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Establishment of three cover crop mixtures in vineyards

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ABSTRACT

Developing sustainable farming practices to support ecosystem functions and services are key issues of agro-ecology and conservation biology. In organic wine production, preserving soil fertility and weed control are essential tasks, because the use of synthetically processed herbicides, pesticides and fertilizers is strongly limited. Thus, it is vital to propose and test alternative techniques to link issues of weed control, preservation of soil fertility and the improvement and conservation of agro-biodiversity. To fulfil these issues, the use of species-rich cover crops became increasingly integrated into organic wine production. We evaluated the establishment of three vineyard cover crop seed mixtures sown in the vineyards of the Tokaj region, East-Hungary to answer the following questions: (i) which sown species were successfully established during the first year after sowing? (ii) Which sown species established successfully even during the second year? (iii) How effective were the sown cover crop seed mixtures in weed control? We evaluated three types of species-rich seed mixtures: Biocont-ECOWIN, Grass-medical forb and Legume seed mixtures. Percentage cover of vascular plant species was recorded in the inter-rows in five 1 × 1 m permanent plots in late June, 2012 and 2013. All sown species established within the study period. During the first year mostly short-lived species established successfully from the sown seed mixtures. During the second year *Lotus corniculatus*, *Medicago lupulina*, *Plantago lanceolata*, *Trifolium repens* and *Trifolium pratense* established the most successfully, and had high cover scores at most sites out of the sown species. A significant weed suppression was detected for all sown mixtures (Biocont-ECOWIN seed mixture: at two sites; Grass-medical forb seed mixture: at every site; Legume seed mixture: at two sites). The magnitude of weed suppression varied with the sown seed mixture. During the first year Biocont-ECOWIN seed mixture was the most successful in weed suppression. During the second year the cover of weeds was suppressed most effectively by Grass-medical forb and Legume seed mixtures. Our findings suggest that high diversity seed mixtures are suitable to establish permanent cover crops, which enables to use them successfully at sites with different abiotic conditions.

1. Introduction

Sustaining ecosystem functions and services, and testing sustainable farming practices are key issues of recent agro-ecological and conservation biological research and policy (Batáry et al., 2011; Kovács-Hostyánszki et al., 2011). To sustain both agricultural production and biodiversity, organic farmers have to apply suitable techniques for both agriculture and biodiversity conservation. Organic farming relies largely on locally available resources, for which sustaining ecosystem services, and the conservation of local agro-biodiversity is essential in the long term. Soil protection (by the mitigation of the effects of erosion and deflation), biological pest- and weed control and the maintenance of ecosystem services (pollination, water purification, soil protection and nutrient cycling) are key issues of organic farming (Batáry et al., 2011; Christ and Burritt, 2013). To fulfil all these issues, organic farming applies sustainable practices, for example the sowing of native cover crops or forb-rich seed mixtures (Török et al., 2011). Several studies demonstrated that organic farming systems are beneficial for the biodiversity of agro-ecosystems (Altieri, 1999; Tomich et al., 2011).

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Table 1
Species composition of the seed mixtures used in the study.

Species	Life form	Biocont-ECOWIN seed mixture	Legume seed mixture	Grass-medical forb seed mixture
Achillea millefolium	P	–	–	1.5 (174.4)
Centaurea cyanus	S	–	–	1.0 (3.2)
Centaurea jacea	P	–	–	1.0 (6.2)
Coronilla varia	P	–	10.0 (28.4)	10.0 (28.4)
Daucus carota	S	1.5 (14.1)	–	–
Fagopyrum esculentum	S	7.5 (3.0)	–	–
Festuca rupicola	P	–	–	30.0 (388.1)
Galium verum	P	–	–	1.5 (44.5)
Linum perenne	P	–	–	1.5 (12.0)
Lotus corniculatus	P	2.5 (18.8)	15.0 (112.5)	10.0 (75.0)
Medicago lupulina	S	15.0 (85.3)	15.0 (85.3)	10.0 (56.9)
Onobrychis viciifolia	P	34.5 (17.9)	14.5 (7.5)	–
Phacelia tanacetifolia	S	2.5 (13.1)	–	–
Plantago lanceolata	P	1.0 (3.8)	5.0 (19.0)	10.0 (38.1)
Salvia nemorosa	P	–	–	1.5 (10.9)
Sanguisorba minor	P	0.5 (0.5)	0.5 (0.5)	0.5 (0.5)
Silene vulgaris	P	–	–	1.5 (31.5)
Sinapis alba	S	5.0 (7.6)	–	–
Trifolium incarnatum	S	7.5 (24.2)	–	–
Trifolium pratense	P	–	15.0 (92.3)	5.0 (30.8)
Trifolium repens	P	7.5 (119.8)	15.0 (239.6)	5.0 (79.9)
Vicia sativa	S	15.0 (2.4)	10.0 (1.6)	10.0 (1.6)
Species number		12	9	16

Abbreviations in column 'life form': P—perennial; S—short-lived. Numbers in round brackets designate the number of thousand seeds per kilogram.

High economic and cultural value is attributed to the wine production and historical vineyards worldwide; thus, it is crucial to minimize the negative impacts associated with wine production and to ensure that the sector remains both economically and environmentally sustainable (Christ and Burritt, 2013). In organic wine production, preserving soil fertility and obtaining a successful weed control are essential, but the use of synthetically processed herbicides, pesticides and fertilizers is strongly restricted (FAO, 1999; Letourneau and Bothwell, 2008). To fulfil these goals, species-rich cover crops became increasingly integrated in organic wine production.

Sowing cover crop seed mixtures in vineyard inter-rows can ensure good soil fertility, soil structure and microbial activity. Cover crops can support the optimal growth of grapevine and the desired yield quantity and quality, while protecting the surroundings with creating habitats for local flora and fauna (Hartwig and Ammon, 2002). Furthermore, the vascular plant diversity of cover crop vegetation contributes to the overall biodiversity of vineyards, and provides an increased aesthetical value for vineyard eco-tourism, and also ensures regulating ecosystem services like pollination or pest-control. Cover cropping is increasingly used in weed control, as cover crops can suppress weeds by shading or by competition for nutrients and water (Creamer et al., 1996; Martin, 1996; Liebman and Davis, 2000). Although, several studies found that cover crops can also suppress the growth of grapevine if the sowing density and species composition of the cover crop seed mixture is inappropriate (Krohn and Ferree, 2005).

In the present study we evaluated the establishment of three types of vineyard cover crop seed mixtures in vineyards of the Tokaj region in North-East Hungary. We aimed to answer the following questions: (i) which sown species established successfully during the first year after sowing? (ii) Which sown species were successfully established even during the second year? (iii) How effective were the sown cover crop seed mixtures in weed control?

2. Materials and methods

In this study we evaluated three seed mixtures (Table 1): Biocont-ECOWIN, Grass-medical forb and Legume seed mixtures. Biocont-ECOWIN seed mixture is a commercially distributed seed mixture by Biocont Hungary Ltd., which was composed during the ECOWIN project (Vér and Takács, 2013). Legume- and Grass-medical forb seed mixtures were composed by the Research Institute of Organic Agriculture (ÖMKi), consulting with local vinegrowers and seed mixture experts.

The study sites were in the Tokaj region, North-East Hungary. Four vineyards were involved in the study: Hétszőlő (Tokaj), Degenfeld (Mád) and Oremus (Tolcsva; low and high). Two of the study sites had neutral or moderately basic pH values, clay loam soils with high N-content (Hétszőlő and Degenfeld), while the other two study sites were characterised by moderately acidic pH values and clay soils being the N-content of Oremus-low lower and the N-content of Oremus-high higher (Table 2). At each site the three seed mixtures were sown in March 2012 in three adjacent inter-rows and three unsown inter-rows were selected as control. The percentage cover of vascular plant species was recorded in the central sown and control inter-rows in five 1 × 1 meter permanent plots in late June, 2012 and 2013 (Fig. 1).

2.1. Data processing

Species were classified as sown and unsown species so that all unsown species were considered weeds. We used three-way repeated measures GLM to evaluate the experiment (Zuur et al., 2009). The cover of sown and weed species were included as dependent variables. 'sites' and 'seed mixtures' were the two fixed factors; 'year' was the repeated measures factor. Differences in cover scores between the two years within sites were analysed with paired *t*-tests. To assess the vegetation development between the first and the second year we calculated a PCA ordination based on log-

Table 2
Soil characteristics of the study sites.

Site	Slope (degree)	pH (KCl)	P_A	NO_3–N
Degenfeld	5	6.22	43	4.14
Hétszőlő	20	7.47	43	12.47
Oremus-low	12	5.29	51	2.18
Oremus-high	3	5.54	51	4.28

Notations: P_A: soil water capacity, expressed by the Arany-type plasticity index. Scores for P_A refer to coarse sand (25>), sand (25–30), sandy loam (30–37), loam (37–42), clay loam (42–50), clay (50–60) and, heavy clay (60<).