.99	6.46
Coco peat	5.14	5.16	5.20	5.43
Pine bark	5.39	5.45	5.49	5.53
Saw dust	6.00	6.20	6.63	6.74
		EC(dSm-1)		
Soil (control)	1.85	1.75	1.59	1.31
Coco peat	1.99	1.53	1.08	0.94
Pine bark	0.86	0.84	0.80	0.80
Saw dust	0.59	0.68	0.75	1.40

Number of days to emergence for amethyst grown in coco peat and pine bark differed significantly (P= 0.015). Amethyst grown in composted pine bark and coco peat emerged after 8.67 and 8.00 days respectively and Bp1 8.00 and 8.33 respectively (Fig 1). However, days to emergence of Bp1 variety differed significantly in coco peat and pine bark.

The differences in the time taken to emerge could be attributed to the media composition as well as the genetic constitution of the potato varieties. Abad *et al.* (2001) reported that the pH and EC values which are acceptable in propagation media ranges between 5.2 – 6.3 and 0.75 - 1.99 dSm^{-1} respectively. The pH recorded for saw dust (6.74) and low EC (0.59dSm^{-1}) (Table 1) had a negative impact on plant emergence as they fall out of the optimum ranges supporting germination. This is also in line with the study by

Perez *et al.* (2014) where it was reported that germination of sweet pepper *(Capsicum annum L.)* was lowest in the substrate (Filter cake amended with Tezontle) due to an elevated EC value of 3.163 dSm^{-1} that is also higher than the acceptable range as stated by Abad *et al.*(2001). In this study, soil, coco peat and pine bark had EC values within the acceptable range which were 1.85dSm^{-1}, 1.99dSm^{-1}, 0.86 dSm^{-1} respectively. This is probably the reason why these media had shorter time to emergence as conditions were optimal.

Table 2. Cation exchange capacity (CEC) of media used in the study.

Treatment	CEC ($cmolkg^{-1}$)
Soil	18
Coco peat	15
Pine bark	14
Saw dust	8

In addition, CEC values between 15 and 25 cmolc $kg^{-1}$is considered sufficient and necessary to cushion sudden pH changes and nutrient availability in substrates (Argo 1998). In regards to this, differences in CEC among the substrates observed (Table 2), saw dust had the lowest (8 cmolc kg^{-1}), falling well below the acceptable range and soil (18 cmolc kg^{-1}), coco peat (15 cmolc kg^{-1}) as well as pine bark (14 cmolc kg^{-1}) falling very closely or within the acceptable range. This resulted in the delayed or longer time to emergence of potatoes in saw dust. Similar results were reported by Perez *et al.* (2014) who observed that germination and growth of sweet pepper (*Capsicum annum L.*) was high in substrate with CEC values within the interval referred to.

Effects of media and variety on number of potato stems

There were significant differences in number of potato stems (P=0.033) of different potato varieties grown in various media. Number of potato stems in the Bp1 variety grown in the various media differed significantly with coco peat having the highest number of stems (7.33) and soil having he least (2.00). Bp1 had the highest number of stems having 7.33 in coco peat and 6.00 in pine bark, compared to Amethyst which had fewer stems of 4.67 and 4.00 in coco peat and pine bark respectively. Both potato varieties had the same number of stems in sawdust which was 3.33. Bp1 had the least number of stems in soil (control) which was 2.00 compared to Amethyst which had 3.33 (Fig 2).

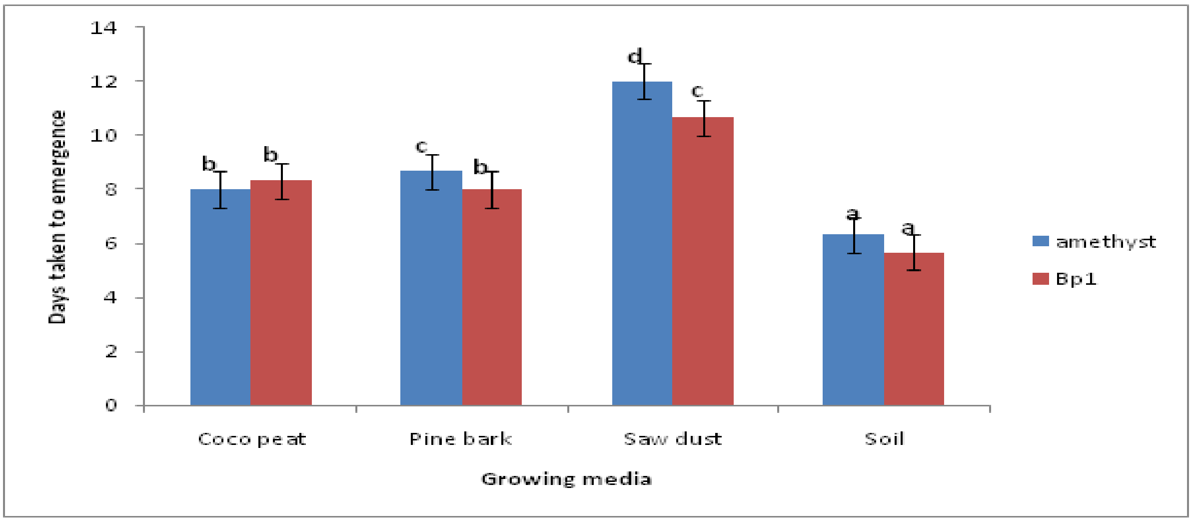

Fig. 1. Days taken to emergence by potato varieties (BP1 and Amethyst) in different growing media (coco peat, saw dust, composted pine bark and soil).

Generally the number of stems influences haulm development and results in high tuber numbers per plant, reducing tuber sizes by reducing the amount of carbohydrates available to each tuber at bulking (Randal, 2000). It can be observed that number of stems was associated with variety and media properties. Among the physical properties, bulk density would be influential. Generally desirable media should have a low BD (<1.5 g/cm3) (Hunt *et al.*, 1992) for optimum movement of air and water through the soil.

A study by McKenzie *et al.* (2004)reported that the substrate where few number of shoots were observed was soil representing a higher bulk density compared to coco peat, pine bark and saw dust. This is also in line with the findings by Nivedeta (1992) on the effects of different soil bulk densities on germination and emergence of sorghum, pearl millet and groundnuts. The author reported that emergence was high in soils with low bulk density as compared to soils with higher bulk densities.

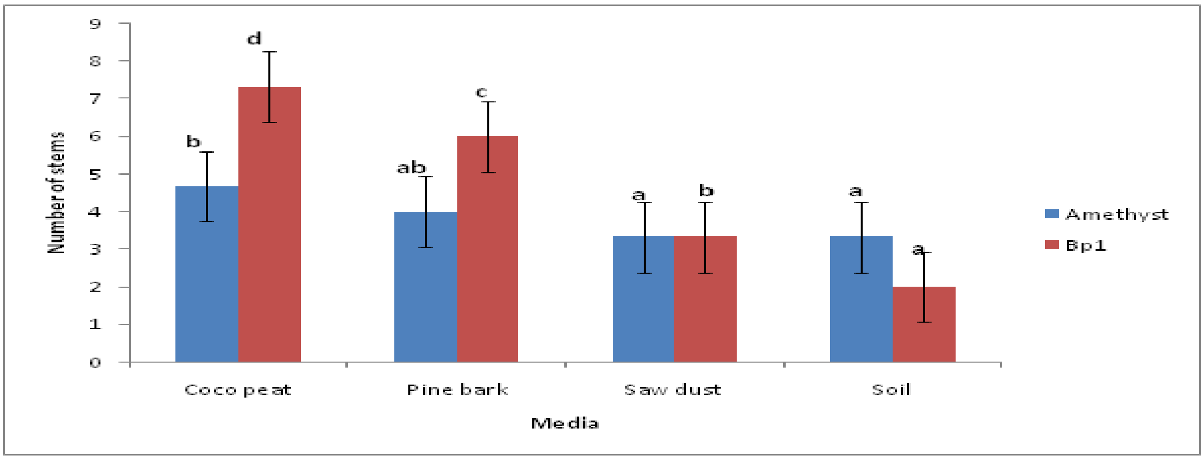

Fig. 2. Number of stems of Amethyst and Bp1 potato varieties grown in different media.

Effects of media and variety on plant height

There were significant differences (P=0.003) in plant height in potato varieties grown in different media. Bp1 attained the tallest potato plants composted pine bark (29.33cm), saw dust (28.67cm) and in coco peat (28.00cm), compared to Amethyst which attained 27.00cm, 26.00cm, and 26.67cm in coco peat, pine bark and saw dust respectively. Amethyst attained a higher plant height in soil (control) 25.67cm compared to Bp1 which attained 21.67cm.

The variation in height could be attributed to the adaptation of the variety in the growing media. These results concur with findings of Khurana*et al.* (2003) who suggested that different potato genotype differ on how they adapt to the planting bed. In addition, the differences can also be attributed to the growing media which provides or promotes the availability of nutrients as reported by Asghari-Zakaria*et al.* (2009) that nutrient uptake is determined by growth media.

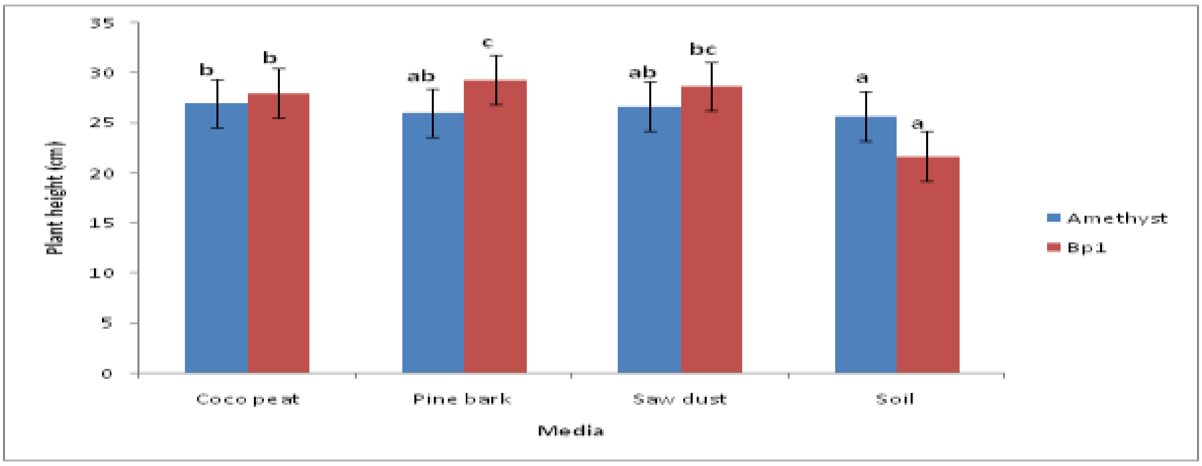

Fig. 3. Plant heights for Amethyst and Bp1 potato varieties in different growing media at 4 weeks.

The difference in height between the soilless media and the soil (control) can also be attributed to the media physical properties such as aeration and bulk density which probably promotes root and shoot development. In potato plants, due to their large volume of biomass in roots, oxygen deficiency negatively affects growth (Cherif *et al*., 1997). Respiration which produces energy for root growth and ion absorption requires oxygen. Media with high bulk densities are more compact compared to those with a low bulk density. Compacted soils tend to reduce pore spaces that enable proper aeration in the media as well as restricting root growth. In addition, non-soil media provide higher water and nutrient holding capacity which promotes growth.

Conclusions

Of the two the varieties grown, Bp1 proved to establish and grow well in pine bark. Amethyst potato variety proved to grow well in coco peat. Generally coco peat and composted pine bark were found to be superior in supporting emergence of both varieties. However, sawdust can also be another potential growing medium if good nutrient management is practiced as it is much cheaper and locally available as media compared to coco peat and composted pine bark.

This helpsin reducing the use of fumigants reducing health and environmental hazards thereby meeting the desired standards in sustainable agriculture. Farmers are recommended to adopt using Bp1 and Amethyst in soilless media such as coco peat, composted pine bark and to a lesser extent sawdust.

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