# Organic recycled mulches in sustainable viticulture: assessment of spontaneous plants communities and weed coverage

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## Abstract

Organic recycled mulching has become an interesting strategy for developing more efficient and sustainable viticulture management. This work aimed to analyse the effect of three different organic mulches [straw (S), grape pruning debris (GPD) and spent mushroom compost (SMC)] and two traditional soil management techniques [herbicide and inter-row tillage] on weed control and the spontaneous plant communities' presence in the vine-line. SMC and herbicide were the treatments with the highest and the lowest weed cover percentage respectively. Inter-row tillage had a delayed weed emergence at the beginning of the vine vegetative cycle but finally, it reached maximum values nearby SMC. GPD and S had similar effects on weed emergence, reaching up to 23% and 31% of the maximum coverage values respectively. An amount of 28 herbaceous species were identified, some of them very isolated and occasional. Principal component analysis (PCA) showed specific species-treatment associations, especially for inter-row tillage and SMC treatments. The different soil management techniques had a clear effect on weed coverage and plant species communities. This study provides interesting information about how organic recycled mulching influences spontaneous plant biodiversity and weed coverage control.

## Introduction

Grapevine is a thoroughly crop in the Mediterranean area, especially in Spain, France and Italy, which represent around 30% of the world's wine-growing area (OIV, 2020). Traditionally, orchards have been cultivated by tillage and herbicide treatment in the row-line (J.G Guerra et al., 2022) due to its low cost, the ease of the process and the high efficiency involved (Manzone et al., 2020). However, it is well known that these practices cause

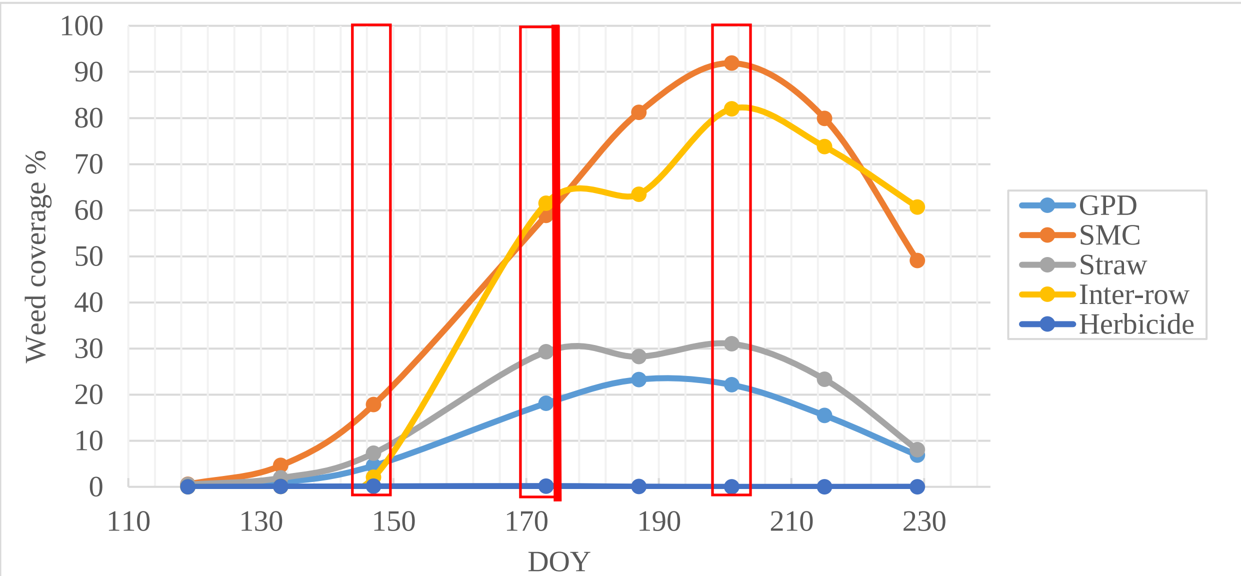


**Figure 1.** Percentage of weed cover for each treatment over the vine vegetative cycle (n=9). The red squares indicate the days on which the weed species were identified. The thick red line indicates the day when the most vigorous plants were cut (weeding machine).

significant problems to human health and the environment (Narayan et al., 2017), such as soil erosion and fertility reduction (Prosdocimi et al., 2016). Moreover, it is widely described that the presence of spontaneous weeds brings multiple benefits to the soil and to the plant, such as providing food and shelter for natural enemies of pests, hosting mycorrhizae, reducing soil erosion, increasing organic carbon content, and consequently increase production and water use efficiency (WUE) (Xu et al., 2015). Despite all the benefits, the excessive presence of weeds is considered one of the main factors in the reduction of production in vines (Cirujeda et al., 2012). To solve this problem, the use of organic mulches has become an interesting alternative to combat conventional soil management. Some examples of benefits that organic mulches can provide to the plant are enhanced soil structure, reduction of extreme soil temperature oscillation, improved WUE, yield increases and control of the weed (Chan et al., 2010). This study presents the results of the effect of three recycled organic mulches (grape pruning residues (GPD), spent mushroom compost (SMC) and straw) and two traditional treatments (herbicide and inter-row tillage) on the growth and presence of spontaneous plants with the following objectives:

1. Assess the ability of the treatments to control the growth of weed during the vine vegetative cycle.
2. Identify the weed species within each treatment, analyse the communities formed and the impact that they could have.

## Materials and methods

### *Study site*

The experiment was conducted in 2021 in a commercial vineyard regulated by the DOCa Rioja located in North-Eastern Spain (42°28'37.8 "N, 2°29'02.8 "W, altitude 502 m.a.s.l). The study plot was characterised by having Haplocalcids soil according to the Soil Resource data (Soil Survey Staff, 2014) and a semiarid continental Mediterranean climate with an annual rainfall of 531.2 mm and an average annual temperature of 13.3 °C (data from a near station of Agro-climatic Information Service of La Rioja (SIAR)). In the experimental vineyard, there were vines of Tempranillo cultivar grafted on Richter-110 and planted in rows (distance between rows was 3 m and plants 1.22 m). They were trained in a bilateral double cordon and drip irrigated.

### *Field experimental design*

The experimental design has been a randomized block design with three replicates (each one of 40 plants) per treatment, in a total of five treatments: three treatments of organic mulches (grape pruning debris (GPD), spent mushroom compost (SMC) and straw (S)), and two conventional soil management treatments (herbicide and inter-row tillage). The treatments were firstly installed in February 2019 and replenished once a year.

### *Weed coverage and plant communities*

The effect of organic mulches on the growth and formation of spontaneous species communities throughout the vegetative cycle of the vineyard was measured every 14 days from DOY 119 to 229 on a total of 3 occasions. Weed coverage (as % cover) was quantified by taking three pictures per replicate (in three replicates per treatment) from a quadrant (0.5 m x 0.5 m) randomly placed directly under the vine rows for the different treatments and subsequently, analysed by the *ImageJ 1.52a* software. In addition, the plant species present in the treatments were monitored and the relative density and relative abundance of each species were calculated (Mueller-Dumbois et al., 1974). Graphic representations and statistical analysis were made using the software *Rstudio* (version 1.3.1093) and *ggplot2*, *plots*, *factoextra*, *FactoMinerR* and *dunn.test* packages.

## Results and discussion

Weed coverage quantification started at DOY 119 (<1% cover in all treatments) and ended at DOY 229 when plant cover was diminished due to the end of the vegetative cycle of weeds. Figure 1 shows the more effective control of weeds under the vine row by the herbicide treatment, which completely inhibits its presence (<1%). Inter-row tillage and SMC were the treatments with the highest weed cover, with maximum values of 82 and 92% respectively. Inter-row tillage had a delay in weed emergence, but quickly reached high values of vegetation cover (Manzone et al., 2020). On the other hand, weed cover results for S and GPD treatments were between those of conventional treatments and SMC, with maximum values of 31 and 23% respectively, indicating good effects of these two mulches in controlling weeds over time.

In total, 28 spontaneous weed species were identified, of which *Convolvulus arvensis* (9.8%), *Amaranthus blitoides* (9.45%), *Chenopodium sp* (8.3%), *Galium aparine* (3.9%) and *Salsola kali* (3.3%) were the most common. Mulching cover affected the presence of plant species and their abundance. An example was the higher presence of *Chenopodium album* (a plant present only in nitrogen-rich soils) in the high nutrient soils, such as the one with SMC (data not shown) (Stokes & Rowley-Conwy, 2002).

The number of weed species (biodiversity) was very different between treatments and also during the vegetative cycle (Table 1). Numerous studies have demonstrated that mulches may have different effects on different weed species (J.G Guerra et al., 2022). In this study, the herbicide treatment has the lowest number of different species (3.7 ± 2.8) and S the highest (8.2 ± 4.1). Thus, S treatment improved weed biodiversity but, at the same time, controlled excessive weed cover.

**Table 1.** Mean number of weed species (n=3) measured at different DOY for each treatment. In each column, different letters indicate significant differences according to Duncan's multiple range test at the 95% confidence level.

| DOY | 147 | 173 | 201 | Total |
|---|---|---|---|---|
| **GPD** | 3 ± 1,7 ab | 9 ± 1,7 ab | 5,7 ± 0,6 | 5,9 ± 2,9 ab |
| **Herbicide** | 1 ± 0 b | 5 ± 1,7 b | 5 ± 3,5 | 3,7 ± 2,8 b |
| **Inter-row** | 4 ± 1 ab | 10,3 ± 2,3 ab | 8 ± 0 | 7,4 ± 3 ab |
| **Straw** | 4,7 ± 1,5 ab | 13,3 ± 1,5 a | 6,7 ± 1,2 | 8,2 ± 4,1 a |
| **SMC** | 6,3 ± 0,6 a | 9,7 ± 1,5 ab | 6,3 ± 1,2 | 7,4 ± 1,9 ab |

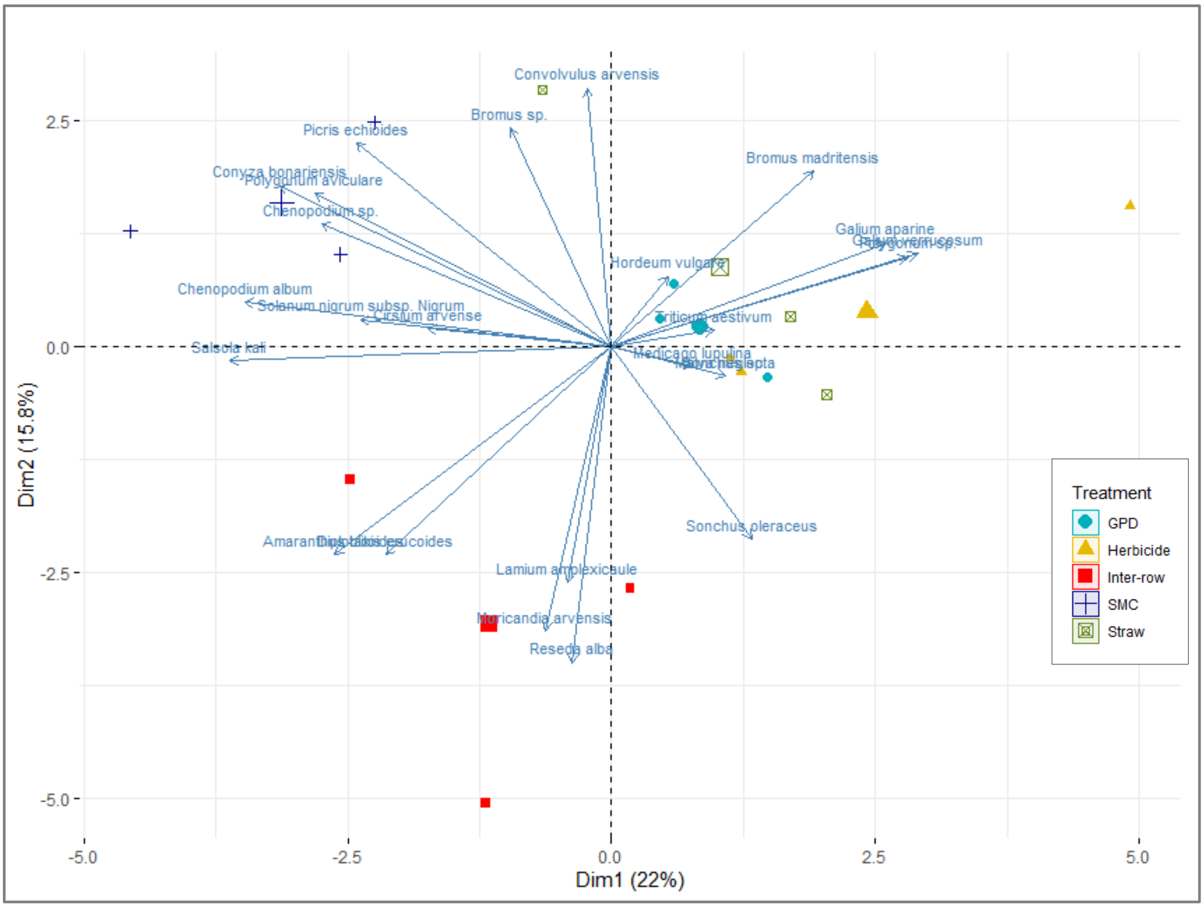


**Figure 2.** PCA biplot (scores and loadings) of relative abundance of each weed specie of different treatments at DOY 173 (22/06/2021).

The principal component analysis plot (Figure 2) showed that the three replicates per treatment were well clustered and that a clear separation between the inter-row tillage and SMC treatment was obtained. Dim 2 clearly segregates Inter-row tillage from the other treatments, mainly because of the lower presence of *Convolvulus arvensis*, whereas GPD, herbicide and S treatments were grouped together, although some differences were still observed.
Accordingly, with Kazakou et al. (2016), in more altered soils, such as the one with inter-row tillage, the community composition tends to converge towards more ruderal species of smaller size, small seed size and large surface areas, such as *Amaranthus blitoides*, *Diplotaxis erucoides*, *Lamium amplexicaule*, *Moricandia arvensis*, *Reseda alba* and *Sonchus oleraceus*. In contrast, more conservative and less soil manipulative treatments, such as SMC treatment, provide other weed diversity and community composition. In this case, more competitive species with higher size and plant cover are present, such as *Chenopodium album*, *Solanum nigrum* subsp. *nigrum*, *Cirsium arvense*, *Polygonum aviculare*, *Conyza bonariensis* and *Picris echioides*

## Conclusion

Organic mulches have different effects on weed cover and community composition. Straw mulch control excessive vegetation and increases weed biodiversity. In contrast, SMC substrate supplies a nutrient pool leading to high vigour weed species and higher weed cover. Organic mulches are an interesting alternative for reducing the use of herbicides, increasing biodiversity, and improving soil quality and water retention capacity.

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