SCAP
SOCIEDADE DE CIÊNCIAS AGRÁRIAS DE PORTUGAL

Cover crops effect on floristic community and yield of maize

Avaliação do efeito de culturas de cobertura na estrutura da comunidade florística e na produtividade da cultura do milho

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SUMMARY

Innovative methods of weed management, such as cover crops, are becoming increasingly necessary. However, despite the objectives set out in the European Green Deal, their adoption by farmers has been gradual, regardless of the advantages they offer in terms of maintaining soil organic matter, preventing erosion and, in particular, reducing the abundance and biomass of weeds. In order to assess the impact of mixtures of Poaceae and Fabaceae as cover crops on the structure of the floristic community of the maize crop, a trial was set up in Ribatejo region comparing the use of cover crops with soil tillage and a control as reference. During the autumn-winter period, the biomass of the cover crop was assessed on five periodic dates accompanied by observations using satellite images. The NDVI (Normalised Difference Vegetation Index) and the amount of biomass were used to assess the effects of cover crops on the floristic community. In spring, the effect of these cultural methods on the abundance and frequency of weeds and on maize productivity was assessed. By the middle of the crop cycle, the NDVI values made it possible to detect significant differences between treatments. At 1.5 months from harvest these differences were not significant, which can be attributed to the development of the crop, which attenuates the effect of weed competition. Cover crops could provide a new opportunity for farmers to increase the sustainability of cropping systems, reducing dependence on herbicides and improving soil quality.

Keywords: weeds, cover crops, NDVI, biomass, maize

RESUMO

São cada vez mais necessários meios inovadores, para a gestão das infestantes, como são as culturas de cobertura. No entanto, e apesar dos objetivos definidos no Pacto Ecológico Europeu, a sua adoção pelos agricultores tem sido gradual independentemente das vantagens que apresentam na manutenção de matéria orgânica do solo, prevenção da erosão e em particular na redução da abundância e biomassa das infestantes. Para avaliar o impacto de misturas de Poaceae e Fabaceae como culturas de cobertura na estrutura da comunidade florística da cultura do milho foi instalado um ensaio no Ribatejo com três modalidades: Testemunha, cultura de cobertura e mobilização do solo. Durante o período de outono-inverno foi avaliada a biomassa da cultura de cobertura em cinco datas periódicas acompanhadas de observações através de imagens de satélite. Recorreu-se ao índice NDVI (*Normalized Difference Vegetation Index*) e à quantidade de biomassa para avaliar o efeitos das culturas de cobertura sobre a comunidade florística. Na primavera avaliou-se o efeito destas medidas culturais nas abundância e frequência das infestantes e na produtividade do milho. Até meio do ciclo da cultura os valores de NDVI permitiram detetar diferenças significativas entre tratamentos. A 1,5 meses da colheita estas diferenças não foram significativas, o que pode ser atribuído ao desenvolvimento da cultura, que atenua o efeito da competição das infestantes. As culturas de cobertura podem constituir uma nova oportunidade para os agricultores aumentarem a sustentabilidade dos sistemas culturais, reduzindo a dependência dos herbicidas e melhorando a qualidade do solo.

Palavras-chave: infestantes, culturas de cobertura, NDVI, biomassa, milho

INTRODUCTION

In irrigated crops from Ribatejo (center Portugal) - a floristic survey was carried out in potato fields from Golegã region, where 118 species of weeds belonging to 19 botanical families were identified. Annual species predominate (88%) over perennial species (12%). Six species stand out in decreasing order of importance in the fields: *Datura stramonium* L., *Amaranthus retroflexus* L., *Calystegia sepium* L., *Sonchus tenerrimus* L., *Cyperus rotundus* L. and *Cyperus esculentus* L.

The diversity, abundance and frequency of weed species reflected the intensity of cultural practices in each crop field. Specific richness ranged from 12 to 25 species per crop field. The total abundance in the least infested field was 6.5 plants per m^2 and reached 128 plants per m^2 in the most infested field (Calha *et al.*, 2022).

Weeds are usually aggregated in patches within the crop (Wiles *et al.*, 1992). This is important from the point of view of management because herbicide use could be reduced by spraying only patches with weed infestation or by adjusting herbicide rate. (Gerhards & Christensen, 2003; Barroso *et al.*, 2004). In order to implement localized applications, it is necessary to know the spatial distribution map of the weed species. Due to the high cost associated with the generation of these maps is important to minimize the frequency of the mapping, therefore, the spatial and temporal stability of the weed patchs is critical. Species with a stable spatial distribution will not require the frequent generation of new maps (López-Granados, 2011).

The aim of this study was to assess the impact of mixtures of Poaceae and Fabaceae as cover crops on the structure of the floristic community of the maize crop, using geostatistical techniques and validate the remote results with *in loco* measurements of cover crop biomass in previous crop and weed abundance in cash crop.

MATERIAL AND METHODS

A field trial was carried in order to study alternative strategies to control main weeds from a potato (one year)-maize (two years) rotation, in Golegã, Ribatejo, Center Portugal (4380373N, 467433E). The field area of 2.5 ha was divided in three strips, 100 m long and 20 m width (Figure 1) with an experimental design of random blocks with three treatments, cover crop (CC): mixture Poaceae x Fabaceae; Tillage (Fs): soil tillage with harrow and a Control (T). Cover cropping density of sowing, date of sowing, harvest by cutting and shredding at date: Maize variety, density of sowing, date of seeding and of harvest. Weed control was conducted in postemergence with sulfonylureas. To evaluate the effect of treatments a sampling area of 1 m^2 (with four replicates) was covered with PE film before herbicide treatment. Samples (seedlings plants m^{-2}) were taken during maize twice per year, one at the beginning (before herbicide application) and at the end of the cropping season (one week before harvest). Sampling points were georeferenced.

The field trial was maintained during three years: 2018/2019 until 2020/2021. In the subsequent

Figure 1 - Experimental site, with indication of trial plot where the three treatments were implemented cover cropping, tillage and control.

campaign similar procedure was followed for each treatment. NDVI were calculated from satellite images for the first year. The following years it was not possible to collect images. Remote detection of field plot during year 1 was carried out by analyzing satellite images taken at five different dates from October 2018 to March 2019. The same procedure was followed during maize copping cycle with satellite images taken at four dates (May to August 2019).

At termination time cover cropping was cut at soil level with a blade linked to the tractor and shredded. Biomass at sampling areas of 1 m^2 was collected for each treatment for dry weight assessment. During maize cropping cycle (15 days after herbicide application) weed abundance and diversity was assessed at 'covered' sampling areas.

RESULTS AND DISCUSSION

The NDVI allows to distinguish the vegetal coverage from bare soil, and could be an useful indicator of weed abundance in crop (Figure 2 and Figure 3).

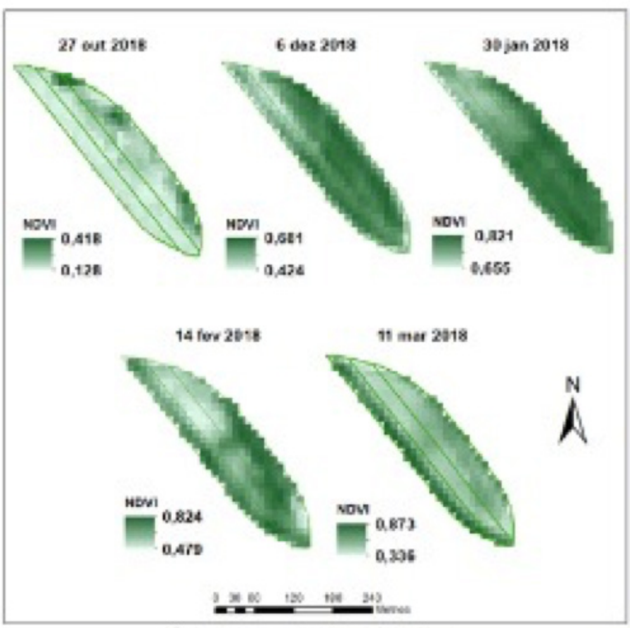

Figure 2 - Normalized Difference Vegetation Index (NDVI) images collected over the experimental site (Sentinel satellite) on five different dates in the early season after cover cropping seeding during fall / winter 2019– year 1.

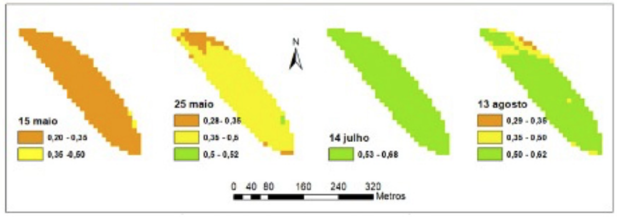

Figure 3 - Normalized Difference Vegetation Index (NDVI) images collected over the maize field (Sentinel satellite) on four different dates after cash crop seeding during spring /summer 2019– year 1.

The NDVI could only distinguish between cover cropping treatment at the second date (27th October) – Figure 2. In cash crop, next season, it was not possible to correlate maize NDVI images with previous treatments (Figure 3). Although the biomass was significant different (Table 1).

Table 1 - Biomass (dry weight) of three treatments in the experimental field (S. João Brito, Golegã) for three cropping cycles (2018/19; 2019/20; 2020/21)

Years	Place	Treatments		
		Control (kg ha^{-1})	Tillage (kg ha^{-1})	Cover crop (kg ha^{-1})
2018/2019	S. João Brito	4 264 ± 916*	3 748 ± 172	7 815 ±1379
2019/2020	S. João Brito	3 702 ± 729	6 50 ± 2052	7 635 ± 2 196
2020/2021	S. João Brito	2 393 ± 319	4 314 ± 897	4 598 ± 989

Cover crop biomass during fall was similar in year 1 and year 2 but decreased significantly to twice less in year 3. CC biomass in year 2 was twice of that of year 3. The results of soil coverage could explain the reduction in weed abundance compared to tillage and control in year 2 (Figure 4a). In year 3 the reduction of weed abundance compared to tillage was not significant, dure to lower biomass – Figure 4 (b). The diversity of weeds was also different in the two years (Figure 5).

Biomass was higher in cover cropping compared to tillage and to control for the first two years. Year 3 represents a different situation where there was a reduction in cover cropping biomass as well as

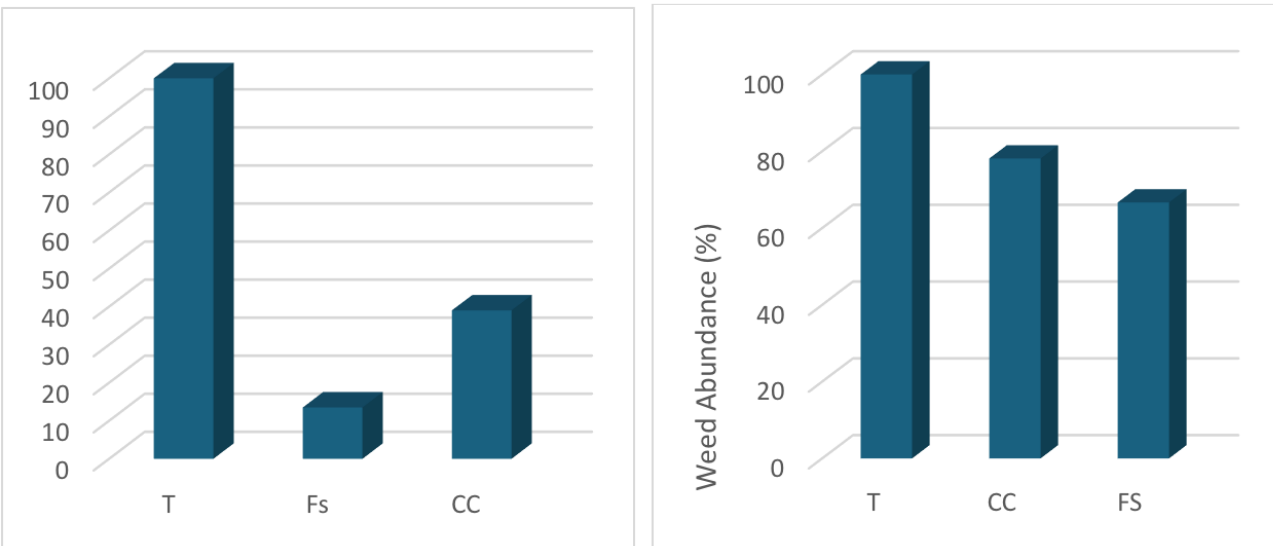

Figure 4 - Weed abundance in maize crop after cover cropping during winter period (CC) compared to control (T) and tillage (FS) – year 1 (left) and year 2 (right).

in the control. On the contrary tillage showed an increase in plant biomass. These results could be explained because 2020 was a much colder and rainy year compared to the previous (INE, 2021). The effect of cover cropping on weed abundance and diversity compared to tillage and control was analyzed in the next crop, maize. Weed abundance was higher in control, for both years, as expected. However the effect of cover cropping and tillage was different in each year.

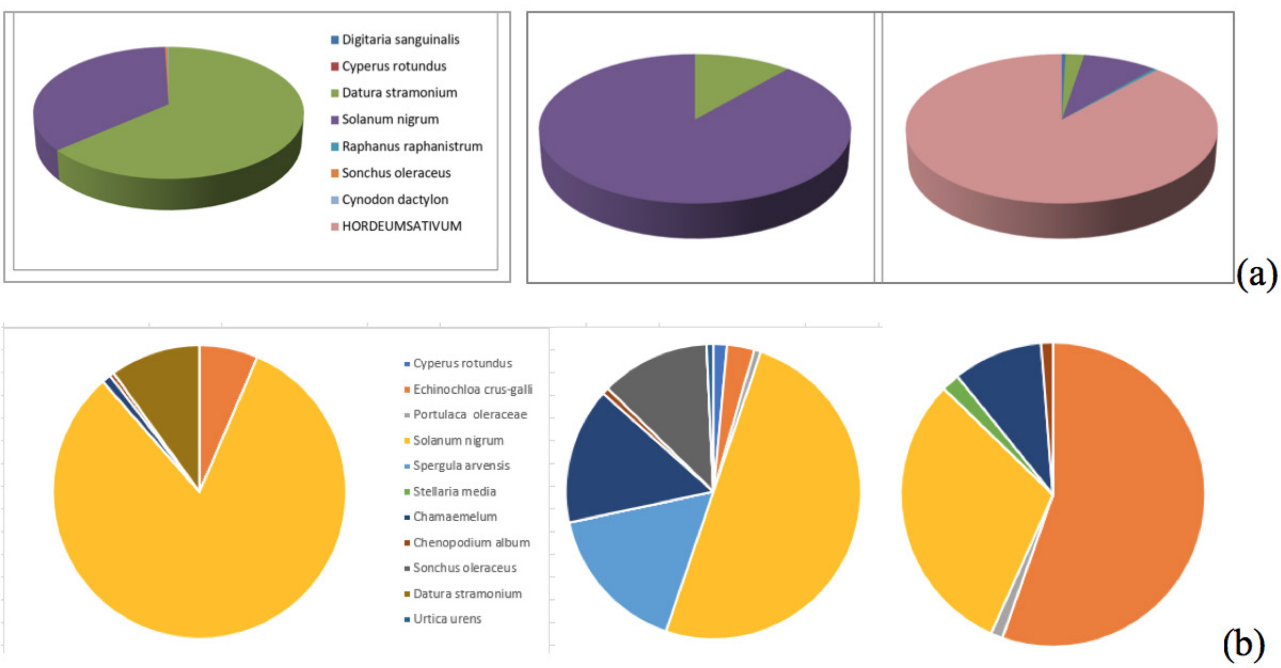

Figure 5 - Diversity of weeds in maize following previous soil management practices: Control (T), Tillage (FS) and Cover cropping (CC, mixture Poaceae x Fabaceae): year 1 (a) and year 2 (b).

In year 1 (S. João de Brito) there were significant differences between treatments compared to control (T). In next season main weeds from maize crop present in control plot *Datura stramonium* L. and *Solanum nigrum* L. were replaced by *Hordeum vulgare* L. in cover cropping plots which contribute to reduce weed abundance in 60% compared to control (Figure 5). Tillage also contributes to reduction of weed abundance but *S. nigrum* remains as the main weed species present. In the second year, the reduction on weed abundance by cover cropping (CC) and tillage (FS) was not evident – Figure 4. Cover cropping reduced *S. nigrum* similar to first year, but *Echinochloa crus-galli* had a high increment. The reduced effect on the second year could explained with lower biomass of cover crop (4 598 kg ha^{-1}) compared to previous years 7 815 kg ha^{-1}.

CONCLUSION

Datura stramonium, Solanum nigrum and *Echinochola crus-galli* were the main maize weeds found in the experimental site. Although the first two suffer a drastic decline in cover cropping compared to control, the results could not be confirmed in the second year at the same experimental site. Cover cropping was very effective in reducing weed abundance of the next crop compared to tillage. However the effect depends on cover crop biomass in the previous year and on weed diversity. Using NDVI to distinguish the vegetal coverage from bare soil, it was only possible to detect significant differences between treatments, by the middle of the maize crop cycle. At 1.5 months from harvest these differences were not significant, which can be attributed to the development of the crop, which attenuates the effect of weed competition. These results could be taken into account when planning site-specific treatments in maize.

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