Original research papers

Growth and Development Response of Kale (*Brassica oleracea* var. acephala L.) Seedlings to Different Commercial Growing Media

ABSTRACT

The study was carried out at Botswana University of Agriculture and Natural Resources (BUAN) formerly Botswana College of Agriculture (BCA) under an 80% net shade house to evaluate the response of kale (*Brassica oleracea* var acephala) to different commercial growing media comprising of cocopeat, hygromix and germination mix. The experiment was set up in a completely randomized design (CRD) with each treatment (medium) replicated four times. Growth parameters measured were; seedling emergence, plant height, number of leaves, leaf area and biomass (both fresh and dry masses). Plant height, leaf area, number of leaves and biomass (fresh and dry) from plants grown on hygromix and germination mix were significantly ($P < .01$) higher than those grown on cocopeat. The same trend was observed in relation to seedling emergence although hygromix performed better than the other growing media. The observations reported in this study suggest that the use of hygromix and germination mix enhanced production of kale seedlings compared to cocopeat with hygromix being the best.

Keywords: Brassicaceae, Brassica oleracea var. a~~A~~cephala L, growing media, kale seedling growth

1. INTRODUCTION

Kale (*Brassica oleracea* var acephala) belongs to the family Brassicaceae. It is closely related to vegetables such as cabbage, cauliflower, broccoli and rape (What is mean). The exact history of this vegetable is more difficult to trace but according to McCollum and Ware [1], kale also referred to as borecole or non-heading cabbage or broccoli grows native in regions of the eastern Mediterranean and Asia. It has also been cultivated as a vegetable for more than 2500 years [2,3].

In growing vegetable seedlings for commercial purposes, the grower must always use a medium with more desirable properties to produce good quality seedlings. Growing media have different properties such as texture, pH and water holding capacities [4,5] that usually vary from one to the other. The looseness of the medium allows root growth and subsequent emergence of the shoot hence proper germination of the plant [4]. All the basic life sustaining conditions especially at germination should be readily available or plants will be affected for life and hence may not perform to the best of its genetic potential [4,5].

A number of commercial media are available for growing seedlings. These growing media consist of either single component or a mixture of components that provide water, air, nutrients and support to plants. They vary greatly in composition, particle size, pH, aeration, nutrient retention and water holding capacity. However, the growing medium used in container culture must have good nutrient and water-holding characteristics, and provide good aeration to the root system [6]. Weight is another important property to be considered so that filled containers can be easily handled. The growing medium should also be free of pathogenic organisms and substances that are toxic to plants. The pore spaces of the medium should be able to provide water and air to avoid poor aeration which can lead to water logging [7]. Production of good healthy strong seedlings is very critical for growth and development of the crop after transplanting. Nurseryman and to some extent farmers raise their own seedlings but the choice of the medium to use is largely determined by the cost that may not be an appropriate assessment tool to use. This has resulted in poor quality seedlings which have mostly been attributed to the medium used. Therefore, the aim of the work reported here was to evaluate the suitability of some of the locally available commercial media for production of kale seedlings. The study looked at the response in relation to emergence, growth and development.

2. MATERIAL AND METHODS

2.1 Experimental site

The work was carried out at the Botswana University of Agriculture and Natural Resources (BUAN) formerly Botswana College of Agriculture (BCA) Sebele campus under an 80% net shade house from March to April 2015. The university campus is located between latitude 24˚33'S and longitude 25˚54'E at elevation of 994 m above sea level.

2.2 Experimental layout, design and cultural practices

Kale (chou-moellier variety) seeds [Starke Ayres (Pty) Ltd., Mpumalanga, South Africa] were sown singly in 200 plugs styrofoam seedling trays filled with the different commercial growth 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 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.

2.3 Data collection

Data collected comprised of seedling emergence and growth parameters [plant height, leaf number and area, and plant biomass (both fresh and dry masses)]. Seedlings emergence was measured cumulatively on daily basis by counting any emerging seedlings from all the 200 plugs per tray until a constant reading was achieved. Twenty five seedlings in the middle of each tray were tagged for growth parameters (plant height and leaf number) measurements that were commenced after appearance of true leaves and continued weekly until termination of experiment (four 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 80ºC using a hot air oven - Scientific Series 2000 [Laval Lab, Inc., Laval (Quebec), Canada].

2.4 Data analysis

Data collected was subjected to analysis of variance (ANOVA) using Analytical Software [8]. Where a significant F-test was observed, separation of means was carried out using Least Significant Difference (LSD) at $P \leq .05$.

3. RESULTS AND DISCUSSION

3.1 Seedling emergence

Seedlings started to emerge three days after sowing in all the media evaluated (Fig. 1). There was no significant difference in emergence between hygromix and germination mix throughout the period of emergence observation except for day 5. However, hygromix reached the highest minimum prescribed 80% emergence by day 6 compared to day 8 for germination mix. The difference between germination mix and cocopeat were not significant from day 4 up to day 7 after which germination mix began to give significantly ($P < .01$) better emergence of 82.67% compared to 73.33% for cocopeat. Hygromix performed significantly ($P < .01$) better than cocopeat throughout the period of emergence observation. Overall, hygromix gave faster, more uniform emergence than all the other media. This could be attributed to the fact that the media have different composition which could have direct and/or indirect effects on seedling emergence, plant growth and development. According to Ghehsareh *et al.* [9], physicochemical properties such as electrical conductivity, cation exchange capacity, water holding capacity and bulk density of different substrates determine plant growth and development.

Adediran [10] obtained the highest seedling emergence and achieved nearly 100% in week one after sowing on hygromix attributing the performance to the slightly acidic nature of the medium. In the present experiment, the minimum highest emergence possible in week one of sowing was recorded. High salinity or alkalinity might cause change in certain enzymatic or hormonal activities in seeds during germination [11] and it is possible cocopeat exhibited the lowest seedling emergence throughout the experiment possibly due to its pH. However, in the experiment conducted by Bhardwaj [12], the overall results obtained revealed that media supplemented with cocopeat gave higher emergence, growth and development of papaya seedlings when compared to media without cocopeat probably due to its water holding capacity trait.

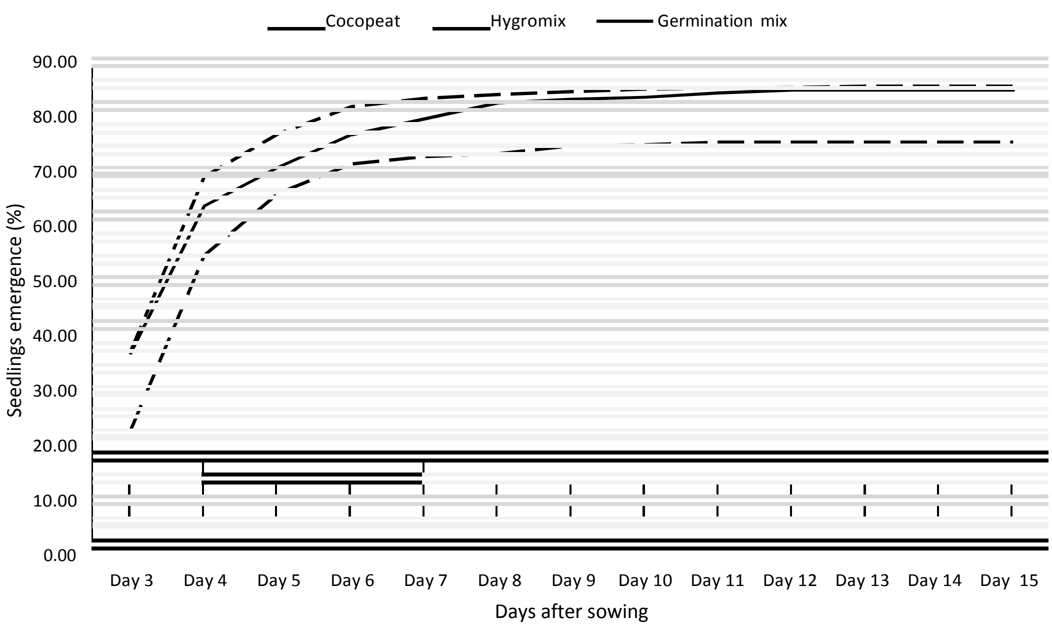

Fig. 1. Effect of commercial growth media on seedling emergence of kale.
Vertical bars are LSD values (P ≤ .05). Differences between means within the LSD value are not significantly different. Where Day 3 to Day 15 are dates from 22 March to 03 April 2015.

3.2 Leaf number and area

Observations made on leaf number and area suggest that cocopeat does not support any plant growth and development as there were virtually no leaves present to be measured at the end of the experiment (Table 1 and Fig. 2). Number of leaves recorded on hygromix and germination mix grown plants were significantly ($P < .01$) higher than those on cocopeat which were specifically non-existent throughout the experiment period. Although there was no significant difference in leaf number between hygromix and germination mix, this trend was not the case with leaf area. The highest leaf area (88.63 cm^2) was obtained under hygromix medium which was significantly ($P < .01$) superior to germination mix (71.02 cm^2). Leaves are the main source of food synthesized for the plant and thus their absence affects plant growth and development. Leaf area is recognized as a crucial growth index determining the capacity of plants to trap solar energy for photosynthesis and has marked effect on growth and yield of plant [13]. The higher leaf area in hygromix and germination mix could be attributed to these media's desirable properties to continuously supply growth factors (nutrients, water and oxygen) throughout the period of seedling development. Kakoei and Hassan [14] reported that the highest number of leaves per cutting observed in *Spathiphyllum wallisii* plants was due to medium characteristics like porosity and water holding capacity. Hygromix and germination mix are formulations made from different components to achieve a substrate with desirable properties that cannot be found in a single material medium like cocopeat used in this experiment. However, cocopeat is known for its high water holding capacity that can be beneficial as well as detrimental if it is not allowed to drain adequately. According to Awang *et al.* [15], cocopeat is considered a good growing media component with acceptable pH, electrical conductivity and other chemical attributes but it has been recognized to have 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. Seeds of kale grown in cocopeat emerged and eventually died while some remained stunted. According to Treder and Nowak [16], due to the usual high initial level of potassium and sodium, the fertilization program of cocopeat should be adjusted carefully to meet plant requirements.

Table 1. Effect of different growing media on leaf number and leaf area of kale seedlings

Growing media	**Weeks after development of true leaves**				
	Number of leaves				Leaf area (cm^2)
	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	1.90^a	2.91^a	3.89^a	4.36^a	88.63^a
Germination mix	1.91^a	2.70^a	3.75^a	4.23^a	71.02^b
Significance	**	**	**	**	**
LSD (0.05)	0.30	0.24	0.27	0.18	2.28
CV (%)	11.87	6.54	5.34	3.16	2.14

*** Highly significant at $P < .01$. Means separated by Least Significant Difference (LSD) Test at $p \le 0.05$, means within columns followed by the same letters are not significantly different. Where week 1 to week 4 are dates from 04 April 2015 to 24 April 2015.*

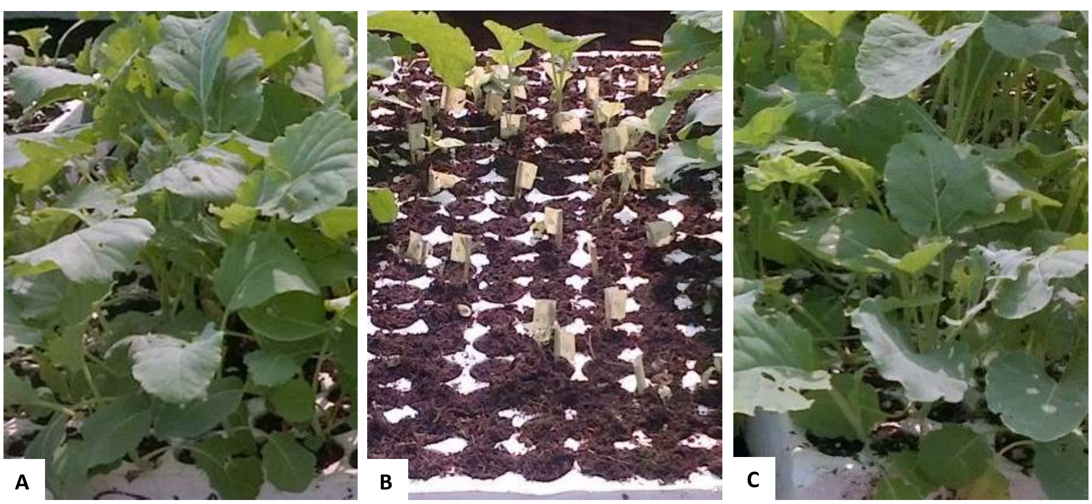

Fig. 2. Effect of growing media on kale seedlings; A- germination mix, B- cocopeat and C- hygromix at week 4 of experiment.

3.3 Plant height

Variability of the different growing media as observed on leaf number and area persisted on plant height as the difference were also highly significant ($P < .01$) (Table 2 and Fig. 2). Hygromix significantly ($P <$

.01) increased kale seedling plant height as compared to other media from weeks 1-3. However, at week 4 the difference between hygromix and germination mix was not significant. At week 3, hygromix grown seedlings had already attained a significant height of 163.96 mm generally considered to be suitable to transport the seedlings. The final (week 4) height was 171.55 mm for hygromix and 156.59 mm for germination mix (Table 2). The highest plant height obtained in hygromix could be attributed to sufficient support for growing seedlings by the medium and allowance of rapid gas exchange between the rhizosphere and atmosphere. According to Awang *et al.* [15], a good growing medium would provide sufficient anchorage or support to 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 thus more rapid plant growth. Cocopeat resulted in no plant seedling growth; and according to Abad *et al*. [17] cocopeat has been recognized to have a high water holding capacity which causes poor air-water relationship leading to low aeration within the medium, which affect oxygen diffusion to the roots. However, the results obtained in some experiments revealed that cocopeat used alone, or as a component of soil medium, is suitable for roses [18], gerbera [19], many potted plants [16,20]; hence, we could be observing genotypic variation at play in the case of kale reported here.

Table 2. Effect of different growing media on plant height of kale seedlings

Growing media	**Plant height (mm)- weeks after development of true leaves**			
	Week 1	Week 2	Week 3	Week 4
Cocopeat	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{b}
Hygromix	51.57^{a}	105.91^{a}	163.96^{a}	171.55^{a}
Germination mix	37.40^{b}	83.59^{b}	136.40^{b}	156.59^{a}
Significance	**	**	**	**
LSD (0.05)	7.74	15.50	20.71	21.35
CV (%)	13.06	12.28	10.35	9.77

*** Highly significant at P < .01. 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 04 April 2015 to 24 April 2015.*

3.4 Plant biomass

Biomass accumulation was not significantly different between hygromix and germination mix but differed significantly ($P < .01$) between these two media and cocopeat which basically did not support any reasonable seedling growth (Table 3 and Fig. 2). This case was the same for both fresh and dry matter. It is worth noting that even though hygromix and germination mix did not differ significantly, there was still some differences recognized. Hygromix exhibited higher biomass (fresh; 0.87 g and dry; 0.56 g) while germination mix followed with 0.85 g fresh matter and 0.55 dry matter. According to Khayyat *et al.* [21], reduced porosity in a medium is a factor which may restrict root formation hence slower plant growth a factor that could have rendered cocopeat unsuitable for seedling growth. However, Treder [22] indicated lilies grown in cocopeat flowered earlier, had higher fresh and dry weight of flowers and leaves, longer flower buds, better root system and lower bulb depletion between planting and flowering. As mentioned earlier under plant height, performance of kale under cocopeat could be an issue of genotypic variation or just the age of plant and in this case seedlings not being able to withstand the rhizosphere conditions influenced by cocopeat properties.

Table 3. Effect of different growing media on kale seedlings biomass accumulation

Growing media	**Shoot weights (g)**	
	Fresh weight	Dry weight
Cocopeat	0.00^{b}	0.00^{b}

Hygromix	0.87[a]	0.56[a]
Germination mix	0.85[a]	0.55[a]
Significance	**	**
LSD (0.05)	0.10	0.11
CV (%)	8.69	14.71

*** Highly significant at P < .01. Means separated by Least Significant Difference (LSD) Test at p≤0.05, means within columns followed by the same letters are not significantly different.*

4. CONCLUSION

Hygromix and germination mix both supported fast and uniform seedling emergence as well as seedling growth. Hygromix is considered a superior medium because it had seedlings emerging faster and reaching transplant size a week earlier than germination mix; thus possibility of early crop maturity. However, both media can be used depending on targeted crop harvest date and financial resources since cost of hygromix is relatively higher than germination mix. Furthermore, there is need to investigate ways of making cocopeat suitable as it is cheaper than the other media.

REFERENCES

1. McCollum JP, Ware GW. Producing vegetables crops, 3rd Edition. The Interstate Printers & Publishers, Inc., United States of America; 1980.
2. Kelly WC, Thompson HC. Vegetable crops. McGraw-Hill Inc., New York; 1957.
3. Balkaya A, Yanmaz R. Promising Kale (*Brassica oleracea* var acephala) populations from Black Sea region, Turkey. New Zealand Journal of Crop and Horticultural Science. 2005; 33(1): 1-7.
4. Both AJ. Plant biology and pathology. Bioresource Engineering. London; 1983.
5. Kuhar TP, Hamilton GC, VanGessel MJ, Sanchez E, Wyenandt CA. Mid Atlantic commercial vegetable production recommendations for 2016. Rutgers, The State University of New Jersey; University of Delaware; University of Maryland; The Pennsylvania State University; Virginia Polytechnic Institute and State University; West Virginia University; U.S. Department of Agriculture, U.S.A; 2016.
6. Biondo RJ, Noland DA. Floriculture: From greenhouse production to floral design. Interstate Publishers, Danville, Illinois; 2000.
7. Rahimi Z, Aboutalebi A, Zakerin A. Comparison of different medium for production of sweet pepper transplant. International Research Journal of Applied and Basic Sciences. 2013; 4(2): 307-310.
8. Analytical Software. STATISTIX 8 for Windows. Tallahassee, Florida, US; 2003.
9. Ghehsareh AW, Borji H, Jafarpour M. Effect of some culture substrates (date-palm peat, cocopeat and perlite) on some growing indices and nutrient elements uptake in greenhouse tomato. African Journal of Microbiology Research. 2011; 5(12): 1437-1442.
10. Adediran JA. Growth of tomato and Lettuce Seedlings in soilless media. Journal of Vegetable Science. 2005; 11(1): 5-15.
11. Smith PT, Comb BJ. Physiological and enzymatic activity of pepper seeds (*Capsicum annum*) during priming. Physiologia Plantarum. 1991; 82: 433-439.
12. Bhardwaj RL. Effect of growing media on seed germination and seedling growth of papaya cv. 'Red lady'. African Journal of Plant Science. 2014; 8(4): 178-184.
13. Mathowa T, Madisa ME, Moshoeshoe CM, Mojeremane W, Mpofu C. Effect of different growing media on the growth and yield of jute mallow (*Corchorus olitorius* L.). International Journal of Research Studies in Biosciences. 2014; 2(11): 153-163.
14. Kakoei F, Salehi H. Effects of different pot mixtures on spathiphyllum (*Spathiphyllum wallisii* Regel) growth and development. Journal of Central European Agriculture. 2013; 14(2): 140-148.
15. Awang Y, Shaharom AS, Mohammad B, Selamat A, Ayub M, Ullah J, Muhammad A. Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of *Celosia cristata*. American Journal of Agricultural and Biological Science. 2009; 4(1): 63-71.

16. Treder J, Nowak J. Zastosowanie podłoży kokosowych w uprawie roślin rabatowych. Zeszyty Problemowe Postępów Nauk Rolniczych. 2002; 485: 335-358.

17. Abad M, Noguera P, Puchades R, Maquieira A, Noguera V. Physico-chemical and chemical properties of some coconut dusts for use as a peat substitute for containerized ornamental plants. Bioresource Technology. 2002; 82(3):241-245.

18. Blom TJ. Coco coir versus granulated roockwool and ‘arching’ versus traditional harvesting of roses in recirculating system. Acta Horticulturae. 1999; 481: 503-507

19. Labeke MC, Dambre P. Gerbera cultivation on coir with recalculating of the nutrient solution; a comparison with roockwool culture. Acta Horticulturae. 1998; 458: 357-362.

20. Dekreij C, Leeuven G. Growth of pot plant treated coir dust as compared to peat. Communications in Soil Science and Plant Analysis. 2001; 32(13): 2255-2265.

21. Khayyat M, Nazari F, Salehi H. Effects of different pot mixtures on Pothos (*Epipremnun aureum* Lindl. and Andre ‘Golden Pothos’) growth and development. American-Eurasian Journal of Agricultural and Environmental Science. 2007; 2:341-348

22. Treder J. The effects of cocopeat and fertilization on the growth and flowering of oriental lily ‘star gazer’. Journal of Fruit and Ornamental Plant Research. 2008; 16: 361-370.