horticultura brasileira

CC BY

Research

RIVERA, B; QUEJ, VH; GUTIÉRREZ, R; ANDRADE, JL; CARRILLO, E; GONZÁLEZ, V; VILLARREAL, EC. 2022. Use of organic substrates on the quality of watermelon seedlings. *Horticultura Brasileira* 40: 261-267. DOI: http://dx.doi.org/10.1590/s0102-0536-20220303

Use of organic substrates on the quality of watermelon seedlings

Benigno Rivera[1]; Victor H Quej[2]*; Roberto Gutiérrez[1]; José L Andrade[3]; Eugenio Carrillo[2]; Vianey González[1]; Edelia C Villarreal[1]

[1]Universidad Popular de la Chontalpa, Cárdenas, Tabasco, México; benigno.rivera@upch.mx; roberto.gutierrez@upch.mx; vgonzalezj@colpos.mx (*author for correspondence); villiba.edecla@hotmail.com; [2]Colegio de Postgraduados, Champotón, Campeche, México; quej@colpos.mx; ceugenio@colpos.mx; [3]Centro de Investigación Científica de Yucatán., Mérida, Yucatán, México; andrade@cicy.mx

ABSTRACT

Watermelon (*Citrullus lanatus*) is a succulent fruit and vine-like plant that is cultivated in Mexico and it generates employment and currency for the country. However, there is the need to research what local organic substrates can substitute peat moss as a culture medium to produce watermelon seedlings of good quality and at low cost. The objective of this study was to evaluate the physical and chemical properties of five local organic substrates as substitutes of the commercial substrate "Peat Moss", for the production of seedlings of two watermelon cultivars, Sun Sweet and Jubilee. Five local organic substrates were studied: cacao husk, compost, vermicompost, bovine manure, coconut fiber and the commercial substrate "Peat Moss" as control. The response variables were percentage of germination, indicators of morphological quality and morphological quality indexes, stability of the clod, and relative efficiency of the local substrates. The best morphological indicators and morphological quality index of the seedlings were found with the substrates cacao husk and vermicompost, with a seedling quality similar to those obtained with the commercial substrate. Compost presented the lowest stability of the clod and relative efficiency. The substrates of cacao husk and vermicompost can substitute the commercial substrate "Peat Moss", in addition to being easy to obtain and of low cost; so they are a viable alternative for rural farmers in the production of watermelon seedlings.

Keywords: *Citrullus lanatus*, cacao husk, vermicompost, coconut fiber.

RESUMO

Influência de substratos orgânicos na qualidade de mudas de melancia

Melancia (*Citrullus lanatus*) é uma planta frutífera, ramadora, cultivada no México, gerando emprego e divisas para o país. Há necessidade de pesquisar substratos orgânicos locais ideais para substituir a turfa como meio de cultura visando produção de mudas de melancia de boa qualidade com baixo custo. Portanto, avaliou-se as propriedades físico-químicas de cinco substratos orgânicos locais (casca de cacau, composto, vermicomposto, esterco bovino, fibra de coco e o substrato comercial "Peat Moss" como controle) como substitutos do substrato comercial "Peat Moss", para produzir mudas das cultivares Sun Sweet e Jubilee. As variáveis de resposta foram: porcentagem de germinação, indicadores de qualidade morfológica e índices de qualidade morfológica, estabilidade do torrão e eficiência relativa dos substratos locais. Os melhores indicadores morfológicos e índice de qualidade morfológica das mudas foram encontrados com os substratos casca de cacau e vermicomposto, com qualidade de mudas semelhantes às obtidas com o substrato comercial. O composto apresentou a menor estabilidade do torrão e eficiência relativa. Os substratos de casca de cacau e vermicomposto são adequados para substituir o substrato comercial "Peat Moss", além de serem de fácil obtenção e de baixo custo, sendo uma alternativa viável para agricultores rurais na produção de mudas de melancia.

Palavras-chave: *Citrullus lanatus*, casca de cacau, vermicomposto, fibra de coco.

Received on March 21, 2022; accepted on August, 1st, 2022

Mexico is the second country capturing most currencies from foreign trade of watermelon (*Citrullus lanatus*). It occupies the tenth place in its production (1,472,459 t) and is the third in exports volume (14% of the total produced) (SIAP, 2020). The state of Tabasco has a surface of 1250,000 ha with high soil-climate potential for the production of watermelon, with potential average yields of 60 t/ha (Aceves-Navarro *et al.*, 2008). However, actual yields are significantly lower than estimated, usually related to changes in air temperature and rainfall patterns (Rivera-Hernández *et al.*, 2016), which originate non-germinated seeds and delays in watermelon planting directly in the field.

The production of watermelon seedlings in containers, using commercial substrates, is a widely used practice to have uniform and high-quality plants, whose characteristics contribute to the survival of plants after transplantation to the field. Peat Moss (most used commercial name) is the standard substrate worldwide to produce seedlings, but it represents 23% of the total production cost. That is why it is necessary to search for other types of substrates of lowest cost (Pascual *et al.,* 2018).

The search for new substrates can be satisfied through the use of local organic substrates, which contribute to the development and healthy seedlings (Schmilewski, 2014). Dalastra *et al.* (2016) found that watermelon plants that grow from seedlings grown in containers with organic substrate showed a greater vegetative development than plants obtained from direct sowing. In Tabasco, particularly in the region of Chontalpa, studies have not been performed yet to understand the potential of some agricultural and industrial byproducts that could eventually be used as substrates in the production of watermelon seedling, such as coconut fiber, cacao husk, different composts and vermicomposts, and even bovine manure. In addition to being an alternative to decrease the costs of seedling production, the accumulated residue would be used (Pascual *et al.*, 2018). However, the organic substrates destined to substitute peat moss ought to be evaluated by their biological, physical and chemical properties, since these can influence both the germination and the growth of seedlings (Dalastra *et al.*, 2016).

The production of seedlings in greenhouses is a practice that guarantees uniform and well-developed plants, which also ensures a better start in the field and, consequently, good production through proper management. Thus, the quality of the substrate plays an important role in the production of seedlings in terms of its physical-chemical characteristics that will influence their growth and development. Consequently, in the evaluation of substrate quality, those with desirable physical-chemical characteristics are identified, since each species or cultivar will have its own water and mineral nutrient requirements for good root development (Schmilewski, 2014). The present work aims to evaluate the physical-chemical properties of five local substrates of organic origin for seedling production of two watermelon cultivars: Sun Sweet and Jubilee.

MATERIAL AND METHODS

Site study and organic substrates

The experiment was carried out in the facilities of the Popular University of Chontalpa, located in the municipality of Cárdenas, Tabasco, Mexico in a greenhouse covered with shade mesh tarp at 50% of the total daily solar radiation. Sowing was performed on November 29, 2019. Five organic substrates were evaluated: cacao husks (CH) that were collected in a farm after extracting the seed; bovine manure (BM), collected in a cattle productive unit after milking; compost (CP) elaborated based on sugarcane *cachaza*, collected one month after milling; coconut fiber (CF) acquired from the Local Agricultural Association of Coconut Producers (*Asociación Agrícola Local de Productores de Coco*) in the municipality of Comalcalco, Tabasco, Mexico; and vermicompost (VC) that was obtained with *Eisenia foetida* fed with sugarcane *cachaza* plus *Canavalia ensiformis* in a proportion of 70:30 (v/v). Composting of the residues CH, BM and CP was carried out according to the procedure described by Ceglie *et al.* (2015). The substrates were dried in the shade, ground and sieved at 2 mm for their analysis. The physical-chemical analysis of the substrates was performed in the laboratory of Colegio de Postgraduados Campus Campeche, Mexico (Table 1). The variables evaluated were: potential of hydrogen (pH) measured with potentiometer in suspension susbstrate solution 1:5; organic matter (OM) by the Walkley and Black procedure; nitrogen (N) extracted with potassium chloride 2N and determined by vapor distillation; assimilable phosphorus (P) by the Bray P1 method; sodium potassium (Na, K) extracted in ammonium acetate 1.0 N, pH 7.0, 1:20 rate and determined by flame emission spectroscopy; calcium and magnesium (Ca, Mg) extracted in ammonium acetate 1.0, pH 7.0, in a 1:20 rate and determined by atomic absorption spectroscopy; iron and magnesium (Fe, Mg) extracted with a DTPA (Diethylenetriamine pentaacetic acid) 1:4 rate and determined by atomic spectroscopy; bulk density test by the tube method (BD). The methodology for the analysis of these variables was carried out according to the Mexican Official Norm NOM-021-SEMARNAT-2000.

Vegetative material

The vegetative materials used were two watermelon cultivars (cv), Sun Sweet and Jubilee, because these are the ones most sown by producers in the state of Tabasco. Polyethylene cups with a volume of 100 mL were used as containers, considering as ideal to produce the watermelon seedling (Araújo *et al.*, 2010).

Experimental design and treatments

A completely random experimental design was used, considering the different substrates as treatments, separately analyzing their effect on watermelon cultivars *Sun Sweet* and *Jubilee*. Each treatment with four repetitions of 150 seedlings per experimental units and each container with a seedling was the experimental unit.

Morphological analysis and quality indexes

To record the response variables, 25 plants per experimental unit were selected at 35 days after sowing (DAS). The evaluated indicators of morphological quality were percentage of emergence (%*E*), which was obtained from counting the emerged plants at 6 and 12 DAS; seedling height (*SH*, cm), root length (*RL*, cm), measured with a ruler; number of roots per seedling (*NR*), visually quantified after washing the roots with tap water; final stem diameter (*SD*, mm), measured with a digital stainless steel vernier; number of true leaves (*NL*); foliar area (*FA*, cm^2/seedling) estimated with the procedure described by Sauceda-Acosta *et al.* (2017); specific leaf area (*SLA*, cm^2/g of dry weight), estimated as a relation between *FA* and dry leaf biomass (*DLB*, g); dry aerial biomass (*DAB*, g); dry root biomass (*DRB*, g) and total dry biomass (*TDB*, g), obtained after drying the seedlings in a Shel Lab FX28 model stove (Sheldon Manufacturing, Cornelius, Oregon, EUA) at 70°C until obtaining constant weight. The morphological quality indexes evaluated were the *DRB*/*DAB* rate; the slenderness index (*SI*) (Duryea, 1985); and Dickson's quality index (*DQI*) (Dickson *et al.*, 1960). The stability of the clod according to the pictorial scale by Gruszynski (2002) where: 1 when more than 50% of the clod is retained in the container; 2 when the clod is separated from the container, but does not remain cohesive; and 3 when the whole root is separated from the container and more than 90% of the clod remains cohesive; the ease of extraction was evaluated according to the procedure described by Acevedo-Alcalá *et al.* (2020), where the release of the seedling from the tray was classified as easy (1), medium (2) and difficult to extract (3). In the last two variables 80 seedling extractions were evaluated per organic substrate. Lastly, the percentage of relative efficiency (*RE*) of organic substrates was quantified, according to the procedure described by Silva *et al.* (2017a), with the following formula:

$$RE(\%) = \frac{CS-LOS}{CS} x - 100 \quad (1)$$

where CS is the commercial substrate, and LOS are the local organic substrates.

Statistical analysis

A one-way variance analysis was carried out for each of the response variables evaluated, and the means, when significant, were compared with Tukey's test ($p \leq 0.05$).

RESULTS AND DISCUSSION

The treatment with the sugarcane *cachaza* compost presented a significantly lower seed emergence percentage at 6 and 12 DAS in the two watermelon cultivars (Figure 1), which is probably due to a greater compacting in the container (Abad *et al.*, 2001; Silva *et al.*, 2017b). In addition, crust formation was observed on the surface of the container due to a higher substrate bulk density (Table 1), and as has been reported in previous experiments (Silva *et al.*, 2014, 2017b). Pascual *et al.* (2018) point out that high values of bulk density affect root aeration and therefore their development. Except sugarcane *cachaza* compost, all other substrates are within the ranges of total porosity (70-85%) considered ideal (Pascual *et al.*, 2018).

The growth of seedlings in the substrates cacao husks and vermicompost promoted significantly greater seedling height and final stem diameter (Table 2) in both watermelon cultivars. The values of *SH* and *SD* obtained by cacao husk and vermicompost were statistically similar to the values obtained with the use of the commercial substrate peat moss in cv. Sun Sweet; the same trend was observed in both variables in cv. Jubilee, with identical statistical results, although with different values. This favorable effect of the cacao husk and vermicompost is attributed to the higher content of nitrogen in both (Table 1). Nitrogen is one of the most essential elements for plants and originates the production of additional proteins, allows the leaves of the plants to grow more, and for these to have greater surface available for photosynthesis. In addition, nitrogen also influences the increase of root biomass, which results in a higher absorption of nutrients and soil water, leading to higher biomass area (Cavalcante *et al.*, 2019). The stem diameter is a variable that is associated with seedling vigor and represents a higher probability of seedlings not bending during transplant (Luna *et al.*, 2014).

A significantly lower number of leaves per seedling in cv. Sun Sweet was present in the treatments with compost and coconut fiber, while in cv. Jubilee this was seen only in the compost treatment. However, all the substrates presented seedlings with more than four leaves, one of the quality criteria that define the ideal moment to transplant watermelon seedlings (Andrade *et al.*, 2017). The root length of the seedlings grown in the commercial substrate was similar ($p \leq 0.05$) to the one obtained in cacao husk and vermicompost in the two watermelon cultivars. Again, in the treatments with compost and coconut fiber, a lower number of roots per seedling was observed in cv. Sun Sweet, while in cv. Jubilee seedlings a significantly lower value was seen in root length in the compost treatment. It seems that watermelon seedlings growth is assigned toward a higher number of roots than root length, which is most marked in cv. Jubilee (Table 2). Larger root formation allows seedlings to further explore the volume of available substrate, allowing for greater water and nutrient absorption. (Souza *et al.*, 2013).

The production of *DAB* and *DRB* resulted equal ($p > 0.05$) in the substrates cacao husk, vermicompost and peat moss in the two watermelon cultivars (Table 2). This higher production of *DAB* and *DRB* can be attributed to the higher number of leaves (Table 2) and the higher foliar area (Table 3) in these substrates (Wright & Westoby, 2001; Wei *et al.*, 2020), which promoted higher light absorption; this indicates that the seedlings grown in these substrates presented higher photosynthetic capacity (Melo *et al.*, 2019). The higher production of *DAB* and *DRB* has been attributed primarily to the nitrogen content, but it is also possibly due to the interaction

Table 1. Physical and chemical properties of organic substrates. Tabasco, Mexico, University of Chontalpa, 2019.

Physical and chemical parameters	Cacao husk	Bovine manure	Coconut fiber	Compost	Vermicompost
Bulk density (g/cm^3)	0.29	0.48	0.13	0.78	0.57
Porosity (%)	77	80	75	63	73
pH (1:10)	8.60	8.40	5.50	7.40	7.70
Total N (mg/g)	14.34	9.32	0.23	8.21	11.08
Total P (mg/g)	6.11	6.21	4.62	22.91	16.29
Total K (mg/g)	24.85	19.34	18.78	4.24	4.87
Total Ca (g/g)	2.18	21.58	14.52	4.25	6.72
Total Mg (g/g)	11.17	9.54	6.14	12.21	13.92
Total Fe (mg/g)	10.34	13.25	87.62	78.66	71.27
Total Mn (mg/g)	135.81	98.52	102.14	124.11	142.34
OM (%)	89.14	66.68	89.94	62.77	74.25

OM = organic matter.

Table 2. Seedling height (SH, cm), stem diameter (SD, mm), number of leaves per plant (NL), root length (RL, cm), number of roots per seedling (NR), weight of the dry aerial biomass (DAB, g), weight of the dry root biomass (DRB, g) in watermelon cv. Sun Sweet and cv. Jubilee. Tabasco, Mexico, University of Chontalpa, 2019.

Organic substrates	*SH*	*SD*	*NL*	*RL*	*NR*	*DAB*	*DRB*
			cv Sun Sweet				
Cacao husk	19.93a	2.73a	7.82a	10.82a	36.81a	0.593a	0.291a
Compost	11.81c	2.34a	5.85b	5.40c	18.61b	0.465b	0.208b
Vermicompost	19.24a	3.04a	8.25a	9.93a	39.87a	0.626a	0.398a
Bovine manure	16.46b	1.71b	8.91a	7.63b	37.98a	0.403c	0.221b
Coconut fiber	12.35c	1.56b	6.12b	6.84bc	32.75b	0.401c	0.182b
Peat moss	21.04a	2.48a	8.05a	9.18a	41.14a	0.575a	0.312a
CV (%)	13.25	11.24	9.78	10.14	14.58	11.54	13.22
			cv Jubilee				
Cacao husk	20.58a	2.71a	8.85a	9.41a	38.13a	0.613a	0.301a
Compost	13.52b	1.36b	6.21b	6.92b	29.22b	0.412b	0.192b
Vermicompost	20.81a	2.87a	8.98a	8.78ab	38.52a	0.606a	0.358a
Bovine manure	14.61b	1.42b	8.21a	7.12b	38.33a	0.503b	0.261b
Coconut fiber	11.87c	1.38b	8.98a	6.88b	36.82a	0.499b	0.201b
Peat moss	19.98a	2.23a	9.52a	9.21a	42.06a	0.605a	0.312a
CV (%)	16.47	13.78	10.54	12.57	11.58	12.87	11.52

Means with different letters in columns are statistically different ($p \leq 0.05$).

between nitrogen and phosphorus that interacted positively to increase the dry matter of the plants (Cavalcante *et al.*, 2019). The *cachaza* compost presented slightly lower nitrogen content than that obtained in the cacao husk and vermicompost, but it presents much higher values in phosphorus, which indicates that the development of the seedling in the compost is limited by physical properties (Table 1).

A statistically higher accumulation of total dry aerial biomass (1.024 g) was obtained in vermicompost, which exceeded in 15.44% the value obtained in the commercial substrate (0.887 g) in cv. Sun Sweet, while in cv. Jubilee no significant differences were found ($p>0.05$) between vermicompost, cacao husk and peat moss in this variable (Table 3). Seedlings with higher root biomass and aerial biomass are more likely to overcome, after transplant, the negative effects of drought and soil compacting (Castillo *et al.*, 2014; Yanyan *et al.*, 2018).

In the substrate cacao husk, leaf area values were observed on seedlings that were statistically equal to the ones obtained in peat moss, in both watermelon cultivars (Table 3). Low values of specific leaf area indicate higher ability of the seedling to resist transplant due to greater thickness and lignification of the leaves (Castillo *et al.*, 2014). According to Cavalcante *et al.* (2019), the leaf growth rate is directly influenced by the contribution of nitrogen. The higher values of leaf area measured in cacao husk and vermicompost are due to a higher number and growth of the leaf lamina of the seedling.

The relation between dry root biomass and dry aerial biomass (*DRB/DAB*) did not present significant differences between the different organic substrates in any of the two watermelon cultivars (Table 3). The values found in this study represent a balanced relation between *DRB* and *DAB* (Bantis *et al.*, 2019a). However, several responses interact among each other when many factors are coincidentally superposed, and therefore, the volume of roots can be a crucial element to evaluate seedling quality (Nakano, 2007; Bantis *et al.*, 2019a). This study did not evaluate the root volume, but it is logical to think that the volume would be higher in cacao husk and vermicompost, since greater root length and higher number of roots were found in these substrates.

The highest *SI* was found in the substrates bovine manure, peat moss and coconut fiber in cv. Sun Sweet, while in cv. Jubilee it was seen in the same substrates plus the compost. This occurs because the *SD* in the seedling was smaller, which represents an imbalance in its growth. The most balanced growth of the seedling was found in the treatment of vermicompost and cacao husk.

In the substrates vermicompost, cacao husk and peat moss, statistically higher values were found in *DQI* in both watermelon cultivars. The *DQI* seen in this study are higher than those reported by Oliveira *et al.* (2015) for cv. Crimson Sweet. Normally, with higher value of *DQI* the quality of the seedling will be greater (Wei *et al.*, 2020), indicating that the seedlings were more vigorous in these substrates. The *DQI* is considered one of the best quality indexes of the seedling because it considers the robustness and the equilibrium of the seedling when calculating biomass distribution of seedlings, considering the results of several important attributes in a single index (Melo *et al.*, 2019; Bantis *et al.*, 2019b).

In the variables of stability and extraction of the seedling from the containers (Table 4), it was observed that, when extracting the seedlings from the substrates cacao husk and peat moss, more than 80% was extracted, which is considered high stability of the substrate and easy extraction (code 3) to medium extraction (code 2). The ease of extraction and the stability of both substrates could be because they present better physical characteristics, since they do not compact and present sufficient cohesion to not detach the root from the root ball and therefore not causing physical damage to the root at the moment of the transplant (Acevedo-Alcalá *et al.*, 2020).

Vermicompost and cacao husk presented the highest *RE* of the five

Table 3. Weight of total dry biomass (TDB, g), foliar area (FA, cm2), specific leaf area index (SLA, cm2/g), dry root biomass and dry aerial biomass rate (DRB/DAB), slenderness index (SI) and Dickinson quality index (DQI), in watermelon cv. Sun Sweet and cv. Jubilee. Tabasco, Mexico, University of Chontalpa, 2019.

Organic substrates	*TDB*	*FA*	*SLA*	*DRB/DAB*	*SI*	*DQI*
cv Sun Sweet						
Cacao husk	0.884b	22.05a	106.23a	0.49a	7.30b	0.094a
Compost	0.673c	12.15b	79.65b	0.45a	5.04c	0.092a
Vermicompost	1.024a	19.34a	88.27b	0.64a	6.32c	0.109a
Bovine manure	0.624c	14.83b	105.14a	0.55a	9.62a	0.054b
Coconut fiber	0.583c	12.31b	87.71b	0.45a	7.91ab	0.057b
Peat moss	0.887b	21.83a	108.47a	0.54a	8.48a	0.085a
CV (%)	15.24	13.21	14.24	11.87	10.98	14.52
cv Jubilee						
Cacao husk	0.914a	20.12a	101.77a	0.49a	7.59b	0.095a
Compost	0.604b	14.01b	96.15a	0.47a	9.94a	0.053b
Vermicompost	0.964a	21.31a	85.47b	0.59a	7.25b	0.107a
Bovine manure	0.764b	15.22b	99.45a	0.52a	10.14a	0.063b
Coconut fiber	0.702b	14.98b	87.77a	0.40a	8.60a	0.063b
Peat moss	0.917a	20.44a	99.52a	0.52a	8.95a	0.084a
CV (%)	12.52	10.25	12.68	10.18	11.08	15.11

Means with different letters in columns are statistically different (p≤0.05).

Table 4. Clod stability (*CS*, %) by code of the scale (1, 2, and 3) and ease of extraction (*EEX*, %) by code of the scale (1, 2 and 3) in two watermelon cultivars, cv. Sun Sweet and cv. Jubilee. Tabasco, Mexico, University of Chontalpa, 2019.

Organic substrates	*CS*			*EEX*		
	% code 1	**% code 2**	**% code 3**	**% code 1**	**% code 2**	**% code 3**
cv Sun Sweet						
Cacao husk	6.25c	12.50b	81.25b	88.75a	7.50c	3.75c
Compost	41.25a	23.75a	35.00d	40.00c	27.50a	32.5a
Vermicompost	16.25b	10.00c	73.75c	80.00a	11.25b	8.75b
Bovine manure	16.25b	13.75b	70.00c	60.00b	17.50b	22.50a
Coconut fiber	13.75b	18.75a	67.50c	63.75b	26.25a	10.00b
Peat moss	0.00d	3.75d	96.25a	92.50a	5.00c	2.50c
CV (%)	42.58	34.81	20.52	36.21	22.21	38.21
cv Jubilee						
Cacao husk	8.75c	6.25c	85.00a	95.00a	2.50b	2.50d
Compost	28.75a	30.00a	41.25c	55.00c	16.25a	28.75a
Vermicompost	16.25b	18.75b	65.00b	77.50b	12.50a	10.00c
Bovine manure	18.75b	16.25b	65.00b	65.00b	15.00a	20.00a
Coconut fiber	17.50b	11.25b	71.25b	71.25b	13.75a	15.00ab
Peat moss	2.50d	5.00c	92.50a	95.00a	3.75b	1.25d
CV (%)	28.25	31.20	23.49	21.64	31.21	41.21

Means with different letters in columns are statistically different (p≤0.05).

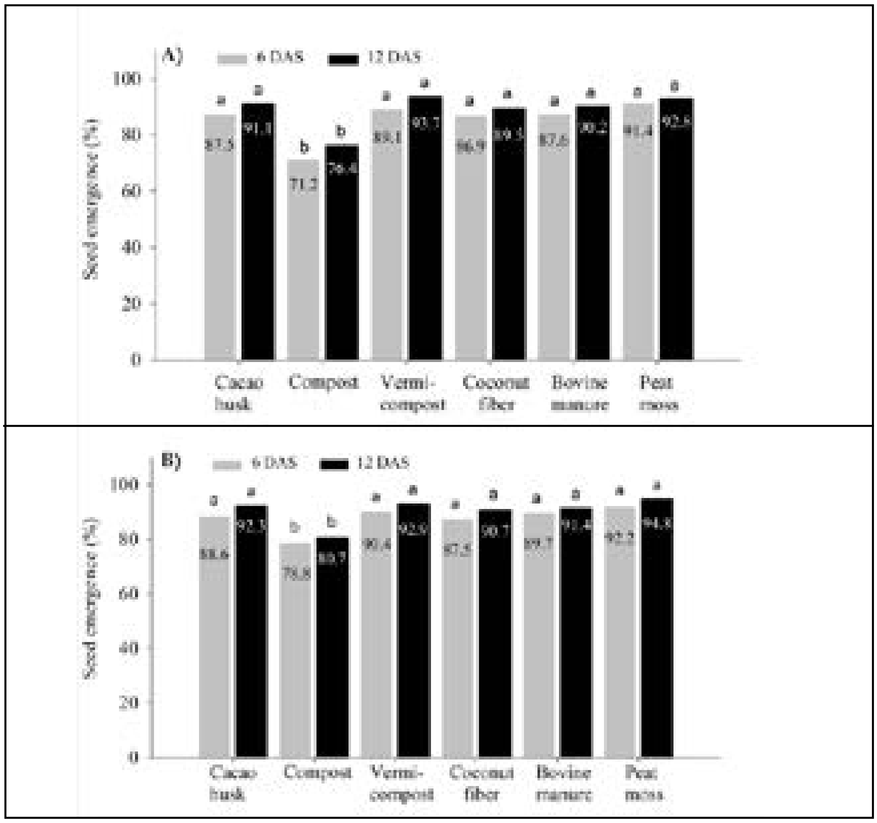

Figure 1. Emergence percentage of watermelon seed at 6 and 12 das. A: cv. Sun Sweet and B: cv. Jubilee. Different letters indicate significant statistical differences (Tukey, p=0.05). Tabasco, Mexico, University of Chontalpa, 2019

organic substrates evaluated compared to the commercial substrate peat moss (Figure 2). Thus, the *RE* values of *SH* and *TDB* variables are close to the origin for cacao husk and vermicompost substrates for both cv. Jubile and cv Sun Sweet. Organic substrates of compost, bovine manure and coconut fiber presented the most negative values, indicating that they are less efficient compared to peat moss. The morphological variables of *SD*, *LA*, *SH*, *TDB* and *FA* presented values above the origin in the cacau husk and vermicompost substrates, indicating that these substrates exceed the efficiency of the commercial substrate peat moss. The response of the relative efficiency is different between cv. Sun Sweet and cv. Jubilee, both in the trend and in the values of the growth variables.

In conclusion, considering morphological quality indicators for both watermelon cultivars, the cacau husk and the vermicompost substrates showed the best results for the growing watermelon seedlings; and the compost and coconut fiber substrates obtained the

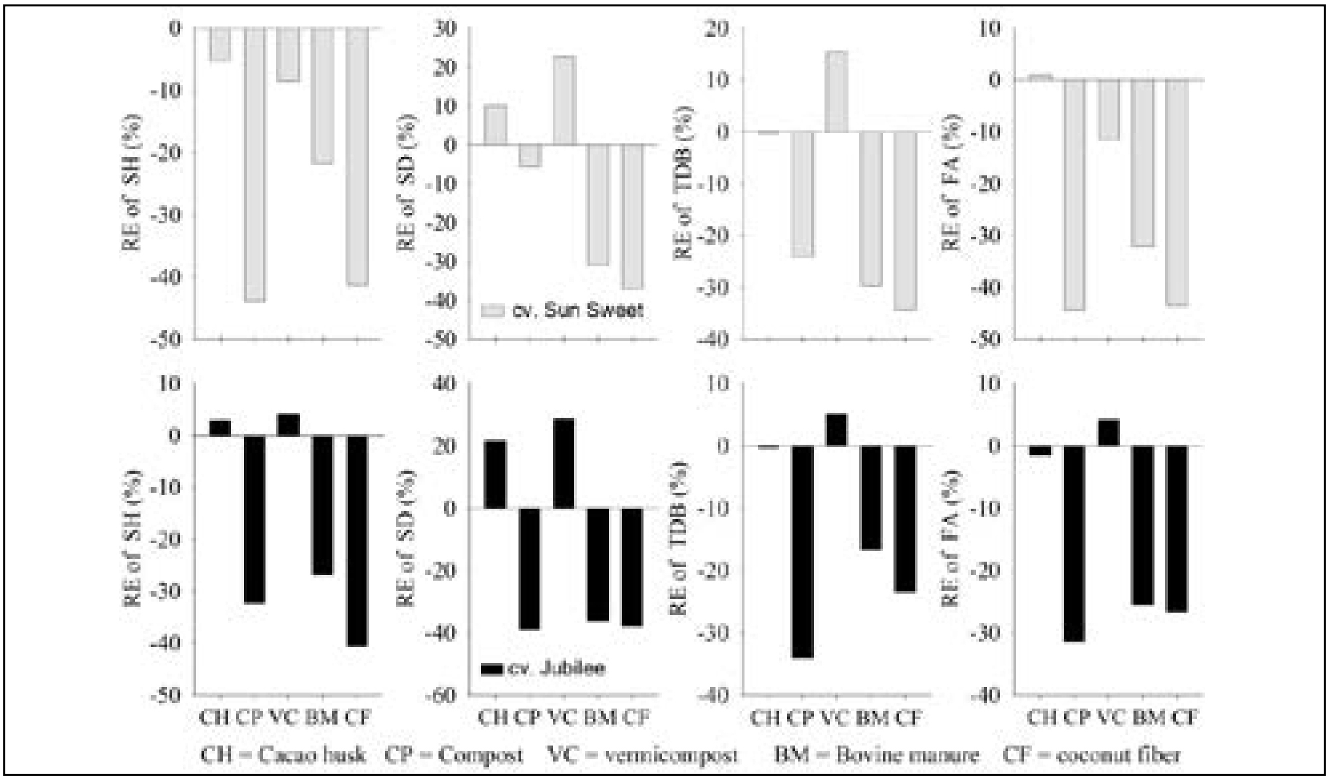

Figure 2. Relative efficiency (RE) of the local organic substrates in relation to the commercial substrate (peat moss): SH= seedling height; SD= stem diameter, TDB= total dry biomass and FA= foliar area in watermelon seedlings. Gray color panel cv. Sun Sweet and black color panel cv. Jubilee. Tabasco, Mexico, University of Chontalpa, 2019

lowest results for seedlings. Likewise, the cacau husk and the vermicompost substrates were evaluated statistically equal to those obtained with the commercial substrate Peat Moos, so they represent a viable alternative for rural producers in the production of watermelon seedlings, whose advantage lies on their low cost and on how easy to get are.

REFERENCES

ABAD, M; NOGUERA, P; BURES, S. 2001. National inventory of organic wastes for use as growing media for ornamental potted plant production: case study in Spain. *Bioresource Technology* 77: 197-200. Available at https://doi.org/10.1016/s0960-8524(00)00152-8

ACEVEDO-ALCALÁ, P; CRUZ-HERNÁNDEZ, J; TABOADA-GAYTÁN, OR. 2020. Abonos orgánicos comerciales, estiércoles locales y fertilización química en la producción de plántula de chile poblano. *Fitotecnia Mexicana* 43: 35-44.

ACEVES-NAVARRO, LA; JUÁREZ-LÓPEZ, JF; PALMA-LÓPEZ, DJ; LÓPZ-LÓPEZ, R; RIVERA-HERNÁNDEZ, B; RINCÓN-RAMÍREZ, JA. 2008. Estudio para determinar zonas de alta potencialidad del cultivo de sandía (*Citrullus lanatus*) en el estado de Tabasco. Colegio de postgraduados-INIFAP-SAGARPA. Tomo V. 30p. Available at https://campotabasco.gob.mx/wp-content/uploads/2021/04/SANDIA.pdf

ANDRADE, HAF; COSTA, NA; CORDEIRO, KV; OLIVEIRA NETO, ED; ALBANO, FG; MATOS, RRSS. 2017. Caule decomposto de babaçu (*Attlea speciosa* Mart.) como substrato para produção de mudas de melancieira. *Cultura Agronômica* 26: 406-416.

ARAÚJO, WBM; ALENCAR, RD; MENDONÇA, V; MEDEIROS, EV; ANDRADE, RC; ARAUJO, RR. 2010. Esterco caprino na composição de substratos para formação de mudas de mamoeiro. *Ciência e Agrotecnologia* 34: 68-73.

BANTIS, F; KOUKOUNARAS, A; SIOMOS, A; MENEXES, G; DANGITSIS, C; DAMIANOS KINTZONIDIS, D. 2019a. Assessing quantitative criteria for characterization of quality categories for grafted watermelon seedlings. *Horticulturae* 5: 1-10.

BANTIS, F; KOUKOUNARAS, A; SIOMOS, AS; RADOGLOU, K; KINTZONIDIS, D. 2019b. Optimal LED wavelength composition for the production of high-quality watermelon and interspecific squash seedlings used for grafting. *Agronomy* 9: 1-11.

CASTILLO, JE; HERRERA, F; LÓPEZ-BELLIDO, RJ; LÓPEZ-BELLIDO, FJ; LÓPEZ-BELLIDO, L; FERNÁNDEZ, EJ. 2014. Municipal solid waste (MSW) compost as a tomato transplant medium. *Compost Science & Utilization* 12: 86-92.

CAVALCANTE, VS; PRADO, RM; VASCONCELOS, RL; ALMEIDA, HJ; SILVA, TR. 2019. Growth and nutritional efficiency of watermelon plants grown under macronutrient deficiencie. *HortScience* 54: 738-742.

CEGLIE, FG; BUSTAMANTE, MA; AMARA, MB; TITTARELLI, F. 2015. The challenge of peat substitution in organic seedling production: optimization of growing media formulation through mixture design and response surface analysis. *PLoS ONE* 10.1371/journal.pone.0128600.

DALASTRA, GM; ECHER, MM; HACHMANN, TL; GUIMARÃES, VF; SCHMIDT, MH; CORBARI, FL. 2016. Desenvolvimento e produtividade da melancia em função do método de cultivo. *Revista de Agricultura* 91: 54-66.

DICKSON, A; LEAF, AL; HOSNER, JF. 1960. Quality appraisal of white spruce and white pine seedling stock in nurseries. *Forestry Chronicle* 36: 10-13.

DURYEA, ML. 1985. Evaluating seedling quality: Importance to reforestation. In: DURYEA ML (ed). Proceedings: Evaluating seedling quality: principles, procedures, and predictive abilities of major tests (p.1-4). Oregon: USA: Forest Research Laboratory, Oregon State University.

GRUSZYNSKI, C. 2002. Resíduo agroindustrial: casca de tungue como componente de substrato para plantas. UFRGS: 41p. (M.Sc. Dissertation).

LUNA, AM; GARCÍA, ER; SERVÍN, JLC; HERRERA, AL; ARELLANO, JS. 2014. Evaluation of different concentrations of nitrogen for tomato seedling production (*Lycopersicon esculentum* Mill.). *Universal Journal of Agricultural Research* 2:305-312.

MELO, RAC; JORGE, MHA; BORTOLIN, A; BOITEUX, LS; RIBEIRO, C; MARCONCINI, JM. 2019. Growth of tomato seedlings in substrates containing a nanocomposite hydrogel with calcium montmorillonite (NC-MMt). *Horticultura Brasileira* 37: 199-203.

NAKANO, Y. 2007. Response of tomato root systems to environmental stress under soilless culture. *Japanese Agricultural Research Quarterly* 41: 7-15.

OLIVEIRA, AMD; COSTA, E; REGO, NH; KUSANO, DM; OLIVEIRA, EP. 2015. Produção de mudas de melancia em diferentes ambientes e de frutos a campo. *Revista Ceres* 62: 87-92.

PASCUAL, JA; CEGLIE, F; TUZEL, Y; KOREN, A; HITCHINGS, R; TITTARELLI, F. 2018. Organic substrate for transplant production in organic nurseries. A review. *Agronomia para o Desenvolvimento Sustentável* 38: 22-35.

RIVERA-HERNÁNDEZ, B; ACEVES-NAVARRO, LA; ARRIETA-RIVERA, A; JUÁREZ-LÓPEZ, JF; MÉNDEZ-ADORNO, JM; RAMOS-ÁLVAREZ, C. 2016. Evidencias del cambio climático en el estado de Tabasco durante el periodo 1961-2010. *Revista Mexicana de Ciencias Agrícolas* 14: 2645-2656.

SAUCEDA-ACOSTA, CP; GONZÁLEZ-HERNÁNDEZ, VA; SÁNCHEZ-SOTO, BH; SAUCEDA-ACOSTA, RH; RAMÍREZ-TOBÍAS, HM; QUINTANA-QUIROZ, JG. 2017. Macfij, método automatizado para medir color y área foliar mediante imágenes digitales. *Agrociencia* 51: 409-23.

SCHMILEWSKI, G. 2014. Producing growing media responsibly to help sustain horticulture. *Acta Horticulturae*1034: 299-305.

SIAP. 2020. Servicio de Información Agroalimentaria y Pesca. Panorama agroalimentrio. Available at https://nube.siap.gob.mx/gobmx_publicaciones_siap/pag/2019/Atlas-Agroalimentario-2019.

SILVA, BLP; CAVALCANTE, MZB; CANUTO, AG; SILVA, AA; CIRQUEIRA, AR. 2017b. Reutilização de resíduos regionais como substratos na produção de mudas de cultivares de alface a partir de sementes com e sem peletização. *Revista de la Facultad de Agronomía* 116: 51-61.

SILVA, JJV; CAVALCANTE, MZB; BRITO, LPS; AVELINO, RC; CAVALCANTE, IHL. 2014. Aproveitamento de materiais regionais na produção de mudas de tomateiro sob adubação foliar. *Ciência Agronômica* 45: 528-536.

SILVA, RF; MARCO, R; ROS, CO; ALMEIDA, HS; ANTONIOLLI, ZI. 2017a. Influência de diferentes concentrações de vermicomposto no desenvolvimento de mudas de eucalipto e pinus. *Floresta e Ambiente* 24: e20160269.

SOUZA, EGF; BARROS JÚNIOR, AP; SILVEIRA, LM; CALADO, TB; SOBREIRA, AM. 2013. Produção de mudas de alface Babá de Verão com substratos à base de esterco ovino. *Caatinga* 26: 63-68.

WEI, H; WANG, M; RYONG, JB. 2020. Effect of supplementary lighting duration on growth and activity of antioxidant enzymes in grafted watermelon seedlings. *Agronomy* 10: 1-18. doi:10.3390/agronomy10030337.

WRIGHT, IJ; WESTOBY, M. 2001. Understanding seedling growth relationships through specific leaf area and leaf nitrogen concentration: generalisations across growth forms and growth irradiance. *Oecologia* 127: 21-29. DOI 10.1007/s004420000554

YANYAN, W; SHUOSHUO, W; MIN, W; BIAO, G; QINGHUA, S. 2018. Effect of different rootstocks on the salt stress tolerance in watermelon seedlings. *Horticultural Plant Journal* 4: 239-249.