Revista de Ciências Agroveterinárias
Universidade do Estado de Santa Catarina (UDESC)

Research Article

Use of cover crops in tomato cultivation in Serra Gaúcha, Southern Brazil

Uso de plantas de cobertura no cultivo de tomate na Serra Gaúcha, Sul do Brasil

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Submission: January 06th, 2026 | Acceptance: February 10th, 2026

ABSTRACT

This study aimed to evaluate the effects of different cover crops, alone or in consortium, on nutrition, productivity, and fruit quality of the Petros tomato variety, cultivated in the Serra Gaúcha region. The experiment was conducted in the field, in tunnel greenhouses, in the municipality of Flores da Cunha, using a randomized block design with six treatments and four replications, including different cover crop species (mix of vetch, black oat and rye with forage turnip, mix of vetch, black oat and rye, rye, white oat, black oat and control using plastic mulch). The variables analyzed included fresh and dry biomass production, chlorophyll index, concentration of foliar macro and micronutrients, and fruit production. The results showed that the treatments with mix + turnip, mix, and rye produced greater biomass than the control and white oat. However, the cover crop mix of vetch, black oats, and rye + forage turnip showed rapid decomposition, favoring the emergence of weeds, while rye maintained greater straw persistence. Plant tissue and productivity analysis did not indicate statistically significant differences between treatments, which was attributed to the intensive fertigation used in the management. It was concluded that the use of cover crops results in a greater supply of dry matter to the soil without negatively affecting tomato productivity and quality. The use of cover crops helps conserve soil and indicates a favorable potential for carbon retention, reinforcing the importance of this practice as a promising practice in sustainable cropping systems.

KEYWORDS: Horticulture. Soil management. Sustainable farming systems.

RESUMO

Este estudo teve como objetivo avaliar os efeitos de diferentes plantas de cobertura, isoladas ou em consórcio, sobre a nutrição, produtividade e qualidade dos frutos da variedade de tomate Petros, cultivada na região da Serra Gaúcha. O experimento foi conduzido em campo, em estufas túnel, no município de Flores da Cunha, utilizando delineamento em blocos casualizados com seis tratamentos e quatro repetições, incluindo diferentes espécies de plantas de cobertura (mistura de ervilhaca, aveia-preta e centeio com nabo forrageiro, mistura de ervilhaca, aveia-preta e centeio, centeio, aveia-branca, aveia-preta e controle com cobertura morta). As variáveis analisadas incluíram produção de biomassa fresca e seca, índice de clorofila, concentração de macro e micronutrientes foliares e produção de frutos. Os resultados mostraram que os tratamentos com mistura + nabo, mistura e centeio proporcionaram maior produção de biomassa em comparação com o controle e a aveia-branca. Contudo, a mistura de cobertura vegetal composta por ervilhaca, aveia-preta e centeio + nabo forrageiro apresentou decomposição rápida, favorecendo o surgimento de plantas daninhas, enquanto o centeio manteve maior persistência da palha. A análise do tecido vegetal e da produtividade não indicou diferenças estatisticamente significativas entre os tratamentos, o que foi atribuído à fertirrigação intensiva utilizada no manejo. Concluiu-se que o uso de plantas de cobertura resulta em maior aporte de matéria seca ao solo, sem ocasionar impactos negativos na produtividade e na qualidade do tomate. A cobertura do solo com plantas de cobertura contribui para a conservação do solo e indica um potencial favorável para a retenção de carbono e a melhoria da qualidade do solo, reforçando a importância dessa prática como promissora em sistemas de cultivo sustentáveis.

PALAVRAS-CHAVE: Horticultura. Manejo de solo. Sistemas de cultivo sustentáveis.

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a vegetable of high socioeconomic and nutritional importance, widely consumed in the human diet. Its cultivation contributes to job and income generation, being carried out both in field systems and in protected environments (SOBRINHO et al. 2022). However, vegetable production is still mostly conducted in conventional cultivation systems, which have contributed to soil degradation, especially through erosion and reduced soil health (DUTRA et al. 2025).

Conventional management, with intensive soil preparation, negatively impacts soil quality by increasing carbon loss in the form of carbon dioxide emissions, exacerbating the effects of climate change on agriculture (ARDENTI et al. 2024). In this context, maintaining soil cover with plants or plant residues has stood out as an efficient strategy to mitigate the negative impacts of these systems. Several studies demonstrate that the use of cover crops improves the physical, chemical, and biological quality of soil, contributing to moisture conservation, reduced erosion, increased organic matter, and greater nutrient cycling efficiency (SCHULTZ et al. 2020, VAN EERD et al. 2025).

In addition, intercropping with cover crops promotes beneficial interactions among soil, plants, and the atmosphere, resulting in increased carbon and nitrogen stocks, greater aggregate stability, and improved soil health indicators. These effects are reflected positively in tomato productivity and fruit quality maintenance, especially when using cover crops composed of grasses and species with deep root systems (KUNESKI et al. 2023a, VAN EERD et al. 2025).

Another relevant aspect of cover crop use is the suppression of weeds and modulation of spontaneous vegetation in the production system. AMARAL & CALHA (2025) highlight that these crops can significantly reduce weed infestation in tomato-growing areas for industry, thereby decreasing herbicide use and increasing the sustainability of production systems.

Despite the advances, the effects of cover crops on productivity can vary depending on the species used, the management adopted, the edaphoclimatic conditions, and the cultivation system employed (COTTNEY et al. 2025). Thus, there are still gaps in selecting the most suitable species and understanding the mechanisms involved across different producing regions.

The use of cover crops in vegetable farming is a relatively recent and understudied practice in the Serra Gaúcha region. Therefore, the objective of this study was to evaluate the effects of different cover crops, either alone or in combination, on tomato plant nutrition and their impact on fruit production in the Serra Gaúcha region, identifying the cover crops that yield the best results under these conditions.

MATERIAL AND METHODS

The experiment was conducted in the field, in the municipality of Flores da Cunha, at the geographic coordinates 29°01'S, 51°15'W and an altitude of 773 m, in an area of 0.12 ha. The climate is classified as Cfb according to the Köppen classification (ALVARES et al. 2013), and the predominant soil type is Cambisol (STRECK et al. 2018). The area was covered with 150 µm plastic sheeting in tunnel-type greenhouses, suitable for growing grapevines in a trellis system, with approximately 40 cm between

rows in each tunnel. Each tunnel housed a raised bed, which averages 50 m in length, 50 cm in width, and 2 m between rows. The soil fertility conditions before the experiment's installation, along with their interpretation, are compiled in Table 1.

Table 1. Soil characterization in the zero - 20 cm layer before the experiment was set up. Flores da Cunha – RS, 2025.

Parameter	Unit	Result	Interpretation
pH	-	6.0	Average acidity [1]
H+Al	$cmol_c \cdot dm^{-3}$	5.1	High [1]
Clay	% w/v	37	Class 3 [2]
CTC $_{pH\ 7.0}$	$cmol_c \cdot dm^{-3}$	17.1	High [2]
Organic Matter	% w/v	5.1	High [2]
Al	$cmol_c \cdot dm^{-3}$	0.03	Low [1]
Ca	$cmol_c \cdot dm^{-3}$	8.8	High [2]
Mg	$cmol_c \cdot dm^{-3}$	2.8	High [2]
K	$mg \cdot dm^{-3}$	174.8	High [2]
P	$mg \cdot dm^{-3}$	39.9	Very high [2]
S	$mg \cdot dm^{-3}$	13.2	High [2]
Zn	$mg \cdot dm^{-3}$	23.6	High [2]
Cu	$mg \cdot dm^{-3}$	> 250	High [2]
Mn	$mg \cdot dm^{-3}$	21.7	High [2]
B	$mg \cdot dm^{-3}$	1.1	High [2]

1 – PREZOTTI & GUARÇONI (2013), 2 – SBCS (2016).

The experimental design was a randomized block design, with six treatments and four replications (Table 2).

Table 2. Plants and densities sown before tomatoes in each treatment. Flores da Cunha – RS, 2025.

Treatment	Cover plants	Density ($kg \cdot ha^{-1}$)
T1	Mix RX330 (48 % vetch cv. Ametista, 38 % black oat cv. IAPAR 61, 12 % rye cv. IPR 89, and 2 % vetch cv. SS Esmeralda) +	60
	Forage turnip cv. Duck's Foot	5
T2	Mix RX330 (48 % Amethyst variety vetch, 38 % IAPAR 61 variety black oats, 12 % IPR 89 variety rye, and 2 % SS Emerald variety vetch)	60
T3	Rye (cv. Temprano)	80
T4	White Oats (cv. IPR Suprema)	60
T5	Black Oats (cv. IAPAR 61 Ibiporã)	60
T6	Control (plastic mulch)	Spontaneous plants

The area designated as the control was maintained with spontaneous plants during the development of the cover crops in the other treatments. In this same treatment, one week before planting the tomato seedlings, mulch was installed with white plastic on top and black plastic where it comes into contact with the soil.

Experiment conduction

The cover crops were sown on June 12, 2024, and developed in the field for five months, until November 12, 2024. During this period, it was necessary to irrigate the area, as rainwater did not adequately penetrate the soil covered by the plastic. This step was carried out using six sprinklers with a flow rate of 3.5 $m^3 \cdot h^{-1}$ (60 $L \cdot min^{-1}$),

whose nozzles had been reduced by approximately 30º to prevent water from hitting the greenhouse cover, ensuring it reached the soil only. Irrigation occurred approximately every three days for about 30 min to maintain the soil near field capacity. To aid their development, urea was applied to all plots 2.5 months after sowing at a rate of 50 kg·ha^{-1}.

The cover crops were desiccated on November 11, 2024. The herbicides Finale (glufosinate ammonium) and Select 240 EC (clethodim) were applied at the recommended doses as indicated in the package inserts.

The tomato seedlings were transplanted in the No-Till System on November 30, 2024. The cultivar used was Petros (Sakata), grafted onto Contrattack (Sakata). One hundred twelve seedlings were transplanted with 25 cm spacing between plants, resulting in an average of 170 seedlings per bed. The plants were trained to a single stem using twine. Weekly pruning of axillary buds was carried out. Training was done by wrapping the main stem around the twine.

One week before the transplant, the product Tricho Turbo, a *Trichoderma*-based product, was applied. *Asperellum* BV10 (21.2 % w/w) was treated at the recommended dose, which was repeated every 30 days until harvest. At transplanting, the seedling trays were immersed in a solution containing Tricho Turbo (1 mL·L^{-1}), BioImune (5 mL·L^{-1}), and Actara (2 g·L^{-1}). BioImune contains 4.2 % w/v of *Bacillus velezensis* BV02, and Actara is a neonicotinoid systemic insecticide with thiamethoxam as its active ingredient.

Fertigation of the plants was carried out by drip irrigation, with two self-compensating drip hoses distributed per bed, over the already desiccated straw. The dripper flow rate was 1.6 L·h^{-1}, and the spacing between them was 20 cm. That is, the irrigation capacity of each bed was 800 L·h^{-1}, with irrigation occurring, on average, between 30–45 min per day, considering a total of six beds, resulting in between 3 – 4 L·day^{-1} of water for each plant, varying according to the climatic conditions of each day.

The mineral fertilizer used was adjusted according to the plant's developmental stage, as shown in Table 3.

Table 3. Fertilization used in relation to the weekly development period of the tomato. Flores da Cunha, 2025.

Week	Krista K [(1)]	Krista Mg [(2)]	MAP [(3)]	MKP [(4)]	SOP [(5)]	Calcinit [(6)]	Boric Acid [(7)]
				g·plant $^{-1}$			
2 - 3	2.0	2.0	0.6	-	-	2.4	-
4	6.0	4.4	4.3	0.96	1.20	3.6	0.30
5 - 14	8.5	4.4	4.3	0.96	1.20	6.6	0.30
15 - 24	6.0	2.2	1.9	2.20	0.86	3.9	0.12

[(1)] YaraTera Krista K (13 % N, 43 % K_2O, 1 % Mg, 1 % S), [(2)] YaraTera Krista MgS (9 % Mg, 12 % S, 1 % K), [(3)] YaraTera MAP (61 % P_2O_5, 12 % N), [(4)] YaraTera MKP (52 % P_2O_5, 34 % K_2O), [(5)] YaraTera Krista SOP (50 % K_2O, 17.5 % S), [(6)] YaraTera Calcinit (15.5 % N, 19 % Ca), [(7)] Boric Acid Fertile Gold (17 % B).

Along with fertigation, 200 g per week of a micronutrient compound with the commercial name BrexilTop was added, containing (w/w): 10.0 % sulfur, 1.5 % magnesium, 2.0 % boron, 5.0 % manganese, 0.5 % molybdenum, 6.0 % zinc, plus 42.0 % lignosulfonate complexing agent to complex Mg, Mn, and Zn.

Given the soil copper level (>250 mg·dm^{-3}), supported by the excessive use of Bordeaux mixture in the previous crop at the experimental site, the plants began to exhibit symptoms of micronutrient deficiency, particularly iron deficiency, possibly due to this imbalance. These symptoms manifested as yellowing, fragility, thinness, and a glassy appearance in the younger leaf blades (SANTOS et al. 2021). To address this deficiency, Ferrilene, a commercially available iron chelate, was applied at 200 g per week, along with fertigation, which proved sufficient to meet the plants' needs.

Ascophyllum nodosum algae extract was also used once a week along with fertigation, which contains 30% w/w total organic carbon and 12% w/w potassium; and 200 g per week of a fertilizer with the commercial name FluviPlex from the brand Aqua do Brasil, composed of 3% w/w nitrogen, 12% w/w potassium and 30% w/w total organic carbon, also containing low molecular weight fulvic acids extracted from leonardite; and 200 g per week of a soil and substrate conditioner with the commercial name BlinPlex. Also from the brand Aqua do Brasil, rich in humic and fulvic acids extracted from leonardite.

Throughout the tomato growing cycle, pesticides were applied to prevent and control pests and diseases that affect this crop. Fungicides and insecticides with active ingredients were used, selected based on the diseases or pests that historically affect the crop, considering the climatic conditions in each period and the plant growth stage. It is important to emphasize that active ingredients were rotated and the information on the product label, such as dosage and safety interval, was followed.

In addition, a simple organic foliar fertilizer called NoStress, containing amino acids as the raw material, 15% w/v of water-soluble nitrogen, and 30% w/v of total organic carbon, was applied every 15 days. This application was mainly used when low autumn temperatures began, due to the stress cold can cause in plants.

Plant assessment

The variables evaluated were fresh and dry plant biomass production of the cover crops (kg·m^{-2}), chlorophyll content, macro and micronutrient content in leaf tissue, fruit mass, number of fruits, and production per plant.

The fresh mass was collected for weighing on 2024-11-05, in samples of 0.25 m², one per replicate, which were weighed and then placed in a DeLeo brand forced-air circulation drying oven, maintained at 40 – 45 °C, where they remained until they reached a constant weight, which was measured on 2024-11-28 to obtain the dry mass.

On December 29, 2024, the total chlorophyll content, as well as chlorophyll A and B, of the plants were measured using a chlorophyll meter. Falker brand chlorophyll is always applied to leaves at the same stage of development, specifically the first leaflet of the second leaf, with each repetition occurring on five plants.

Regarding nutritional aspects, leaf subsamples were collected in each replicate at the stage between full flowering and first fruits, with the first leaf, without petiole, below the second flower cluster, as suggested by VELOSO et al. (2020). The leaves were grouped, and a sample from each treatment was sent to the Soil Chemistry and Fertility Laboratory at the University of Caxias do Sul for the determination of macro- and micronutrients in leaf tissue.

Harvesting began on February 15, 2025, with the first fruits changing color. For the first two months, harvesting was done manually twice a week; in the third month, once a week. After the evaluations concluded on May 3, 2025, the plant still retained production potential.

At harvest, fruits from the experimental areas were separated by replicate and then evaluated for the mass of fruits harvested that day. In total, the fruits from 120 plants were evaluated, with five plants per replicate, for a total of 20 plants per treatment.

The data obtained were analyzed for homoscedasticity using Levene's test and for normality using the Shapiro-Wilk test (SPSS 21.0). Mean comparisons were performed using analysis of variance (ANOVA) and, if significant, followed by Tukey's test ($p \leq 0.05$) using AgroEstat software version 1.1.0.712.

RESULTS AND DISCUSSION

Regarding the results for the fresh mass (kg·ha-1) of the cover crops (Table 4), the RX 330 + turnip mix treatment yielded higher production than white oats, black oats, and the control. Regarding dry matter ($kg \cdot ha^{-1}$), the treatments "mix RX330+turnip", "mix RX330", and "rye" had the highest dry matter production, not differing statistically from each other, and equal to that of black oats. The control had the lowest fresh and dry mass production among the treatments, differing significantly only from white oats.

Table 4. Fresh and dry mass of different cover crops in tomato cultivation. Flores da Cunha, 2025.

Treatments	Fresh matter $kg \cdot ha^{-1}$	Dry matter $kg \cdot ha^{-1}$
Mix RX330 + forage turnip	13.950 a	3.850 a
Mix RX330	10.150 ab	3.600 a
Rye	9.650 ab	4.650 a
White oats	6.450 bc	1.700 bc
Black oats	9.250 b	3.200 ab
Control (plastic mulch)	3.330 c	1.100 c
CV (%)	21.67	25.54

Means followed by different letters in the column differ from each other by Tukey's test ($p < 0.05$). CV: Coefficient of variation. Mix RX330: vetch, oats, and rye.

In the "mix RX 330 + turnip" treatment, the vetch and forage turnip plants showed vigor in terms of fresh mass production (Figure 1); however, after desiccation, their matter decomposed very quickly, which led to more rapid and dense weed emergence than in the other treatments. A similar result was obtained in the "mix RX 330" treatment without forage turnip.

This characteristic is justified by the low carbon/nitrogen (C/N) ratio of these species. On the other hand, the grasses in this mix exhibited a straw-like structure that lasted longer, which is consistent with their high C/N ratio (LIMA FILHO et al. 2023).

The rye treatment was statistically equivalent to the mix in both aspects; however, in the field, it lasted significantly longer, resulting in more uniform coverage of the plot and reduced weed development. This characteristic is also explained by the plant's C/N ratio, which is much higher than that of legumes and cruciferous plants (LIMA

FILHO et al. 2023). The control had the lowest fresh and dry mass among all treatments.



Figure 1. Visual aspect of soil covers, before and after desiccation in treatments with different cover crops preceding the tomato cv. Petros crop. Flores da Cunha – RS. T 1 Mix 330 (vetch, oats, and rye), T2 Mix 330, T3 Rye, T4 white oats, T5 black oats, and T6 Control (plastic mulch).

Regarding nutrient cycling, as shown in Table 5, none of the treatments differed statistically. This result may have occurred because daily fertigation was carried out throughout the period (Table 3), possibly masking the effects of the cover crops.

Table 5. Macronutrients present in the leaves of tomato cv. Petros in different ground covers. Flores da Cunha – RS, 2025.

Treatments	N	Ca	Mg	P	K	S
	g·kg^{-1}					
Mix RX330 + forage turnip	28.4 ^{ns}	74.4 ^{ns}	10.0 ^{ns}	3.4 ^{ns}	26.5 ^{ns}	7.2 ^{ns}
Mix	28.5	73.2	9.7	3.2	28.5	8.0
Rye	28.4	71.7	9.4	3.9	28.8	7.3
White oats	27.2	83.0	10.6	3.4	28.0	7.3
Black oats	27.5	81.9	9.5	3.6	28.8	8.1
Control (plastic mulch)	27.7	66.5	8.9	3.9	27.0	8.2
CV (%)	5.6	12.8	9.8	16.6	12.7	11.3

^{ns} = not significant between treatments by the F test ($p < 0.05$). CV: Coefficient of variation. Mix RX330: vetch, oats, and rye.

According to VELOSO et al. (2020), the adequate levels of macronutrients, expressed in g·kg^{-1}, should be within the following ranges: N from 40 to 60; Ca from 14 to 40; Mg from 4 to 8; P from 4 to 8; K from 30 to 50, and S from 3 to 10 (VELOSO et al. 2020). Therefore, nitrogen levels were lower than indicated in all treatments, suggesting a need to adjust the dose of this element in fertigation. Calcium, in turn, had very high levels in all treatments. Nutrients such as phosphorus, potassium, and magnesium were close to the ideal range.

As with the macronutrients, the micronutrients (Table 6) did not show significant differences between treatments.

Table 6. Micronutrients present in the leaves of tomato cv. Petros in different ground covers. Flores da Cunha – RS, 2025.

Treatments	Zn	Cu	B	Mn	Fe
			mg·kg^{-1}		
Mix RX330+ forage turnip	61.9 ^{ns}	232.9 ^{ns}	84.6 ^{ns}	96.0 ^{ns}	175.7 ^{ns}
Mix 330	78.3	279.6	97.5	92.8	239.5
Rye	71.8	253.5	93.9	128.4	431.9
White oats	73.5	316.4	101.7	126.3	120.8
Black oats	63.4	237.5	92.1	108.6	149.1
Control (plastic mulch)	72.3	323.5	91.1	105.5	219.8
CV (%)	20.9	13.3	9.1	20.0	78.9

^{ns} = not significant between treatments by the F test ($p < 0.05$). CV: Coefficient of variation. Mix RX 330: vetch, oats, and rye.

According to VELOSO et al. (2020), adequate micronutrient levels (mg·kg^{-1}) occur in the range of: Zn from 30 to 100; Cu from 5 to 15; B from 30 to 100; Mn from 50 to 250, and Fe from 100 to 300. According to the results, the plants absorbed much more copper than recommended in all treatments. This can be attributed to its high levels in the soil (Table 1).

In the chlorophyll index evaluation, the control stood out in chlorophyll A, B, and total chlorophyll. For chlorophyll A content, the control showed a significant difference only in relation to white and black oats (Table 7). However, for chlorophyll B and total chlorophyll content, the control differed significantly from all individual grasses, which presented the lowest values.

Table 7. Chlorophyll A, B, and total index in the leaf of tomato cv. Petros as a function of different ground cover plants. Flores da Cunha, 2025.

Treatments	Chlorophyll index		
	A	B	Total
Mix RX330 + forage turnip	46.7 abc	11.7 abc	58.4 abc
Mix 330	48.6 ab	12.4 ab	61.0 ab
Rye	46.8 abc	10.9 bcd	57.7 bc
White oats	44.3 c	9.8 d	54.1 c
Black oats	44.7 bc	10.1 cd	54.8 c
Control (plastic mulch)	49.8 a	13.1 a	62.9 a
CV (%)	12.9	25.1	13.6

Means followed by different letters in the column differ from each other by Tukey's test ($p < 0.05$). CV: Coefficient of variation. Mix RX 330: vetch, oats, and rye.

The lower chlorophyll index observed in treatments containing grasses grown in isolation can be attributed to microbial nitrogen immobilization. According to WANG & SONG (2024), nitrogen immobilization in soil occurs when microorganisms assimilate inorganic forms of nitrogen and incorporate it into their biomass, temporarily reducing the availability of nitrogen to plants and influencing nitrogen dynamics in agricultural systems. This process may have occurred during the decomposition of cover crops, which already had a low nitrogen supply, as evidenced by the nutritional analysis results (Table 5).

Besides, a tendency of lower fruit production did not show statistically significant differences between treatments, as shown in Table 8.

Table 8. Yield components of tomato cv. Petros as a function of different cover crops. Flores da Cunha, 2025.

Treatments	Fruit mass	Number of fruits	Production
	g·fruit^{-1}	Fruits·plant^{-1}	g·plant^{-1}
Mix RX330 + forage turnip	266 ^{ns}	27.4 ^{ns}	7510 ^{ns}
Mix 330	270	26.1	7237
Rye	286	26.7	7837
White oats	274	28.0	7798
Black oats	285	27.9	8109
Control (plastic mulch)	274	24.9	6987
CV (%)	9.14	6.47	8.63

^{ns} = not significant between treatments by the F test ($p < 0.05$). CV: Coefficient of variation. Mix RX330: vetch, oats, and rye.

The fruits were evaluated over a three-month harvesting period, until the end of the experiment, with an average of five bunches per plant. It should be noted that the first bunches produced denser fruits with a size well above average, and after the third bunch, they maintained a consistent size and health until the end of the evaluations.

The harvest results obtained can be considered satisfactory across all treatments, given the production levels reported in the literature (FAYAD et al. 2019), which indicate a fruit mass per plant (five bunches) of around 5500 g, while the average obtained in this experiment was 7500 g per plant. Furthermore, the same study reports an average fruit mass of 194 g, whereas in the present work, the average mass across all treatments was 275 g per fruit.

The high yield can be attributed to the number of fruits per plant and the fruit size of the variety used, combined with proper management, daily fertigation, and good soil conditions. Climatic conditions also favored production, as since the seedlings were transplanted, there have been no significant periods of humidity that could promote disease, nor any adverse weather conditions.

During the research, it was observed that the main benefits associated with sowing cover crops were related to soil conservation. These plants contribute significantly to improving the soil's physical structure, functioning as multifunctional tools of great relevance for sustainable management (GENTSCH et al. 2024, YAN & ARTHUR 2025).

According to FUTERMAN et al. (2025), the use of cover crops reduced soil loss compared to bare-soil areas, while decreasing the depth and area of furrow formation, effectively mitigating erosion. In this sense, it was observed that, in the spaces between the rows and in the two side flowerbeds where there were cover crops, the furrows formed by the passage of vehicles and by water drainage were shallower, which helped preserve the surface layers of the soil and facilitated the daily management of the area. Therefore, in years with adverse weather conditions, which did not occur during the experimental period but are becoming increasingly frequent, soil cover tends to reduce the risk of erosion-related losses.

Furthermore, the long-term increase in carbon and nitrogen levels in the soil has already been observed by KUNESKI et al. (2023b) with the use of grass and

cruciferous intercropping, being considered an efficient strategy to add C and N to the soil, since the simultaneous cultivation of different cover crop species produces straw with an intermediate C/N ratio, allowing the roots to explore different soil layers and making nutrient cycling more efficient.

On the other hand, whitefly (*Bemisia tabaci*) infestation was observed in treatments containing vetch. According to ISLAM et al. (2017), biological nitrogen fixation in vetch, a host for this insect, can alter the quality and quantity of volatile compounds, thereby attracting this insect.

Another relevant aspect concerns the cost of cover crops, which corresponds to approximately 10% of the value invested in plastic mulching. Added to this is the environmental liability associated with the use of plastic, which, over time, fragments and is incorporated into the soil, generating persistent residues and potential negative impacts on the environment.

The no-till farming system is not yet widely adopted in the Serra Gaúcha region; however, the use of cover crops is gradually being tested by fruit growers and, to a lesser extent, by vegetable growers, who, when using plastic mulch, fear production losses and management difficulties.

According to this research, production is not significantly affected by the presence of cover crops, which contribute to soil conservation and directly support cultural practices, potentially impacting the long-term sustainability of production. It is worth noting that, according to SALISU et al (2025), short-term studies indicate rapid changes in physical and microbial soil attributes. However, gains in soil organic carbon are generally limited. More consistent evidence of organic carbon accumulation, improved soil structure, and nutrient cycling is observed in long-term trials, which also demonstrate the persistent effects of cover crops throughout rotations.

Therefore, it is essential to promote research into new cropping systems in this region, which is crucial for agribusiness in Rio Grande do Sul, given the varying climatic patterns from year to year. In addition to exploring other cover crops and intercropping systems, this will provide producers with increasingly clear and reliable guidance on this management practice, which generates numerous benefits for the soil in both the short and, especially, long term.

CONCLUSION

Based on the findings of this research, it can be concluded that the presence of cover crops does not alter the production of Petros variety tomatoes. Furthermore, the nutrition, quality, and production of tomatoes are not influenced by the tested cover crop species. Thus, it was concluded that the use of cover crops results in a greater supply of dry matter to the soil, without causing negative impacts on tomato productivity and quality. Soil covered with cover crops contributes to soil conservation. It indicates a favorable potential for carbon retention and improved soil quality, reinforcing the importance of this practice as a promising practice in sustainable cropping systems.

NOTES

AUTHOR CONTRIBUTIONS

Conceptualization, methodology, and formal analysis**, Mayara Toscan and Elaine Damiani Conte**; investigation**, Mayara Toscan**; resources and data curation **Elaine Damiani Conte**; writing-original draft preparation**, Mayara Toscan**; writing-review and editing**, Wendel Paulo Silvestre and Elaine Damiani Conte**; visualization**, Wendel Paulo Silvestre**; supervision, **Elaine Damiani Conte**. All authors have read and agreed to the published version of the manuscript.

FUNDING

This work was not supported by any funding agency.

INSTITUTIONAL REVIEW BOARD STATEMENT

Not applicable for studies not involving humans or animals.

INFORMED CONSENT STATEMENT

Not applicable because this study did not involve humans.

DATA AVAILABILITY STATEMENT

The data can be made available under request.

ACKNOWLEDGEMENTS

The authors would like to thank the University of Caxias do Sul for providing the infrastructure and resources to carry out the analyses.

CONFLICTS OF INTEREST

The authors have no conflict of interest to disclose.

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