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Weed Control Efficacy of Cover Crop as Green Mulching in Rice Cultivation

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Introduction

Weed management is one of the most troublesome aspect in rice cultivation, especially in organic rice (Rao et al., 2017). The adoption of cover crop, sowed during the intercropping period after rice harvest, may not only help to improve soil fertility but can also contribute in reducing weed infestations in the subsequent cropping season. Weed control efficacy of the technique depends on several factors, such as the selected rice variety, the termination technique, the type of weed species and the chosen cover crop species (Singh et al., 2015). The most suitable cover crop species are those that are able to emerge and grow quickly and that are highly competitive, such as rye, clover, ryegrass, and some brassica species (Ferrero et al., 2018). A technique that has recently been applied in Italian organic rice cultivation is the green mulching which consists of flooding the field after cover crop termination in order to start degradation of the biomass and the potential production of phytotoxic compounds (Vidotto et al., 2018). In order to assess the effect of using cover crops as green mulching on weed control and rice yield, a study was carried out in 2017 and 2018 in the two organic rice farms near Vercelli.

Materials and Methods

The study was conducted at two sites, located in Livorno Ferraris and Rovasenda. In each site, three different rice fields were sown in autumn, after rice harvest, with either *Vicia villosa*, *Lolium multiflorum*, or a mixture of both (*V. villosa* 40% + *L. multiflorum* 60%). An additional field at both sites without cover crop was considered as a control reference. Cover crops were sown in plowed fields, with the exception of Rovasenda in 2017, in which the cover crops were sown in non-tilled soil. Cover crop grew through the winter and rice was broadcasted within the cover crop in May.

After few days, roller-crimping and shredding were adopted to terminate the cover crops in half of each field. Within 10 days after sowing, the field was flooded for about a week to promote the degradation of the cover crop biomass. Then, the fields were dried to permit rice rooting and afterwards the rice was cultivated in flooding conditions without further weed control. The effect on weed density and weed cover on the soil was evaluated through the growing season. At harvest, rice yield, some yield components (hectoliter weight, number of seeds per panicle, etc.) and weed and crop biomass were determined.

A laboratory study was also conducted to assess the effect of submersion water, collected during cover crop biomass degradation after termination (3 to 4 samplings) and before the drying for rice rooting, on the germination of two weeds: weedy rice (*Oryza sativa*) and barnyardgrass (*Echinochloa crus-galli*). At each sampling time, 20 seeds of weedy rice and 25 seeds of barnyardgrass were placed in Petri dish with 5 mL of submersion water; 3 replications were made for water samples taken from each condition (cover crop species and termination method). Petri dishes were incubated in a growth chamber at constant 25°C with 16h light/8h dark and arranged in a RCBD design. Seed germination was recorded daily for 15 days. Regression analyses conducted between total germination (%) and the duration of the germination test (days), were used to determine in each condition the weed germination speed expressed as the time to reach 50% germination (G_{50}).

Results

Better cover crop emergence and establishment were observed when cover crop were sown in plowed fields. *L. multiflorum* showed a constant high biomass before termination at both sites in the two years,

while *V. villosa* had a more variable development as it was particularly sensitive to climatic conditions. This species showed a high biomass in 2017 at Livorno F., with a consequent high suppressive effect against weeds. Conversely, in 2018, *V. villosa* growth was limited because of the spring frosts occurred at both sites. In general, the green mulching significantly affected weed density. The best weed suppression was observed with *L. multiflorum* both crimped or shredded, in particular at Rovasenda, with values of weed density < 60 plants m^{-2} recorded in June. The highest weed density was observed in the control plots with values often higher than 900 plants m^{-2}. At both sites, rice yield was variable in the two years but with average values in line with those recorded in organically grown rice obtained with other techniques. Higher yields were observed in 2018, with the highest values (> 5 t ha^{-1}) observed in the shredded mixture field at both sites, and also in the plot with shredded *V. villosa* at Livorno F. Lowest yield (1 t ha^{-1}) were recorded in 2017 in the control field at both sites and in the crimped mixture at Livorno F. The termination methods did not significantly affect both weed density and rice yield.
The laboratory study showed that the submersion water had a very low effect on weed germination. The final total gemination reached values above 90% and 75%, for weedy rice and barnyardgrass, respectively, in all the tested conditions. Some effects of the submersion water on germination speed were observed, in particular for weedy rice. Slightly faster germination of the two weeds was recorded in the case of shredded mixture of cover crops. G_{50} for weedy rice showed average values of about 3 days, with significant lower values in case of water from *L. multiflorum* and the cover crop mixture at Livorno F.; at Rovasenda G_{50} was about 5 days, with the mixture being able to accelerate the germination compared to the other conditions. Barnyardgrass showed at Livorno F. a faster germination in case of water taken from the shredded mixture of cover crops, with average values of G_{50} of 4 days. At Rovasenda, the average G_{50} was 7 days, with the faster germination observed for crimped *V. villosa*.

Conclusions

The results of the study highlighted that green mulching can reduce weed infestations, even though alone is not able to complete avoid weed development. Some critical issues of the technique were observed, such as the need of a good cover crop establishment and growth, that eventually results in abundant biomass production and significant weed suppression. It was also observed that a good cover crop emergence was obtained in plowed soil compared to the non-tilled one. The study showed that the choice of the cover crop species has a key role: some species, such as *V. villosa*, can be very sensitive to low temperatures and their success can be hampered in certain years. The partial suppressive effect of the technique observed in this study seems more related to the mulching effect and not to the inhibition of germination caused by phytotoxic compounds, even though a slight faster weed germination was observed using water taken from the flooded cover crop fields.

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