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No-tillage improves summer rocket yields by reducing soil temperature and weed density and increasing soil potassium contents

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Abstract: Introducing a grass cover crop into the rocket production system is an option to increase diversity and sustainability. The objective of this study was to evaluate the effectiveness of no-tillage system for growing rocket (*Eruca sativa*) cultivars in two successive crops (cover crop – rocket first crop – rocket second crop) in the summer, using ruzigrass (*Urochloa ruziziensis*) as cover crop, and its effects on weed management and soil fertility and temperature. A randomized block experimental design with four replications was used, in a 2×3 split-plot arrangement consisting of two soil management systems (1 - no-tillage – NT; 2 - conventional tillage - CT) in the plots and three rocket cultivars (Cultivada, Folha Larga, and Selecta) in the subplots. The dry and fresh weight of rocket and soil temperature and macronutrient contents were evaluated and weed species were identified and counted. The results showed that the cultivars exhibited similar adaptability to NT. However, rocket yield increased in the second crop in NT system. Soil temperature during the hottest times of the day decreased by up to 3.8 ℃ due to the introduction of the grass cover crop into the system. Weed infestation in the first crop decreased by 74.8% in NT (135.2 plants m^{-2}) compared to CT (536.1 plants m^{-2}). *Digitaria horizontalis* was the weed species that presented the highest density in both soil management systems. Soil K contents increased after the two rocket crops in NT system. The results indicate that the rocket cultivars can be successfully grown under no-tillage system, contributing to the sustainability of the crop production system.

Keywords: *Eruca sativa*, leaf vegetable, sustainability, no-tillage, *Urochloa ruziziensis*, cover crops.
Abbreviations: Ca _ Calcium; CEC_Cation Exchange Capacity; CT_Conventional Tillage; K _ Potassium; LL _ Leaf Length; LW _ Leaf Width; Mg _ Magnesium; NP_ Number of Plants; NL_ Number of leaves; NT_No-Tillage; P _ Phosporus; SDW_Shoot Dry Weight; SFW_Shoot Fresh Weight.

Introduction

Conservation agriculture has emerged as a method for increasing sustainability of production systems (Lundy et al., 2015; Pittelkow et al., 2015). No-tillage system contributes to the development of a sustainable, low-carbon, and resource-efficient agriculture, promoting the use of crop residues to improve soil characteristics (Mondal and Chakraborty, 2022). Including cover crops in an agricultural production system allows for an integrated weed and nutrient management, with benefits for other important agroecosystem properties, including soil fertility, soil moisture retention, and biodiversity (Isik et al., 2009).

There is limited information on the use of cover crops in vegetable production. Vegetable growers need information to select suitable cover crops and understand how they affect weed suppression, soil properties, and vegetable crop yields (Kruse and Nair, 2016).

The use of cover crops has shown significant increases in soil nutrient content, organic matter, cation exchange capacity, and base saturation (Nascente et al., 2015). These plants provide several agroecosystem services; they accumulate large amounts of nutrients, prevent nutrient loss through leaching, and improve nutrient availability for the subsequent crop (Büchi, et al. 2018; García-González et al., 2018).

The low availability or absence of approved herbicides for minor crops forces growers to adopt integrated systems with non-chemical weed control methods (Shem-Tov et al., 2006; Panacci et al., 2017). Although cover crops are not widely used in vegetable production (Mennan et al., 2020), introducing these plants into production systems can assist in weed control (Isik et al., 2009; Kruse and Nair, 2016; Hirata et al., 2021).

The selection of cover crop species is essential and should be based on the goals and constraints of using cover crops. Differences in cover crop performance indicate their different abilities to compete with weeds (Büchi et al., 2018). Weed population dynamics can also be modified by different production systems (Ngouajio et al., 2003).

Cultivars of the same species may exhibit different productive performance depending on the production system (Ferreira et al., 2009), affecting their competitive potential with weeds (Lamego et al., 2013).

Rocket cultivars have been evaluated under various production systems (Schmidt et al., 2017; Silva et al., 2019), which is important for the adoption of technologies for different environments. According to Pittelkow et al. (2015), agronomic and environmental factors affect yields of crops grown under no-tillage systems; although widely used worldwide, no-tillage performance is highly dependent on cultivation conditions.

There is a lack of information on impacts of soil conservation systems on vegetable crops. Thus, the objective of this study was to evaluate the effectiveness of no-tillage system for growing rocket (*Eruca sativa*) cultivars, using ruzigrass as cover crop, and its effects on weed management and soil fertility and temperature.

Table 1. Weed species in successive rocket crops (Crop 1 - December 2015 and Crop 2 - February 2016) with different cultivars grown under no-tillage (with ruzigrass as cover crop) and conventional tillage systems.

	Crop 1					
	Rocket cultivars					
	Cultivada	Folha	Selecta	Cultivada	Folha Larga	Selecta
	No-tillage			**Conventional tillage**		
Weed species	plants m^{-2}					
Digitaria horizontalis	44.4	175.0	27.8	244.4	194.4	302.8
Eleusine indica	11.1	22.2	11.1	116.7	175.0	247.2
Cyperus difformis	19.4	44.4	13.9	22.2	33.3	22.2
Chenopodium album	8.3	0.0	2.8	22.2	36.1	33.3
Commelina benghalensis	0.0	11.1	2.8	36.1	8.3	16.7
Amaranthus sp	0.0	0.0	0.0	19.4	11.1	19.4
Portulaca oleracea	0.0	0.0	0.0	13.9	5.6	5.6
Richardia brasiliensis	0.0	0.0	0.0	5.6	0.0	0.0
Sida sp	0.0	2.8	0.0	2.8	0.0	0.0
Bidens pilosa	0.0	2.8	0.0	2.8	0.0	0.0
Cenchrus echinatus	0.0	5.6	0.0	0.0	0.0	0.0
Indigofera hirsuta	0.0	0.0	0.0	0.0	2.8	2.8
Urochloa decumbens	0.0	0.0	0.0	2.8	0.0	0.0
Gnaphalium spicatum	0.0	0.0	0.0	0.0	2.8	0.0
TOTAL	**83.2**	**263.9**	**58.4**	**488.9**	**469.4**	**650.0**

	Crop 2					
	Rocket cultivars					
	Cultivada	Folha	Selecta	Cultivada	Folha Larga	Selecta
	No-tillage			**Conventional tillage**		
Weed species	plants m^{-2}					
Digitaria horizontalis	22.2	44.4	55.6	47.2	44.4	33.3
Eleusine indica	8.3	13.9	0.0	13.9	38.9	13.9
Cyperus sp	11.1	22.2	11.1	8.3	2.8	2.8
Commelina benghalensis	11.1	11.1	2.8	11.1	11.1	11.1
Chenopodium album	2.8	5.6	2.8	0.0	0.0	0.0
Amaranthus sp	0.0	2.8	5.6	2.8	0.0	0.0
Richardia brasiliensis	8.3	0.0	0.0	2.8	0.0	0.0
Indigofera hirsuta	2.8	0.0	0.0	2.8	0.0	0.0
Portulaca oleracea	2.8	0.0	0.0	0.0	0.0	0.0
TOTAL	**69.4**	**100.0**	**77.9**	**88.9**	**97.2**	**61.1**

Results

Weed variables and ruzigrass straw decomposition

Meteorological data recorded during the experiment period are shown in Figure 1. The rocket cultivars showed no significant differences in weed density (Figure 2 A), which was high in the first rocket crop, but significantly lower in the no-tillage (135.2 plants m^{-2}) compared to the conventional tillage system (536.1 plants m^{-2}) (Figure 2 B).

In the second rocket crop, weed density decreased significantly compared to the first crop (82.4 plants m^{-2}), with no significant difference among cultivars or between soil management systems (Figures 2 C and D).

The interaction between cultivars and soil management systems was significant for weed dry weight in the first crop (Figures 3 A and B). Weed dry weight was lower in the no-tillage (NT) system with the rocket cultivar Cultivada; when comparing cultivars, Cultivada crops presented higher weed dry weight than the other cultivars grown in the conventional tillage (CT) system.

In the second crop, the total weed dry weight was low and did not differ significantly among the evaluated rocket cultivars (Figure 3 C). Weed dry weight was higher under CT than under NT conditions (Figure 3 D). The emerged weed species in the two crops are shown in Table 1.

The most abundant weed grass species in the first crop was *Digitaria horizontalis*, representing 60.9% of the weeds in NT and 46.1% in CT. *Eleusine indica* represented 33.5% and 10.9% of the weeds in CT and NT, respectively. *Cyperus difformis* represented 4.8% (CT) and 19.2% (NT). The broad leaf species found included *Chenopodium album* and *Commelina benghalensis*, although at low density.

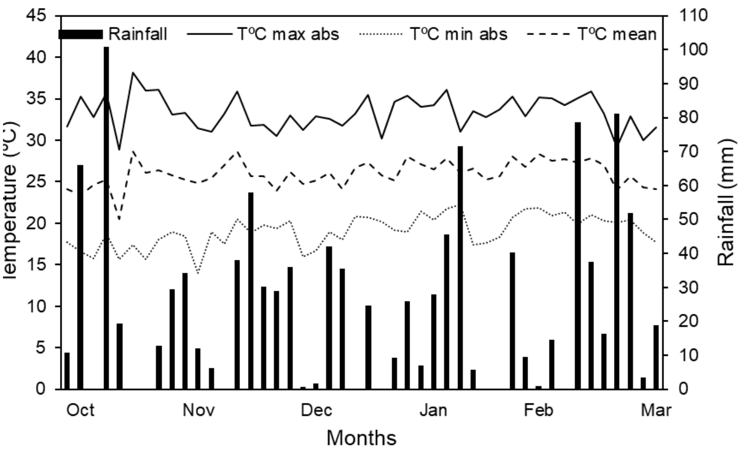

Figure 1. Rainfall depths and maximum, mean, and minimum air temperatures during experiment with rocket crops using ruzigrass as cover crop (September 2015 to March 2016). Source: Ciiagro (2023).

The cultivars exhibited a similar pattern, except for Folha Larga in NT, which showed significantly density of the species *D. horizontalis* compared to the other cultivars. However, this result may be attributed to the cluster effect, as no difference in total weed density was found for the rocket cultivars.

Table 2. Soil temperature in successive rocket crops (Crop 1 - December 2015 and Crop 2 - February 2016) with different cultivars grown under no-tillage (with ruzigrass as cover crop) and conventional tillage systems.

	Time in hours (Crop 1)			
	8:00 AM	11:00 AM	2:00 PM	5:00 PM
Management	**Soil temperature °C**			
No-tillage	22.2a	24.4b	28.2b	28.9a
Conventional tillage	21.1b	25.2a	32.0a	29.8a
CV_a(%)	1.4	2.1	6.0	2.7
Cultivars				
Cultivada	21.7a	24.4a	29.5a	29.2a
Folha Larga	21.8a	25.0a	30.5a	29.6a
Selecta	21.5a	25.0a	30.3a	29.3a
CV_b(%)	1.4	3.5	4.3	2.8
	Time in hours (Crop 2)			
	8:00 AM	11:00 AM	2:00 PM	5:00 PM
Management	**Soil temperature °C**			
No-tillage	23.1a	24.1a	27.3b	28.9a
Conventional tillage	22.9b	24.1a	28.8a	29.8a
CV_a(%)	0.5	0.9	4.5	2.2
Cultivars				
Cultivada	23.1a	24.1a	27.7a	29.2a
Folha Larga	23.0a	24.1a	28.3a	29.6a
Selecta	23.0a	24.1a	28.1a	29.3a
CV_b(%)	0.8	0.6	2.3	1.5

Means followed by the same letter in the columns are not significantly different by the Tukey's test at a 5% probability level.

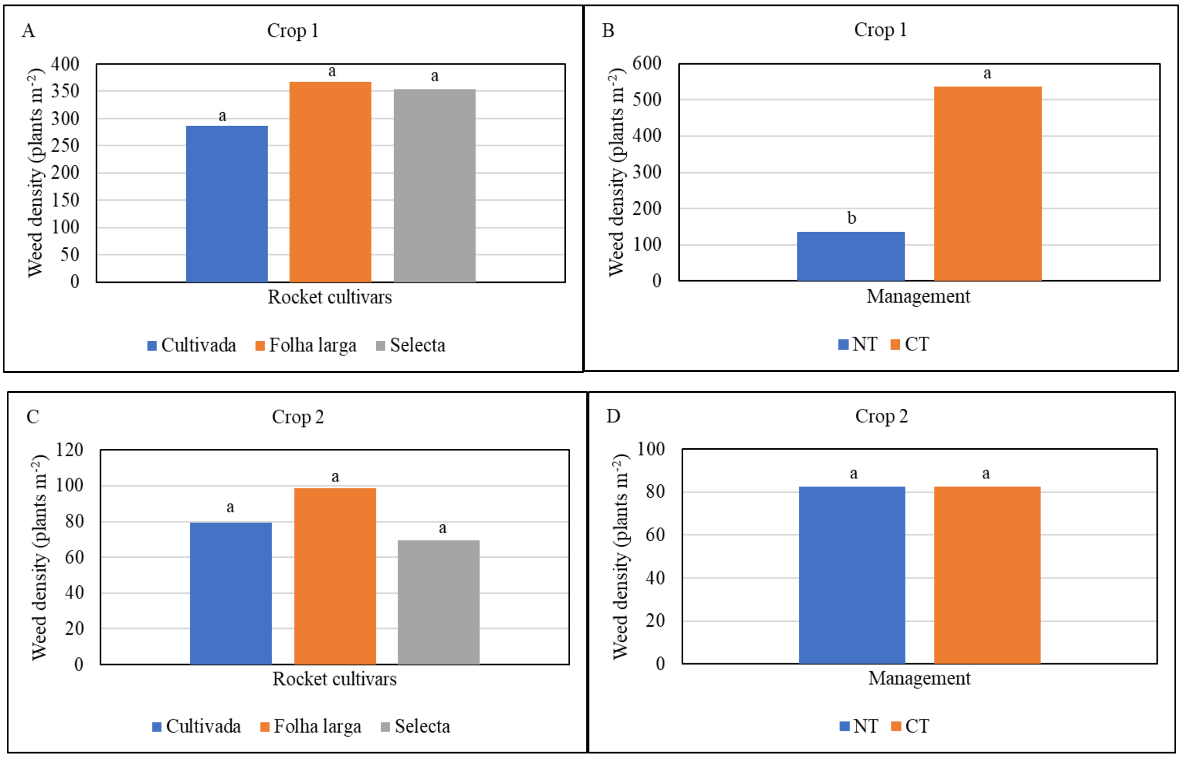

Figure 2. Weed density in successive rocket crops (Crop 1 - December 2015 and Crop 2 - February 2016) with different cultivars grown under no-tillage with ruzigrass as cover crop (NT) and conventional tillage (CT) systems.

In the second crop, the species *D. horizontalis* showed higher density than other weed species, although with a significant decreased density, mainly under CT conditions. The number of weed species decreased compared to the first rocket crop.
Considering the *U. ruziziensis* straw decomposition over time, the initial straw amount was 7.3 Mg ha^{-1}, which decreased by approximately 50% (3.6 Mg ha $^{-1}$) by the end of the second rocket crop cycle.

Soil temperature
The interaction between rocket cultivars and soil management systems was not significant for soil temperature in both rocket crops (Table 2). Cultivars did not differ significantly from each other, indicating that the different morphology of the cultivars did not affect this variable. Soil temperature in NT was 1.1 °C higher in the morning (8:00 AM), but it was 0.8 °C and 3.8 °C higher in CT at 11:00 AM and 2:00 PM, respectively, compared to those in NT; soil temperatures were similar between soil management systems at 5:00 PM. In the second crop, soil temperature in the morning (8:00 PM) followed the trend of the first crop, 0.2 °C higher in NT at 8:00 AM, but 1.5 °C higher in CT at 2:00 PM.

Table 3. Production and morphological variables of successive rocket crops (Crop 1 - December 2015 and Crop 2 - February 2016) with different cultivars grown under no-tillage (with ruzigrass as cover crop) and conventional tillage systems.

	SFW	SDW	LW	LL	NP	NL
Crop 1						
	SFW	**SDW**	**LW**	**LL**	**NP**	**NL**
Management	(g hole^{-1})		(cm)		(hole^{-1})	
No-tillage	52.6a	4.7a	7.2b	21.2b	3.9a	27.4b
Conventional tillage	70.8a	6.2a	8.4a	24.5a	3.8a	30.0a
CV_a(%)	27.9	27.4	4.7	6.9	6.2	4.6
Rocket cultivars						
Cultivada	64.4a	5.8a	8.0a	24.4a	3.8a	30.0a
Folha Larga	63.8a	5.5a	8.0a	22.6ab	3.9a	28.3a
Selecta	56.9a	5.1a	7.3a	21.5b	3.8a	27.8a
CV_b(%)	15.3	12.2	9.0	6.5	3.5	7.0
Crop 2						
	SFW	**SDW**	**LW**	**LL**	**NP**	**NL**
Management	(g hole^{-1})		(cm)		(hole^{-1})	
No-tillage	76.5a	5.4a	8.3a	26.0a	3.9a	27.3a
Conventional tillage	67.6b	4.8b	8.1a	24.5b	3.7a	24.1a
CV_a(%)	8.6	2.9	6.8	3.5	6.0	14.2
Rocket cultivars						
Cultivada	73.3ab	5.23ab	8.2a	26.6a	3.7a	26.5ab
Folha Larga	62.3b	4.53b	7.9a	23.8b	3.8a	23.0b
Selecta	80.5a	5.53a	8.5a	25.4ab	3.9a	27.6a
CV_b(%)	13.5	13.9	7.3	4.9	7.8	12.9

CV = coefficient of variation; SFW = shoot fresh weight; SDW = shoot dry weight; LW = leaf width; LL = leaf length; NP = number of plants; NL = number of leaves. Means followed by the same letter in the columns are not significantly different by the Tukey's test at a 5% probability level.

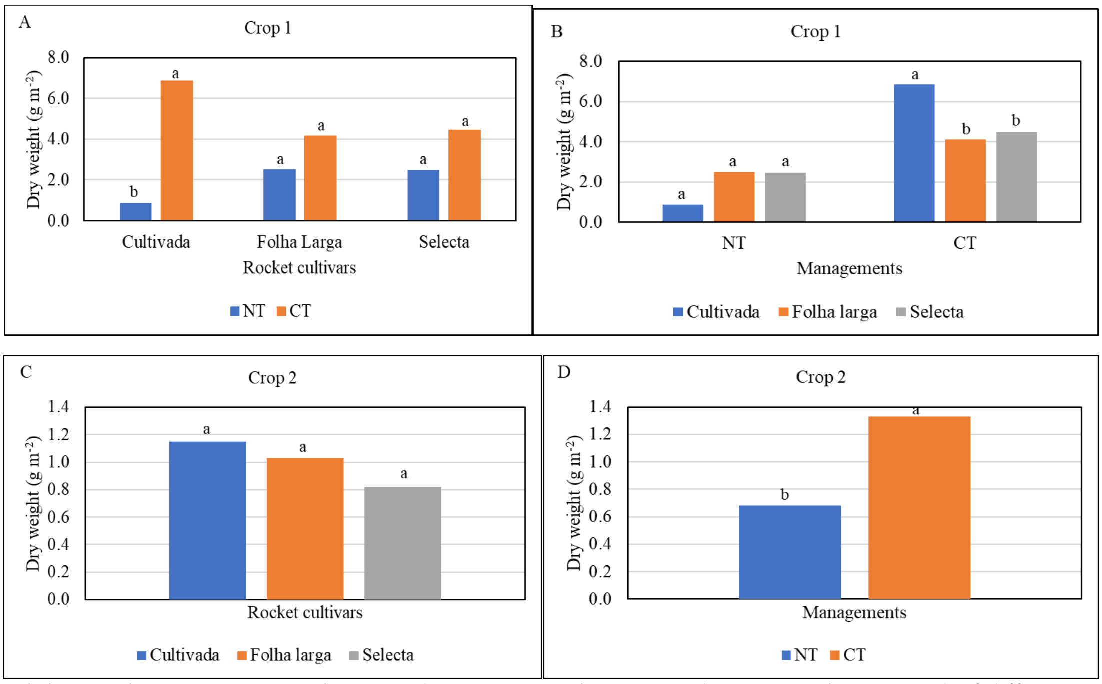

Figure 3. Weed dry weight in successive rocket crops (Crop 1- December 2015 and Crop 2 - February 2016) of different cultivars grown under no-tillage with ruzigrass as cover crop (NT) and conventional tillage (CT) systems.

Rocket yield

The interaction between rocket cultivars and soil management systems was not significant for rocket yield in any of the crops, indicating similar performance of the cultivars regardless of the soil management system (Table 3).

The comparison between cultivars showed no significant difference in mean shoot fresh (SFW) and dry (SDW) weights in the first crop. The cultivars presented similar leaf width (LW), but Cultivada presented longer leaf length (LL) (24.4 cm) than Selecta (21.5 cm). The cultivars presented no difference in the number of plants and leaves.

Rocket yield was similar between soil management systems, considering SFW and SDW. However, NT resulted in a lower number of leaves (27.4) than CT (30.0); leaf length and width were also lower (21.2 and 7.2 cm, respectively) compared to CT (24.5 and 8.4 cm, respectively).

The cultivars showed differences in leaf yield in the second crop. Folha Larga presented lower SFW and SDW (62.3 and 4.5 g hole^{-1}, respectively) than Selecta (80.5 and 5.5 g hole^{-1}, respectively). This difference may be attributed to the lower number of leaves (23.0) of the cultivar Folha Larga compared to Selecta (27.6).

The soil management systems showed a significant difference in rocket yield in the second crop. SFW and SDW were 76.5 and 5.4 g hole^{-1} in NT and 67.6 and 4.8 g hole^{-1} in CT, respectively. Additionally, using the NT system resulted in rocket plants with larger-sized leaves.

Table 4. Soil chemical properties of the 0.0-0.20 m layer after two successive rocket crops (Crop 1- December 2015 and Crop 2- February 2016) with different cultivars grown under no-tillage (with ruzigrass as cover crop) and conventional tillage systems.

	OM	P	K	Mg	Ca	CEC	pH
	(g dm^{-3})	(mg dm^{-3})		(mmolc dm^{-3})			($CaCl_2$)
Management							
No-tillage	14.3a	96.4a	2.8a	14.2a	43.0a	73.3a	6.1a
Conventional tillage	13.8a	77.5a	2.5b	12.3a	38.0a	66.5a	6.1a
CV_a(%)	11.9	33.1	5.8	23.7	16.5	13.2	1.4
Rocket cultivars							
Cultivada	14.3a	79.5a	2.7a	12.5a	39.2a	67.4a	6.2a
Folha Larga	13.7a	85.0a	2.7a	13.3a	40.5a	70.0a	6.1a
Selecta	14.2a	96.5a	2.6a	14.0a	41.8a	72.4a	6.1a
CV_b(%)	5.1	21.2	14.9	13.2	11.6	8.4	2.3

CV = coefficient of variation; OM = organic matter; P = phosphorus; K = potassium; Mg = magnesium; Ca = calcium; CEC = cation exchange capacity; pH = potential of hydrogen. Means followed by the same letter in the columns are not significantly different by the Tukey's test at a 5

Soil fertility

The interaction between cultivars and soil management systems was not significant for soil fertility-related variables (Table 4). The cultivars did not affect soil fertility by the end of the two crop cycles.

Organic matter contents in NT (14.3 g dm^{-3}) and CT (13.8 g dm^{-3}) did not differ significantly. The organic matter content before planting the crops was 14.0 g dm^{-3}, therefore, there were no significant changes.

Regarding macronutrients, only K contents showed significant difference between soil management systems; NT resulted in a higher K content (2.8 mmolc dm^{-3}) compared to the CT system (2.5 mmolc dm^{-3}).

Ca-to-Mg ratio was approximately 3.0 in both soil management systems, indicating adequate ratios for both rocket crops. Mg contents were higher, and Ca contents were lower, compared to the values found in the initial soil analysis.

Soil pH was similar between treatments and close to that found in the initial soil analysis before the crop establishment (6.0).

Cation exchange capacity (CEC) was similar between treatments, with 73.3 mmolc dm^{-3} in NT and 66.5 mmolc dm^{-3} in CT treatments; CEC in the initial soil analysis was 76.5 mmolc dm^{-3}.

Discussion

Weed variables, soil temperature, and ruzigrass straw decomposition

The results found for weed control in the NT system confirm those of other studies on leaf vegetables (Isik et al., 2009; Kruse and Nair, 2016; Hirata et al., 2018), indicating a significant contribution of NT with *U. ruziziensis* to weed control. One of the factors for this control is the effect of the physical barrier created by grass straws, mainly on weed species with small seeds.

There was a higher density of grass species, mainly *D. horizontalis*, which was suppressed in treatments with *U. ruziziensis*. This result confirms those found by Mondo et al. (2010), who reported that the absence of light negatively affects the germination of seeds of this species, indicating the importance of light for its germination (positive photoblastic). They also reported that germination percentage and speed under light incidence were higher under alternating temperatures.

Thus, soil temperature is also a factor that contributes to control seed dormancy in weeds, which often require alternating temperatures for germination. The findings of the present study showed that straw on the soil is a thermal insulating component that reduces temperature fluctuations, increasing low temperatures in the early morning and decreasing high temperatures during the afternoon. Therefore, this effect reduces temperature alternation and impacts seed dormancy of weed species.

According to Freitas et al. (2021), high temperatures can increase germination rates and speed of weed species. Additionally, the straw layer can also reduce the emergence speed, which can affect the plant's competitive potential; thus, it serves as a cultural weed control measure.

Although the straw had partially decomposed over the rocket crop cycle, the absence of soil disturbance was also a contributing factor to the decrease in weed density. The soil in the beds was not turned for the second rocket crop, which was a determining factor for the reduction in weed density in both soil management systems in the second crop. Theisen and Bianchi (2010) found that reducing soil exposure in maize seeding rows reduced the emergence of weeds such as *Bidens* sp. (55%), *Signalgrass plantaginea* (up to 37%), *Ipomoea* sp. (50%), and *Raphanus raphanistrum* (26%). Plaza et al. (2015) reported that soil tillage is a disturbance that increases the occurrence of suitable conditions for weed emergence.

Rocket yield

Although studies have shown significant interaction between genotype and soil preparation for some crop species, resulting in differences among cultivars (Roohi et al., 2022; Newton et al., 2012), this interaction was not significant for the rocket cultivars evaluated in the present study.

However, Newton et al. (2012) reported that differences in root morphological characteristics (length, depth, and angle) among cultivars can result in different performances between soil preparation systems. In the present study, variations in the morphological characteristics of the cultivars were small and alternating among cultivars when comparing the two rocket crops; this explains the similar response to the evaluated soil management systems. Regarding the cultivar factor, meteorological variations in each crop cycle may have impacted each cultivar differently, explaining the variations among cultivars in the two crops.

The effect of soil management systems on rocket yield, assessed through the SFW and SDW of plants, was not significant in the first crop, but the use of NT system affected the size and number of leaves. According to Flower et al. (2021), areas with low plant residue contents are prone to erosion and have low water retention capacity. However, large amounts of plant residues can hinder the crop establishment. Considering that the initial straw content in the first rocket crop was 7.3 Mg ha^{-1}, the establishment of seedlings may have been slightly delayed, resulting in decreases in SFW and SDW. Hirata et al. (2015) found that excess straw contents hindered the initial establishment of seedlings in lettuce crops grown under NT conditions with *Pennisetum glaucum*.

Studies have shown that growing rocket plants under no-tillage system usually results in lower initial yields; however, its effect on soil quality for subsequent crops results in similar or higher rocket yields (Herrera et al. 2013; Pittelkow et al. 2015), as found in the present study.

The increased rocket yield under NT conditions in the second crop denotes the high sustainability of this production system, mainly considering that there was more rainfall in the second crop, which was a negative condition for rocket crops. However, the straw formed by the grass species provided plant protection from rainfall splashes. Kruse and Nair (2016) reported that cover crops can be successfully integrated into vegetable cropping systems.

Soil fertility

Organic matter contents were similar between the soil management systems; this can be explained by the impact of the cropping history of the experimental area, which included crop rotation with *Avena sativa* in the winter, with incorporation of straw into the soil. Man et al. (2021) evaluated a long-term experiment on crop rotation diversity under conventional tillage and soil conservation systems and found similar soil organic carbon contents between these systems, probably due to a balance between carbon loss through degradation and carbon gains by incorporation of plant residues into the soil.

The higher K contents in the soil under NT conditions is attributed to K releases by *U. ruziziensis* grasses. The initial decomposition of *U. ruziziensis* straw was high in both rocket crops, which may have contributed to increased soil K contents. According to Rani et al. (2023), crop residues are usually rich in K, and the continuous addition of these residues in agricultural soil conservation systems can affect K dynamics and supply to crops up to a certain limit.

Torres and Pereira (2008) found higher soil K accumulation for grass species and greater K releases by millet, oats, *Brachiaria* sp., and *Crotalaria* sp. in the first 42 days after implementation. *Brachiaria* sp. presented the shortest half-life and the highest K release rate.

Although the contents of other macronutrients did not differ significantly between the soil management systems, the phosphate fertilizer source applied was thermophosphate, which was incorporated into the soil for the cover crop implementation, 84 days before the conventional crop, and did not impact rocket crop yield and soil nutrient contents.

Materials and Methods

Location and meteorological data

The experiment was conducted at the São Paulo Agrobusiness Technology Agency (APTA Regional), in Presidente Prudente, SP, Brazil (22°07'21"S, 51°23'17"W, and 460 m of altitude). The region's predominant climate is Aw, according to the Köppen-Geiger classification, characterized by rainy summers and dry winters.

Soil characterization

The soil of the experimental area was classified as a Argissolo Vermelho-Amarelo Distrófico arênico (Typic Hapludult), according to the Brazilian Soil Classification System (Santos et al., 2018) with loamy sand texture (6.5% clay, 9.1% silt, and 84.4% sand), and predominance of fine sand. The area had a history of lettuce cultivation in the summer and *Avena sativa* in the winter. The results of the soil chemical analysis were: pH ($CaCl_2$) = 6.0; organic matter = 14 g dm^{-3}; base saturation = 86%; P = 91.0 mg dm^{-3}; Zn = 2.8 mg dm^{-3}; Fe = 17.0 mg dm^{-3}; Mn = 9.9 mg dm^{-3}; Cu = 2.3 mg dm^{-3}; B = 0.17 mg dm^{-3}; K = 2.5 mmol$_c$ dm^{-3}; Ca = 45.0 mmol$_c$ dm^{-3}; Mg = 18.0 mmol$_c$ dm^{-3}; cation exchange capacity = 76.5 mmolc dm^{-3}; and H+Al = 11.0 mmol$_c$ dm^{-3}.

Treatments and experimental design

The experiment was conducted in a randomized block design, with four replications, using a 2×3 split-plot arrangement consisting of two soil management systems (1 - no-tillage – NT; 2 - conventional tillage - CT) in the plots and three rocket cultivars (Cultivada, Folha Larga, and Selecta) in the subplots. The rocket crop was planted in the same beds twice in a row (first and second crops).

Cover crop implementation

The soil of the experimental area was prepared with a harrow leveler, and beds of 1.2 m in width and 0.30 m in height were raised using a bed lifter. Pelleted ruzigrass seeds were broadcasted at a rate of 17 g m^{-2} and incorporated into the soil surface layer at late September 2015. Burndown was performed using glyphosate (1,440.0 g a.e. ha^{-1}) when the height of ruzigrass canopy was between 0.65 to 0.70 m (76 days after sowing).

The beds were raised soon before the rocket was planted in the conventional tillage system (without cover crops).

Rocket planting

Rocket seedlings were grown in 288-cell trays and transplanted to the beds at 15 days after sowing, with a spacing of 0.10 m between plants and 0.30 m between rows. The seedlings were thinned, maintaining four plants per hole.

A drip irrigation system was used; three hoses were distributed on the beds, with emitters spaced 0.20 m apart and a flow of 1.4 L h^{-1} per emitter.

Thermophosphate fertilizer (P_2O_5 = 16%, Ca = 16%, Mg = 6.5%, B = 0.1%, Cu = 0.05%, Mn = 0.3%, Zn = 0.55%, S = 6.0%, and Si = 9.0%) was applied at a rate of 100 g m^{-2}. It was incorporated into the beds when the ruzigrass was sownin the no-tillage system and the rocket seedlings were transplanted in the conventional system. N (urea) and KCl were applied by weekly fertigation, following the recommendations of Trani et al. (2014).

The rocket seedlings were transplanted in December 2015 (first crop) and February 2016 (second crop) and harvested 26 and 30 days after transplanting, respectively; the successive rocket crops were grown in the same beds, without soil turning.

Measured variables

The weed community was sampled before weeding by throwing a 0.3 × 0.3 m frame twice in each experimental plot. Shoots of plants within the framewere collected and identified, and then the number of plants of each species was counted. These plant materials were dried in a forced air circulation oven at 65 °C and weighed to determine their dry weights.

Soil temperature at a depth of 2.5 cm was determined in the week before harvest at four times of the day (8:00 AM, 11:00 AM, 2:00 PM, and 5:00 PM) in the two crops. It was measured using K-type thermocouple temperature sensors with 10 mm diameter stainless steel rigid rods coupled to digital thermometers.

Rocket plants in the central rows of the plots were harvested by cutting them at ground level, discarding plants at the ends of the rows. Plant fresh and dry weights and leaf lengths and widths were measured.

Soil samples were collected from the 0-0.20 m soil layer in the experimental plots after the second rocket crop. The soil was analyzed for P, K, Mg, Ca, and organic matter contents, pH, and cation exchange capacity.

Grass straw in the treatments with *U. ruziziensis* was sampled and dried in a forced air circulation oven at 65 °C at planting and after the two rocket crops.

Statistical analysis

The obtained data were subjected to analysis of variance and the means were compared by the Tukey's test at a 5% probability level. The statical analyses were performed using the software Assistat (Silva, 2008).

Conclusion

The results showed that rocket cultivars can be successfully grown under no-tillage system using ruzigrass (*Urochloa ruziziensis*) as a cover crop, resulting in increases in rocket yield in the second crop and soil potassium contents, with reductions in weed density and soil temperature peaks.

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