Efeitos da adubação orgânica na produção e qualidade pós-colheita de coentro (*Coriandrum sativum* L.)

Effects of organic fertilization on production and postharvest quality of coriander (*Coriandrum sativum* L.)

Efectos de la fertilización orgánica en la producción y la calidad poscosecha del cilantro (*Coriandrum sativum* L.)

Recebido: 20/07/2020 | Revisado: 09/08/2020 | Aceito: 12/08/2020 | Publicado: 17/08/2020

Sara Beatriz da Costa Santos
ORCID: https://orcid.org/0000-0001-8888-9104
Universidade Federal da Paraíba, Brasil
E-mail: sarabeatrizsol@gmail.com
Solange de Sousa
ORCID: https://orcid.org/0000-0002-8587-4828
Universidade Federal da Paraíba, Brasil
E-mail: solange_ufpb@yahoo.com.br
Vênia Camelo de Souza
ORCID: https://orcid.org/0000-0002-1847-9182
Universidade Federal da Paraíba, Brasil
E-mail: venia_camelo@hotmail.com
George Rodrigo Beltrão da Cruz
ORCID: https://orcid.org/0000-0002-8480-4625
Universidade Federal da Paraíba, Brasil
E-mail: georgebeltrao@hotmail.com
Thiago de Souza Melo
ORCID: https://orcid.org/0000-0003-1862-9571
Universidade Federal da Paraíba, Brasil
E-mail: thiagosoumelo@hotmail.com
Ivan Sérgio da Silva Oliveira
ORCID: https://orcid.org/0000-0002-0046-146X
Universidade Federal da Paraíba, Brasil
E-mail: ivantecagro@gmail.com

Josinaldo da Silva Henrique
ORCID: https://orcid.org/0000-0002-7001-1560
Universidade Federal da Paraíba, Brasil
E-mail: josinaldoufpb@gmail.com
Aline Cavalcanti Dantas
ORCID: https://orcid.org/0000-0002-3669-9584
Universidade Federal da Paraíba, Brasil
E-mail: alicdantas188@gmail.com
Kênia Lira de Souza
ORCID: https://orcid.org/0000-0002-7778-8815
Universidade Federal da Paraíba, Brasil
E-mail: kennya-lira@outlook.com

Resumo

Este trabalho compara a produtividade e a qualidade pós-colheita de C. *sativum* produzido em sistemas orgânicos e convencionais. Utilizamos um experimento em blocos casualizados com cinco tratamentos e seis repetições cada. Os tratamentos incluíram um controle (C-: sem fertilização), três doses de esterco bovino como fertilização orgânica (35, 70 e 105 kg de N ha^{-1}, denominados T35, T70 e T105, respectivamente) e um convencional (C +: 70 kg de N ha^{-1} de fertilização convencional). Avaliamos a morfometria, produtividade e características físico-químicas de todas as plantas utilizadas. O efeito das doses de fertilizantes orgânicos foi analisado por meio de regressões polinomiais. As diferenças entre controle, adubação convencional e adubação orgânica com 70 Kg de N ha^{-1} de esterco foram testadas com contrastes ortogonais. As doses de N utilizadas na adubação orgânica influenciam à atividade de água e proteínas das folhas de *C. Sativum*, promovendo seu decréscimo. Os contrastes influenciaram a produtividade, massa fresca total, massa fresca da parte aérea, massa seca da parte aérea, massa seca da raiz, a massa seca total, a atividade de água, acidez titulável, sólidos solúveis, carotenoides, clorofila total, clorofila b, do *C. sativum* foi influenciada pelas comparações. O sistema convencional apresentou maior produtividade e melhor qualidade pós-colheita do que o sistema orgânico. Devido ao ciclo curto do C. *sativum*, recomendamos o uso de fertilizantes orgânicos antes da semeadura, pois o atraso na mineralização do esterco pode impedir que as plantas se beneficiem dos insumos nutricionais.

Palavras-chave: Adubação; Sustentabilidade; Compostos bioativos.

Abstract

This work compares the productivity and postharvest quality of *C. sativum* produced in organic and conventional systems. We used a randomized block experiment with five treatments and six repetitions each. Treatments comprised a negative control (C-: without fertilization), three doses of bovine manure as organic fertilization (35, 70, and 105 kg of N ha $^{-1}$, named T35, T70, and T105 respectively), and a positive control (C+: 70 Kg of N ha $^{-1}$ of conventional fertilization). We evaluated the morphometry, productivity, and physical-chemical characteristics of all plants used. The effect of organic fertilizer doses was analyzed using polynomial regressions. The differences among negative control, the positive control, and the organic fertilization with 70 Kg of N ha $^{-1}$ of manure were tested with orthogonal contrasts. The doses of N used in organic fertilization influence the water and protein activity of *C. Sativum* leaves, promoting their decrease. The contrasts influenced the productivity, total fresh weight, fresh weight of the aerial part, dry weight of the aerial part, dry weight of the root, the total dry weight, water activity, titratable acidity, soluble solids, carotenoids, total chlorophyll, chlorophyll b, *C. sativum* was influenced by comparisons. The conventional production system using ammonium sulfate as the source of nitrogen promoted higher productivity and better postharvest quality in the culture of *C. sativum*. The period of implementation of bovine manure hampered the organic system. We suggest the fertilization with bovine manure before sowing, providing the necessary time for its mineralization during the cultivation cycle.

Keywords: Fertilization; Sustainability; Bioactive compounds.

Resumen

Este trabajo compara la productividad y la calidad poscosecha de *C. sativum* producido en sistemas orgánicos y convencionales. Usamos un experimento de bloques al azar con cinco tratamientos y seis repeticiones cada uno. Los tratamientos incluyeron un control (C-: sin fertilización), tres dosis de estiércol bovino como fertilización orgánica (35, 70 y 105 kg de N ha^{-1}, denominados T35, T70 y T105, respectivamente) y uno convencional (C +: 70 kg de N ha^{-1} procedente de fertilización convencional). Evaluamos la morfometría, productividad y características fisicoquímicas de todas las plantas utilizadas. El efecto de las dosis de fertilizantes orgánicos se analizó mediante regresiones polinomiales. Las diferencias entre control, fertilización convencional y fertilización orgánica con 70 kg de N ha^{-1} de estiércol se probaron con contrastes ortogonales. Las dosis de N utilizadas en la fertilización orgánica influyen en la actividad hídrica y proteica de las hojas de *C. sativum*, favoreciendo su disminución. Los contrastes influyeron en la productividad, peso fresco total, peso fresco de la parte aérea, peso seco de la parte aérea, peso seco de la raíz, peso seco total, actividad del agua, acidez titulable, sólidos solubles, carotenoides, clorofila total, clorofila b, *C. sativum* fue influenciado por las comparaciones. El sistema convencional mostró mayor productividad y mejor calidad poscosecha que el sistema orgánico. Debido al ciclo corto de *C. sativum*, recomendamos el uso de fertilizantes orgánicos antes de la siembra, ya que el retraso en la mineralización del estiércol puede evitar que las plantas se beneficien de los aportes nutricionales.

Palabras clave: Fertilizando; Sustentabilidad; Compuestos bioactivos.

1. Introduction

Vegetable growing systems are classified as conventional or organic. Conventional systems use synthetic fertilizers and pesticides in their crop treatments, whereas organic systems avoid the use of such products that are potentially harmful to the environment and human health (Santos et al., 2017). However, crop productivity and quality of vegetables depend on several factors, including the kind of nutrient supplied to plants (Septembre-Malaterre et al., 2018).

Comparisons between organic and conventional production, regarding the effects of pre-harvest treatments on postharvest performance of crops, have been addressed in several studies. In general, organic foods have a higher amount of phenolic compounds, anticancer and antioxidants, such as anthocyanins, isoflavones, and carotenoids, in addition to having less nitrate and heavy metals than conventional ones (Yu et al., 2018).

Nitrogen (N) in soil fertilization strengthens the production of numerous cultivation systems. The adequate supply affects the quality, composition of volatile compounds, and components of the initial yield of aromatic plants (Angeli et al., 2016). The ammonium sulfate synthetic fertilizer is widely used to provide nitrogen in conventional crops, while cattle manure is an alternative organic source for fertilization (Kandil et al., 2017; Ramalho et al., 2016).

As much of vegetable crops, the *Coriandrum sativum* L., known as coriander, can be produced both through conventional and organic systems. It is an annual herb belonging to the Apiaceae family, popularly used in cooking all over the world. The leaves compose and decorate several typical dishes, standing out among the most sought vegetables in the aromatic herbs market. The food industry has the highest demand for *C. sativum* worldwide (Grangeiro et al., 2011; Lopéz et al., 2016).

In Brazil, the culture of *C. sativum* has simple production techniques, with an unordered application of inputs, such as seeds and fertilizers, resulting in low productivity. Besides, sharp price fluctuations increase the vulnerability of producer families and affect the development of production hubs (Cavalcante et al., 2016).

Although healthy and ecologically advantageous, some organic fertilizers, such as the cattle manure, might affect crop productivity and vegetable quality when compared to synthetic ones, influencing the decision of family producers about what kind of fertilizer to apply. In this context, the present study aimed to evaluate the productivity and postharvest quality of *C. sativum* produced in organic and conventional systems.

2. Material and Methods

2.1. Experimental area

The study occurred in the experimental field of the Agriculture Sector of the Center for Human, Social and Agrarian Sciences (CCHSA) in the Federal University of Paraíba (UFPB).

The experimental design consisted of randomized blocks with five treatments in six repetitions. Treatments comprised a negative control (C-: without fertilization), three doses of organic fertilization (35, 70, and 105 kg of N ha^{-1}, named T35, T70, and T105 respectively), and a positive control (C+: 70 Kg of N ha^{-1} of conventional fertilization). The source of organic fertilization was bovine manure and the mineral source was ammonium sulfate. Quantities followed the results of soil analysis and recommendations of the Agronomic Institute of Pernambuco - IAP (2008).

The chemical and soil fertility analysis provided the following results (at 0-20 cm depth): pH (1; 2.5) = 6.20; P = 41.43; K^+ = 61.62 mg/dm^3; Na = 0.2 H^++Al^{+3} = 2.81; Al^{+3} = 0.05; Ca^{+2} = 3.30; Mg^{+2} = 3.0; BS = 6.48; CEC = 9.28 in $cmol_c/dm^3$; V = 69.68; M = 0.77%; and Organic Matter = 35.52 g/Kg. The bovine manure was produced in the bovine culture sector of CCHSA/UFPB, obtained the following results for chemical and fertility analysis: pH (1, 2, 5) = 8.7; P = 820.05; K^+ = 109.45 in mg/dm^3; Na = 1.70; H^++Al^{+3} = 0.0; Al^{+3} = 0.0; Ca^{+2} = 3.50; Mg^{+2} = 2.36; BS = 7.84; CEC = 7.84 in $cmol_c/dm^3$; and Organic Matter = 325.56g/Kg.

We use seeds of *C. sativum* 'Verdão'. Seed water content and germination tests were done according to the methodology of Brasil (2009). The experimental area was cleaned by manual weeding, and ten 1 x 1 m plots were arranged in each block. The spacing was 25 x 10 cm, in which the two central rows constituted the useful portion of 0.40 m^2, discarding the border. The fertilizer was deposited directly on the beds on the day of sowing.

C. sativum was harvested at 35 days after sowing, in commercialization phase (before flowering), and transported to the Post-Harvest Laboratory of the Center for Human, Social, and Agrarian Sciences at the Federal University of Paraíba for measuring quantitative variables, Pereira et al., (2018).

2.2. Variables measuring

The height of *C. sativum* was measured from root to apex, with a graduated ruler, and the value expressed in centimeters (cm). The stem diameter was measured between the root and the stem, the neck, with the aid of a Metrotoos® digital caliper, the result was expressed in millimeters (mm). The number of stems was obtained by manual counting.

The total fresh mass was obtained weighing the plant in a semi-analytical Radwag® scale, model WTB 2000. Then, the root and aerial parts were separated and weighed individually to get the fresh weight of each one. The material was packed in paper bags and deposited in an oven at 65°C for 48 hours to obtain the dry weights.

Productivity was estimated from the mass of plants located in the useful portion of each treatment and the data expressed in hectares (Linhares et al., 2015). The activity of water (Aw) was measured in an Aqualab®4TE device. The protein content was estimated using the Kjeldahl method (Ial, 2008). The lipids were measured following Folch et al. (1957). We used the difference method to obtain total carbohydrates (Holland et al., 1994). The pH measurements were performed with a bench pHmeter Mpa 210 - MS Tecnopon®, according to Ial (2008).

The water content and the mineral residue were determined using ten grams (g) of a homogeneous sample of *C. sativum*, placed in an oven (New Ethics®, model 400/2ND-300), and cooled in a desiccator (Mylabor®, model MY048) (Ial, 2008). The titratable acidity (% malic acid) was measured diluting 10 g of crushed and homogenized *C. sativum* leaves with 50 mL of distilled water. We used a standardized solution of 0.1 N sodium hydroxide (NaOH) for titration (Ial, 2008). The soluble solids (ºBrix) were obtained in a digital refractometer. The ratio of soluble solids to titratable acidity (SS/TA) was calculated as described by Fichinello et al. (2008). The determination of carotenoids (Total Chlorophyll, A, and B) occurred according to the methodology of Nagata and Yamashita (1992).

2.3. Statistical analysis

The effect of organic fertilizer doses was investigated by polynomial regression analysis. The differences between organic and conventional fertilization were tested by orthogonal contrasts between treatments: negative control, 70 kg of N ha^{-1} of organic fertilizer, and positive control (conventional fertilization). The analyzes were performed in the statistical software R version 3. 4. 1. (R core team, 2017).

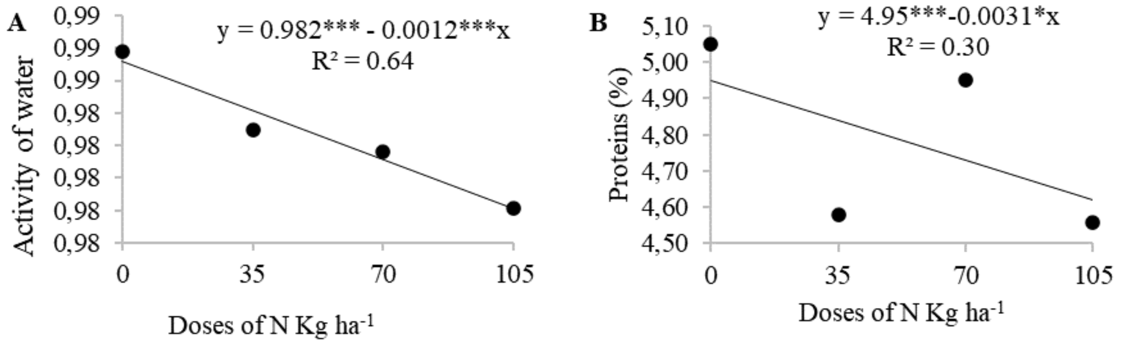
3. Results and discussion

3.1. Analysis of organic fertilizer doses

The seeds of *C. sativum* had 8.6% of water content, which is similar (or near) to the average of the species (Pereira et al., 2011). The germination percentage was 85%, overtaking the 65% minimum for the commercialization of *C. sativum* seeds Brasil (2019).

The average values of water and protein activity decreased linearly ($p < 0.01$) with the increase in organic fertilizer doses (Figure 1 A and B). The minimum water activity was 0.966 at a dose of 105 kg N ha^{-1}, and the maximum was 0.9879 in the negative control (0 kg N ha^{-1}).

Figure 1. Water activity in *Coriandrum sativum* L. treated with different doses of organic fertilizer.



ns not significant, $^{***}p < 0.001$, $^{**}p < 0.01$, and $^{*}p < 0.05$. Source: Authors.

The increase in organic fertilizer doses did not promote a significant effect on the following variables: plant height, stem diameter, number of stems, productivity, total fresh weight, fresh shoot weight, fresh root weight, total dry weight, dry shoot weight, dry root

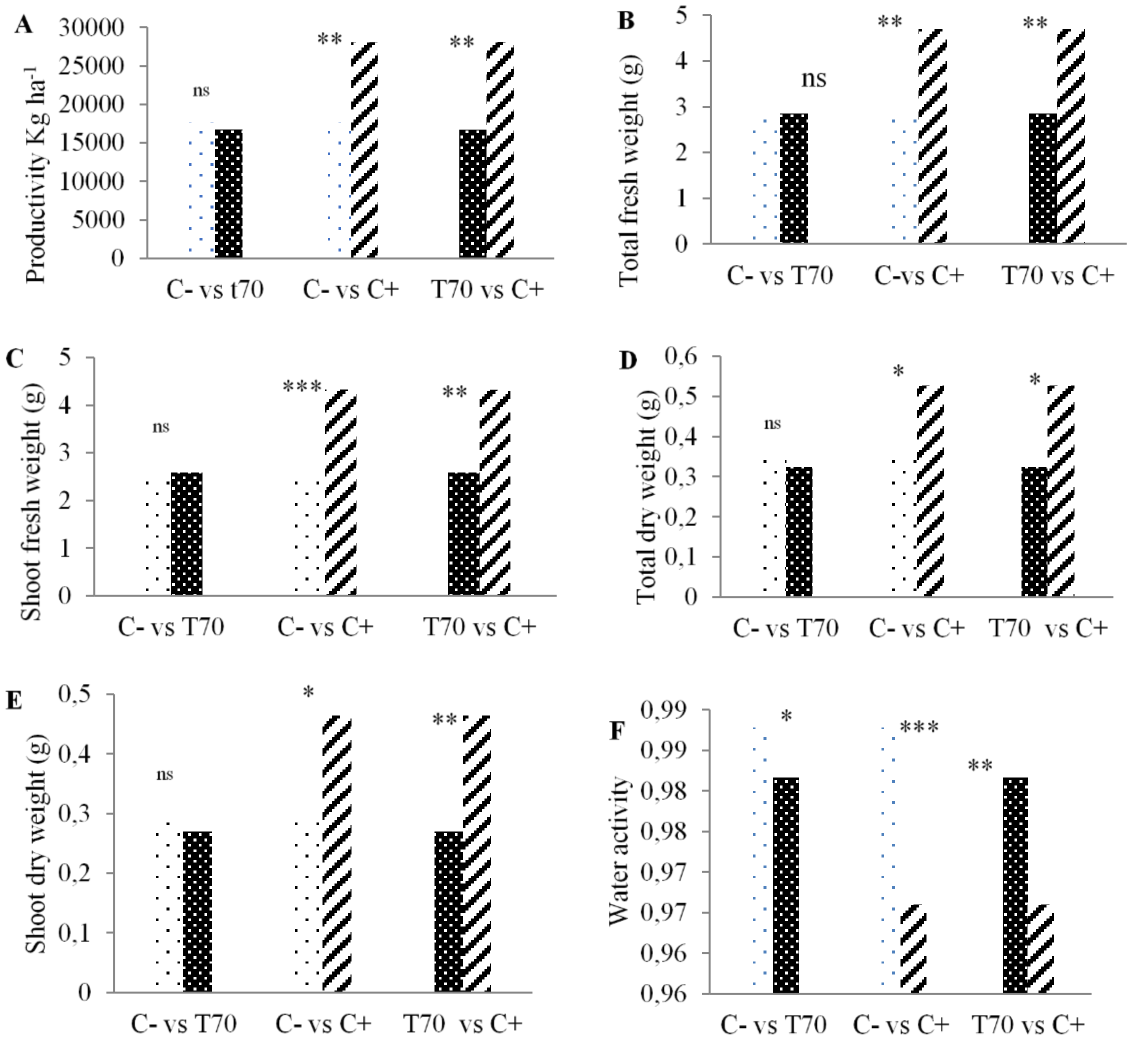
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i9.6912

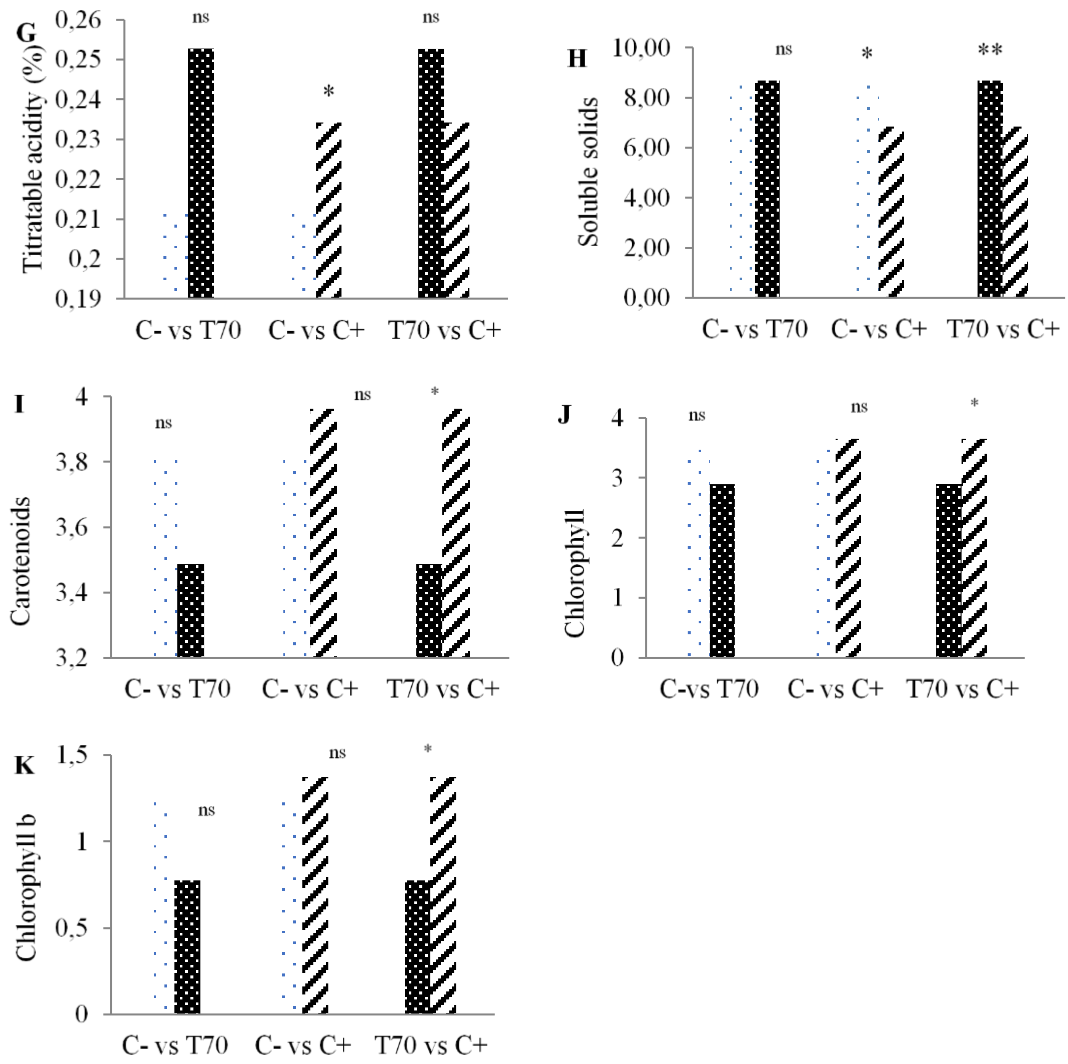
mass, lipids, total carbohydrates, pH, ash, humidity, titratable acidity, soluble solids, soluble solids and titratable acidity ratio, carotenoids, total chlorophyll, chlorophyll a, and chlorophyll b. Probably the time of incorporation of bovine manure into the soil did not allow mineralization, keeping the necessary nutrients unavailable for absorption. Linhares et al. (2015), applying bovine manure as a nitrogen source, observed that the yield and height of *C. sativum* were influenced both by the manure doses and by the time of incorporation. Their results showed maximum of green mass at a dose of 60 t ha^{-1} and when the fertilizer was incorporated forty-six days before sowing.

3.2 Analysis of orthogonal contrasts

Os contrastes influenciaram productivity per hectare, total fresh weight, shoot fresh weight, total dry weight, shoot dry weight, water activity , total titratable acidity, soluble solids, carotenoids, total chlorophyll, and chlorophyll b, Figure 2 (A, B, C, D, E, F, G, H, I, J, K).

Figure 2. Orthogonal contrasts for productivity per hectare (A), total fresh weight (B), shoot fresh weight (C), total dry weight (D), shoot dry weight (E), water activity (F), total titratable acidity (G), soluble solids (H), carotenoids (I), total chlorophyll (J), and chlorophyll b (K) of *C. sativum* as a function of different nitrogen sources. C-= without fertilization; T70= Organic and C+= Conventional.





ns not significant, ***p <0.001, **p <0.01, and *p <0.05. Source: Authors.

The conventional treatment had higher values than the negative control and organic treatment for the following variables: productivity (28.11, 17.61, and 16.66 Kg ha^{-1}, respectively), total fresh weight (4.68, 2.72, and 2.85 g), shoot fresh weight (4.32, 2.44, and 2.57 g), total dry mass (0.52, 0.35, and 0.32 g), and shoot dry weight (0.46, 0.29, and 0.26 g).

Several studies confirm that the use of increasing doses of nitrogen from ammonium sulfate in *C. sativum* promotes the development and growth of plants, including a linear increase in leaf area (Cerqueira et al., 2016).

Other sources of nitrogen, such as urea, also improve several characteristics of *C. sativum*. When associated with suitable irrigation depths, urea can increase the number of leaves, the plant height, and the crop yield (Angeli et al., 2016).

Even though our study failed to demonstrate the efficiency of organic fertilization, other studies report its several advantages. For example, organic fertilization promotes a higher production than conventional systems, improvements in soil characteristics, increase in cation exchange capacity, elevation of pH, and maintenance of plant hormones production and other substances that stimulate plant development and resistance (Sodré et al., 2013).

The rate of mineralization of bovine manure in this experiment influenced the results. Probably, more time would be necessary to observe better or similar data to the conventional system (Figueiredo et al., 2012).

The water activity of *C. sativum* was superior in the organic treatment to the conventional treatment (0.98 and 0.97, respectively; $p < 0.01$), while the negative control was higher to the organic ($p < 0.05$). The soluble solids of organic treatment were also superior to the conventional (8.67 and 6.83, respectively; $p < 0.01$). The titratable acidity was higher in the conventional treatment than the plants without fertilization (0.23 and 0.21, respectively; $p < 0.05$).

Conventional treatment showed higher values than organic treatment for the following variables: carotenoids (3.96 and 3.48, respectively), total chlorophyll (3.64 and 2.89), and chlorophyll b (1.37 and 0.77).

4. Conclusions

The conventional production system using ammonium sulfate as the source of nitrogen promoted higher productivity and better postharvest quality in the culture of *C. sativum*. The period of implementation of bovine manure hampered the organic system.

We suggest the fertilization with bovine manure before sowing, providing the necessary time for its mineralization during the cultivation cycle.

References

Angeli, K. P., Delazari, F. T., Nick, C., Ferreira, M. G., Silva, D. J. H. (2016). Yield components and water use efficiencyin coriander under irrigation and nitrogen fertilization. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 20(5), 415-420.

Brasil. Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretária de Defesa Agropecuária. - Brasília, DF: Mapa/ACS,2009, 395 p.

Brasil. 2019. Instrução Normativa nº 42, de 17 de setembro de 2019. (Estabelece as Normas para a Produção e a Comercialização de Sementes). Diário Oficial da União, Poder Executivo, Brasília, DF, 6 p.

Cavalcante, A. R., Júnior, J. A. S., Gheyi, H. R., Dias, N. S., Paz, V. P. S. (2016). Produção e composição mineral do coentro em sistema hidroponico de baixo custo. *Irriga*, 21(4), 685-696.

Ceglie, F. G., Amodio, M. L., Colelli, G. (2016). Effect of Organic Production Systems on Quality and Postharvest Performance of Horticultural Produce. *Horticulturae*, 2(4), 1-7.

Cerqueira, F. B., Santana, S. C., Santos, W. F., Freitas, G. A., Nunes, T. V., Siebeneichler, S. C. (2016). Doses de nitrogênio nas respostas morfofisiológicas de coentro (*Coriandrum sativum* L.). *Global Science and Technology*, 9(1), 15 – 21.

Fichinello, J. C., Nachitigal, J. C., Kersten, E. *Fruticultura: Fundamentos e Práticas*. Pelotas: Embrapa Clima Temperado, 2008, 175 p.

Figueiredo, C. C.; Ramos, L. M., Mcmanus, C. M., Menezes, A. M. (2012). Mineralização de esterco de ovinos e sua influência na produção de alface. *Horticultura Brasileira*, 30(1), 175-179.

Folch, J., Lees, M., Stanley, G. H. S. (1957). A simple method for the isolation and purification of total lipides from animal tissues. *The Journal of Biological Chemistry*, 226(1), 497-509.

Grangeiro, L. C., Santos, A. P., Freitas, F. C. L., Simão, L. M. C., Neto, F. B. (2011). Avaliação agroeconômica das culturas da beterraba e coentro em função da época de estabelecimento do consórcio. *Revista Ciência Agronômica*, 42(1), 242-248.

Ial - Instituto Adolfo Lutz (2008). Métodos físico-químicos para análise de alimentos. Coordenadores: Odair Zenebon, Neus Sadocco Pascuet e Paulo Tiglea. São Paulo: Instituto Adolfo Lutz, 1020 p.

Iap - Instituto Agronômico de Pernambuco (2008). Recomendações de adubação para o Estado de Pernambuco: 2ª aproximação. Cavalcante, F. J. A. Recife: Instituto Agronômico de Pernambuco, 212 p.

Holland, B., Brow, J., Buss, D. H. Fish and Fisfh Products, Third Supplement to MacCance and Winddoeson's The composition of foods. *The royal society of chemistry and ministry of agriculture, fisheries and food*. Cambridge, 5° ed., 1994, 462p.

Kandil, A. T., Cheira, M. F., Gado, H. S., Soliman, M. H., Akl, H. M. (2017). Ammonium sulfate preparation from phosphogypsum waste**.** *Journal of Radiation Research and Applied Sciences*, 10(1), 24-33.

Linhares, P. C. F., Pereira, M. F. S., Moreira, J. C., Paiva, A. C. C., Assis, J.P., Sousa, R.P. (2015). Rendimento do coentro (*Coriandrum sativum* L) adubado com esterco bovino em diferentes doses e tempos de incorporação no solo. *Revista Brasileira de Plantas Medicinais*, 17 (3), 462-467.

Lopéz, N. A. P., Cano-Sosa, J., Poblano, F. C., Rodríguez-Buenfil, I. M., Ramos-Díaz, A. (2016). Different Responses of the Quality Parameters of *Coriandrum sativum* to Organic Substrate Mixtures and Fertilization. *Agronomy*, 6(21), 1-10.

Pereira, M. F. S., Torres, S. B., Linhares, P. C. F., Paiva, A. C. C., Paz, A. E. S., Dantas, A. H. (2011). Qualidade fisiológica de sementes de coentro *Coriandrum sativum* L. *Revista Brasileira de Plantas Medicinais*, 13(especial), 518-522.

Pereira A.S. et al. (2018). Metodologia da pesquisa científica. [e-book]. Santa Maria. Ed. UAB/NTE/UFSM.

Ramalho, W. B., Linhares, P. C. F., Maracajá, P. B., Almeida, A. M. B., Morais, A. P. (2016). Desempenho econômico do consórcio de coentro com beterraba, adubados com doses de jitirana, combinada com esterco bovino. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, 11(1), 78-83.

R core team. R: *A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria, 2017.

Santos, J. S., Kuba, C. A., Santos, F. A. G., Batista, A. S., Sitolino, S. C. P., Pereira, A. C. C., Giuffrida, R., Santarém, V. A. (2017). Análise parasitológica em alfaces cultivadas em diferentes sistemas de produção. *Semina: Ciências Agrárias,* v. 38(2), 801-808.

Sodré, A. C. B., Haber, L., Luz, J. M. Q., Marques, M. O. M. Rodrigues, C. R. (2013). Adubação orgânica e mineral em melissa. *Horticultura Brasileira*, 31(1), 147-152.

Yu, X., Guo, L., Jiang, G., Song, Y., Mumino, M. A. (2018). Advances of organic products over conventional productions with respect to nutritional quality and food security. *Acta Ecologica Sinica*, 38, 53–60.

Percentage of contribution of each author in the manuscript

Sara Beatriz da Costa Santos – 20%

Solange de Souza – 10%

Vênia Camelo de Souza– 10%

George Rodrigo Beltrão da Cruz – 10%

Thiago de Souza Melo – 10%

Ivan Sérgio da Silva Oliveira – 10%

Josinaldo da Silva Henrique – 10%

Aline Cavalcanti Dantas– 10%

Kênia Lira de Souza – 10%