Agrociencia Uruguay 2023 | Volume 27 |Supplement |Article e1232
DOI: 10.31285/AGRO.27.1232
ISSN 2730-5066

I Jornada Técnica del Grupo de Protección Vegetal - EEMAC

Do service crops always involve effective weed management?

¿Los cultivos de servicio siempre implican un manejo efectivo de malezas?

As culturas de serviço implicam sempre uma gestão eficaz das infestantes?

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Received *01 Aug 2023*
Accepted *02 Aug 2023*
Published *13 Sep 2023*

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1. Introduction

Agriculture is facing a growing problem of herbicide resistance, with 269 resistant weed species recognized worldwide[1]. This has led to a sharp decrease in the number of herbicide tools available, and is the result of a production system based almost exclusively on chemical control[2]. The sustainability of agricultural activity requires greater diversification in management practices. Although this responds to the installed resistance problem, it also incorporates production alternatives that allow mitigating environmental impacts. All this has resulted in the revaluation of integrated weed management, including cultural measures based on the population dynamics of weeds and their interaction with crops[3].

Integrated weed management combines direct strategies, such as the rational application of herbicides and mechanical practices, with indirect or cultural strategies such as the use of weed suppressive crops. Suppressive crops are considered to be those that, due to their growth and development characteristics or their allelopathic potential, are capable of reducing weed proliferation[4].

On the other hand, agricultural rotation has proven to be a fundamental tool in weed management at the system level[5-6]. Its effects can be enhanced if the strategic inclusion of suppressive crops is also considered.

2. Service crops and their effect on weediness

In recent years in Uruguay there has been a growing adoption of cover crops as an alternative to reduce soil erosion processes. Although the main objective of these crops is to reduce erosion, their implementation offers an unprecedented opportunity to promote multiple ecosystem services. For this reason, in recent times, they have been called "service crops"[7-11]. Inclusion of these crops in the rotation has affected ecosystem services, such as erosion control, nutrient cycling, organic matter formation, water quality regulation, and pest, weed and disease control[12-15].

None of these crops can provide all the ecosystem services previously mentioned. The criteria for selecting species should be based on a series of characteristics and steps that guarantee that they provide the functions the system needs, and for this it is necessary to know and consider the limitations of each production system.

Among the multiple services reported for these crops, numerous investigations have highlighted their weed suppressive effect. These crops are able to reduce the weediness present between 25 and 90% depending on the crop, highlighting the importance of the species to be used[16]. Other studies found large differences between species, reporting that black oats and rye presented the highest suppressive values, achieving reductions in ryegrass that reached 95%[17-18].

The Malherbology Group (Faculty of Agronomy, Udelar) has been studying the effects of service crops since 2015. During these years, field evaluations have verified their suppressive effect in relation to the different degrees of cover of each crop. On the other hand, strong indications of allelopathic effects of some of the species studied in the laboratory have emerged.

The results obtained are of great interest and have proven to be very reliable since they have been observed in different years and conditions. However, it should be noted that these results always depended on the crops used, their productive management and the target weed species, demonstrating that including service crops in the rotation does not always imply an effective allelopathic effect.

First, the effectiveness of this tool will depend on the type of weeds to be controlled. The planning of the service crop is done pre-emergent to the weeds to be managed, and therefore, all the knowledge about the history of weeding, as well as the diagnosis and identification of the most relevant weed species of the farm will be of vital importance. The diversity of weed species implies different results of tolerance to any control tool, generating that not all weeds respond in the same way to the inclusion of service crops. In our studies, service crops capable of 90% of weed suppression always showed a cover equal to or higher than 80%, showing a direct relationship between the two in most cases. However, this relationship is not only based on the amount of cover, but also on the timing of cover generation, which defines greater success the earlier it is generated.

It is to be expected that weeds that are less sensitive to light will respond less to cover generation. Weeds such as *Conyza* spp., *Bowlesia incana*, *Coronpus didymus*, *Anagallis arvensis*, *Cerastium glomeratum*, *Poa annua* and *Lolium multiflorum* were affected by the use of some service crops. In contrast, the service crops used were inefficient in suppressing cruciferous weeds.

The service crop selected also largely defines the effect on weeds. As already mentioned, species differ in the ground cover achieved. But they also differ in the amount of roots, the biomass produced, the stubble quality according to their C:N ratio, and the allelopathic potential[19].

Results have shown differential effects among species when evaluating weed suppression. The grassy service crops (black oats, white oats, rye, and ryegrass) showed suppressions close to 90% in all the years evaluated of the aforementioned weeds. The leguminous crops (*Trifolium resupinatum* and *Trifolium vesiculosum*), on the other hand, showed significantly lower suppression than the grasses (67%), with the exception of *Vicia villosa*, the only legume capable of matching the values achieved by the grass crops.

Each of the aforementioned crops has a characteristic interference power, defined by its ability to compete for resources with weeds and its allelopathic potential. A high initial growth rate and the ability to colonize space allow the crop comparative advantages, making it more competitive for light, nutrients and water.

Some authors define that the fulfillment of many ecosystem services depends on crops reaching 4-5 Mg ha-1 of dry biomass[11]. This value is considered by some technicians and researchers as the indispensable minimum for service crops to fulfill their functions[20-21]. In the case of service in weeds, the most interfering species will always be the one that achieves rapid colonization and greater initial growth and development. Therefore, when evaluating the performance of each species, it will not be the amount of dry matter produced at the end of the cycle that matters most, but the generation of rapid total cover.

The relationship between cover and degree of suppression is evaluated in most of the service crops evaluated. Despite this, there are some species, such as rye, where high levels of weed suppression are not justified by the generation of cover, allowing the hypothesis of allelopathic power to be generated. The bibliography reports that crops that have proven to present weed suppressive capacity, such as rye (*Secale cereale*), oats (*Avena sativa* and *Avena strigosa*), vetch (*Vicia villosa* and *Vicia sativa*) and some clovers (*Trifolium incarnatum L*., T. *subterraneum*, *T. pratense* and *T.*

alexandrinum), present the capacity to release secondary metabolites with allelopathic potential during the crop cycle, as well as from their stubble[22-25]. This leads to the conclusion that, although the amount of cover generated quickly influences to a great extent the suppressive power of the crops on weeds, allelopathic characteristics in some of the crops used could generate the same or even greater interference power of the crops. The interference power depends on the natural characteristics of the species, as well as on the technology associated with the crop. The associated technology includes planting technology and density, nutritional management and the possible use of selective herbicides.

The productive decisions made in each of the service crops should be aimed at the optimal management of each species. Each crop should be sown using the recommended densities and on the recommended sowing date, taking into account the different requirements of grasses and legumes. The sowing scenario must be clean, allowing the crop to implant and colonize the space without the need to compete with weeds in their first stages of growth. Nutritional management including fertilization and inoculation —the latter only in legumes— is recommended.

3. Effect of service crops at the system level

Although the suppressive effect of service crops on winter weeds has been demonstrated, weed management by this cultural tool goes beyond the cultivation stage, offering a weed management approach to the system as a whole.

Service crops should always seek benefits at the system level, generating effects at the level of (i) winter weeding present during the crop cycle, (ii) weeding of the following fallow, (iii) summer weeding, and (iv) residual effect on the following year's winter weeding. Without mentioning the first point, where the effect on weeds comes from a crop in vegetative stage, the suppression of spring summer weeding will be generated from the decomposing plant stubble of the crop sown in the previous season.

As for the stubble, it is important to select species that avoid the rapid decomposition of their stubble, allowing soil cover to be maintained for a longer period of time. Stubble from a leguminous service crop (e.g., *Vicia villosa*) will decompose faster than stubble from a grass crop, due to a very low C:N ratio compared to grass crops[26]. In this case, even if the crop has shown a significant suppressive effect during the winter, it could be favoring total weeding within the system.

As for the residual effect of these crops the following winter, it is achieved by preventing the weeds present from reaching the reproductive stage. In this way, cultural tools for weed management that allow weeds to develop and reach reproductive stages could reduce the soil seed bank in the long term.

On the other hand, the use of herbicides for the desiccation of service crops is the most usual practice among agricultural producers in the country. Tolerance to herbicides can be variable among species, and therefore the active ingredient used in each case can be very variable, especially when the service crop is legumes[27]. The moment of desiccation or suppression turns out to be a strategic moment in weed management. A good diagnosis that allows recognizing all the weed species that are coexisting with the service crop will allow including in the herbicides used for desiccation those active ingredients necessary to control the weeds that have remained in this stage.

The flexibility offered by the drying of a crop that does not need to reach physiological maturity to be harvested is one of the greatest benefits that this tool offers for weed management. The possibility of bringing forward the date of suppression allows the application to less developed weeds, preventing them from reaching reproductive stages. This allows ending the weed cycle, preventing them from forming viable seeds. In this way, even if the sown crop has not suppressed 100% of the weeds present, the management at the system level is considered highly successful. All this shows that in most weeds the use of herbicides within the crop is not necessary.

In no-tillage systems, there is another alternative that is not very widespread among farmers in the country, but has been used for decades in Brazil and Paraguay, which is mechanical drying through rolling. This technology consists of passing over the crop a cylinder of between 30-60 cm in diameter containing blunt leaves and which weight is adjusted to damage the vascular tissue of the plant, causing it to dry without cutting or pulling. In this way, it allows eliminating or reducing the usual dose of herbicides to finish the cycle of service crops, in addition to depositing the residue uniformly on the soil surface, improving coverage and thus the suppression of future weeds[28]. It should be noted that this technology is only successful in some crops and requires the crops to be at a certain stage of development, limiting the benefit of flexibility mentioned above.

4. Final considerations

Service crops imply an effective weed management, as long as the weeds present in the field are susceptible to this tool, the choice of the crop species contemplates this objective, and the management of each species is optimal, respecting and guaranteeing all its requirements.

Keywords: service crops, weeds, cultural management

Palabras clave: cultivos de servicio, malezas, manejo cultural

Palavras-chave: culturas de serviço, ervas daninhas, gestão cultural

Transparency of data

Available data: The information that supports this expanded abstract was cited in the document itself.

Author contribution statement

The Malherbology Group of the Faculty of Agronomy (Udelar) conceptualized the manuscript and developed the methodology, collected and interpreted the data, designed and carried out the data analysis. L. R. wrote the article, and all members of the group agreed with what was published.

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