SCAP
SOCIEDADE DE CIÊNCIAS AGRÁRIAS DE PORTUGAL

Effect of cover crops on the weed flora of processing tomatoes in a regenerative agriculture system with underground irrigation

Efeito de culturas de cobertura na vegetação associada a cultura de tomate para industria produzido em sistemas de agricultura regenerativa com rega enterrada

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SUMMARY

Cover crops (CC) are plants grown to provide regulating, supporting, and cultural ecosystem services in managed environments. Numerous studies have investigated the impact of cover crops on weeds. Winter cover crops suppressed both weed biomass and weed population density in spring crops, particularly early in the cash crop growing season. However, to effectively use weed suppression services from cover crops, farmers must carefully select species that fit within their rotations and suppress their problematic weeds. Field experiments investigated the weed suppression potential of winter CCs and their effects on processing-tomato grown with underground irrigation in non-tillage system. Treatments were: *Lolium multiflorum* -A, pea (*Pisum sativum*) - E; faba bean (*Vicia faba*) – F; wheat (*Triticum aestivum*) – T, Control No CC+ No tillage - Tsm; Control No CC+ tillage - Tcm. CC aboveground biomass ranged from 580 kg ha^{-1} (*T. aestivum*) to 2393 kg ha^{-1} (*Vicia faba).* Main weeds in tomato crop ranked in importance *Cyperus rotundus, Setaria verticillata, Digitaria sanguinalis, Portulaca oleracea* and *Heliotropium europaeum.* Weed density was reduced between 44 % and 70 % with cover crop relative to tillage. *Lolium multiflorum* and *Vicia faba* were also more effective in reducing the weed biomass. Tomato productivity ranged from 84 t ha^{-1} (T) to 123 t ha^{-1} (F). Contrary to expectations, Poaceae cover crops were not the most effective in suppressing weeds, compared to Fabaceae. The *Vicia faba* species had the greatest effect on weed population density compared to the control in bare soil and also contributed to greater productivity of processed tomatoes.

Keywords: conventional tillage; no-tillage; weed density, Poaceae cover crops; Fabaceae cover crops

RESUMO

As culturas de cobertura (CC) são plantas cultivadas para fornecer serviços dos ecossistemas reguladores, de apoio e culturais em ambientes geridos. Numerosos estudos investigaram o impacto das culturas de cobertura nas infestantes. As culturas de cobertura de inverno suprimiram a biomassa de infestantes e a sua abundância nas culturas de primavera, particularmente no início do ciclo cultural. No entanto, para as culturas de cobertura serem eficazes na supressão das infestantes, os agricultores devem selecionar cuidadosamente as espécies que se enquadram nas suas rotações. Neste estudo avaliou-se a eficácia das culturas de cobertura de inverno na redução da abundância e biomassa das infestantes e o efeito na produtividade do tomate de indústria, cultivado em sementeira directa com rega enterrada. Os tratamentos foram: *Lolium multiflorum* - A, ervilha (*Pisum sativum*) - E; fava (*Vicia faba*) - F; trigo (*Triticum aestivum*) - T, Testemunha Sem CC e sem mobilização - Tsm; Testemunha Sem CC e com mobilização - Tcm. A biomassa das culturas de cobertura variou de 580 kg ha^{-1} (*T. aestivum*) a 2393 kg ha^{-1} (*Vicia faba*). As principais infestantes da cultura do tomate foram por ordem decrescente de importância *Cyperus rotundus, Setaria verticillata, Digitaria sanguinalis, Portulaca oleracea* e *Heliotropium europaeum*. A densidade de infestantes foi reduzida entre 44% e 70% com as culturas de cobertura em relação à Testemunha total (Tsm). As espécies *Lolium multiflorum* e *Vicia faba* foram as CC mais eficazes na redução da biomassa das infestantes. A produtividade do tomate variou de 84 t ha^{-1} (T) a 123 t ha^{-1} (F). Contrariamente às expetativas, as culturas de cobertura Poaceae não foram as mais eficazes na redução das infestantes, em comparação com as Fabaceae. A *Vicia faba* teve o maior efeito na redução da abundância das infestantes em relação à Testemunha total (Tsm) e também contribuiu para uma maior produtividade no tomate de indústria.

Palavras-chave: sementeira convencional; sementeira directa; densidade de infestantes, culturas de cobertura, Poaceae; Fabaceae

INTRODUCTION

Processed tomatoes are the most economically important horticultural crop in Portugal. Monoculture is very common in the Lezíria Tejo region. The "European Green Deal" aims to guarantee the sustainability of production systems, reduce the environmental footprint of food systems, and strengthen resilience against crises and to ensure healthy and accessible food. The "Farm to Fork" EU strategy proposes reducing the amount of pesticides used by around 50% by 2030; promoting the biodiversity of agro-ecosystems; combating climate change through carbon neutrality; increasing soil fertility by encouraging technologies that promote carbon sequestration in the soil. One of the technologies that contributes to the sustainability of crop production systems is the installation of cover crops (CC), i.e. the installation of a crop between two main crops. In the region's irrigated systems, the main crop is almost always considered to be in spring-summer. Thus, CC is installed at the beginning of the agricultural year (autumn) to be harvested and/or incorporated into the soil at the end of winter or beginning of spring. Different crop family (Poaceae, Fabaceae, Brassicaceae, Asteraceae) can be chosen and species selected either for single cropping or for mixtures. This technology can be associated with the conservation agriculture system, when CC residues are left in the soil, covering more than 30% of the soil surface. CCs have several advantages, whether from an agronomic, environmental and/or economic point of view. They can contribute to reducing nitrate leaching improving soil fertility by reducing erosion, increasing the soil's OM content and improving its structure increasing biodiversity in the agro-system. Another important advantage of CC is its potential to control certain weed species (Lemessa & Wakjira, 2015; Sias *et al*., 2021). In Portugal, several research projects have been carried out to assess the positive externalities of introducing CC into horticultural and/or maize monoculture production systems (MaisSolo; Hortinf; Horticover; SoilLife projects). However, given the enormous diversity of factors that can influence the impact of CC on weed control (crop to be planted; soil type and fertility; climatic conditions; cultural succession; installation technologies; production system; soil seed bank) it is necessary to establish and increase knowledge on the impact and its effect on weed vegetation. The aim of this study was to to investigate weed suppression potential of winter planted cover crops and their effect on subsequent processed tomato yield.

MATERIAL AND METHODS

In January 2023, a set of cover crops (CC) were sown in an experimental field located in Quinta do Galinheiro, Santarém (39º15'6.21''N; 8º42'6.13''W) where a three year rotation have been implemented since 2020. The experimental design was a randomized complete block with six treatments and three replications. Treatments included four winter-planted CC: Tri -wheat (*Triticum aestivum* L.); A - ryegrass (*Lolium multiflorum* Lam.); F -faba bean (*Vicia faba* L.); E - peas (*Pisum sativum* L.); and two control plots without CC: TCmob -with tillage; TSm - without tillage. The preceding crop for the CCs was maize, which was also planted in a direct seeding system in spring 2022. The maize residues were shredded and kept on the soil surface. The field trial was carried out on a Eutric Cambisol (FAO, 1978) with a sandy-white texture (83.6% sand, 9.1 % silt, 7.3 % clay), a low OM content (1.9%) and high level of assimilable phosphorus and potassium (411 mg kg^{-1} P_2O_5 and 68 mg kg^{-1} K_2O) and a low cation exchange capacity (4.52 me 100 g^{-1}).The graph in Figure 1 shows the thermopluviogram based on the daily averages of maximum, average and minimum temperature and accumulated daily rainfall for the period from 20th May to 11th September 2023.

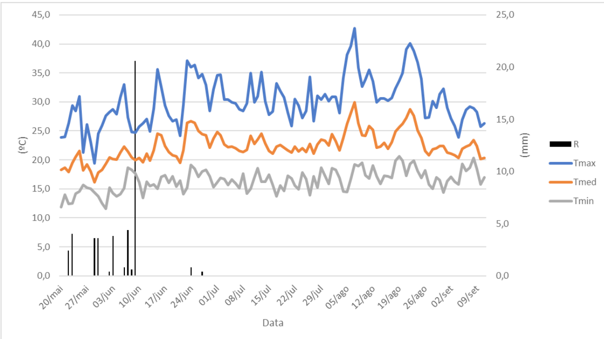

Figure 1 - Thermopluviogram for the 2023 field trial.

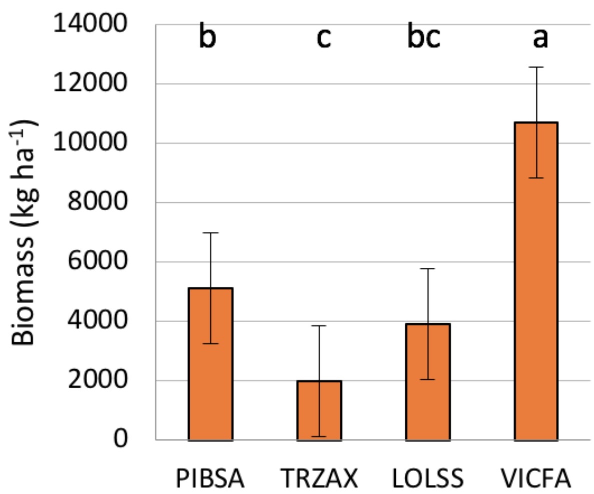

Figure 2 - Cover crop above ground biomass by species at termination time.

Cover crops were installed manually at the end of 2023, in no tillage system. The seeding density was 40 kg ha^{-1} (ryegrass), 160 kg ha^{-1} (wheat), 80 seeds m^{-2} (peas) and 20 seeds m^{-2} (faba bean). CC were not fertilized nor irrigated. For biomass samples (0.25 m^2) were collected in mid-May in each plot. The pelargonic acid herbicide (Belouka, 7% a.i., Belchim) was applied (600 cp L ha^{-1}) prior to installation of tomato crop. The tomato total fertilization ranged 150 kg ha^{-1} of N, 105 kg ha^{-1} of P_2O_5 and 150 kg ha^{-1} of K_2O. Manual planting of the 'H1015' tomato cultivar was carried out on June 1st, at a density of 3.33 plants m^{-2}. Three fungicide treatments were applied. Circa 110 days after planting, four plants were harvested per treatment and repetition to determine the number and weight of total and commercial fruits. At the same time, weeds were collected in the plot central line (0.25 m^2), identified and separated by species and dry biomass was determined.

RESULTS AND DISCUSSION

Cover crop aboveground biomass (dry weight) ranged from 580 kg ha^{-1} (*T. aestivum*) to 2,393 kg ha^{-1} (*Vicia faba*) – Figure 2. The biomass of Fabaceae cover crops was significantly higher than that of Poaceae (F=21.5634; P< 0.001). Particularly noteworthy was *Vicia faba* with 10,696±2,393 kg ha^{-1} compared to *Pisum sativum* with half of the biomass (5,125±1,805 kg ha^{-1}) – Figure 2. Main weeds in tomato crop ranked in importance *Cyperus rotundus* L., *Setaria verticillata* (L.)P.Beauv., *Digitaria sanguinalis* (L.)Scop., *Portulaca oleracea* L. and *Heliotropium europaeum* L.– Table 1.

Weed density was reduced between 44% and 70% with cover crop relative to tillage – Figures 3 and 4. *Lolium multiflorum* and *Vicia faba* were also more effective in reducing the weed biomass – Figure 3. The success of cover cropping as weed management measures depends on a complex of factors, including species selection, crop management (nitrogen and water availability) and, in particular,

Table 1 - Weed species density and mean relative abundance registed in the cover crop treatments

		Mean relative abundance (%)								
Cover crop treatment	Total density (pl/m^2)	*Cyperus* sp.	*Setaria* sp.	*Digitaria sanguinalis*	*Heliotropium europaeum*	*Portulaca oleracea*	Other broadleaves	Annual grasses	Annual broadleaves	Perennial weeds
Control – No till	73	11	7	2	7	0	18	9	73	14
Control + till	330	5	0	0	0	2	5	2	330	47.25
Triticum aestivum	141	9	25	4	11	0	34	14	141	26.5
Lolium multiflorum	77	23	0	0	0	0	23	0	77	14
Vicia faba	96	14	0	0	0	0	14	0	96	15.5
Pisum sativum	166	4	4	0	4	0	7	4	166	24.75

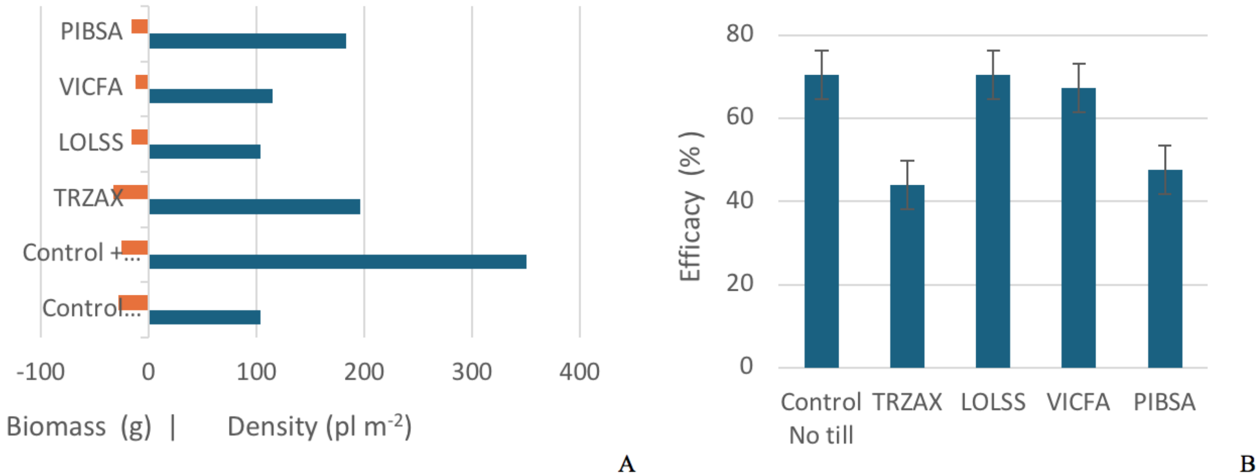

Figure 3 - Effect of cover crops compared to no cover crop (Control, no till and Control + till) in terms of weed biomass and weed density (A) and Efficay of CC on weeds up to 7 wk after planting of main crop (tomato) (B) CC-PIBSA (*Pisum sativum*); VICFA (*Vicia faba*); LOLSS (*Lolium multiflorum*); TRZAX (*Triticum aestivum*).

termination methods: mowing, roller-crimping, shredding, burying or natural mulching. (Rouge *et al.*, 2022; Wang *et al.*, 2022).

Vicia faba as a green manuring cover crop was effective in controlling annual weeds in maize as the following crop (*Amaranthus retroflexus* L., *Chenopodium album* L., *Solanum nigrum* L. and *D. sanguinalis*) as well as perennial weeds such as nutsedge (*C. rotundus*) (Álvarez-Iglesias *et al.*, 2018). Which corroborates the results of our study, where *V. faba* was shredded at harvest and used as natural mulching.

Lolium multiflorum in certain conditions could exerts allelopathic effects (San Emeterio *et al.*, 2004). So several mechanisms acting for weed control could be expected.

Contrary to expectations Poaceae cover crops were not the most effective in suppressing weeds, compared to Fabaceae. *Vicia faba* had the highest effect on weed population density relative to the bare-ground control (Control no till) and also contributed to higher productivity in the processed tomato – Figure 3.

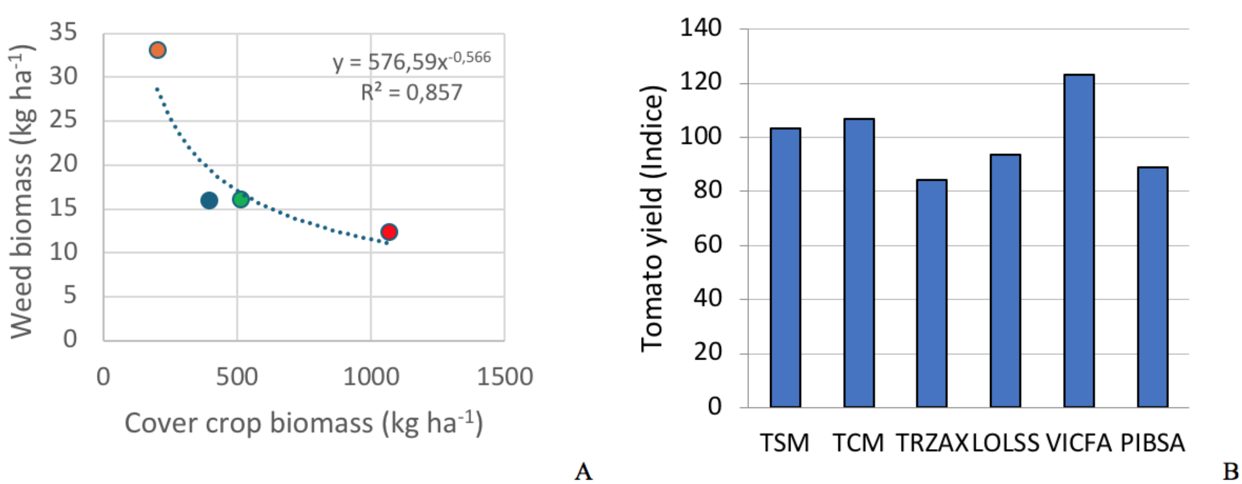

Figure 4 - Weed suppression across CC biomass per species ● PIBSA (*Pisum sativum*); ● LOLSS (*Lolium multiflorum*); ● TRZAX (*Triticum aestivum*) ● VICFA (*Vicia faba*) (A) and effect of winter cover crops on subsequent processed tomato yield (B).

Tomato productivity (yield index, %) ranged from 84 % (*T. aestivum*) to 123% (*V. faba*) and the previous cover crop does not affect tomato yield (F=0.6692; P > 0,05)– Figure 4B. According to Sias *et al.* (2021) the release of allelochemicals promotes changes in the soil, altering the balance of microorganisms in the rhizosphere of the main crop and weed species, contributing to the impoverishment of the latter.

CONCLUSION

Vicia faba was the most effective cover crop for weed management in our study. It contributed with the higher biomass for soil cover. The mechanisms that contribute for weed control either soil cover or allelopathy, were not studied. From literature it is known that total phenolics content of roots and stems significantly contributed to *V. faba* allelopathy. However the use of *V. faba* as a cover crop preceding tomato did not carried a risk of allelopathic effects, which did not have a negative impact on tomato yield.

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