ea engenharia agrícola
Journal of the Brazilian Association of Agricultural Engineering
ISSN: 1809-4430 (on-line)

KALE SEEDLINGS PRODUCTION IN DIFFERENT SUBSTRATES, CELL VOLUMES AND PROTECTED ENVIRONMENTS

Doi:http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v37n1p46-53/2017

EDILSON COSTA[1*], THAYLA M. R. DE C. CURI[2], THIAGO FIGUEIREDO[3], FLÁVIO F. DA S. BINOTTI[4], ELIANA D. CARDOSO[4]

[1*]Corresponding author. Universidade Estadual de Mato Grosso do Sul/UEMS/ Cassilândia - MS, Brasil.
E-mail: mestrine@uems.br

ABSTRACT: The kale is a brassica, this vegetable presents importance on nutritional and economic patterns. The present study aimed to evaluate the effect of different substrates, trays and protected environment in the formation of kale seedlings. The experiment was conducted in two greenhouses located at the State University of Mato Grosso do Sul - MS. The first environment consisted of an agricultural greenhouse with polyethylene film cover, while the second was an agricultural nursery with monofilament screen and mesh to offer 50% of shading. In each protected environment were used 72 and 128 cells tray and six different compositions of substrates with organic material based on cassava branches (CB) and cattle manure (CM): 1) 100% CM; 2) 20% CM + 80% CB; 3) 40% CB + 60% CM; 4) 60% CB + 40% CM; 5) 80% CB + 20% and CM; 6) 100% CB. The seedlings were evaluated according to the parameters: dry mass of seedlings, stem diameter and plant height. The agricultural nursery was the most suitable for the formation of kale seedlings, with 72 cells tray and the substrate composed of organic matter with 20% of cassava branches and 80% of cattle manure.

KEYWORDS: *Brassica oleracea* var. *acephala*, cassava branches, cattle manure, greenhouse, multi cells.

INTRODUCTION

The kale (*Brassica oleracea* var. *acephala*) is a brassica that presents important impact on the nutritional matter by richness in iron, calcium, vitamin A and ascorbic acid as well as the economic matter considering the increasing expansion of the organic vegetables market. Scientific studies are directed to this vegetable in order to better understand its development and its requirements in relation to the environment, inputs, substrates and related pests (SILVA et al., 2012; FERREIRA et al., 2014; BARROS et al.; 2015). The brassica originate in cold weather and can be produced in tropical climate due to the genetic improvement, which allowed greater resistance and adaptation to heat (MALUF et al., 1988). Allied to plant breeding, cultivation in protected environments enabled the production at different times of the year, which helps positively meeting the demand of the consumer market (RAMPAZZO et al., 2014).

Greenhouses for crop protection against attack by pests and climatic conditions, offer higher quality and plants precocity, as well as saving on raw materials and water - in Brazilian semiarid region this feature is extremely important due to the water be a limited resource at various period throughout the year (COSTA & LEAL, 2011; SILVA et al., 2012). However, there is still much to improve in the greenhouses to ensure the homogeneity of the weather conditions throughout the day, since the natural ventilation system enables the occurrence of temperature peaks during the day and lower temperatures of cultivated plants at night (COSTA & LEAL, 2011). In addition to the vegetation, the quality of the plants associated with the proper management enables increased productivity of this vegetable (SEDIYAMA et al., 2014).

The major breakthrough in the vegetable cultivation was the production of individual seedlings using cell trays filled with substrate (CUNHA et al., 2014). This technique has facilitated

[2] Universidade Estadual de Campinas/ Campinas - SP, Brasil.
[3] Universidade Estadual de Mato Grosso do Sul/ Aquidauana - MS, Brasil.
[4] Universidade Estadual de Mato Grosso do Sul/ Cassilândia - MS, Brasil.
Received in: 5-4-2016
Accepted in: 9-19-2016

handling, and a great nutritional and pest control ensuring quality, space utilization and cost reduction. The production system in Styrofoam trays (expanded polystyrene) began to be used in Brazil in 1984, and its main advantage is the formation of more uniform seedlings of better quality with the highest number of seedlings per unit area and better pest control (PEREIRA et al., 2012; BLANK et al., 2014).

Another aspect to be considered in the production of seedlings is the substrate, holding the soil function, providing support to the plant, nutrients, water and oxygen. Its origin can be animal, vegetable, mineral and artificial. The substrate can be chemically active or inert, with high capacity to retain water or low matric potential easily found in the region, low cost and free of pests and plant pathogens (MONTEIRO et al., 2012; CUNHA et al., 2014).

In this context, this study aimed to evaluate the formation of kale seedlings, Georgia cultivar as function of substrates manure-based and cassava branches in greenhouses with different types of multi cellular trays.

MATERIAL AND METHODS

This experiment was conducted in the experimental area of the State University of Mato Grosso do Sul (UEMS), in the University Aquidauana Unit (Latitude -20º27’00” South, Longitude-55º40’12” West, 174 m height) with tropical humid climate and annual average temperature of 29ºC (Aw, according to Köppen). The study to evaluate the formation of kale plants (*Brassica oleracea* var. *acephala*), Georgia cultivar was developed between the months from June to September 2009.

The seedlings were grown in two different protected environments whose characteristics were:

- A1: Arched agricultural greenhouse, east-west orientation, with dimensions (width x length x-height) of 6.4 x 18.0 x 4.0 m, galvanized steel frame, zenital opening along the length of the greenhouse ridge, covered with polyethylene film of 150μm, light diffuser having thermal reflector screen 50% from the film, installed at 3.30 m tall having opening / closing manual mobile and front and side closures with monofilament in black, and mesh with50% of shadow.

- A2: Agricultural screen nursery, east-west orientation, with dimensions of 6.4 x 18.0 x 3.5 m, galvanized steel structure, closing at 45º, with monofilament screen in black, and mesh with 50% of shade.

The multi cellular trays had 72 and 128 cells, termed R1 and R2, respectively.

The organic base substrates (containing Cattle manure - CM and Cassava Branches - CB) were homogenized by a mixer, and then used to fill the trays in the following proportions:

S1)100% CM;

S2) 20% CB + 80% CM;

S3) 40% CB + 60% CM;

S4) 60% CB + 40% CM;

S5) 80% CB + 20% CM and;

S6) 100% CB

The development of the experiment is shown in a diagram form in Figure 1.

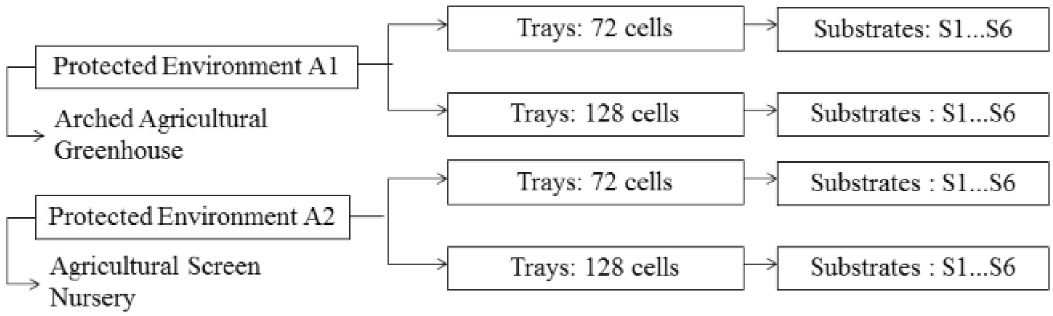

FIGURE 1. Diagram of the experiment.

The manure was collected from milk producers in the region and passed the composting process for 30 days being humidified and upturned daily. The cassava branches were crushed in hammer mill type, sieve 12, on June 1st, 2009 and composted for 15 days. Both materials were sieved on sieve hoop diameter of 55 cm and diameter of the mesh hole of 0.5 cm. For better uniformity of the materials on substrates, the mixture of manure with cassava branches occurred in a cement mixer. The analyzes of the two substrates were performed in the laboratory of Embrapa Agropecuária Oeste (CPAO) in relation to pH in $CaCl_2$ [adm], humidity [%], organic carbon [%] Nitrogen [%], phosphorus [%] potassium [%] and calcium [%], magnesium [mg kg^{-1}], sulfur [mg kg^{-1}] and sodium [mg kg^{-1}]. The analyzes results were for cassava branches (CB), 9.24; 15.54%; 39.21%; 1.26%; 0.28%; 1.58%; 1.47%; 0.34 mg kg^{-1}; 0.17 mg kg^{-1}; 0.02 mg kg^{-1}, and for cattle manure (CM), 6.16; 35.95%; 31.61%; 2.29%; 0.32%; 0.19%; 0.47%; 0.09 mg kg^{-1}; 0.23 mg kg^{-1}; 0.28 mg kg^{-1} respectively.

Sowing was done on July 2nd, 2009, using two seeds per cell. Irrigation was manual trying not to soak the substrate and maintaining adequate conditions to the seedlings. There was no additional fertilization. Seven days after plant emergence, thinning was done, leaving only one seedling per cell. From thinning it was measured the height of the seedlings (cm) at seven days interval that is, when the seedlings were 16 (PH1), 23 (PH2) and 30 (PH3) days after sowing (DAS). At 40 days after sowing, the stem diameter (mm) in the transition region between the branches and the roots of seedlings (SD) was measured with the aid of a caliper. For measurement of the dry mass seedling parameter (DM) in grams at 40 DAS, the seedlings were dried in a forced circulation hoop oven at 65° C for 72 hours and subsequently the material was weighed on a balance of accuracy (accurate to 0.001 g).

There was no repetition in the protected environments, and each one was considered an experiment. Within each environment the experiment was conducted in a completely randomized design with two factors (containers x substrates), with 6 repetitions. The environments were evaluated by analysis of experiments groups (BANZATTO & KRONKA, 2013).

Data were submitted to analysis of variance (F test) and the means were compared by Tukey test for the substrates and t test for containers and environments, all at 5% probability, with Sisvar software (FERREIRA, 2010).

RESULTS AND DISCUSSION

To proceed to the analysis of experiments groups and compare the protected environment, a triple factor was necessary where the residual mean squared (RMS) of the treatments (containers versus substrates) within each protected environment did not exceed the ratio 7:1, i.e., the ratio between the largest and smallest RMS was not greater than 7 (BANZATTO & KRONKA, 2013).

For plant height (PH1, PH2, PH3), stem diameter (SD) and plant dry matter (DM), the ratio between the highest and lowest RMS was, respectively, 1.29; 2.01; 1.36; 1.05; 5.69, allowing the analysis of experiments groups and comparison of protected environments.

Interactions between environments and containers (E x C) showed interference of the cell volume in seedling growth where the largest volume of cells (trays with 72 cells) led plants to greater heights, larger diameter and biomass accumulation, except obtained height at 16 DAS in a screened nursery (Table 1). Authors also evaluated the quality of seedlings observed that trays with 72 cells formed the best seedlings (OLIVEIRA et al., 2012; COSTA et al., 2011). This result reinforces that higher volumes help the growth and seedlings development, although does not present the best cost and benefit from the economic point of view by the low use of space.

By observing the effect of the containers within the environments, it is observed that in the 72 cells tray seedlings grown in protected environment A2 (screened nursery) showed higher seedling height in relation to those produced in a greenhouse at the beginning and end of seedling development phase, as well as higher biomass. The A2 environment also provided seedlings with better growth and development compared to the A1 environment (greenhouse) for the tray of 128 cells, in this case the seedlings had higher dry phytomass and greater height, but the stem diameter did not differ between the studied environments. The smallest development and growth observed in the plastic greenhouse environment (A1) may be associated with increased evapotranspiration in this environment (COSTA et al., 2009).

TABLE 1. Interactions between environments and containers (E x C) for plant height (PH) evaluated at 16, 23 and 30 days after sowing (DAS), stem diameter (SD) and dry mass (DM) of the kale seedlings evaluated at 40 DAS (UEMS, Aquidauana, 2009).

	Height of seedling [cm]					
	16 DAS [days]		23 DAS [days]		30 DAS [days]	
Trays	E1	E2	E1	E2	E1	E2
C1	2.03 Ab*	2.24 Ba	4.10 Aa	3.98 Aa	4.57 Ab	4.73 Aa
C2	1.98Ab	2.30 Aa	2.43 Bb	2.86 Ba	2.80 Bb	3.10 Ba
	Stem Diameter [mm]		Dry mass [g]			
C1	1.65 Aa	1.55 Ab	0.068 Ab	0.094 Aa		
C2	1.21 Ba	1.27 Ba	0.036 Bb	0.050 Ba		

*Equal upper-case letters in the columns and lower-case letters in the lines do not differ by the Tukey test for substrates and t student test for environments and containers, both at 5% probability; ** E1 = greenhouse; E2 = agricultural nursery; C1 = tray of 72 cells; C2 = tray of 128 cells.

In the interaction between the environment and the substrate (E x S) it was found that the substrate contains 100% of cattle manure (S1) held in two areas (E1 and E2) and the 72-cell tray (C1) larger seedlings in three seasons of parameters evaluation, a result also observed in sugar apple seedlings and eucalyptus growth (DANTAS et al., 2013; MELO et al., 2014). However, the first evaluation in agricultural greenhouse (E1) and the second and third evaluation in the tray of 128 cells (C2), the plants of this substrate showed no differences in plant height of the substrate with 60% of cattle manure (S3).

The substrate with 80% manure (S2), whether or not differing from substrate with 60% (S3) in the screened nursery (E2), the second evaluation of height showed satisfactory performance for the plants height in the two cultivation environments and tray of 72 cells, that is, produced bigger seedlings than substrates with 0.20 and 40% of manure. Studies reported that the formation of cherry tomato seedling was properly attributed to a screened nursery with the substrate whose composition was 50% from cassava branches and 50% cattle manure (COSTA et al., 2015).

For the substrate with 60% of manure (S3), agricultural greenhouse (E1) provided higher plants that the screened nursery (E2) in the first collect, but for the other substrates highlighted the screened nursery, which presented higher seedlings. In the second collect for the S3 and S5 substrates the environments did not differ, but for the other substrates the greenhouse showed higher plants. The third height collect point for S2, S4 and S6 substrates the environments were similar and for other screened nursery promoted bigger seedlings (Table 2).

For S1, S2, S4 and S6 substrates from the first collect, as well as the S3 from third collect, the containers had plants with similar heights, not differing significantly. S3 from the first and second collect, the 128 trays provided higher seedlings. For the S5 from three collect and S1, S2, S4, and S6 from the last two collect, the tray with larger cell volume (tray with 72 cells) showed higher seedlings (Table 2). In studies evaluating different substrates on the development of kale was observed that the use of coconut fiber as substrate was most effective on growth and dry mass accumulation in plants in relation to manure (LACERDA et al., 2012). It was also observed that as increases the percentage / amount of manure substrate in relation to cassava branches there is increase in seedling height parameter to 16, 23 and 30 DAS in different kale cultivation environments. The use of manure substrate positively assists in the branches dry matter and provides better plant development conditions (CUNHA et al., 2014).

In the production of Chinese kale seedlings, the authors observed that organic substrates, formulated with 100% and 85% of organic compound showed better results at 15 and 28 DAS, respectively, and the substrate with 90% compound, 3% sand and 7% of basalt powder showed the best performance for the formation of seedlings and development in the field (TESSARO et al., 2013).

TABLE 2. Interactions between environments and substrates (E x S), between containers and substrates (C x S) for plant height (PH) evaluated at 16, 23 and 30 days after sowing (DAS) of kale seedlings (UEMS, Aquidauana, 2009).

	Height (cm)					
	16 DAS		23 DAS		30 DAS	
Substrates	E1	E2	E1	E2	E1	E2
S1	2.33 Ab*	2.90 Aa	4.26 Aa	4.12 Aa	4.75 Ab	5.28 Aa
S2	2.06 Bb	2.57 Ba	4.09Aa	3.42BCb	4.51 Ba	4.58 Ba
S3	2.32 Aa	2.15 Cb	2.88Bb	3.55 Ba	3.33 Cb	3.60 Ca
S4	1.94BCb	2.16 Ca	2.93 Bb	3.18CDa	3.32 Ca	3.39Ca
S5	1.87 Cb	2.05 Ca	2.74Bb	3.35BCa	3.20CDb	3.49Ca
S6	1.48 Db	1.82 Da	2.68Ba	2.88 Da	3.02 Da	3.15 Da
	C1	C2	C1	C2	C1	C2
S1	2.60 Aa	2.63 Aa	5.18 Aa	3.19 Ab	6.49 Aa	3.54 Ab
S2	2.33 Ba	2.30 Ba	4.97 Aa	2.54 Bb	6.22 Ba	2.86 Bb
S3	2.15 Cb	2.32 Ba	3.37 Ba	3.06 Ab	3.53 Ea	3.40 Aa
S4	2.06 Ca	2.04 Ca	3.68 Ba	2.43BCb	3.99 Ca	2.72 Bb
S5	2.06 Ca	1.87 Db	3.61 Ba	2.48 Bb	3.88CDa	2.80 Bb
S6	1.62 Da	1.68 Ea	3.44 Ba	2.11 Cb	3.78 Da	2.39 Cb

*Equal upper-case letters in the columns and lower-case letters in the lines do not differ by the Tukey test for substrates and t student test for environments and containers, both at 5% probability; ** E1 = greenhouse; E2 = agricultural nursery; C1 = tray of 72 cells; C2 = tray of 128 cells; S1 = 100% cattle manure and 0% cassava branches; S2 = 80% cattle manure and 20% cassava branches; S3 = 60% cattle manure and 40% cassava branches; S4 = 40% cattle manure and 60% cassava branches; S5 = 20% cattle manure and 80% cassava branches; S6 = 0% cattle manure and 100% cassava branches.

In agricultural greenhouse (E1), the seedlings had higher dry matter in the substrate with 100% of cattle manure (S1) followed by substrate with 80% (S2). But in a screened nursery S2 showed greater accumulation of biomass than S1. In two containers, the substrate with 100% of cattle manure (S1) provided higher dry biomass, but the tray of 72 cells (C1) did not differ from S2. For the stem diameter, S2 substrate was superior from the others, followed by S1 in C1 container; However in C2, S1 showed larger diameter than the others (Table 3).

There is a predominance of variables presented higher values in S1 and S2 substrates because these substrates contained higher amounts of manure and consequently greater amount of nutrients that promote further growth in height, diameter and accumulation on biomass. In these substrates, the screened nursery promoted greater accumulation of biomass, as well as for the substrate S3. The substrates with 40% (S4) and 20% (S5) manure the environments did not differ, and to 0% of manure (S6), the greenhouse provided higher dry mass than the screened nursery (Table 3)

The higher biomass and the largest diameter of the stem were obtained in the container with greater volume of cells (72 cells tray, R1) for most tested substrates, except S4 for dry mass and stem diameter, as well as S5 only to the diameter where the recipients did not differ (Table 3).

In guanandi seedlings (*Calophyllum brasiliense* Cambèss), substrate-based on eight underground parts and two parts of coarse sand, with dose increases of 0, 2, 4 and 6 parts of dairy cattle manure (v : v : v) performing liming to raise the base saturation index of about 20 (initial), 35, 50 and 65% (91% of PRNT), ARTUR et al. (2007) found no need to liming and manuring. In this study, the results diverged from ARTUR et al. (2007), because the doses of 80 and 100% were more conducive to the formation of kale seedlings.

Manure composting form can have promoted appropriate conditions for the development of kale seedling in substrate with 80 and 100% of this material combined with higher amount of nutrients because ARAUJO NETO et al. (2009) presents that the organic source is responsible for moisture retention and the supply of part of the nutrients. In organic system, the use of manure mixed with organic waste such as rice hulls and shredded coconut, did not promote the quality of pepper seedlings, being inferior to the substrate containing earthworm humus and Plantmax® (ARAÚJO NETO et al., 2009). It is observed that in the above-mentioned study (ARAUJO NETO et al., 2009; ARTHUR et al., 2007), using maximum of 1/3 (33%) of manure in the substrate composition, however in this experiment it was possible to get best seedlings using 80-100% of manure. The cattle biofertilizers application at the highest dose led to significant increases in plant height, stem diameter, root length and the remaining variables, accentuating the harmful effects of salinity of the water in the papaya production (VÉRAS et al., 2015).

TABLE 3. Interactions between environments and substrates (E x S), between containers and substrates (C x S) for dry mass (DM) and stem diameter (SD) of kale seedlings evaluated at 40 days after sowing (DAS) (UEMS, Aquidauana, 2009).

	Stem diameter (mm)			
	E1	E2	C1	C2
S1	1.79 Aa	1.80 Aa	2.01ABa	1.58 Ab
S2	1.73 Aa	1.79 Aa	2.18 Aa	1.34ABb
S3	1.49 Ba	1.53 Ba	1.83Ba	1.19 BCb
S4	1.28 BCa	1.23 Ca	1.28 Ca	1.23 BCa
S5	1.16 Ca	1.08 Ca	1.16 Ca	1.08 Ca
S6	1.12 Ca	1.00 Ca	1.11 Ca	1.00 Cb
	Dry mass (g)			
S1	0.096 Ab	0.120 Ba	0.143 Aa	0.073 Ab
S2	0.072 Bb	0.139 Aa	0.144 Aa	0.066 Ab
S3	0.050 Cb	0.091 Ca	0.093 Ba	0.048 Bb
S4	0.032 Da	0.038 Da	0.033 Ca	0.037 Ba
S5	0.030 Da	0.027 DEa	0.041 Ca	0.017 Cb
S6	0.034 Da	0.017 Eb	0.033 Ca	0.018 Cb

*Equal upper-case letters in the columns and lower-case letters in the lines do not differ by the Tukey test for substrates and t student test for environments and containers, both at 5% probability; ** E1 = greenhouse; E2 = agricultural nursery; C1 = tray of 72 cells; C2 = tray of 128 cells; S1 = 100% cattle manure and 0% cassava branches; S2 = 80% cattle manure and 20% cassava branches; S3 = 60% cattle manure and 40% cassava branches; S4 = 40% cattle manure and 60% cassava branches; S5 = 20% cattle manure and 80% cassava branches; S6 = 0% cattle manure and 100% cassava branches.

CONCLUSIONS

The use of different environment, containers and substrates influenced the formation of kale seedlings. The screened nursery covered with Sombrite® provided more vigorous seedlings in relation to seedlings grown in a greenhouse, using substrates containing 80 and 100% of cattle manure. The tray of 72 cells led to higher seedling and more dry mass.

ACKNOWLEDGEMENTS

The authors want to thank for FUNDECT, CNPq and CAPES

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