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Cover crops for no-tillage vegetable systems as a climate crisis mitigation strategy in organic Cucurbitaceae production[1]

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ABSTRACT

The conventional vegetable farming model aggravates the climate crisis, whereas the no-tillage system provides a sustainable alternative. This study aimed to identify winter cover crops for single cropping and intercropping by evaluating the biomass production and degradability, as well as their impact on Cucurbitaceae production in organic no-tillage system. The experiment was conducted in an area with *Cucurbita pepo* var. *melopepo* and other with *Cucumis sativus*. A randomized complete block design was used, with three replicates. The treatments included the single cropping of black oat (*Avena strigosa*), rye (*Secale cereale*) and vetch (*Vicia sativa*), as well as the intercropping systems black oat + vetch, black oat + vetch + radish (*Raphanus sativus*), rye + vetch + radish and winter fallow. The Poaceae treatments showed a higher biomass production and half-life, with the black oat biomass contributing to the greatest zucchini yield, whereas the Japanese cucumber showed a superior performance when grown with cover crops. Thus, the black oat + vetch + radish or rye + vetch + radish intercropping systems are the most recommended ones for the organic no-tillage system.

KEYWORDS: Biomass production, sustainable agriculture, 2030 Agenda.

RESUMO

Plantas de cobertura para sistemas de plantio direto de hortaliças como estratégia de mitigação da crise climática na produção orgânica de Cucurbitáceas

O modelo convencional de produção de hortaliças contribui para a crise climática, enquanto o sistema de plantio direto é uma alternativa sustentável. Objetivou-se identificar plantas de cobertura de inverno em sistemas de cultivo solteiro e consorciado, por meio da avaliação da produção e degradabilidade da biomassa e de seus efeitos sobre a produção de Cucurbitáceas, em sistema de plantio direto orgânico. O experimento foi conduzido em uma área com *Cucurbita pepo* var. *melopepo* e outra com *Cucumis sativus.* Utilizou-se delineamento experimental em blocos casualizados, com três repetições. Os tratamentos incluíram o sistema de cultivo solteiro de aveia-preta (*Avena strigosa*), centeio (*Secale cereale*) e ervilhaca (*Vicia sativa*), os consórcios aveia-preta + ervilhaca, aveia-preta + ervilhaca + nabo-forrageiro (*Raphanus sativus*), centeio + ervilhaca + nabo-forrageiro e pousio invernal. Os tratamentos da família *Poaceae* apresentaram maior produção de biomassa e meia-vida, com a biomassa da aveia-preta contribuindo para a maior produtividade de abobrinha, ao passo que o pepino japonês apresentou desempenho superior quando cultivado com as plantas de cobertura. Assim, os sistemas de consórcio aveia-preta + ervilhaca + nabo-forrageiro ou centeio + ervilhaca + nabo-forrageiro são os mais recomendados para o sistema de plantio direto orgânico.

KEYWORDS: Produção de biomassa, agricultura sustentável, Agenda 2030.

INTRODUCTION

Integrating social and economic development with environmental preservation is still a significant challenge. In 2015, the United Nations Organization approved the 2030 Agenda for Sustainable Development. It comprises 17 sustainable development goals (SDGs), which promote social well-being, sustainable development and environmental protection (UNO 2018). It is crucial to consider strategies that stimulate the effective integration of these goals with local agricultural practices to achieve a sustainable balance among economic, social and environmental development.

In Brazil, horticulture plays a significant social and economic role. It comprises a wide

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variety of plant species. Among them, members of the *Cucurbitaceae* family stand out. They include Japanese cucumber (*Cucumis sativus*) and zucchini (*Cucurbita pepo* var. *melopepo*). However, even in organic systems, vegetable production involves intensive soil management, primarily for bed formation and weed control, which hastens soil degradation (Manzatto et al. 2019). Therefore, promoting sustainable technological development in organic vegetable production systems, making them biologically diverse and sustainable over time, is crucial.

No-tillage vegetable systems can improve this situation. They promote plant health by avoiding soil disturbance, rotating crops, adding 10 t ha^{-1} of biomass, and providing adequate nutrition. These systems involve minimal soil disturbance, increasing the soil's organic matter content and carbon sequestration, preventing erosive processes and stimulating soil biological activity (Comin et al. 2016, Vezzani et al. 2019). Moreover, the addition of biomass, through biomass deposition on the soil surface, significantly affects soil temperature variables, resulting in reduced thermal amplitude and soil moisture retention. Thus, it promotes nutrient cycling and the input of nutrients, water and total organic carbon through this biomass decomposition in the system (Hoffmann et al. 2018).

The no-tillage vegetable systems' feasibility relies on integrating cover crops into vegetable production. These crops facilitate biomass addition, which is crucial, given the vegetables' short cycle and limited soil protection due to low residue production (Comin et al. 2016). Common cover crops, from families such as *Fabaceae*, *Poaceae* and *Brassicaceae*, are grown in single cropping or intercropping systems. *Poaceae* species are characterized by rapid growth and high lignin content. They decompose slowly, enhancing soil aggregate structure and stability (Wutke et al. 2023). *Fabaceae* offers nitrogen fixation benefits from the atmosphere, though it shows a slower initial growth and quicker decomposition rates. Forage radish (*Raphanus sativus*), a prominent *Brassicaceae*, is commonly intercropped with black oat and vetch. It is known for its resilience and substantial biomass production (Wutke et al. 2023).

There is much knowledge on the benefits of cover crops for grain production systems, mainly due to advances and research related to no-tillage in annual crops. However, despite the numerous benefits provided by this system, its application in horticulture is still incipient. Thus, there are few studies and results on no-tillage vegetable systems in vegetable production, particularly in organic systems. This system represents an alternative to the conventional model, and aims to mitigate climate change by optimizing natural and socioeconomic resources and protecting the agroecosystem (Vezzani et al. 2019).

No-tillage vegetable systems comprise a strategic and sustainable agricultural practice to mitigate climate change and significantly impact food production (Vezzani et al. 2019). Furthermore, these systems directly contribute to achieving the SDGs 2, 12 and 15. For example, the SDG 2 targets aim to double agricultural productivity and income for small-scale producers (2.3), ensure sustainable food production systems and implement resilient agricultural practices (2.4), as well as to maintain the diversity of cultivated plants (2.5). In turn, the SDG 12 targets involve promoting the sustainable management and efficient use of natural resources (12.2) and strengthening scientific and technological capacities to transition to more sustainable production patterns (12.a). Meanwhile, the SDG 15 targets include ensuring the conservation, restoration and sustainable use of ecosystems (15.1), restoring degraded soils (15.3) and reducing the degradation of natural habitats and halting biodiversity loss (15.5) (UNO 2018). Achieving these targets requires understanding the rotation or intercropping of these species with vegetables, considering factors such as planting times, cycle duration, plant arrangement and growth habits of all species within the system.

Thus, this study aimed to evaluate the production of Japanese cucumber (cv. Soldier) and Italian zucchini (cv. Caserta) in organic no-tillage vegetable systems. Moreover, it aimed to assess the production and degradability of winter cover crop biomass from the *Fabaceae*, *Poaceae* and *Brassicaceae* families in single cropping and intercropping systems.

MATERIAL AND METHODS

Two experiments were conducted in the agrarian settlement Filhos de Sepé, in Viamão, Rio Grande do Sul state, Brasil, in 2020. The study sites were designated as Area A (-30.079530ºS, -50.838165ºW and altitude of 36 m) and Area B

(-30.098991ºS, -50.838165ºW and altitude of 111 m). The soil in the Area A is classified as Gleyic Dystric Fragic Planosol (FAO 2015), whereas in the Area B it is classified as Abruptic Dystric Acrisol (Embrapa 2006, FAO 2015). The climate is Cfa, according to the Köppen & Geiger classification.

Soil samples from 0-10 cm and 10-20 cm depths (SBCS 2016) were collected in both areas for soil fertilization recommendations. In the Area A, pH in H_2O = 5.90; P = 69.00 mg dm^{-3}; K = 90.00 mg dm^{-3}; CEC = 4.30 $cmol_c$ dm^{-3}; and organic matter = 1.30 %. In the Area B, pH in H_2O = 5.09; P = 25.00 mg dm^{-3}; K = 65.00 mg dm^{-3}; CEC = 3.90 $cmol_c$ dm^{-3}; and organic matter = 1.00 %. Meteorological data, including global radiation, cumulative rainfall and temperatures were sourced from the Porto Alegre meteorological station of the National Institute of Meteorology. Averages for these variables were computed across the growth cycles of cover crops (May to October) and vegetables (October to December).

The treatments included single cropping and intercropping systems: black oat (*Avena strigosa*); rye (*Secale cereale*); vetch (*Vicia sativa*); black oat + vetch; black oat + vetch + radish (*Raphanus sativus*); rye + vetch + radish; and winter fallow, characterized by spontaneous growth, primarily comprising *Lolium multiflorum*. The experimental design followed a randomized complete block design, with three replicates. Each plot measured 7.5 m^2 (2.5 x 3.0 m), totaling 24 experimental units.

At 15 days before sowing the cover crops, soil preparation involved eradicating spontaneous plants, followed by plowing and harrowing. On May 29, 2020, the cover crops were broadcast seeded in the Area A, in a field pre-fertilized with 6.25 t ha^{-1} of poultry litter. In the Area B, sowing occurred on June 19, 2020, with a topdressing of 5.00 t ha^{-1} of poultry litter. Specific seeding densities were applied for each treatment: black oat and vetch at 142.0 kg ha^{-1}, and rye at 121.0 kg ha^{-1}. For black oat + vetch, a density of 71.0 kg ha^{-1} was used for each species. Similarly, for black oat + vetch + radish, the densities were 47.0, 47.0 and 11.5 kg ha^{-1}, respectively, for each species. For rye + vetch + radish, the applied densities were 40.0, 47.0 and 11.5 kg ha^{-1}, respectively, for each species.

In the Area A, at 127 days after sowing (DAS), on Oct. 06, 2020, the cover crops were suppressed, followed by transplanting zucchini (*Cucurbita pepo* var. *melopepo* cv. Caserta) spaced at 0.50 x 0.50 m. In the Area B, on Oct. 16, 2020, the cover crops were physically suppressed by mowing at 117 DAS, followed by transplanting Japanese cucumber seedlings (*Cucumis sativus* cv. Soldier) spaced at 1.0 x 1.0 m. Both sets of seedlings were produced in expanded polystyrene trays with 72 cells, each with a volume of 113 mL, and transplanted when they had three fully expanded leaves. They received topdressing fertilization of 10 t ha^{-1} with poultry litter.

Damping-off symptoms occurred at 7 days after transplanting (DAT) the Japanese cucumber. *Trichoderma* sp. was applied for control using the StimuControl® commercial product, at the manufacturer's recommended dose, repeated at 14 and 21 DAT. The zucchini harvesting began at 35 DAT and ended at 60 DAT (Dec. 06, 2020), whereas the Japanese cucumber harvesting began at 47 DAT (Dec. 12, 2020). Harvests were conducted weekly. For both experiments, parameters including average fruit weight (g), average fruit length (cm) and total yield (t ha^{-1}) were determined for the harvested fruits. When analyzing the agronomic variables of the vegetables, 4 Japanese cucumber and 6 Italian zucchini plants were evaluated per experimental unit.

In order to assess the treatment biomass production (t ha^{-1}), the aboveground biomass from each experimental unit was sampled using a 0.5 x 0.5 m frame, at 10 days before cover crop lodging in the Area A and 8 days in the Area B (Salman 2013). Samples were weighed on a precision scale (0.1 g resolution), dried in a forced-air circulation oven at 65 ºC until reaching constant weight, and reweighed. Winter fallow characterization included identifying the main species in the treatment plot (Lorenzi 2000), with *Lolium multiflorum* predominance, alongside species such as *Bidens pilosa*, *Conyza bonariensis*, *Cynodon dactylon* and *Daucus pusillus*.

Biomass degradability was assessed using 2-mm-mesh litterbags (Thomas & Asakawa 1993) measuring 0.20 x 0.20 m. Ten grams of cover crop biomass from each treatment were placed inside the litterbags, positioned on the soil surface in each plot, and retrieved at 15, 30, 45 and 60 DAT. The retrieved bags were dried in an oven at 65 ºC until reaching constant weight and weighed again. The results were fitted using the exponential model by Wieder & Lang (1982): X = Xoexp(-kt). This equation determines the decomposition coefficient *k*, where *X* represents the remaining biomass after time *t* and *Xo* is the initial biomass. The *k* values allow calculating the biomass half-life ($t_{1/2}$), indicating the time required for 50 % of the material to degrade. The equation was: $t_{1/2} = 0.693/k$ (Thomas & Asakawa 1993).

The results were subjected to analysis of variance (Anova) using the RStudio (version 4.2.2) software. Mean comparisons were performed using the Duncan test at 5 % of significance. Then, regression analysis was applied to the collected data on the remaining biomass to determine the most suitable model for each dataset.

RESULTS AND DISCUSSION

According to Table 1, the intercropping of rye + vetch + radish, black oat + vetch + radish, and the rye single cropping did not show statistically significant differences in the Area A. Furthermore, they were superior to the other treatments, regarding dry biomass production for the system. Following these, the black oat single cropping and the black oat + vetch intercropping did not show statistical differences. The lowest biomass production occurred in the vetch single cropping and winter fallow, which were statistically equivalent. In the Area B, the biomass production of the rye single cropping showed a value higher than the other treatments. It approached the biomass quantity recommended by the no-tillage vegetable systems (Vezzani et al. 2019), lacking only 2.1 t ha^{-1} to reach this value. The cover crops intercropping and black oat single cropping did not show significant differences in biomass production, yielding intermediate values, when compared to other treatments.

In contrast, the vetch single cropping and winter fallow showed the lowest biomass production among all treatments. Notably, when vetch was with black oat, black oat + radish and rye + radish, the potential for biomass production increased significantly. Intercropping hairy vetch with rye or black oat and radish resulted in a higher biomass production than for single cropping, as observed in the Area A with similar intercrops. Inter-species consortia typically demonstrate a greater biomass production due to the symbiosis' improved resource use (Watthier et al. 2020). The increased biomass production in intercropping systems involving black oat, rye and radish aligns with findings from other studies (Michelon et al. 2019, Teixeira et al. 2023). Furthermore, these authors reported significantly higher biomass production values than those observed here for the same species and cropping systems.

The biomass production of cover crops is influenced by management practices and several factors, including climatic, geographic and soil conditions (Chauvin et al. 2015, Acharya et al. 2022). Photosynthetically active solar radiation directly influences plant development (Taiz & Zeiger 2013). Therefore, consecutive periods of cloudiness

Table 1. Dry biomass production, degradation coefficient (k), winter cover crops half-life ($t_{1/2}$) and *Cucurbita pepo* var. *melopepo* cv. Caserta (Area A) and *Cucumis sativus* cv. Soldier (Area B) yields in organic no-tillage vegetable systems.

Area	Cover plant	Dry biomass (t ha^{-1})	k (g day^{-1})	$t_{1/2}$ (days)	R
Area A	Rye + vetch + radish	5.61 a[1]	0.01087^{ns}	61.08 b	-0.84
	Rye	5.60 a	0.00752	102.55 a	-0.91
	Black oat + vetch + radish	5.03 a	0.01196	64.12 b	-0.99
	Black oat	2.76 b	0.009768	78.26 ab	-0.94
	Black oat + vetch	2.71 b	0.01066	68.04 b	-0.99
	Winter fallow	1.52 c	0.01167	65.92 b	-0.98
	Vetch	1.11 c	0.00894	47.52 b	-0.75
CV (%)		10.08	24.51	28.26	-
Area B	Rye	8.97 a	0.0090 c	80.66 a	-0.99
	Black oat + vetch + radish	5.61 b	0.01283 b	59.58 ab	-0.96
	Rye + vetch + radish	5.52 b	0.01182 bc	65.50 ab	-0.89
	Black oat	5.23 b	0.01065 bc	73.83 a	-0.96
	Black oat + vetch	4.81 b	0.01140 bc	63.27 ab	-0.98
	Winter fallow	2.47 c	0.01101 bc	77.03 a	-0.97
	Vetch	1.19 c	0.01607 a	47.83 c	-0.95
CV (%)		16.83	16.08	20.52	-

[1] Means followed by the same letter do not differ by the Duncan test at 5 % of probability. ^{ns} no statistical difference; R: Pearson's correlation coefficient between the biomass *k* and $t_{1/2}$; CV: coefficient of variation.

occurring after the establishment and during the growth of cover crops may have significantly impacted their production. Studies indicate that rye outperforms other winter cereals due to its ability to initiate physiological growth activity at lower temperatures than other winter cereals (Acharya et al. 2022, Baga et al. 2022).

Soil waterlogging in the Area A's Gleyic Dystric Fragic Planosol (FAO 2015, Embrapa 2006) may have impacted the cover crop biomass production, since an excess of water in the soil is known to hinder the crop growth and yield (Floss 2004). Anaerobiosis induced by waterlogging leads to anaerobic respiration, characterized by low energy efficiency and the production of lactic acid and ethanol as by-products. These acidic compounds cause root cell death, reducing nutrient and water absorption efficiency (Floss 2004). Furthermore, both study areas showed a low organic matter content (1.30 % in the Area A and 1.00 % in the Area B). Nitrogen is crucial for improving crop yield, especially during the vegetative phase (Taiz & Zeiger 2013). In tropical and subtropical soils, organic matter is the primary nitrogen source (Souza et al. 2018). In organic farming, poultry manure is commonly used as a nitrogen fertilizer, yet its nutrient content can be inconsistent. The composting process of poultry manure results in nitrogen loss through organic matter oxidation, compromising its effectiveness as N source (Rizzo et al. 2022). Therefore, the low soil organic matter content and the fertilizer source's inefficiency may have influenced the cover crop biomass production in both areas.

The findings from the winter fallow treatment in both experimental areas underscore the importance of incorporating cultivated cover crops into no-tillage vegetable systems, as implemented here. The treatments featuring cultivated plants showed a superior biomass production than those with spontaneous vegetation. Spontaneous vegetation typically presents slower growth rates and a lower plant population density than seeded crops, resulting in reduced biomass yield (Oliveira et al. 2016).

None of the cover crops achieved the 10t ha^{-1} recommended by the no-tillage vegetable system (Comin et al. 2016). However, black oat + vetch + radish and rye + vetch + radish showed potential for a higher dry biomass production. Intercropping improves crop diversification, a key aspect of no-tillage vegetable systems; thus, it promotes more sustainable and resilient agroecosystems (Vezzani et al 2019). Therefore, the intercropping of cover crops, particularly among *Poaceae*, *Fabaceae* and *Brassicaceae* families, should be used to establish organic no-tillage vegetable systems under the conditions observed here.

Table 1 shows the biomass degradation rate (k), half-life ($t_{1/2}$) and Pearson's linear correlation coefficient among the variables. In the Area A, there was no statistically significant difference among the treatments for k; however, for the $t_{1/2}$ variable, *Poaceae* (rye and black oat) showed higher values, with black oat being statistically equivalent to the other treatments. There is a negative linear relationship ($p < 0.001$) between k and $t_{1/2}$, indicating that these variables are inversely proportional. It explains the statistical difference observed among the treatments for $t_{1/2}$, highlighting the biomass effect on its duration in the soil. In the Area B, the lowest k occurred in the vetch single cropping. The intercropping treatments black oat + vetch + radish, rye + vetch + radish, black oat + vetch, and the black oat single cropping and winter fallow showed no statistical differences. Among these, rye + vetch + radish, black oat + vetch, winter fallow and black oat single cropping also did not differ from the rye single cropping, which showed the lowest k value. Regarding $t_{1/2}$, only the vetch single cropping differed, showing the shortest $t_{1/2}$, whereas the other treatments did not differ. In this location, there is also a negative correlation ($p < 0.001$) between k and $t_{1/2}$ for all treatments.

The cover crop decomposition kinetics, shown using the exponential decay model in Figure 1, revealed distinct biomass decline patterns across the treatments. The intercropping treatments black oat + vetch + radish and rye + vetch + radish had a similar remaining biomass at 15, 30 and 45 DAT in both plots, indicating that either black oat or rye can serve as the *Poaceae* component in intercropping. In both areas, the highest percentage of remaining biomass loss occurred between 15 and 30 DAT (Figure 1). Differences were observed among the curves obtained for the treatments, mainly explained by the dynamics of biomass decomposition directly related to the quantity of C, N, lignin content and cellulose, as well as the relationship among these variables. *Poaceae* and *Fabaceae* have distinct chemical compositions in their biomass. In their studies, Oliveira et al. (2016) and Souza et al. (2018) observed higher lignin and cellulose contents and a higher C:N ratio in the *Poaceae* biomass, when compared to *Fabaceae*. They also highlighted higher values in rye, if compared to other species in the same family, and noted that the *Poaceae*, *Fabaceae* and radish forage consortium provided an intermediate C:N ratio and lignin content.

The mixture of *Poaceae* and *Fabaceae* significantly influences the biomass characteristics, particularly the C:N ratio and lignin content, affecting the decomposition dynamics and nutrient

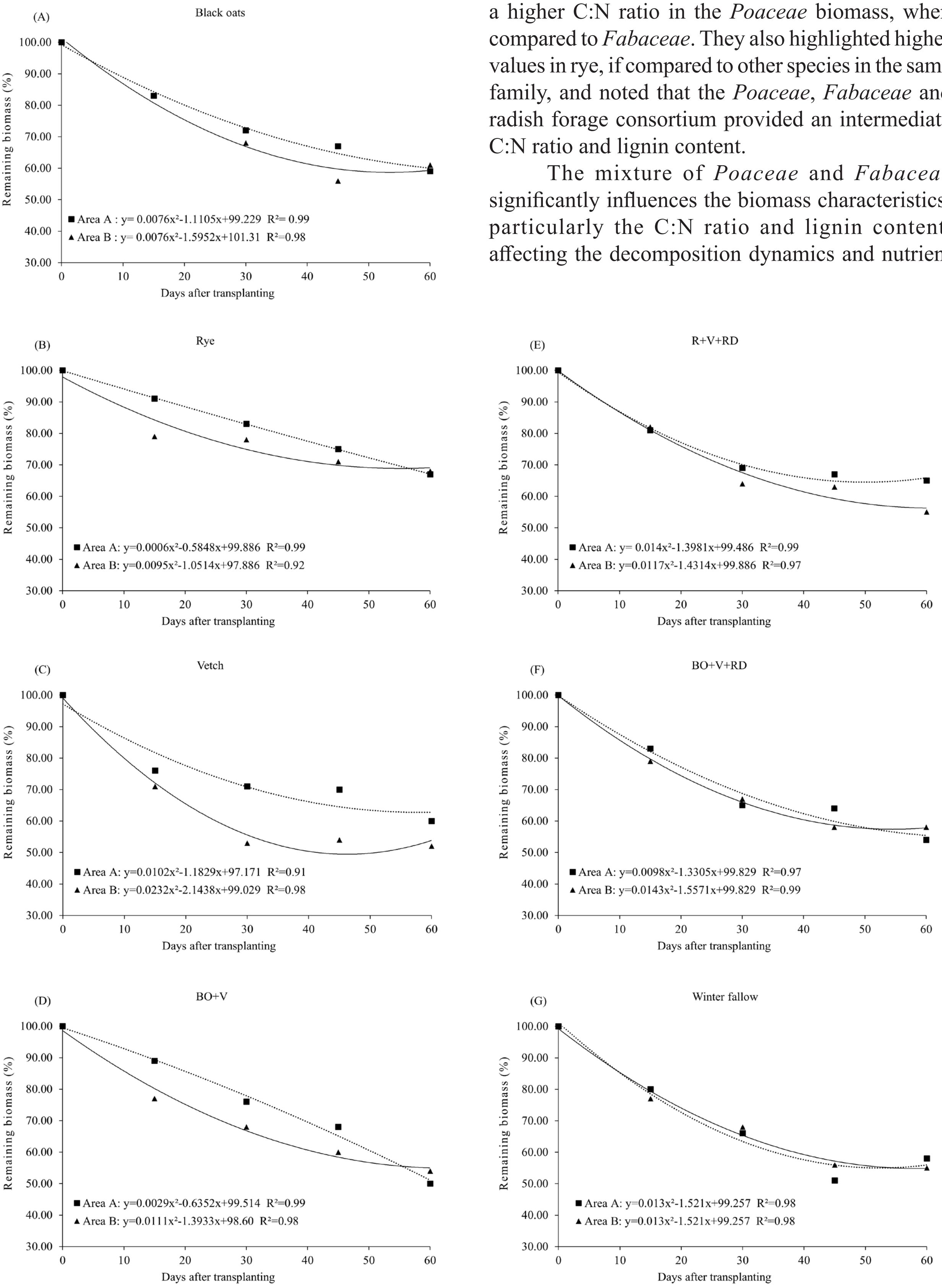

Figure 1. Remaining biomass of black oat (BO), rye (R), vetch (V), BO + V, R + V + radish (RD), BO + V + RD and winter fallow. Decomposition at 15, 30, 45 and 60 days after transplanting *Cucurbita pepo* var. *melopepo* cv. Caserta.

mineralization (Oliveira et al. 2016, Watthier et al. 2020). In this study, the vetch decay was notably more pronounced than in the treatments containing *Poaceae*. While the *Poaceae* single cropping treatments and the ones intercropped with rye or black oat in the Area B did not statistically differ, regarding *k* and $t_{1/2}$, they outperformed the vetch single cropping, a member of the *Fabaceae* family. Despite the black oat biomass being 72 % lower than recommended, it showed the best response regarding the zucchini yield in its succession.

Regarding fruit production (Figures 2A, 2B and 2C), black oat showed the highest yield (Figure 2A) and average fruit weight (Figure 2B) for the zucchini crop, whereas there were no significant differences for average fruit length (Figure 2C) among the treatments. For Japanese cucumber (Figure 2), there were no statistically significant differences in all analyzed variables among the treatments with cultivated plants, except when compared to the winter fallow. The performance of the Japanese cucumber may have been affected by damping-off damage, despite the pathogen control with *Trichoderma* sp. Additionally, the phosphorus (P) content in the soil may have influenced this performance, as P is an essential macronutrient, whose low availability can be limiting for plant growth (Taiz & Zeiger 2013, Nieves-González et al. 2018).

Studies on zucchini (Chaurasia & Sachan 2020, Mkhabela et al. 2020, Nasser et al. 2022) and Japanese cucumber (Tamwing et al. 2020, Vale et al. 2022) have demonstrated superior results in the variables assessed here; however, some points are worth highlighting. Regarding Japanese cucumber, this study was conducted without vertical trellising, what may have influenced its yield. Furthermore, soil characteristics, such as low organic matter content in the study areas and low efficiency of the main nitrogen fertilization source used in organic agriculture (poultry litter), may have contributed to the vegetable crops' low yield.

Research conducted by Warisman et al. (2024) on zucchini and Japanese cucumber, Wahocho et al. (2016) on zucchini, and Vale et al. (2022) on Japanese cucumber indicate that Cucurbitaceae respond positively to high nitrogen doses. These plants have a wide leaf area, enhancing light absorption and consequently the photosynthetic rate. However, to maximize this capacity, it is essential to adequately supply essential nutrients, including nitrogen. Therefore, the studies confirm that nitrogen fertilization is a limiting factor for zucchini and cucumber production.

Adapting horticulture to climate change is essential, due to the growing environmental impacts on agroecosystems. Even in organic systems, intensive soil management leads to a greater reliance on external inputs, soil degradation and yield decline (Freeman et al. 2022). No-tillage vegetable systems offer an alternative to conventional vegetable production, serving both as a conservation method and a tool for transitioning to more sustainable systems (Vezzani et al. 2019). However, implementing no-tillage vegetable systems faces technical challenges, particularly due to the complexity of vegetable production and integration of cover crops.

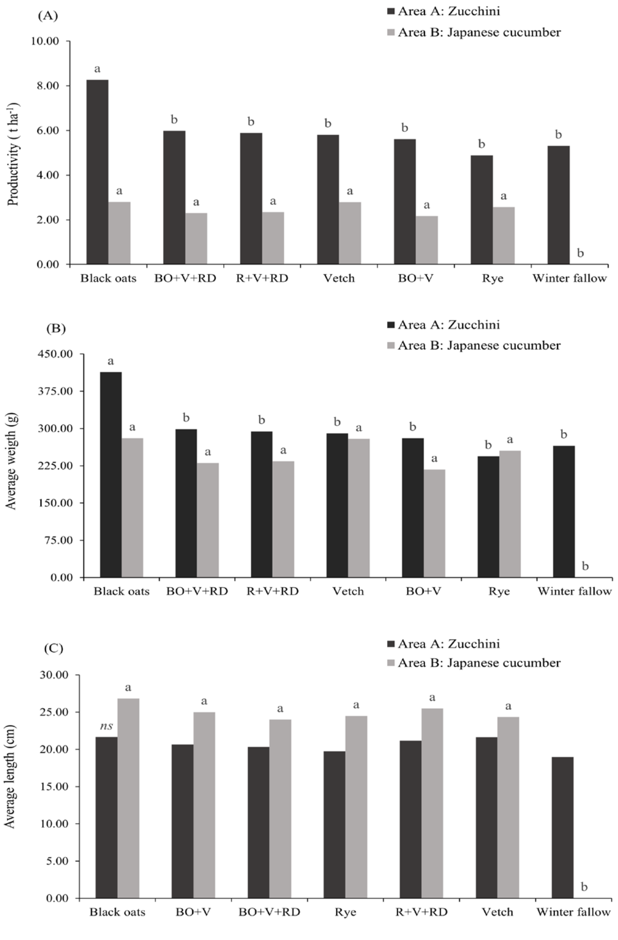

Figure 2. Average yield (A), weight (B) and length (C) of *Cucurbita pepo* var. *melopepo* cv. Caserta (Area A) and *Cucumis sativus* cv. Soldier (Area B) grown on black oat (BO), rye (R), vetch (V), BO + V, R + V + radish (RD), BO + V + RD and winter fallow in an organic no-tillage vegetable system.

The diversity of crops, small production areas and lack of techniques for using cover crops without herbicides highlight the need for research on crop rotation and intercropping. Information on no-tillage systems in organic farming is scarce, as existing knowledge is mainly directed to conventional farmers in the Santa Catarina state, Brazil. Ensuring food security and promoting sustainable food systems are intertwined. The no-tillage vegetable systems developed in Santa Catarina show a potential for sustainable agriculture and ecosystem restoration, supporting the SDGs. Nevertheless, transitioning agroecosystems requires a systemic approach, further research and initiatives to support this process.

CONCLUSIONS

1. Soil characteristics significantly influence biomass production and cover crop degradability;
2. The Poaceae species, especially rye, produce more biomass and are less degradable than Fabaceae; however, intercropping systems further increase the biomass production;
3. Using intercropping combinations such as black oat + vetch + radish or rye + vetch + radish is recommended, and zucchini yields in organic no-tillage vegetable systems were higher following black oat cultivation, whereas all the cover crops significantly impacted the Japanese cucumber production.

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