PESQUISA AGROPECUÁRIA GAÚCHA

doi: https://doi.org/10.36812/pag.202430148-60

ORIGINAL ARTICLE

Soil and organic phytosanitary management on onion productivity in Serra Gaúcha, Southern Brazil

Maurício Rigo Panazzolo[1], Wendel Paulo Silvestre[2*], Luis Carlos Diel Rupp[3], Leandro Venturin[4], Valdirene Camatti Sartori[1]

Abstract - Onions are an important vegetable crop in Serra Gaúcha. However, adequate soil, nutrition, and disease management depend on harvest production and quality. Thus, using organic products as an alternative to conventional management methods has grown recently. This study aimed to evaluate the effect of different soil and phytosanitary management of organic origin on onion productivity. Three soil management methods were tested: soil without vegetation cover, soil with vegetation cover, and soil with vegetation cover plus Bokashi compost. The subplots corresponded to the weekly application of ginger extract, biweekly application of Bordeaux mixture, and control (water) for phytosanitary treatments. None of the phytosanitary treatments had any effect on the crop. Soil management influenced the severity of leet rust (*Puccinia porri*), where the use of straw and the concurrent application of straw and Bokashi reduced the severity. Straw and straw associated with Bokashi, although it produced plants with lower height and stem diameter, promoted greater bulb masses and productivity and increased soil fertility. Thus, the concomitant use of straw and Bokashi can be a strategy to increase onion productivity, which aligns with the principles of organic agriculture.

Keywords: Bokashi. No-till farming. Plant extracts. Straw.

Manejo de solo e fitossanitário orgânico na produtividade de cebola na Serra Gaúcha, Sul do Brasil

Resumo - A cebola é uma importante cultura olerícola da Serra Gaúcha. No entanto, a produção e qualidade da colheita dependem de um manejo adequado do solo, nutrição e das doenças. Assim, a utilização de produtos orgânicos como alternativa aos métodos convencionais de manejo vem crescendo nos últimos anos. Este estudo visou avaliar o efeito de diferentes manejos de solo e fitossanitários de origem orgânico sobre a produtividade da cebola. Testou-se três manejos de solo, sendo solo desprovido de cobertura vegetal, solo com cobertura vegetal e solo com cobertura vegetal mais composto Bokashi. Para os tratamentos fitossanitários, as subparcelas corresponderam à aplicação semanal de extrato gengibre, aplicação quinzenal de calda bordalesa e controle (água). Nenhum dos tratamentos fitossanitários teve efeito sobre a cultura. O manejo de solo influenciou a severidade da ferrugem (*Puccinia porri*), onde o uso de palhada e a aplicação concomitante de palhada e Bokashi reduziram a severidade. Palhada e palhada associada a Bokashi, embora tenha produzido plantas com menor altura e diâmetro de colo, promoveu maiores massas de bulbo e produtividade e incrementou a fertilidade do solo. Assim, o emprego concomitante de palhada e Bokashi pode ser uma estratégia para aumentar a produtividade da cebola, alinhado aos princípios da agricultura orgânica.

Palavras-chave: Bokashi. Extratos vegetais. Palhada. Plantio direto.

[1] Laboratório de Agricultura Orgânica, Universidade de Caxias do Sul, Caxias do Sul, RS, Brasil.
[2] Laboratório de Estudos do Sistema Planta-Ambiente (LESPA) e Programa de Pós-Graduação em Engenharia de Processos e Tecnologias (PGEPROTEC), Universidade de Caxias do Sul, Caxias do Sul, RS, Brasil. *Corresponding author: wpsilvestre@ucs.br
[3] Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Bento Gonçalves, RS, Brasil..
[4] Centro Ecológico da Serra, Ipê, RS, Brasil.

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

Introduction

Inadequate soil management leads to its degradation, accentuating modern agriculture's difficulties. Erosion, loss of natural fertility, and self-recovery capacity are factors that make this segment even more vulnerable. The conventional system usually presents the negative aspect of destructuring the soil, thus reducing the soil's water retention capacity and affecting its biology, negatively impacting the supply of nutrients and their storage capacity. Furthermore, the consequences of ongoing climate change (extreme heat waves) corrupt the so-called soil ecosystem services, compromising biological and physical processes in the soil (Blanchy *et al.*, 2023).

Onion (*Allium cepa* L.) is among the most consumed foods in the world due to its antioxidant and anticancer properties. China is the world's largest onion producer, responsible for around 30 % of world production. On the same scale, Brazil is in ninth place as the largest producer in South America. In Brazil, onions occupy the third position in economic importance, right after tomatoes and potatoes, with 48,985 ha of cultivation and production of 1,656 thousand tons in 2022 (IBGE, 2022). With acreage that extends from the South to the Northeast region, Rio Grande do Sul State is the fourth largest national producer of onion (IBGE, 2022), with the planting system being used in the South of Brazil mainly by family farming. However, the crop can be attacked by various diseases, leading to indiscriminate use of pesticides when good agricultural practices are not respected.

The great importance of this vegetable is mainly linked to its social aspect. It is estimated that 70 % of Brazilian onion growing comes from family farming, mainly in the South and Northeast regions, involving around 60 thousand families with onion growing as their main activity (Leite, 2014).

The occurrence of diseases, such as leek rust (*Puccinia porri*), is a common problem in onion farming. However, growing concern for the environment and more sustainable practices require searching for and developing less aggressive and persistent products to control agricultural diseases and pests (Naqvi, 2004). Plant extracts and Bordeaux mixture are already consolidated in organic agriculture. Kowalska and Smolinska (2008) reported the antimicrobial and control effect of natural extracts on onion and garlic pathogens, and the potential for using natural products as an alternative for controlling and combating diseases and agricultural pests is recognized (Naqvi, 2004; Belo; Du Troit; Lahue, 2023). However, the potential for using alternative disease control in onion crops is still largely unexplored (Sharma *et al.*, 2016; Belo; Du Troit; Lahue, 2023).

Among the options for phytosanitary treatments in organic farming, the Bordeaux mixture (calcium oxide and copper sulfate dissolved in water) is widely used due to its simplicity, broad history of use, and allowance for use in organic farming systems (Lamichhane *et al.*, 2018). On the other hand, there is an increasing interest in using plant extracts and other natural products as potential control disease agents in place of synthetic pesticides and inorganic compounds (Souto *et al.*, 2021; Zhang *et al.*, 2023). Ginger (*Zingiber officinalis*) and its extracts have an acknowledged antifungal effect against phytopathogenic fungi, with the potential to be used in field conditions (Miranda *et al.*, 2021; Kalhoro *et al.*, 2022; Xi *et al.*, 2022).

Regarding onion crop management, some studies evaluate nutrient supply, highlighting that nutrient availability is closely related to soil management. According to Fayad *et al.* (2019), onion cultivation can

Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

be carried out using the direct vegetable planting system (DVPS), which recommends soil disturbance restricted to the planting line, with continuous use of vegetable cover and crop rotations.

Using alternative strategies, such as new inputs in soil management, has aroused considerable interest as a technology, mainly due to its low environmental impact (Shin *et al.*, 2017; Ramírez-Gottfried *et al.*, 2023). The so-called direct planting system (DPS) presents advantages in onion cultivation concerning conventional soil management (Higashikawa *et al.*, 2022). In addition to increasing productivity, this management reduces soil erosion and improves the ecological environment (Du; Li; Effah, 2022).

Onion cultivation in the direct planting system in straw is recommended due to the protection and improvement of the soil's chemical, physical, and biological quality, favored by cover crops (Comin *et al.*, 2018), and increased productivity (Oliveira *et al.*, 2016).

The Bokashi compound is widely used in organic agriculture, and it has been reported that its use in onion cultivation had positive effects on the growth and productivity of this vegetable species (Álvarez-Solís *et al.*, 2016; Lasmini *et al.*, 2018; Sawadogo *et al.*, 2022). However, few studies have explored the effect of applying Bokashi organic compost on productivity in onion cultivation in a direct planting system using straw.

Thus, this work aimed to evaluate the effect of the type of soil management and phytosanitary management on the production of *Allium cepa* in the Serra Gaúcha region.

Materials and Methods

The experimental design adopted was bifactorial, with nine treatments and three replications. Each experimental unit (replicate) corresponded to a bed, measuring 1.0 m x 30.0 m. Each type of soil management was subdivided into three subplots, where they received the respective phytosanitary treatments. Each subplot consisted of 115 onion seedlings with a spacing of 15 cm between rows and 15 cm between seedlings, totaling approximately 40 plants per square meter. A spacing of 1.0 m between beds was used to isolate each replicate and avoid cross-contamination among treatments.

The 'Early Creole' onion variety of *Allium cepa* was used. The experiment was carried out from July to December, in the years 2009 and 2010, corresponding to two production cycles, conducted in the experimental area at the Biotechnology Institute of the University of Caxias do Sul (29°09'56"S and 51°08'56'W and an altitude of 760 m), Rio Grande do Sul State, Brazil. The soil of the experimental field was classified as Clay Loam with wavy relief (Tedesco *et al*., 1995).

To achieve the proposed objectives, soil management and conservation techniques were used, with *a* consortium of *Pennisetum glaucum* (millet), in the amount of 100 kg·ha^{-1}, *Crotalaria juncea* (sunn hemp) 20 kg·ha^{-1}, and *Canavalia ensiformis* (pig beans) 50 kg·ha^{-1}, sown in January each year and sown in June for later transplantation of seedlings. The organic compound Bokashi (120 g·m^{-2}) was added twenty days before seedling transplantation (July 2009 in the first and July 2010 in the second harvest, respectively).

Bokashi compost was prepared using 40 kg of litter, 200 kg of wheat bran, 6 L of molasses, 6 L of milk, 240 kg of tung cake, 240 kg of natural phosphate, 80 kg of oyster flour, 8 kg of cassava flour, 16 kg of ash, 32 kg of brown sugar, and 480 kg of earth (Meirelles; Rupp, 2005).

According to Köppen's classification, the climate is Cfa - humid subtropical (Alvares *et al.*, 2013), where for July and August 2009, the average temperature was 13.5 ºC, and the accumulated precipitation was

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

169.7 mm. Between September and December of the same year, the average temperature was 20.8 ºC, and accumulated precipitation was 254.0 mm. For the year 2010, in July and August, the average temperature was 14.0 ºC, and the accumulated rainfall was 140.8 mm. Between September and December, the average temperature was 17.8 ºC, and the accumulated precipitation was 115.0 mm, according to data from INMET (2024).

Three types of soil management were tested: the soil without vegetation cover (uncovered – control), the soil with straw vegetation cover, and the soil with straw vegetation cover plus applying Bokashi compost at a dose of 120 $g \cdot m^{-2}$. For organic phytosanitary treatments, the subplots corresponded to a weekly application of ginger extract (*Zingiber officinale*) at a dose of 100 $g \cdot L^{-1}$; a biweekly application of Bordeaux mixture at a dose of 1.0 % (w/v), and the control (water with adhesive spreader). A completely randomized experimental design was carried out with three replications.

For the plots that received phytosanitary treatments, an adhesive spreader based on crushed prickly pear leaves (*Opuntia* sp.) was used at a dose of 2 $kg \cdot 100\ L^{-1}$ water), allowing the products to remain adhered for longer, improving its efficiency (Sartori; Venturin, 2016). Spraying began 20 days after transplanting the seedlings and continued until the onion bulbs were filled.

The variables analyzed 120 days after transplanting the seedlings were plant height, stem diameter, and number of leaves with leet rust (*Puccinia porri*) symptoms for five central plants within each subplot, evaluating the severity and percentage of disease incidence in the different phytosanitary treatments and soil management, totaling 135 evaluated plants. The degree of severity of foliar disease was determined using a rating scale from 1 to 5: (1) Plant without symptoms (no incidence of disease); (2) Plant with up to 25 % of infected leaf area; (3) Plant with 25 – 50 % of infected leaf area; (4) Plant with 50 – 75 % of infected leaf area; (5) Plant with infected leaf area above 75 % (Galván *et al.*, 1997). Sampling was done to determine the average bulb mass and crop productivity by harvesting 18 bulbs in the central rows within each subplot at the end of the production cycle.

Soil fertility in the experimental area before (January 2009) and after the application of treatments (February 2011), as well as the field yield of the Bokashi compost produced, were evaluated according to the procedures described by Tedesco *et al.* (1995). For soil fertility analyses, soil samples with a depth of 10 cm were collected and homogenized in different soil management.

The experiment followed a complete bifactorial design, being the factors the phytosanitary treatments (ginger extract, Bordeaux mixture, and control) and the soil management types (uncovered soil, straw, and straw with Bokashi compost). The data obtained were evaluated for homoscedasticity (Levene's test) and normality of residuals (Shapiro-Wilk test). The results were submitted to factorial Analysis of Variance (ANOVA). The treatment means were compared using the Tukey test ($p < 0.05$) using the Agroestat® software (Maldonado Júnior; Barbosa, 2015).

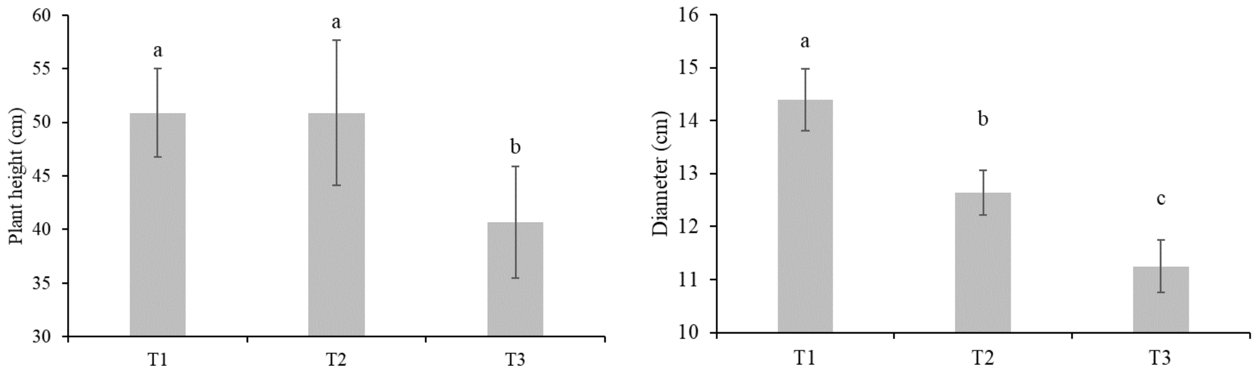
Results and Discussion

None of the phytosanitary treatments affected the agronomic characteristics of onion cultivation. On the other hand, soil management had a significant effect on plant height and collar diameter (Fig. 1).

Regarding the height of onion plants, bare soil and straw management promoted greater height. According to Bettoni *et al.* (2013), the growth of *A.*

Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

cepa and other species results from its interactions with the environment. Therefore, the difference in variable height between different soil management may be related to the plants' ability to adapt to the environment (Silva *et al.*, 2017). Álvarez-Solís *et al.* (2016), testing the fertilization with Bokashi and other fertilizers, reported that while most biometric parameters of onion were enhanced by applying Bokashi, plant height was not affected, with results similar to the control. The authors hypothesized that plant height may be driven chiefly by genetic factors rather than the nutritional conditions of the crop.



(A) (B)

Figure 1. Effect of soil management on plant height (A) and stem diameter (B) of *Allium cepa* in two cultivation cycles. Means followed by the same letter do not differ using the Tukey test ($p < 0.05$). T1 – Uncovered; T2 – Straw; T3 – Straw with Bokashi compost.

Concerning neck diameter, it can be observed that plants grown in bare soil had the largest diameters, while plants in the straw and Bokashi compost treatment had the smallest diameters. This behavior may be associated with the presence of specific classes of microorganisms (lactic acid and photosynthetic bacteria, yeasts, and actinomycetes) in Bokashi compost, which may have stimulated other biological activities in onion, with deleterious effects on plant growth or stimulating plants to deviate photoassimilates to storage in bulbs (Barnes, 2009). As observed by Abdissa, Tekalign and Pant. (2011), adding macronutrients (N and P) did not influence neck diameter of onions grown in Northeast Ethiopia, suggesting that nutrients probably do not affect this biometric parameter.

It is important to observe that plant height and neck diameter, while important biometric parameters, are not directly associated with crop yield and bulb mass, which was increased by applying Bokashi compost and straw (Table 2). The leading cause of this improved crop development is associated with the concentration of organic matter (OM), which increases in soil under direct planting, being the main responsible for the greater capacity for cation exchange, water adsorption, and improvement of soil structure (Primavesi, 2002). Greater amounts of OM were observed in this work in soil with straw and straw with the Bokashi compound, as can be seen in Table 1. Yao *et al.* (2017) found that using straw in combination with synthetic fertilizer containing N was beneficial for soil fertility and crop yield. According to these authors, this practice can significantly alter soil microbial activity

Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

and the relative availability of C and N, both known to regulate emissions of nitrous oxide (N_2O) and nitric oxide (NO) from the soil. Furthermore, maintaining soil cover with straw has been proposed to promote soil fertility and minimize negative environmental impacts. According to Abalos *et al.* (2013) and Kuneski *et al.* (2023), straw conservation can play multiple roles in soil N_2O and NO fluxes, influencing the relative availability of C and N and the state of soil aeration.

According to Miao, Stewart, and Zhang (2011), the use of fertilizers and straws is a practice that promotes better results when compared to the individual application of inorganic fertilizers or straws, and the combined application can overcome the disadvantages of applying a single source of fertilizer. The combined application promoted larger harvests, improved soil fertility, and reduced soil acidification problems. Zhao *et al.* (2015) observed a 7 % yield increase in cereal production when straw was incorporated.

Bokashi is a fermented compound used mainly by family farmers. According to Andayani, Hayat, and Mursalin (2023), the bokashi compound works by improving the natural fertility of the soil and the absorption of nutrients by plants. Also, according to this author, the Bokashi compound provides plants with more balanced nutrition, meeting the demands of the vegetative development of various crops. However, in the present study, the concurrent application of Bokashi compost next to the soil with straw caused smaller plant height and stem diameter. Regarding this behavior, Xavier *et al.* (2019) commented that the response of crops to the use of Bokashi compost can be variable according to factors such as the chemical composition of the materials used in its production, in addition to the N and C contents, and the response capacity of each crop.

According to the statistical analysis, the presence and development of leek rust in the crop showed that none of the phytosanitary treatments had a significant effect. However, the type of soil management influenced the degree of severity without affecting incidence rates (Fig. 2).

Using straw and the joint application of straw and Bokashi compost reduced the severity of leek rust in the crop compared to the control (uncovered soil). Managing agricultural crops using straw is increasingly encouraged, aiming to reduce the adverse effects of climate change. Furthermore, the straw decomposition process stimulates soil microbiota and mineralization processes involving microorganisms and enzymes, positively impacting the OM transformation processes and nutrient cycling and absorption by the root-soil-microorganism system (Liu *et al.*, 2023).

One of the explanations for the reduction in disease severity when treating straw with bokashi compost may be due to the higher potassium content (Table 1). According to Rengel, Cakmak and White *et al.* (2023) and Amtmann and Srivastava (2023), one factor in increasing crop resistance against diseases is mainly attributed to different sources of potassium in the soil solution.

The results regarding soil fertility parameters in the area depending on the soil management applied are presented in Table 1.

The results of soil analyses within the different treatments showed that the parameters of pH, OM, P, K, Ca, B, Mg, and CEC had their levels increased by applying straw (T2) and straw with applying the Bokashi compound (T3). Using straw (T2) and the joint application of straw and Bokashi (T3) increased soil nutrient content, especially MO, P, K, Mg, and B, increasing pH, pH-SMP, and CEC.

In an experiment with onion, Souza *et al.* (2013) found that when cover crops were deposed, they

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

modified the chemical attributes of the soil, with changes in the levels of exchangeable K and available P depending on the cover plant species used. These same authors found that the average production and total production of onion were higher in treatments with cover crops in the two harvests evaluated.

Table 1. Chemical characteristics of the soil before and after the installation of the experiment.

Sample	Clay	pH	pH-SMP	P	K	OM	Al	Ca	Mg	B	CEC
	$g \cdot kg^{-1}$	-	-	$mg \cdot dm^{-3}$		$g \cdot kg^{-1}$	$cmol_c \cdot kg^{-1}$	$cmol_c \cdot dm^{-3}$		$mg \cdot kg^{-1}$	$cmol_c \cdot kg^{-1}$
Bokashi	21	6.4	6.4	419.6	599	45	0.0	47.7	78.3	0.2	307.0
AE/T1	32	5.6	5.7	38.5	288	25	0.1	60.0	25.3	0.4	61.5
T2	44	5.9	6.0	56.8	350	27	0.0	70.8	30.0	0.6	153.0
T3	52	6.1	6.2	77.5	406	29	0.0	69.5	34.2	0.5	149.0

AE – area before implementing the experiment; T1 – uncovered soil; T2 – straw; T3 – straw with Bokashi compound; CEC – cation exchange capacity; OM – organic matter.

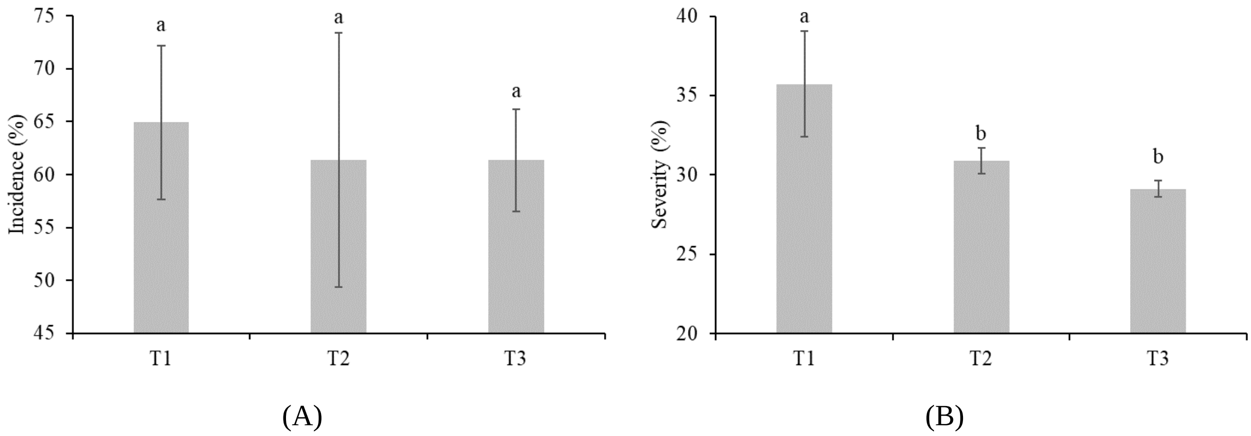


Figure 2. Effect of soil management on the incidence (A) and severity (B) of leek rust (*Puccinia porri*) in *Allium cepa* cv. Early Creole in two cultivation cycles. Means followed by the same letter do not differ from each other using the Tukey test ($p < 0.05$). T1 – Uncovered; T2 – Straw; T3 – Straw with Bokashi compost.

Table 2. Mass of bulbs and estimated productivity of *Allium cepa* cv. 'Early Creole' subjected to different soil management systems, considering the average of two production cycles.

Parameter	Uncovered	Straw	Straw and Bokashi compost
Average bulb mass (g)	61.6 b	62.6 b	77.2 a
Estimated productivity ($t \cdot ha^{-1}$)	14.8 b	15.0 b	18.5 a

Values followed by the same letter do not differ from each other using the Tukey test ($p < 0.05$).

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

It is also important to note that phosphorus participates in the induction of resistance and the activation of the photosynthetic process, making it beneficial to increase the available levels of this element for absorption by plants (Plaxton; Lambers, 2015; Lambers, 2022).

Soil management significantly affected the average mass of bulbs and crop productivity, while none of the phytosanitary treatments significantly influenced these parameters. Data regarding the average mass of bulbs and estimated onion productivity depending on the soil management used are shown in Table 2.

It can be noted that the straw treatment plus Bokashi compost promoted greater productivity and average bulb mass. It is suggested that the Bokashi composite arrangement and cover plants used in this experiment (*P. glaucum*, *C. juncea*, and *C. ensiformis*) created a favorable edaphic environment, favoring greater porosity in the surface layer of the soil and promoting nutritional factors for the development of the bulbs. According to Loss *et al.* (2017), the direct vegetable planting system increased aggregation rates, total porosity, and volumetric moisture compared to the conventional planting system.

Maintaining soil cover with straw has been proposed to promote soil fertility and minimize negative environmental impacts. According to Abalos *et al.* (2013) and Chen *et al.* (2013), crop straw conservation can play multiple roles in soil N_2O and OM fluxes, influencing relative C and N availability and soil aeration status. It is important to highlight that the direct vegetable planting system (SPDH) uses practices aimed at regenerative and organic agriculture, with frequent soil coverage and restricted soil disturbance, promoting improvements in the edaphic attributes of this environment (Kuneski *et al.*, 2023).

In an experiment with onions, Souza *et al*. (2013) found that incorporating cover crops into the soil promoted an increase in average and total onion production in two harvests evaluated. The increase in productivity of different crops through the use of direct planting with straw was also observed by other authors (Huang *et al.*, 2013; Ferreira *et al.*, 2023), suggesting the potential for using this tool to promote the improvement of the characteristics of the soil and, consequently, the crops planted.

Some authors have demonstrated that the use of Bokashi biofertilizer has a positive effect on the production of various crops, both vegetables, fruits, and cereals (Ribeiro *et al.*, 2015; Saiter *et al.*, 2016; Reis Júnior *et al.*, 2017). Bokashi compost provides nutrients and beneficial microorganisms to the soil, in addition to restoring the balance of nutritionally degraded areas, being an important tool used in organic and regenerative agriculture (Reis Júnior *et al.*, 2017; Kruker *et al.*, 2023).

Other studies have confirmed only the long-term positive effects of using straw combined with inorganic fertilizer application on crop yields (Zhao *et al.*, 2015). According to Xavier *et al.* (2019), the response to the use of Bokashi can be variable according to factors such as the chemical composition of the materials used in its production, the N and C contents, and the response capacity of each crop.

None of the phytosanitary treatments tested had affected onion diseases during the experiment. The type of soil management affected the severity of the disorders, in which the use of straw and the concurrent application of straw and Bokashi reduced the severity of the disease on the plants. Soil management influenced the biometric and productivity characteristics of onion cultivation. The use of straw and straw associated with the Bokashi compound, although it produced plants with lower height and diameter of the neck, promoted greater bulb masses and estimated productivity, in addition to increasing soil fertility compared to bare soil. Thus, using straw associated with Bokashi compost can be an efficient strategy to increase the productivity of onion crops, complying with organic and regenerative agriculture principles.

Conflict of Interests

The authors declare that the research was conducted in the absence of any potential conflicts of interest.

Ethical Statements

The authors confirm that the ethical guidelines adopted by the journal were followed by this work, and all authors agree with the submission, content and transfer of the publication rights of the article to the journal. They also declare that the work has not been previously published nor is it being considered for publication in another journal.

The authors assume full responsibility for the originality of the article and may incur on them any charges arising from claims, by third parties, in relation to the authorship of the article.

Open Access

ORCID

Maurício Rigo Panazzolo
https://orcid.org/0009-0002-8709-9770
Wendel Paulo Silvestre
https://orcid.org/0000-0002-9376-6405
Luis Carlos Diel Rupp
https://orcid.org/0000-0001-8678-2047
Leandro Venturin
https://orcid.org/0009-0004-0230-3109
Valdirene Camatti Sartori
https://orcid.org/0000-0002-8107-5893

References

ABALOS, D. *et al.* Role of maize Stover incorporation on nitrogen oxide emissions in a non-irrigated Mediterranean barley field. **Plant and soil**, v. 364, p. 357–371, 2013. https://doi.org/10.1007/s11104-012-1367-4.

ABDISSA, Y.; TEKALIGN, T.; PANT, L. M. Growth, bulb yield and quality of onion *(Allium cepa* L.*)* as influenced by nitrogen and phosphorus fertilization on vertisol I. growth attributes, biomass production and bulb yield. **African Journal of Agricultural Research**, v. 6, n. 14, p. 3252-3258, 2011.

ALVARES, C. A. *et al*. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, v. 22, n. 6, p. 711-728, 2013. https://doi.org/10.1127/0941-2948/2013/0507.

ÁLVAREZ-SOLÍS, J. D. *et al*. Effect of bokashi and vermicompost leachate on yield and quality of pepper *(Capsicum annuum)* and onion *(Allium cepa)* under monoculture and intercropping cultures. **Ciencia e Investigación Agraria**, v. 43, n.2, p. 243-252, 2016. https://doi.org/10.4067/S0718-16202016000200007.

AMTMANN, A.; SRIVASTAVA, A. K. Potassium and plant disease. *In:* Datnoff, L. E.; Elmer, W. H.; Rodrigues, F. A. (Eds.). **Mineral nutrition and plant disease**. St Paul: APS Press, 2023. p. 105–140.

ANDAYANI, S.; HAYAT, E. S.; MURSALIN, A.

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

Effect of bokashi quail manure and rice husk biochar on soil pH and soybean plants growth. **IOP Conference Series: Earth and Environmental Science**, v. 1160, 012023, 2023. https://doi.org/10.1088/1755-1315/1160/1/012023.

BARNES, S. P. **Bokashi Composting**: Performance Monitoring to assess the Potential of Commercial Level Applications. Queenstown, 2009. Available from: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=5b2146585f2194a90895b04230ff8be080bca12e. Accessed: Mar. 28, 2024.

BELO, T.; DU TROIT, L. J.; LAHUE, G. T. Reducing the risk of onion bacterial diseases: A review of cultural management strategies. **Agronomy Journal**, v. 115, n. 2, p. 459-473, 2023. https://doi.org/10.1002/agj2.21301.

BETTONI, M. M. *et al.* Crescimento e produção de sete cultivares de cebola em sistema orgânico em plantio fora de época. **Semina: Ciências Agrarias**, v. 34, n. 5, p. 2139-2152, 2013. https://doi.org/10.5433/1679-0359.2013v34n5p2139.

BLANCHY, G. *et al.* Soil and crop management practices and the water regulation functions of soils: a qualitative synthesis of meta-analyses relevant to European agriculture. **Soil**, v. 9, p. 1–20, 2023. https://doi.org/10.5194/soil-9-1-2023.

CHEN, H. *et al.* Soil nitrous oxide emissions following crop residue addition: a meta-analysis. **Global Change Biology**, v. 19, n. 10, p. 2956–2964, 2013. https://doi.org/10.1111/gcb.12274.

COMIN, J. J. *et al.* Carbon and nitrogen contents and aggregation index of soil cultivated with onion for seven years using crop successions and rotations. **Soil and Tillage Research**, v. 184, p. 195–202, 2018. https://doi.org/10.1016/j.still.2018.08.002.

DU, C.; LI, L.; EFFAH, Z. Effects of Straw Mulching and Reduced Tillage on Crop Production and Environment: A Review. **Water**, v. 14, 2471, 2022. https://doi.org/10.3390/w14162471.

FAYAD, J. A. *et al.* (Org.). **Sistema de plantio direto de hortaliças**: método de transição para um novo modo de produção. 2. ed. Florianópolis: Epagri 2019. 78 p.

FERREIRA, A. C. B. *et al.* Cover plants in second crop: nutrients in straw and cotton yield in succession. **Pesquisa Agropecuária Tropical**, v. 53, e75032, 2023. https://doi.org/10.1590/1983-40632023v5375032.

GALVÁN, G. A. *et al.* Screening for resistance to anthracnose (*Colletotrichum gloeosporioides* Penz.) in *Allium cepa* and its wild relatives. Euphytica, v. 95, p. 173-178, 1997. https://doi.org/10.1023/A:1002914225154.

HIGASHIKAWA, F. S. *et al.* Use of Compost in Onion Cultivation under No-Tillage System: Effect on Nutrient Uptake. **Communications in Soil Science and Plant Analysis**, v. 54, n. 9, p. 1215-1238, 2022. https://doi.org/10.1080/00103624.2022.2139388.

HUANG, T. *et al.* Net global warming potential and greenhouse gas intensity in a double-cropping cereal rotation as affected by nitrogen and straw management. **Biogeosciences**, v. 10, n. 12, p. 7897–7911, 2013. https://doi.org/10.5194/bg-10-7897-2013.

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E

ESTATÍSTICA. **Produção de cebola**. IBGE, 2022. Available from: https://www.ibge.gov.br/explica/producao-agropecuaria/cebola/br. Accessed: Mar. 12, 2023.

INMET. INSTITUTO NACIONAL DE METEOROLOGIA. **Sistema tempo – tabelas de dados das estações**. INMET, 2024. Available from: https://tempo.inmet.gov.br/TabelaEstacoes/A001. Accessed: Jan. 24, 2024.

KALHORO, M. T. *et al.* Fungicidal properties of ginger (*Zingiber officinale*) essential oils against *Phytophthora colocasiae*. **Scientific Reports**, v. 12, 2191, 2022. https://doi.org/10.1038%2Fs41598-022-06321-5.

KOWALSKA, B.; SMOLINSKA, U. The effect of selected plant materials and extracts on the development of bacterial diseases on onion. **Vegetable Crops Research Bulletin**, v. 68, p. 33-45, 2008. https://doi.org/10.2478/v10032-008-0003-6.

KRUKER, G. *et al.* Quality of Bokashi-Type Biofertilizer Formulations and Its Application in the Production of Vegetables in an Ecological System. **Horticulturae**, v. 9, n. 12, 1314, 2023. https://doi.org/10.3390/horticulturae9121314.

KUNESKI, A. C. *et al.* Total Carbon and Nitrogen and Granulometric Fractions of Soil Organic Matter Under No-Till System and Conventional Tillage with Onion Cultivation. **Revista de Gestão Social e Ambiental**, v. 17, n. 9, e04144, 2023. https://doi.org/10.24857/rgsa.v17n9-010.

LAMICHHANE, J. R. *et al.* Thirteen decades of antimicrobial copper compounds applied in agriculture. A review. **Agronomy for Sustainable Development**, v. 38, 28, 2018. https://doi.org/10.1007/s13593-018-0503-9.

LAMBERS, H. Phosphorus Acquisition and Utilization in Plants. **Annual Review in Plant Biology**, v. 73, p. 17–42, 2022. https://doi.org/10.1146/annurev-arplant-102720-125738.

LASMINI, S. A. *et al.* Improvement of soil quality using bokashi composting and NPK fertilizer to increase shallot yield on dry land. **Australian Journal of Crop Science**, v. 12, n. 11, p. 1743-1749, 2018. https://doi.org/10.21475/ajcs.18.12.11.p1435.

LEITE, D. L. **Produção de sementes de cebola**. Pelotas: Embrapa Clima Temperado, 2014. 9 p.

LIU, L. *et al.* Regulation of straw decomposition and its effect on soil function by the amount of returned straw in a cool zone rice crop system. **Scientific Reports**, v. 13, 15673, 2023. https://doi.org/10.1038/s41598-023-42650-9.

LOSS, A. *et al.* Atributos físicos do solo em cultivo de cebola sob sistemas de plantio direto e preparo convencional. **Revista Colombiana de Ciências Hortícolas**, v. 11, n. 1, p. 105-113, 2017. https://doi.org/10.17584/rcch.2017v11i1.6144.

MALDONADO JÚNIOR, W.; BARBOSA, J. C. **Experimentação Agronômica & AgroEstat**. São Paulo, 2015.

MEIRELLES, L. R; RUPP, L. C. D. (Org.). **Cartilha de Agricultura Ecológica – Princípios Básicos**. Ipê: Centro Ecológico, 2005. 39 p.

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.

recomendações práticas para transição agroecológica. Curitiba: Instituto Emater, 2017. 87 p.

MIAO, Y.; STEWART, B. A.; ZHANG, F. Long-term experiments for sustainable nutrient management in China. A review. **Agronomy for Sustainable Development**, v. 31, p. 397–414, 2011. https://doi.org/10.1051/agro/2010034.

MIRANDA, M. *et al.* Antifungal activity of *Zingiber officinale* Roscoe (ginger) oil and extracts, associated with carnauba wax nanoemulsions, on fungal control of harvest papaya. **Acta Horticulturae**, v. 1325, p. 191-198, 2021. https://doi.org/10.17660/ActaHortic.2021.1325.28.

NAQVI, S. A. M. H. **Diseases of Fruits and Vegetables**: Diseases and Management. Vol. 2. Dordecht: Kluwer Academic Publishers, 2004. 686 p.

OLIVEIRA, R. A. *et al.* Cover crops effects on soil chemical properties and onion yield. **Revista Brasileira de Ciência do Solo**, v. 40, p. 1–17, 2016. https://doi.org/10.1590/18069657rbcs20150099.

PLAXTON, W. C.; LAMBERS, H. Phosphorus Metabolism in Plants. **Annual Plant Reviews**, v. 48, p. 1–449, 2015. https://doi.org/10.1002/9781118958841.

PRIMAVESI, A. **O manejo ecológico do solo:** a agricultura em regiões tropicais. São Paulo: Nobel, 2002. 549 p.

RAMÍREZ-GOTTFRIED, R. I. *et al.* Compost Tea as Organic Fertilizer and Plant Disease Control: Bibliometric Analysis. **Agronomy**, v. 13, 2340, 2023. https://doi.org/10.3390/agronomy13092340.

REIS JÚNIOR, J. R. *et al.* **Defensivos alternativos**:

RENGEL, Z., CAKMAK, I.; WHITE, P. J. (Eds.). **Marschner's mineral nutrition of plants**. 4 ed. London: Academic Press, 2023. 816 p.

RIBEIRO, A. P. *et al.* **Bokashi e EM**: "fermentos da vida". UFV: Viçosa, 2015. 13 p.

SAITER, O. *et al.* **Efeito do adubo orgânico fermentado bokashi no desempenho agronômico do brócolis americano**. Teresópolis: Programa Rio Rural, 2016. 5 p.

SARTORI. V. C.; VENTURIN. L. **Tecnologias alternativas para o fortalecimento da agricultura familiar na Serra Gaúcha**. Caxias do Sul: Educs, 2016. 112 p.

SAWADOGO, J. *et al.* Effects of biological fertilizers on the yields of onion (*Allium cepa* L.) and on soil physico-chemical, microbiological properties in the Centre-weste of Burkina Faso. **International Journal of Innovation and Applied Studies**, v. 35, n. 2, p. 249-259, 2022.

SHARMA, K. *et al.* Economical and environmentally-friendly approaches for usage of onion (*Allium cepa* L.) waste. **Food & Function**, v. 7, n. 8, p. 3354-3369, 2016. https://doi.org/10.1039/C6FO00251J.

SHIN, K. *et al.* Variability of Effective Microorganisms (EM) in bokashi and soil and effects on soil-borne plant pathogens. **Crop Protection**, v. 99, p. 168-176, 2017. https://doi.org/10.1016/j.cropro.2017.05.025.

SILVA, L. L. *et al.* Crescimento vegetativo e teor de fósforo em cultivares de cebola. **Brazilian Journal of Applied Technology for Agricultural Science**, v. 10, n. 3, p. 7-14, 2017. https://doi.org/10.5935/PAeT.V10.N3.01.

SOUTO, A. L. *et al.* Plant-Derived Pesticides as an Alternative to Pest Management and Sustainable Agricultural Production: Prospects, Applications and Challenges. **Molecules**. v. 26, 4835, 2021. https://doi.org/10.3390/molecules26164835.

SOUZA, M, J. J. *et al.* Matéria seca de plantas de cobertura, produção de cebola e atributos químicos do solo em sistema plantio direto agroecológico. **Ciência Rural**, v. 43, p. 21-27, 2013. https://doi.org/10.1590/S0103-84782012005000150.

TEDESCO, M. J. *et al.* **Análise de solos, plantas e outros materiais.** Porto Alegre: UFRGS, 1995. 174 p.

XAVIER, M. C. G. *et al.* Produtividade de repolho em função de doses de bokashi. **Revista de Agricultura Neotropical**, v. 6, n. 1, p. 17-22, 2019. https://doi.org/10.32404/rean.v6i1.2372.

XI, K.Y. *et al.* Antifungal Activity of Ginger Rhizome Extract against *Fusarium solani*. **Horticulturae**, v. 8, 983, 2022. https://doi.org/10.3390/horticulturae8110983.

YAO, Z. *et al.* Straw return reduces yield scaled N_2O plus NO emissions from annual winter-based cropping systems in the North China Plain. **Science of Total Environment**, v. 15, n. 590-591, p. 174-185, 2017. https://doi.org/10.1016/j.scitotenv.2017.02.194.

ZHANG, P. *et al.* Recent advances in the natural products-based lead discovery for new agrochemicals. **Advanced Agrochem**, v. 2, n. 4, p. 324-339, 2023. https://doi.org/10.1016/j.aac.2023.09.004.

ZHAO, H. *et al.* Straw incorporation strategy on cereal crop yield in China. **Crop Science**, v. 55, n. 4, p. 1773–1781, 2015. https://doi.org/10.2135/cropsci2014.09.0599.

ISSN: 0104-907. ISSN ONLINE: 2595-7686.
Received on 17 Dec. 2023. Accepted on 12 Sept. 2024.