Revista Brasileira Multidisciplinar
ISSN 1415-3580
e-issn 2527-2675
http://revistarebram.com/index.php/revistauniara

Qualidade da couve crespa cultivada em sistema hidropônico utilizando biofertilizantes por adubação foliar

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Palavras-chave

Brassica Oleracea L.
Var
Acephala
Cor
Hidroponia
Fertilização
Aceitação

Keywords

Brassica Oleracea L.
Var
Acephala
Color
Hydroponics
Fertilization
Acceptance

Resumo: Este estudo visou avaliar as características agronômicas, físico-químicas e sensoriais da couve crespa cultivada em sistema hidropônico, com e sem fertilização foliar. Para as análises agronômicas, os seguintes parâmetros foram avaliados: os comprimentos do caule, folha, pecíolo, planta inteira e sistema radicular; diâmetro do caule, largura da folha; massa fresca do caule, folha, planta inteira e sistema radicular e número de folhas por planta. As análises físico-químicas realizadas foram: umidade das folhas e raiz, sólidos solúveis, pH, índice de clorofila e cor instrumental. Para a análise sensorial, foi aplicado o teste triangular para verificar uma possível diferença entre os tratamentos, com interpretação tabulada. Um teste de aceitação foi aplicado. Os dados das análises agronômicas e físico-químicas, aceitação e intenção de compra foram avaliados pela análise de variância e teste de Tukey ($p \leq 0{,}05$). Quando tratada com fertilização foliar, a planta inteira mostrou comprimento = 48,50 cm, diâmetro = 49,58, massa fresca = 75,92 g e 11,58 folhas. Estes parâmetros não se diferenciaram estatisticamente do tratamento controle. Porém, a análise de cor instrumental revelou que as couves que receberam fertilização foliar eram mais escuras e com menor saturação que as convencionais. Os tratamentos também não se diferiram significativamente para clorofila, sólidos solúveis e pH. Os avaliadores perceberam diferença entre os tratamentos – porém, não houve diferenças na aceitação dos atributos sensoriais avaliados e nem na intenção de compra. Portanto, a fertilização foliar pode interferir nas características sensoriais da couve, mas não afeta sua aceitação.

Quality of curly kale cultivated in hydroponic system using biofertilizer by leaf fertilization

Abstract: This study aimed to evaluate the agronomic, physicochemical and sensory characteristics of curly kale cultivated in hydroponic system, with and without leaf fertilization. For the agronomic analysis, the following parameters were evaluated: the lengths of the stem, leaf, petiole, whole plant and root system; stem diameter, leaf width; fresh mass of the stem, leaf, whole plant and root system, and number of leaves per plant. The physicochemical analyses evaluated were: moisture of the leaves and root, soluble solids, pH, chlorophyll index and instrumental color. For the sensory analysis, the triangle test was applied to verify a possible difference between the treatments, with tabulated interpretation. An acceptance test was applied. The data from the agronomic and physicochemical analyses, acceptance and purchase intention were evaluated by analysis of variance and Tukey's test($p \leq 0.05$). When treated with leaf fertilization, the whole plant of kale showed length = 48.50 cm, diameter = 49.58 cm, fresh mass = 75.92 g and 11.58 leaves. These parameters were not statistically different from the control treatment. However, the instrumental color analysis revealed that the kales which received leaf fertilization were darker and presented lower color saturation than the conventional ones. The treatments also did not differ statistically regarding the chlorophyll, soluble solids and pH. The evaluators noticed a difference between the treatments – however, there were no differences in the acceptance of the sensory attributes evaluated nor in purchase intention. Therefore, the leaf fertilization may interfere in the kale sensory characteristics, but not affect its acceptance.

Recebido em: 03/08/2021
Aprovação final em: 06/12/2021
DOI: https://doi.org/10.25061/2527-2675/ReBraM/2021.v24i3.1253

Introduction

Curly kale, or *kale*, is a vegetable with nutraceutical properties and its consumption has been increasing in Brazil (NOVO *et al*., 2010). According to Korus & Kmiecik (2007), the Winterbor kale hybrid is rich in carotenoids, beta-carotene and chlorophylls, presenting higher values than other hybrids.

It can be considered a source of phenolic compounds, carotenoids, vitamin C and glucosinolates, being able to supply in the intake of 100 g, 100% of the recommended daily intake of vitamin A and 40% of vitamin C (USDA, 2006; SIKORA; BODZIARCZYK, 2012; BECERRA-MORENO *et al*., 2013).

Noboa, *et al.,* 2019) evaluated the preference among four curly kale hybrids, composed of three curly kales (Darkibor, Redbor and Starbor) and one collard-green (Butter Green) under hydroponic system, and they did not find significant difference for preference and purchase intention among the hybrids, although differences have been observed regarding green color, size and crunchiness of the leaves, besides productivity, and Redbor was the kale perceived as the greenest with the lowest production compared to the other curly kales, whereas collard-green presented the biggest size in relation to the curly kales, and Redbor and Starbor were perceived as the most crunchy.

An alternative to the conventional cultivation of vegetables is the use of hydroponic systems of the NFT (Nutrient Film Technique) type. These systems present several benefits, such as higher productivity, efficiency in the use of water and fertilizers, and advantage in commercialization, since the leaves tend to be cleaner than in conventional cultivation (PURQUERIO *et al.,* 2018).

The type of fertilization directly influences the agronomic quality of the vegetables (BERNARDI *et al.,* 2005), including curly kale (KORUS, 2010), such as improvements in the aerial part of the plant, at different concentrations (BENÍCIO; DA SILVA; LIMA, 2012). Supporting this, Lovatto, *et al.* (2011) showed the feasibility of using cow urine as liquid biofertilizer for leaf fertilization of kale at 20 and 30%, observing higher concentration of root and leaf fresh matter and leaf dry matter, and Balcău *et al.,* 2012) evaluated the effect of fertilization on the quality of the Winterbor hybrid.

Regarding the method of application, Fageria *et al.* (2009) reported that leaf fertilization provides a faster use of the nutrients, besides allowing the correction of the deficiencies observed over a short period. Nevertheless, it is necessary to consider that when applied to the soil, the nutrient has long influence, whereas leaf application tends to be temporary, and several applications may be required. Furthermore, the authors report that leaf application is more efficient for micronutrients.

Given its high content of organic compounds, the application of biofertilizer together with the nutrient solution may cause modifications in its stability, and consequential damages to the plants. Recent studies show the efficiency of the classical nutrient solution in the cultivation of curly kale (NOBOA *et al.,* 2019). Nonetheless, no studies on the possible effects of leaf fertilization with biofertilizer were found for curly kale under hydroponic system, despite the high absorption potential of its leaves, which have great contact surface.

The aim of this study was to verify whether the cultivation of curly kale with leaf biofertilization under hydroponic system promotes alterations in their agronomic, physicochemical and sensory characteristics.

Material and methods

Experimental design and seedling production

The experiment was conducted under the hydroponic system in Araras (SP, Brazil), in the Center for Agricultural Sciences of the Federal University of São Carlos (CCA/UFSCar), at latitude 22º21'25" South, longitude 47º23'03" West and altitude 646m, a region characterized by dry winter and rainy summer.

The kale used was *Brassica oleracea* L. var. *acephala*, Winterbor hybrid. Seedling production was performed in a commercial nursery (IBS Mudas), located in Piracicaba (SP, Brasil). Seedling transplantation in the NTF system occurred on April 27th, 2018.

The experiment was performed using completely randomized design with four repetitions. Each plot was composed of 45 plants, each of which was placed on a bench where six profiles were used, with holes of 5 cm and average distance of 15 cm. Each pack corresponded to one plant, in other words, each pack originated from one seedling from one cell on the tray.

The production of biofertilizer for application on the leaves was performed according to the model described by Vario dos Santos (1995), in a 200-L barrel, where fresh manure, brown sugar, raw milk and water were deposited, under anaerobic system, for 30 days. The hydroponic nutrient mineral solution was maintained with pH between 5.5 and 6.5 and electric conductivity between 1.4 and 1.8 (FURLANI *et al.*, 2009). The circulation of the nutrient solution happened every 15 minutes during the day and during the night, for 15 minutes every 4 h, in all treatments.

The Control (C) treatment received the nutrient solution under hydroponic system, exclusively. The treatment with leaf fertilization (LF) received both the nutrient solution under hydroponic system (by root) and the biofertilizer (by leaf). The biofertilizer was used in leaf fertilization, being applied daily, in the morning period, using backpack sprayer (brand Jacto, model PJH, 20 liters, nozzle JD 12, with double piston and maximum pressure of 100 psi). Regarding syrup volume, 2.524 L.m^2 were applied, resulting in 53 mL of biofertilizer per plant. The kales were evaluated 30 days after transplanting with six random plants from each plot.

Agronomic evaluations

All agronomic analyses evaluated, relative to the unit of length, used the centimeter (cm): length of stem, leaf, petiole, whole plant and root system; stem diameter, leaf width (the biggest leaf of the plant); fresh mass in grams: of the stem, leaf, whole plant and root system; and counting of the number of leaves per plant (leaf with length > 4 cm).

For the measurements of width and length, a measuring tape graduated in cm was used; stem length was measured from the collar to the apical meristem of the highest plant of the pack (AZEVEDO *et al.*, 2012). A pachymeter was employed for stem diameter. These analyses occurred in 4 blocks per treatment, and each block consisted in 6 plants, with the values presented being the means per treatment.

The fresh masses of the leaves, petiole, root and whole plant were determined in a precision scale, in triplicate per treatment, with the results expressed in mass (g) per unit (pack).

Physicochemical evaluations

The physicochemical parameters of the kales were evaluated selecting the third or fourth completely developed leaf, from the apex to the base of the plant (TRANI *et al.,* 2015) of the four central plants, in triplicate per analysis.

The parameters evaluated were: total soluble solids (SST, °Brix), determined by digital refractometer (KÜSS, DR 201-95) (AOAC, 2012), pH determined using a digital potentiometer (Model MA-522, Marconi, Piracicaba, Brazil) (AOAC, 2012).The moisture of the leaves (%) and root (%) was determined by drying in oven at 105 ºC, according to the method 012/IV (IAL, 2008).

The instrumental color was analyzed by the parameters Hue color angle (°Hue), chroma and luminosity (L*), using a Chroma Meter CR-400 colorimeter of 8mm in diameter and CIE C standard illuminant (Konica Minolta Sensing, Tokyo, Japan). The total chlorophyll index in the leaves was analyzed using the Chlorophyll Meter SPAD-502 (Konica Minolta Sensing, Tokyo, Japan), with the results expressed in SPAD units.

Sensory evaluation of difference and acceptance

This study was approved by the UFSCar ethics committee (CAAE: 95217118.0.0000.5504).

The sensory tests were performed in individual cabins with white light and the taster received one leaf from each kale, at room temperature, on white plastic plates and coded with three digits.

Triangular test

Initially, the triangular test was used (ABNT - NBR ISO, 2013) with 34 evaluators who consume kale, consisting of 16 women and 18 men, between 18 and 60 years old. Among the evaluators, 64.71% were less than 25 years old. Each one received three coded samples, two of which equal and one different, to identify the different sample.

Acceptance test

Subsequently, the same evaluators, who were identified as consumers of vegetables in the triangular test, participated in the acceptance test, where the following parameters were evaluated: color, aroma, texture, global impression per leaf and global impression per pack unit. The purchase intention of the pack was also evaluated. A seven-point scale (1=disliked very much and 7=liked very much) was used (MEILGAARD; CIVILLE; CARR, 2007).

Statistical analysis

For the analysis of the agronomic, physicochemical, acceptance and purchase intention data, the analysis of variance and the Tukey's mean difference test (5% of probability) were applied, using the software Statistica (version 13.5.0.17). Regarding the triangular test, the result was based on the number of correct judgements in relation to the total judgements, with 14 being the minimum number of correct answers to detect statistical difference at the level of 5% (ABNT, 2013).

Results and discussion

There was no statistical difference among the agronomic parameters evaluated ($p \geq 0.05$), suggesting that the application of the leaf fertilization, when combined with hydroponic fertilization in NFT, did not result in alteration of the agronomic properties of the vegetable (Table 1).

For the curly kale hybrid Winterbor, Balcău *et al.* (2012) found the length of the whole plant (height) between 38.5 and 44.0 cm, which are slightly smaller than the values found in this study.

The observed number of leaves, leaf length and leaf width (Table 1) were inferior to those found by Balcău *et al.*, 2012 (between 18.4 and 21.5 cm; 23.45 and 25.34; and 14.12 and 14.47 cm, respectively).

Noboa *et al.* (2019) evaluated the parameters of different curly kale hybrids produced under hydroponic system, and reported considerably superior values for the fresh mass of the aerial part (between 71.00 and 99.60) and number of leaves (15.05 to 23.35), although the fresh mass of the root system reported by the authors (between 24.86 and 32.21 g), as well as root length (24.08 to 26.94 cm), leaf width (8.86 to 14.49 cm), petiole length (10.93 to 14.83 cm) were very close to those observed in this study (Table 1). Regarding stem diameter, this study obtained values very close to those observed by Noboa, *et al.* (2019).

According to Benício; Da Silva; Lima (2012) and Lovatto *et al.* (2011), the application of biofertilizer in leaf fertilization in kale seedlings results in better plant development; nevertheless, this content might result both in non-significant effects, if insufficient, and phytotoxic if excessive, such as retardation in growth, flowering or fruiting caused by physiological stress.

Therefore, in addition to the quality of the biofertilizer applied, it is necessary to consider the volume of this biofertilizer that is applied, searching for a vegetable of high performance, which presents quality for both the producer and the consumer.

The analysis of instrumental color (Table 2) revealed that the kales which received leaf fertilization presented lower luminosity (darker) and color saturation, indicating there was a mixture of colors, making the visualization of hue difficult. On the other hand, the treatment without leaf fertilization, conventional, presented intense green color. Nonetheless, these attributes did not affect acceptance by the evaluators in the sensory analysis.

Other studies relating kale instrumental color to leaf fertilization have not been found. Nevertheless, according to Fageria *et al.* (2009), the response of cultures to leaf fertilization is highly variable, and the input of a certain nutrient is inappropriate, either by deficiency or excess, the plants present certain growth disorders, such as reduced growth or discoloration of the leaves. Therefore, it is suggested that color alteration in the kales evaluated in this study might be a consequence of the content of nutrients applied on the leaves together with the fertilization by the hydroponic solution, although not in sufficient intensity to affect other parameters.

Table 1 - Agronomic parameters of the curly kales produced under hydroponic system (± standard deviation).

Parameter	Treatment	Stem	Leaf	Petiole	Whole plant	Root system
Length (cm)	LF	11.57a ±0.46	14.58a ±0.64	11.83a ±1.28	48.50a ±2.20	26.79a ±2.62
	C	11.85a ±1.68	14.84a ±0.43	12.56a ±0.96	49.58a ±2.82	28.19a ±1.81
Diameter (cm)	LF	4.89a ±0.30	NA	NA	NA	NA
	C	4.82a ±0.25	NA	NA	NA	NA
Width (cm)	LF	NA	11.52a ±0.41	NA	NA	NA
	C	NA	11.93a ±0.36	NA	NA	NA
Fresh mass (g)	LF	5.04a ±0.82	47.79a ±6.49	NA	75.92a ±8.66	23.25a ±1.71
	C	5.54a ±0.63	47.25a ±7.36	NA	74.58a ±9.47	21.79a ±2.48
Number (n)	LF	NA	11.58a ±0.61	NA	NA	NA
	C	NA	11.25a ±0.29	NA	NA	NA

Means followed by distinct letters in the columns differ from each other ($p \leq 0.05$) by the Tukey's test. LF = leaf fertilization; C = control. NA = Not Assessed.

Fonte: Elaborado pelos autores.

Table 2 - Results from the instrumental analysis of color and physicochemical and instrumental parameters of the curly kales produced in hydroponic system (± standard deviation).

Treatment	Cl	L*	°Hue	Chroma	Moist. leaves	Moist. root	TSS	pH
LF	48.53a ±2.73	34.61b ±0.66	132.26a ±1.31	11.92b ±2.32	92.13a ±0.38	93.37a ±0.80	4.7a ±0.27	6.14a ±0.06
C	46.79a ±1.65	35.99a ±0.46	128.39b ±051	14.52a ±1.89	92.07a ±0.46	93.05a ±0.45	5.4a ±0.16	6.14a ±0.05

Means followed by distinct letters in the lines differ from each other (p≤0.05) by the Tukey's test; LF = leaf fertilization; C = control; Cl = chlorophyll, SPAD units; Moist. = moisture (%) L* = Luminosity (0= black and 100= white); TSS = total soluble solids (°Brix).

Fonte: Elaborado pelos autores.

Although not statistically significant, it is noted that the control treatment presented higher chlorophyll content than the treatment with leaf fertilization, which might justify its more intense green color.

Regarding the participating evaluators, 64.71% were below 25 years old, 8.82% between 26 and 30 years old, 5.88% between 31 and 35 years old, and 20.59% above 35 years old. In terms of monthly consumption, 32.35% claimed to consume kale up to twice a month, 38.24% from three to five times, 20.59% between six and 10 times, and 8.82% declared consumption superior to 10 times per month. Nevertheless, when asked about the monthly purchase frequency, 61.76% claimed they obtained the vegetable once or twice in the period, whereas only 29.41% obtain it between three and five times, and only 8.82% between six and 10 times per month. Such data suggest the importance of a vegetable with long shelf life, since the frequency of purchase tends to be considerably smaller than the frequency of consumption.

Comparing the data of monthly consumption and monthly purchase, it was noted that, although 61.76% reported they bought the vegetable from zero to two times, only 32.35% reported the consumption in the same period. This result suggests the importance of a vegetable with high durability, thus avoiding food waste by the consumer.

The triangular test (Table 3) revealed statistical difference among the treatments, probably related to the difference in instrumental color among the kales (Table 2).

Table 3 - Results of the triangular and acceptance tests, and purchase intention, of the curly kales produced under hydroponic system (± standard deviation).

	Tests (n)	Triangular Correct (n)	Color	Aroma	Flavor	Texture	GI-L	GI-P	PI
LF	34	19*	5.79a ±1.07	4.82a ±1.31	5.56a ±1.31	6.00a ±0.95	6.09a ±0.83	6.12a ±1.04	4.38a ±0.78
C	34		5.62a ±1.16	4.79a ±1.45	5.53 ±1.46	5.76a ±1.13	5.76a ±1.05	5.71a ±1.00	4.09a ±0.83

Means followed by different letters in the columns differ from each other (*p*≤0.05). *Minimum significant value: ≥14. LF = leaf fertilization; C = control. GI-L = Global impression, leaf; GI-P = Global impression, pack; PI = purchase intention, pack.

Fonte: Elaborado pelos autores.

The results obtained in the acceptance test showed that there were no differences between the two treatments (Table 3). Although there were no differences, it was observed that for all attributes and global impression, the kales with leaf fertilization obtained higher means. No attribute was classified in the negative region of the scale (disliked very much, disliked moderately and disliked slightly).

Noboa *et al.* (2019) suggested that the variations among sensory attributes do not affect the preference and purchase intention of curly kale by the consumers. In this study, it was observed that although there is at least one difference between the kales, determined by the triangular test, there was no influence in the acceptance of this vegetable in any sensory parameter.

Conclusion

The application of leaf biofertilizer on the curly kale cultivated under hydroponic system, under the conditions observed in this study, did not promote agronomic alterations in the vegetable, and the differences in instrumental color and chlorophyll did not interfere in the acceptance by the consumer, which remained positive for both treatments, although the samples can be visually differentiated.

Acknowledgment

Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES) – Financing Code 001.

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