Ciência Téc. Vitiv. 27 (2) 73-82. 2012

VINEYARD WEED COMMUNITY DYNAMICS IN THE DÃO WINEGROWING REGION

DINÂMICA DA VEGETAÇÃO INFESTANTE DAS VINHAS DA REGIÃO VITIVINÍCOLA DO DÃO

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(Manuscrito recebido em 16.10.2012. Aceite para publicação em 08.01.2013)

SUMMARY

With the aim of analysing the influence of both the sub-region and weed-control practices on vegetation composition and dynamics in the Portuguese Dão Winegrowing Region, 120 vineyards were surveyed for weeds and winegrowers were asked to respond to a questionnaire in 2008. 206 *taxa* distributed across 31 families were recorded, with a predominance of *Fabaceae, Asteraceae* and *Poaceae*. The predominant vineyard inter-row soil management techniques were cover cropping (53%), with some cover sown but mostly relying on resident vegetation, and soil tillage (31%). Herbicides were applied in the row in 46%, and in the overall area in 4%, of the vineyards. Canonical correspondence analysis revealed significant effects of the sub-region and the different soil management strategies on vineyard community structure. Compared with the last (and only) study, which took place in 1950, weed composition was different and species diversity increased. The present study showed that resident vegetation also increased plant diversity. The dynamics of the perennial weed species *Cynodon dactylon* and *Convolvulus* arvensis must be carefully evaluated in order to avoid severe competition with the vine.

RESUMO

Com o objetivo de avaliar a influência da sub-região e dos métodos de gestão do solo da vinha na composição e dinâmica da vegetação infestante, no final do Inverno de 2008, foram efetuados 120 levantamentos florísticos e inquéritos aos viticultores nas sete sub-regiões da região vitivinícola do Dão. Registaram-se 206 táxones, distribuídos por 31 famílias, com predominância das *Fabaceae, Asteraceae* e *Poaceae*. Em mais de metade das vinhas (53%) procedia-se ao enrelvamento na entrelinha, semeado ou, predominantemente, natural, e num terço (31%) à mobilização total. Relativamente à aplicação de herbicidas, em 4% das vinhas fazia-se monda química em toda a área e em 46% aplicavam-se herbicidas na linha. A aplicação da análise canónica de correspondências mostrou que a composição da vegetação infestante presente nas vinhas era influenciada quer pela sub-região quer pela técnica de gestão do solo. Verificou-se um aumento na diversidade florística em relação ao último e único estudo efetuado em 1950. O nosso estudo mostrou ainda que o enrelvamento natural também aumentou a diversidade florística. A dinâmica das infestantes perenes como *Cynodon dactylon* e *Convolvulus arvensis*, presentes em todos os sistemas de de gestão do solo inventariados, exige um adequado programa de controlo de forma a evitar situações de elevada competição com a videira.

Key words: weeds, soil management, biodiversity, *Vitis vinifera*.
Palavras-chave: infestantes, gestão do solo, biodiversidade, *Vitis vinifera.*

INTRODUCTION

After the advent of herbicides and until recently, Portuguese vineyard soil management practices typically involved integrating soil tillage in the inter row with post- and pre-emergence herbicides in the row, with less emphasis on the incorporation of other control methods (Monteiro and Moreira, 2004). In the last two decades, vineyard soil management systems have been changing in Portugal; however, information about the importance of the methods applied and their implications for weed community dynamics is scarce. The need to reduce costs and make grape production more sustainable has prompted the use of alternative weed control practices that optimize production while maintaining profits. Cover cropping is consequently gaining popularity among Portuguese winegrowers.

Vineyard natural cover cropping can cause significant reductions in vine vegetative growth and yield, because the swards compete with vines for water and nutrients (Afonso *et al*., 2003; Celette *et al*., 2008; Lopes *et al*., 2011; Monteiro *et al*., 2012). Other studies in Portugal have shown that in some viticultural regions, resident vegetation can also be an important ecological vineyard management tool for controlling vigour and enhancing wine quality (Monteiro and Lopes, 2007; Lopes *et al*., 2008) and reducing pest densities (Campos *et al*., 2006).

The opinion that plant identification, plant richness (number of species) and diversity (relative abundance of species) play a major role in contributing to human welfare is emerging in land and crop management. Indeed, knowledge of the distribution and infestation of plant communities and the ecological factors involved in their diversity and variability is a determinant factor in rational weed control (Michez and Guillerm, 1984). Species compositional changes have been observed for different weed management systems (Wrucke and Arnold, 1985; Teasdale *et al*., 1991; Monteiro *et al*., 2008). Some weed species do not display a unique association with management practices, growing equally well in all systems. Zaragoza *et al*. (1989) reported that species number can be significantly reduced in no-till herbicide systems, but that annual grasses and perennial weed species predominate.

The identification of vineyard weeds and their relationship with ecological factors are well documented for most Portuguese winegrowing regions (Cerejeira, 1985; Barata, 1987; Espírito Santo, 1987; Ribeiro, 1988; Lopes, 1989; Moreira, 1990; Aguiar, 1992; Mira *et al*., 1999; Espírito Santo *et al*., 2000), but there is a paucity of published research on vineyard weed communities in the Dão winegrowing region. A single study on 26 mostly manually cultivated vineyards was carried out in 1950 (Pinto da Silva, 1971). However, the viticulture of the Dão is of great economic, importance because it covers about 20.000 ha, or 16% of the region's total agricultural area (Afonso, 2003). There is therefore a need for further studies on weed management strategies across the entire region and the response to them in terms of weed community dynamics.

At the same time, sustainable viticulture needs a multistrategy approach where weeds are responsive not only to weed control, but also to numerous other facets of viticulture. When the winegrower chooses a natural (resident vegetation) or sown cover crop, information about plant species that adapt well to the relevant ecological and agronomical factors is fundamental in order to avoid negative impacts on wine grape production. Annual plant species with a short life cycle and auto-sown or perennials that regenerate soon after the first autumn rains, preferably with low water consumption (Lopes *et al*., 2004), are recommended. There is also a need for research on cover cropping plant species (which are frequently considered to be weeds), as they might enhance biodiversity, wine quality and vineyard aesthetics, all of which are very important to the recent increase in the agro-tourism business. The present project's objectives were thus to use the weed-vineyard and winegrower surveys to: (1) characterize weed composition and density; (2) evaluate the ecological influence (sub-region) on plant-species composition and diversity in order to identify appropriate plant species for cover cropping; and (3) determine which soil management practices are used and their effects on weed community composition.

MATERIAL AND METHODS

The study was conducted in commercial vineyards throughout the Dão winegrowing region, Central Portugal, from March until May 2008. Vineyard-vegetation and winegrower surveys (120) were carried out in the seven Dão sub-regions. The site location of each survey is described by Caetano (2009). Individual plant species density was estimated using the scale proposed by Barralis (1975), where 1 = < 1; 2 = 1 to 2; 3 = 3 to 20; 4 = 21 to 50; and 5 > 51 plants/m^{-2}. The average density (D), absolute frequency (FA) and relative frequency (FR) for each species per survey were then calculated according to Barralis (1976):

$$D = (0.5n1+1.5n2+11.5n3+35.5n4+75.5n5)/(n1+n2+n3+n4+n5) \quad \text{(eq. 1)}$$

n1, n2, n3, n4, n5 – number of surveys where the species presented a density of 1, 2, 3, 4 and 5, respectively;

$$FA = n – a \quad \text{(eq. 2)}$$

n – total number of surveys;

a – number of surveys where the species was absent;

$$FR = 100*(n – a) / n \quad \text{(eq. 3)}$$

The weed infestation degree was evaluated according to Michez and Guillerm (1984) in a plot created by the relationship between FR (abscissa) and D (ordinate).

Plant species were also grouped according to annual broad-leaved species, annual grass species, perennial broad-leaved species, perennial grass species and other monocotyledons.

Canonical correspondence analysis (CCA) was used to elucidate weed community structure and associations, as they might be affected by geographical location (sub-region) and by soil management practices in the inter-row (treatments) (ter Braak and Smilauer, 1998). Analysis was based on weed species density per survey. Treatments were treated as independent variables and species density as dependent variables. The geographic variables were the seven sub-regions: Alva, Besteiros, Castendo, Serra da Estrela, Silgueiros, Terras de Azurara, and Terras de Senhorim. The soil management practice variables were: soil tillage (MOB), chemical control (HERB), resident vegetation (RNA), and sown cover crop (RSE). CCA was performed in CANOCO (Canoco for Windows version 4.5), with axis scores centred to interspecies distances and biplot scaling. Automatic forward selection with Monte Carlo permutation test was used to determine the significance of the treatments. Treatment centroids and canonical coefficients for the species are presented in biplots. Proximity of species score to a treatment centroid signifies that the species had the highest density in that treatment.

RESULTS AND DISCUSSION

Weed vegetation composition and diversity

A total of 206 *taxa* were surveyed in inter-row for the region as a whole (Table I). In 1950, Pinto da Silva (1971) identified 84 *taxa* as dominants and 60 as casuals. Most of these 144 *taxa* were also recorded in the present study.

The observed *taxa* are distributed across 31 families, with *Fabaceae*, *Asteraceae*, *Poaceae* and *Caryophyllaceae* the dominant ones (Table II). Considering only the dominant *taxa* referred by Pinto da Silva (1971)

60 years ago, the main families were *Asteraceae* (25%), *Poaceae* (20.2%), *Caryophyllaceae* (8.3%), and *Fabaceae* (4.8%). For the casual species in the same study, *Fabaceae* represented 10% a value that is lower than the one recorded in the present study. In our study the three dominant families included 55% of the total surveyed *taxa*. This percentage was higher than in other portuguese viticultural regions, as evidenced by Cerejeira (1985) in the Ribatejo (40.7%), Barata (1987) in Palmela, Sesimbra and Setúbal (37%), Espírito Santo (1987) in Bombarral (46.7%), Ribeiro (1988) in the Douro (37%), Lopes (1989) in Bairrada (40%), Aguiar (1992) in Óbidos (41%) and Mira *et al*. (1999) in Évora and Borba (50%).

The relationship between weed relative frequency and average species density is illustrated in Figure 1 and the corresponding values are presented in Table I. *Taxa* with a very high infestation degree (group ++++) were not found in Dão vineyards.

Many species with a high infestation degree (group +++) were found in the surveys – e.g. the annual broad-leaved species *Chamaemelum fuscatum, Conyza albida, Ornithopus compressus, Spergula arvensis* and *Trifolium glomeratum*, the annual grass species *Lolium rigidum, Poa annua* and *Vulpia bromoides* and the perennial broad-leaved species *Convolvulus arvensis* and *Hypochaeris radicata*. Most of the recorded species in the high infestation group are winter annuals whose growth season ended in late spring. Particular attention must be paid to the genus *Conyza*, because *C. albida* was found throughout the Dão region, while *C. bonariensis* was only observed in the Serra da Estrela and Alva sub-regions. The species in this genus frequently behave like perennials in cover-cropping systems, increasing their density annually. Controlling *Conyza* spp. chemically is difficult because the efficacy of the registered herbicides for vineyards is low.

A considerable number of species with a medium degree of infestation (group ++) were recorded as both annuals and perennials. Most of the annual grass species were included in this group (*Agrostis* sp., *Avena* spp., *Briza* spp. *Bromus* spp., *Hordeum* sp. *Lolium multiflorum, Poa annua, Vulpia geniculata),* as were some *Fabaceae* species that are appropriate for cover cropping – e.g. *Medicago arabica*, *Lotus conimbricensis, Lotus hispidus* (Serra da Estrela sub-region only), *Lupinus angustifolius* ssp. *reticulatus, L. gredensis, L. luteus, Ornithopus pinnatus, O. sativus* ssp. *isthmocarpus, Trifolium cernuum, T. incarnatum, T. michelianum, T. repens, T. resupinatum* and *T. vesiculosum* (Table I; Figure 1). Some perennial broad-leaved species (*Andryala integrifolia, Chondrilla juncea, Plantago lanceolata, Rumex pulcher*) and the perennial grass *Cynodon dactylon* also displayed a medium degree of infestation. In general, these species were found throughout the region and seemed well adapted to the different management practices. Most of these *taxa* were also considered weeds by Pinto da Silva (1971) and, if improperly managed, they could be water-competitive with the vines due to their deep roots. *Cynodon dactylon* rhizomes can grow deep and regenerate even at 40 cm depth (Moreira, 1978).

Finally, the low (+) and very low (0) infestation groups comprise about 20% of the species we found (Table I, noted only in the lower left corner of Figure 1).

Effect of sub-region on weed communities

Canonical correspondence analysis (CCA) revealed significant community differences among sub-regions (Figure 2). Although all the species recorded were included in the multivariate analysis, only those with the greatest ability to explain the differences between sub-regions are shown in Figure 2. The first canonical axis in the biplot of flora species explained 26.5% of the variance between sub-regions, while the second axis explained 22.3%. Based on the ordination diagram, five groups of weed species are well related with one or more particular sub-regions. The weed communities associated with the Serra de Estrela (rSE = -0.71) were distinct from those linked to Besteiros (rBEST = 0.85), as can be seen from its opposite position on axis 1; Terras de Senhorim (rTERSE = 0.70) was distinct from Alva (rALV = 0.33), based on its opposite position on axis 2. The weed communities associated with Terras de Azurara, Castendo and Silgueiros were similar, all positively related with axis 2. Having said this, many *taxa* have scores close to the axis origins, indicating their ubiquity in all sub-regions, and others were surveyed in more than, or only, one sub-region (Table I; Figure 2). The combination of the data presented by sub-region in Table I with Figure 2 revealed a large number of weed species associated with each of the five sub-regional groups.

When considering the species with specific interest for cover cropping and with high value for vineyard agro-tourism, we observed that:

i) The Serra da Estrela sub-region was associated with the presence of *Agrotis pourretii, Vulpia geniculata, Lotus corniculatus* ssp. *corniculatus, L. hispidus, Ononis spinosa, Trifolium cernuum, Vicia cordata,* and the *Papaveraceae Papaver hybridum.*

ii) In the Alva sub-region *Medicago sativa, Trifolium dubium* and *Lytrum junceum,* and in Besteiros *Lathyrus sylvestris, Medicago arabica, Epilobum tetragonum, Galactites tomentosa, Anagallis arvensis* var. *caerulea, Torilis nodosa, Ranunculus bulbosus* and *Myosotis persoonii*, particularly stand out.

iii) The following *taxa* were associated with the Terras de Senhorim sub-region: *Trifolium nigrum, Poa bulbosa, Centhranthus calcitrapae, Filago pyramidata* and *Phalaris aquatica.*

iv) The group composed of the Terras de Azurara, Castendo and Silgueiros sub-regions was correlated

TABLE I

Absolute frequency (FA), relative frequency (FR - % of the total surveys) and average abundance (AM – no. of plants m-2) of the taxa recorded between row throughout the Dão winegrowing region. Sub-region: 1 – Serra da Estrela; 2 – Alva; 3 – Besteiros; 4 – Silgueiros; 5- Terras de Azurara; 6 – Terras de Senhorim; 7 – Castendo. MOB – soil tillage over the between row; RNA - permanent resident vegetation between row; RSE – permanent sown cover crop between row; HERB – herbicide treatment between row. • - *Taxa* recorded in the sub-region; X - Taxa recorded in the soil management practices.

Frequência absoluta (FA), frequência relativa (FR - % em relação ao total de inventários) e abundância média (D. - nº plantas m-2) dos táxones inventariados na entrelinha. Sub-região: 1 – Serra da Estrela; 2 – Alva; 3 – Besteiros; 4 – Silgueiros; 5 - Terras de Azurara; 6 – Terras de Senhorim; 7 – Castendo. MOB – mobilização do solo; RNA – enrelvamento natural permanente; RSE – enrelvamento semeado permanente; HERB – controlo químico.

Bayer Code/Scientific name		*Taxa* Data			Sub-region							Soil management			
		FA	FR	D	1	2	3	4	5	6	7	MOB	RNA	RSE	HERB
Annual broad-leaved species															
AMIMA	*Ammi majus* L.	3	2.5	4.5		●				●		X	X		
ANGAR	*Anagallis arvensis* L. var. *arvensis* L.	24	20.0	15.9	●	●	●	●	●	●	●	X	X	X	X
ANGCO	*Anagallis arvensis* L. var. *caerulea* (L.) Gouan	1	0.8	1.5			●						X		
ANTAR	*Anthemis arvensis* L.	27	22.5	13.6	●	●	●	●	●	●	●	X	X	X	X
AILLO	*Anthyllis lotoides* L.	5	4.2	3.1	●						●	X	X		
APHAU	*Aphanes australis* Rydb.	7	5.8	8.9	●	●	●			●		X	X	X	X
ARBTH	*Arabidopsis thaliana* (L.) Heynh.	1	0.8	0.5	●								X		
ASTPE	*Astragalus pelecinus* (L.) Barneby ssp. *pelecinus*	1	0.8	11.5	●								X		
BRSBA	*Brassica barrelieri* (L.) Janka ssp. *barrelieri*	40	33.3	7.8	●	●	●	●	●	●	●	X	X	X	X
BRSBO	*Brassica barrelieri* (L.) Janka ssp. *oxyrrhina* P.W.Ball. & Hey.	17	14.2	7.6	●	●			●	●	●	X	X	X	
CLDAR	*Calendula arvensis* L.	69	57.5	12.7	●	●	●	●	●	●	●	X	X	X	X
CAPRU	*Capsella rubella* Reuter	24	20.0	9.7	●			●	●	●	●	X	X	X	X
CARHI	*Cardamine hirsuta* L.	28	23.3	9.1	●	●	●		●	●	●	X	X	X	X
CRUTE	*Carduus tenuiflorus* Curt.	3	2.5	4.1					●	●		X	X		
CENCA	*Centhranthus calcitrapae* L.	1	0.8	1.5						●			X		
CERGL	*Cerastium glomeratum* Thuill.	103	85.8	19.8	●	●	●	●	●	●	●	X	X	X	X
ANTPR	*Chamaemelum fuscatum* (Brot.) Vasc.	95	79.2	20.5	●	●	●	●	●	●	●	X	X	X	X
ANTMI	*Chamaemelum mixtum* L.	20	16.7	23.8	●	●			●	●		X	X	X	X
CHEAL	*Chenopodium album* L.	28	23.3	38.9	●	●			●	●	●	X	X	X	X
CHYSE	*Chrysantemum segetum* L.	18	15.0	5.1	●	●	●	●	●	●	●	X	X		X
CHYMY	*Coleostephus myconis* (L.) Rchb. f.	58	48.3	16.9	●	●	●	●	●	●	●	X	X	X	X
ERIFL	*Conyza albida* Spreng.	86	71.7	19.4	●	●	●	●	●	●	●	X	X	X	X
ERIBO	*Conyza bonariensis* (L.) Cronq.	3	2.5	40.8	●	●						X	X		
CZRRE	*Coronilla repanda* (Poir.) Guss. ssp. *dura* (Cav.) Cout.	2	1.7	1.0	●							X	X		
CGLLI	*Corrigiola litoralis* L.	15	12.5	6.5	●		●		●	●	●	X	X	X	X
CVPCA	*Crepis capillaris* (L.) Wallr.	24	20.0	12.8	●	●	●		●	●	●	X	X	X	X
CVPVV	*Crepis versicaria* L.	1	0.8	11.5						●					X
DAUCA	*Daucus carota* L. ssp. *carota*	23	19.2	7.3	●	●	●	●	●	●	●	X	X	X	X
EHIPL	*Echium plantagineum* L.	61	50.8	6.6	●	●	●	●	●	●	●	X	X	X	X
EROAE	*Erodium aethiopicum* (Lam.) Brumh.& Thell	52	43.3	10.1	●		●	●	●	●	●	X	X	X	X
EROBO	*Erodium botrys* (Cav.) Bertol.	3	2.5	24.2	●				●			X	X		
EROMO	*Erodium moschatum* (L.) L'Hér.	71	59.2	17.6	●	●	●	●	●	●	●	X	X	X	X
POLCO	*Fallopia convolvulus* (L.) Á. Löve	2	1.7	18.0	●					●			X		X
FILPY	*Filago pyramidata* L.	2	1.7	0.5						●	●	X			X
FUMMU	*Fumaria muralis* Koch	53	44.2	4.4	●	●	●	●	●	●	●	X	X	X	X
GCTTO	*Galactites tomentosa* Moench	2	1.7	6.0			●				●	X			
GALPR	*Galium parisiense* L.	3	2.5	0.5		●	●					X	X		X
GALPD	*Galium parisiense* L. ssp. *divaricatum* (Pourr. ex Lam.) Rouy & EG. Camus	5	4.2	16.9	●	●			●	●			X	X	
GAMOC	*Gamochaeta calviceps* (Fernald.) Cabrera	3	2.5	12.8					●	●			X		
GERDI	*Geranium dissectum* L.	27	22.5	13.6	●	●	●	●	●	●	●	X	X	X	X
GERMO	*Geranium molle* L.	14	11.7	19.6	●	●			●	●		X	X		X
GERPP	*Geranium purpureum* Vill.	1	0.8	1.5	●								X		
GERRO	*Geranium robertianum* L.	1	0.8	1.5	●								X		
GERRT	*Geranium rotundifolium* L.	3	2.5	19.5						●		X		X	X
HYNCR	*Hedypnois cretica* (L.) Dum.-Courset	2	1.7	23.5			●		●			X			
HYCGL	*Hypochaeris glabra* L.	39	32.5	15.9	●	●	●	●	●	●	●	X	X	X	X
IAIMO	*Jasione montana* L.	3	2.5	0.8	●				●	●			X		
IUNBU	*Juncus bufonius* L.	5	4.2	3.3	●	●				●		X	X	X	
LACSE	*Lactuca serriola* L.	15	12.5	4.6	●	●			●	●	●	X	X	X	X
LAMAM	*Lamium amplexicaule* L.	25	20.8	6.4	●			●	●	●	●	X	X	X	X
LAMPU	*Lamium purpureum* L.	18	15.0	4.1	●	●		●	●	●	●	X	X	X	X
LTHAG	*Lathyrus angulatus* L.	13	10.8	7.6	●	●	●		●	●		X	X	X	X
LTHOD	*Lathyrus odoratus* L.	1	0.8	0.5					●					X	
LVACR	*Lavatera cretica* L.	5	4.2	25.1	●					●			X		
LINSP	*Linaria spartea* (L.) Willd.	15	12.5	5.4	●		●		●	●	●	X	X		X
FILGA	*Logfia gallica* (L.) Cosson & Germ.	18	15.0	6.5	●	●	●	●	●	●		X	X		X
LOTIM	*Lotus conimbricensis* Brot.	5	4.2	5.5		●	●		●	●			X		X
LOTSU	*Lotus hispidus* Desf. ex DC.	1	0.8	11.5	●								X		
LUPAT	*Lupinus angustifolius* L. ssp. *reticulatus* (Desv.) Cout.	11	9.2	16.4	●			●	●	●	●	X	X	X	
LUPGR	*Lupinus gredensis* Gand.	38	31.7	3.5	●	●	●	●	●	●	●	X	X	X	X
LUPLU	*Lupinus luteus* L.	21	17.5	4.6	●	●		●	●	●	●	X	X	X	X
LUPMI	*Lupinus micranthus* Guss.	6	5.0	1.3	●				●			X	X	X	
MALPA	*Malva parviflora* L.	15	12.5	11.2	●	●			●	●	●	X	X	X	X
MEDAB	*Medicago arabica* (L.) Huds.	1	0.8	75.5			●					X			
MEDPO	*Medicago polymorpha* L.	17	14.2	19.4	●	●	●		●	●		X	X	X	X
ATHOR	*Misopates orontium* (L.) Raf.	31	25.8	7.9	●					●	●	X	X	X	X
MYODI	*Myosotis discolor* Pers.	3	2.5	0.8	●	●							X		
MYOPE	*Myosotis persoonii* Rouy	1	0.8	0.5			●					X			
OROCO	*Ornithopus compressus* L.	109	90.8	26.8	●	●	●	●	●	●	●	X	X	X	X
OROPI	*Ornithopus pinnatus* (Mill.) Druce	37	30.8	15.3	●	●	●	●	●	●	●	X	X	X	X
OROSI	*Ornithopus sativus* Brot. ssp. *isthmocarpus* (Coss.) Dostál	18	15.0	26.9	●	●			●	●	●	X	X	X	
PAPDU	*Papaver dubium* L.	5	4.2	12.1	●					●	●	X	X		X
PAPHY	*Papaver hybridum* L.	1	0.8	75.5	●								X		
PARCY	*Paronychia cymosa* (L.) DC.	8	6.7	4.9	●						●	X	X		X
PICEC	*Picris echioides* L.	5	4.2	2.7	●	●	●			●		X	X		X
PLACO	*Plantago coronopus* L.	11	9.2	7.9	●					●		X	X		X
PLALG	*Plantago lagopus* L.	52	43.3	9.3	●	●	●	●	●	●	●	X	X	X	X
POYTE	*Polycarpon tetraphyllum* (L.) L.	2	1.7	0.5		●				●		X			X
POLAV	*Polygonum aviculare* L.	32	26.7	14.2	●	●			●	●	●	X	X	X	X
POLPE	*Polygonum persicaria* L.	2	1.7	6.5					●			X	X		
POLRU	*Polygonum rurivagum* Boreau	2	1.7	6.5					●	●		X			
GNALA	*Psedognaphalium luteo-album* (L.) Hill. & B. L. Burtt	10	8.3	0.8		●	●		●	●		X	X	X	X
PULPA	*Pulicaria paludosa* Link	1	0.8	0.5							●				X
RANMU	*Ranunculus muricatus* L.	6	5.0	6.2	●	●	●	●				X	X	X	
RANTL	*Ranunculus trilobus* Desf.	4	3.3	12.3			●		●		●	X	X		X
RAPRA	*Raphanus raphanistrum* L.	99	82.5	15.3	●	●	●	●	●	●	●	X	X	X	X
RUMBU	*Rumex bucephalophorus* L.	34	28.3	15.4	●	●	●	●	●	●	●	X	X	X	X
SCRAN	*Scleranthus annuus* L.	6	5.0	4.7	●				●			X	X	X	
SCSVE	*Scorpiurus vermiculatus* L.	1	0.8	0.5	●								X		
SENLI	*Senecio lividus* L.	19	15.8	4.3	●	●	●	●	●	●	●	X	X	X	X
SENVU	*Senecio vulgaris* L.	88	73.3	11.0	●	●	●	●	●	●	●	X	X	X	X
SILGA	*Silene gallica* L.	73	60.8	10.3	●	●	●	●	●	●	●	X	X	X	X
SINAR	*Sinapis arvensis* L.	1	0.8	1.5	●								X		
SOLSU	*Solanum sublobatum* Willd.	2	1.7	6.5	●							X	X		
SONAS	*Sonchus asper* (L.) Hill ssp. *asper*	11	9.2	2.8	●	●	●			●	●	X	X	X	X
SONOL	*Sonchus oleraceus* L.	22	18.3	11.7	●	●			●	●	●	X	X		X
SONTE	*Sonchus tenerrimus* L.	81	67.5	6.9	●	●	●	●	●	●	●	X	X	X	X
SPRAR	*Spergula arvensis* L.	83	69.2	25.0	●	●	●	●	●	●	●	X	X	X	X
SPBPU	*Spergularia purpurea* (Pers.) G. Don f.	16	13.3	5.8	●		●		●	●	●	X	X	X	X
STAAR	*Stachys arvensis* (L.) L.	52	43.3	5.0	●	●	●	●	●	●	●	X	X	X	X
STEME	*Stellaria media* (L.) Vill.	97	80.3	16.3	●	●	●	●	●	●	●	X	X	X	X
TOLBA	*Tolpis barbata* (L.) Gaertn.	21	17.5	16.4	●	●			●	●	●	X	X	X	X
TOINO	*Torilis nodosa* (L.) Gaertn.	1	0.8	0.5			●								X
TRFAN	*Trifolium angustifolium* L.	19	15.8	17.5	●			●	●	●	●	X	X		X
TRFAR	*Trifolium arvense* L.	25	20.8	13.9	●	●	●	●	●	●	●	X	X	X	X
TRFCA	*Trifolium campestre* Schreber	5	4.2	12.1		●	●	●			●	X	X		
TRFCE	*Trifolium cernuum* Brot.	1	0.8	75.5	●								X		
TRFDU	*Trifolium dubium* Sibth.	6	5.0	24.5	●	●			●				X	X	
TRFGL	*Trifolium glomeratum* L.	70	58.3	21.5	●	●	●	●	●	●	●	X	X	X	X
TRFIN	*Trifolium incarnatum* L.	5	4.2	49.9	●				●	●				X	X

TABLE I (continuation)

Absolute frequency (FA), relative frequency (FR - % of the total surveys) and average abundance (AM – no. of plants m-2) of the taxa recorded between row throughout the Dão winegrowing region. Sub-region: 1 – Serra da Estrela; 2 – Alva; 3 – Besteiros; 4 – Silgueiros; 5- Terras de Azurara; 6 – Terras de Senhorim; 7 – Castendo. MOB – soil tillage over the between row; RNA - permanent resident vegetation between row; RSE – permanent sown cover crop between row; HERB – herbicide treatment between row. • - *Taxa* recorded in the sub-region; X - Taxa recorded in the soil management practices.

Frequência absoluta (FA), frequência relativa (FR - % em relação ao total de inventários) e abundância média (D. - nº plantas m-2) dos táxones inventariados na entrelinha. Sub-região: 1 – Serra da Estrela; 2 – Alva; 3 – Besteiros; 4 – Silgueiros; 5 - Terras de Azurara; 6 – Terras de Senhorim; 7 – Castendo. MOB – mobilização do solo; RNA – enrelvamento natural permanente; RSE – enrelvamento semeado permanente; HERB – controlo químico.

Bayer Code/Scientific name		*Taxa* Data			Sub-region							Soil management			
		FA	FR	D	1	2	3	4	5	6	7	MOB	RNA	RSE	HERB
Annual broad-leaved species															
TRFMI	*Trifolium michelianum* Savi	8	6.7	52.0	●	●			●	●			X	X	X
TRFNI	*Trifolium nigrescens* Viv.	1	0.8	11.5						●					X
TRFRS	*Trifolium resupinatum* L.	12	10.0	55.3	●	●			●	●		X	X	X	X
TRFSL	*Trifolium stellatum* L.	2	1.7	43.5	●					●			X		X
TRFST	*Trifolium striatum* L.	2	1.7	23.5	●				●				X	X	
TRFSU	*Trifolium subterraneum* L.	16	13.3	30.5	●	●	●		●	●	●	X	X		X
TRFVE	*Trifolium vesiculosum* Viv.	4	3.3	59.5	●				●	●				X	X
URTUR	*Urtica urens* L.	3	2.5	27.5	●	●							X		
VERAG	*Veronica arvensis* L.	15	12.5	9.1	●	●			●	●	●	X	X	X	X
VERHE	*Veronica hederifolia* L.	4	3.3	3.5					●	●	●	X	X		
VERPE	*Veronica persica* Poir.	13	10.8	6.8	●	●	●	●	●	●	●	X	X	X	X
VICAN	*Vicia angustifolia* L.	35	29.2	15.0	●	●	●		●	●	●	X	X	X	X
VICBE	*Vicia benghalensis* L.	4	3.3	9.0	●				●	●			X	X	X
VICSC	*Vicia cordata* Wulf. ex. Hoppe	2	1.7	6.5	●								X		
VICVV	*Vicia dasycarpa* Ten.	1	0.8	1.5					●					X	
VICDI	*Vicia disperma* DC.	3	2.5	12.5	●					●		X	X		X
VICHI	*Vicia hirsuta* (L.) Gray	17	14.2	15.7	●		●		●	●	●	X	X	X	X
VICLU	*Vicia lutea* L.	16	13.3	17.6	●	●		●	●	●	●	X	X	X	X
VICPS	*Vicia pseudocracca* Bertol.	2	1.7	6.5						●		X			X
VICSA	*Vicia sativa* L.	26	21.7	13.2	●	●	●	●	●	●	●	X	X	X	X
VIOAR	*Viola arvensis* Murray	10	8.3	16.0	●						●	X	X	X	

Bayer Code/Scientific name		*Taxa* Data			Sub-region							Soil management			
		FA	FR	D	1	2	3	4	5	6	7	MOB	RNA	RSE	HERB
Annual grass species															
AGSSA	*Agrostis pourretii* Willd.	1	0.8	11.5	●							X			
AIRCA	*Aira caryophyllea* L. ssp. *caryophyllea*	5	4.2	10.1	●	●						X	X		
AIRCU	*Aira cupaniana* Guss.	3	2.5	15.8	●	●						X			X
AVEBA	*Avena barbata* Link	41	34.2	15.4	●	●	●		●	●	●	X	X	X	X
AVESA	*Avena sativa* L.	3	2.5	15.8	●				●	●		X		X	
BRZMA	*Briza maxima* L.	5	4.2	9.5	●				●			X	X	X	
BRZMI	*Briza minor* L.	6	5.0	8.5		●	●			●		X	X		
BRODI	*Bromus diandrus* Roth	48	40.0	19.7	●	●	●		●	●	●	X	X	X	X
BROMO	*Bromus hordeaceus* L.	4	3.3	6.3	●						●	X	X		
BROMA	*Bromus madritensis* L.	10	8.3	23.1	●	●			●	●	●		X		X
HORLE	*Hordeum murinum* L. ssp. *leporinum* (Link) Archangeli	15	12.5	9.4	●				●	●	●	X	X	X	
LOLMU	*Lolium multiflorum* Lam.	13	10.8	58.7	●	●			●	●		X	X	X	X
LOLRI	*Lolium rigidum* Gaudin	67	55.8	30.1	●	●	●	●	●	●	●	X	X	X	X
LOLTE	*Lolium temulentum* L.	1	0.8	11.5	●								X		
MIPMI	*Mibora minima* (L.) Desv.	23	19.2	25.0	●			●	●	●	●	X	X	X	X
POAAN	*Poa annua* L.	97	80.8	27.4	●	●	●	●	●	●	●	X	X	X	X
VLPBR	*Vulpia bromoides* (L.) S. F. Gray	45	37.5	24.9	●	●	●		●	●	●	X	X	X	X
VLPGE	*Vulpia geniculata* Link	2	1.7	43.5	●								X		

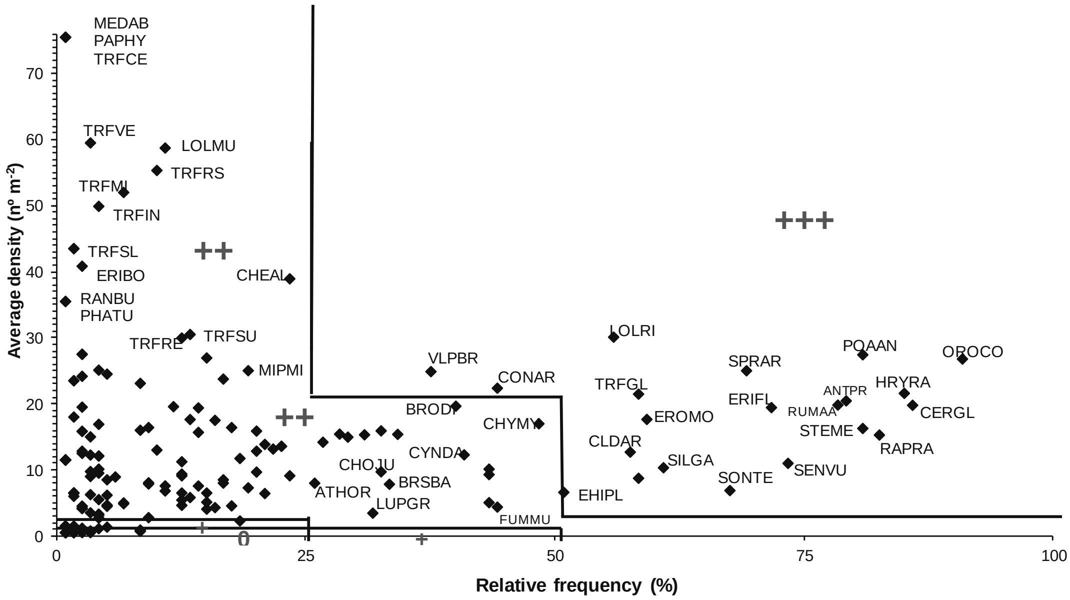
Bayer Code/Scientific name		*Taxa* Data			Sub-region							Soil management			
		FA	FR	D	1	2	3	4	5	6	7	MOB	RNA	RSE	HERB
Perennial broad-leaved species															
AHRBE	*Anarrhinum bellidifolium* (L.) Willd.	1	0.83	0.50	●							X			
ADYIN	*Andryala integrifolia* L.	70	58.33	8.73	●	●	●	●	●	●	●	X	X	X	X
CENAR	*Centaurea aristata* Hoffmanns. & Link	2	1.7	0.5	●						●	X			
CHOJU	*Chondrilla juncea* L.	39	32.5	9.7	●	●	●		●	●	●	X	X	X	X
CNQDE	*Conopodium majus* (Gouan) Loret	2	1.7	0.5	●						●	X	X		
CONAR	*Convolvulus arvensis* L.	53	44.2	22.4	●	●	●	●	●	●	●	X	X	X	X
CZSMU	*Cytisus multiflorus* (L'Hér.) Sweet	1	0.8	0.5	●								X		
DIKPU	*Digitalis purpurea* L.	3	2.5	4.2	●		●					X	X		
EPIAD	*Epilobium tetragonum* L.	1	0.8	11.5			●								X
HERSC	*Herniaria scabrida* Boiss.	1	0.8	11.5	●							X			
HYPHU	*Hypericum humifusum* L.	6	5.0	4.5	●		●		●			X	X		X
HYPLI	*Hypericum linarifolium* Vahl	5	4.2	1.1	●				●	●		X	X	X	X
HYPPA	*Hypericum perforatum* (L.) ssp. *angustifolium* DC.	2	1.7	1.5					●	●				X	X
HYPPE	*Hypericum perforatum* (L.) ssp. *perforatum*	3	2.5	1.2	●					●			X	X	
HYPUN	*Hypericum undulatum* Willd.	10	8.3	0.7	●				●	●		X	X		X
HRYRA	*Hypochaeris radicata* L.	102	85.0	21.6	●	●	●	●	●	●	●	X	X	X	X
LTHSY	*Lathyrus sylvestris* L.	1	0.8	1.5			●					X			
LEBNT	*Leontodon taraxacoides* (Vill.) Mérat	3	2.5	27.5	●		●					X	X		
LOTCO	*Lotus corniculatus* L.ssp.*corniculatus*	1	0.8	11.5	●								X		
LOTUL	*Lotus pedunculatus* Cav.	4	3.3	0.8	●	●				●		X	X		
LYTJU	*Lytrum junceum* Banks & Solander	1	0.8	11.5		●						X			
MEDSA	*Medicago sativa* L.	1	0.8	1.5		●							X		
MENRO	*Mentha rotundifolia* (L.) Hudson	4	3.3	0.5	●		●		●	●		X	X	X	X
ONOSP	*Ononis spinosa* L. ssp. *spinosa*	1	0.8	0.5	●								X		
OXACO	*Oxalis corniculata* L.	1	0.8	0.5		●						X			
OXAPC	*Oxalis pes-caprae* L.	1	0.8	11.5	●							X			
PLALA	*Plantago lanceolata* L.	12	10.0	13.0	●				●	●	●	X	X	X	X
RANBU	*Ranunculus bulbosus* L.	1	0.8	35.5			●								X
REIPI	*Reichardia picroides* (L.) Roth	6	5.0	4.5	●			●		●	●	X	X		X
RESPH	*Reseda phyteuma* L.	3	2.5	4.2		●			●	●			X	X	X
RUMAA	*Rumex acetosella* L. ssp. *angiocarpus* (Murb.) Murb.	94	78.3	19.8	●	●	●	●	●	●	●	X	X	X	X
RUMCO	*Rumex conglomeratus* Murray	1	0.8	11.5						●			X		
RUMCR	*Rumex crispus* L.	8	6.7	5.0	●	●				●		X	X	X	
RUMPU	*Rumex pulcher* L.	20	16.7	8.0	●	●	●	●	●	●	●	X	X	X	X
SANMM	*Sanguisorba minor* Scop. ssp. *magnolii* (Spach) Briq.	4	3.3	0.8	●	●				●		X	X		X
SANVE	*Sanguisorba verrucosa* Link	10	8.3	0.9	●		●	●	●	●	●	X	X		X
SENJA	*Senecio jacobaea* L.	3	2.5	4.2		●				●			X		X
SSMCA	*Sesamoides interrupta* (Boreau) G. López	5	4.2	10.1	●					●		X	X		
SILVU	*Silene latifolia* Poir.	2	1.7	0.5	●							X	X		
SOLNI	*Solanum nigrum* L.	3	2.5	4.5	●	●			●				X		
SONAG	*Sonchus asper* (L.) Hill ssp. *glaucescens* (Jord.) Ball	11	9.2	8.1	●	●	●		●	●	●	X	X	X	X
CHYVU	*Tanacetum vulgare* L.	1	0.8	0.5	●							X			
TERFU	*Taraxacum fulvum* Raunk.	1	0.8	1.5				●				X			
TAROF	*Taraxacum officinale* (L.) Weber	2	1.7	6.5	●	●						X			
THPVI	*Thapsia villosa* L.	1	0.8	0.5						●		X			
TRFPR	*Trifolium pratense* L.	1	0.8	0.5					●				X		
TRFRE	*Trifolium repens* L.	15	12.5	30.0	●	●	●		●		●	X	X		
VIORI	*Viola riviniana* Reichenb.	1	0.8	0.5						●			X		
Perennial grass species															
CYNDA	*Cynodon dactylon* (L.) Pers.	49	40.8	12.3	●	●	●	●	●	●	●	X	X	X	X
DACGL	*Dactylis glomerata* L.	4	3.3	9.8	●				●	●		X	X	X	
HOLLA	*Holcus lanatus* L.	2	1.7	0.5	●						●	X	X		
HOLMO	*Holcus mollis* L.	4	3.3	15.0					●	●		X	X		
PANRE	*Panicum repens* L.	1	0.8	11.5					●			X			
PHATU	*Phalaris aquatica* L.	1	0.8	35.5						●				X	
POABU	*Poa bulbosa* L.	1	0.8	11.5						●			X		
POHVI	*Polypogon viridis* (Gouan) Breistr.	20	16.7	8.5	●	●	●	●	●	●	●	X	X		X
Other monocotyledons															
MUSCO	*Muscari comosum* (L.) Mill.	22	18.3	2.3	●	●	●	●	●	●	●	X	X	X	X
Number of *Taxa*	**206**				**160**	**101**	**84**	**51**	**120**	**136**	**95**	**154**	**170**	**102**	**118**

TABLE II

Number and taxa percentage by botanical family.

Número e percentagem dos táxones inventariados por família botânica.

Family	*Taxa* (Nº)	(%)	Family	*Taxa* (Nº)	(%)
Apiaceae	5	2.4	*Onagraceae*	1	0.5
Asteraceae	39	18.9	*Oxalidaceae*	2	1.0
Boraginaceae	3	1.5	*Papaveraceae*	3	1.5
Brassicaceae	7	3.4	*Plantaginaceae*	3	1.5
Campanulaceae	1	0.5	*Poaceae*	26	12.6
Caryophyllaceae	11	5.3	*Polygonaceae*	9	4.4
Chenopodiaceae	1	0.5	*Primulaceae*	2	1.0
Convolvulaceae	1	0.5	*Ranunculaceae*	3	1.5
Fabaceae	48	23.3	*Resedaceae*	2	1.0
Geraniaceae	8	3.9	*Rosaceae*	3	1.5
Hypericaceae	5	2.4	*Rubiaceae*	2	1.0
Juncaceae	1	0.5	*Scrophulariaceae*	7	3.4
Lamiaceae	4	1.9	*Solanaceae*	2	1.0
Liliaceae	1	0.5	*Urticaceae*	1	0.5
Lythraceae	1	0.5	*Violaceae*	2	1.0
Malvaceae	2	1.0			
Nº of Total *Taxa* (206)	**138**			**68**	



<table>
<tr><th rowspan="2">Average density (D)
(nº of plants/m²)</th><th colspan="3">Relative frequency (FR)
(%)</th></tr>
<tr><th>< 25</th><th>25 - 50</th><th>> 50</th></tr>
<tr><td>1 < 1</td><td>0</td><td>+</td><td rowspan="2">++</td></tr>
<tr><td>2 = 1 to 2</td><td>+</td><td rowspan="2">++</td></tr>
<tr><td>3 = 3 to 20</td><td rowspan="2">++</td><td rowspan="2">+++</td></tr>
<tr><td>4 = 21 to 50</td><td>+++</td></tr>
<tr><td>5 > 50</td><td colspan="2">+++</td><td>++++</td></tr>
</table>

Figure 1 - Vineyard plant species infestation according to relative frequency (%) and average density (nº of plants m-2) (Michez and Guillerm, 1984). 0: very low; +: low; ++: medium; +++: high; ++++: very high. Bayer codes for full species names are given in Table I.

Grau de infestação dos táxones de acordo com a sua frequência relativa e abundância média (nº de plantas m-2) (Michez & Guillerm, 1984). 0: muito fraco; +: fraco; ++: médio; +++: elevado; ++++: muito elevado. As espécies são identificadas pelo respetivo código Bayer, referido no Quadro I.

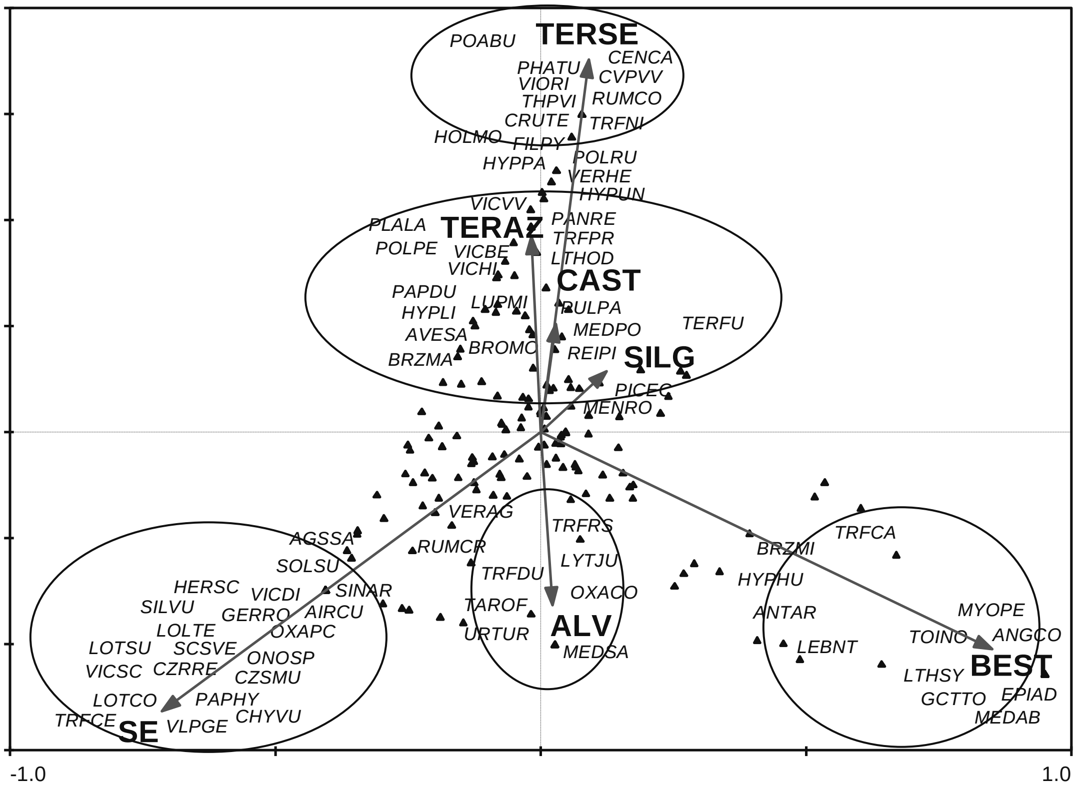


Figure 2 - Vineyard plant species sub-region biplot from canonical correspondence analysis at Dão winegrowing region. Bayer codes for full species names are given in Table I. Sub-regions: ALV – Alva; BEST – Besteiros; CAST –Castendo; SE – Serra da Estrela; SILG – Silgueiros; TERAZ - Terras de Azurara; TERSE – Terras de Senhorim.

Ordenação gráfica resultante da análise canónica de correspondências para os táxones identificados em vinhas da Região do Dão e sua relação com as sete sub-regiões. As espécies são identificadas pelo respetivo código Bayer, referido no Quadro I. Sub-regiões: ALV –Alva; BEST –Besteiros; CAST –Castendo; SE –Serra da Estrela; SILG – Silgueiros; TERAZ - Terras de Azurara; TERSE – Terras de Senhorim.

with many species, such as *Vicia dasycarpa, V. benghalensis*, *Trifolium pratense, V. hirsuta, Taraxacum fulvum,* and *Pulicaria paludosa.*

Effect of soil management on weed communities

The surveyed vineyard soil management practices are shown in detail in Figure 3. Looking solely at the inter-row practices, the resident vegetation was used in 47% of the surveyed vineyards, sown cover cropping in 6%, soil tillage in 41%, and chemical control in 6%. Total soil tillage was carried out in 31% of the vineyards and inter row tillage were managed in 10% of vineyards surveyed. Herbicides were also applied before vine budbreak in 46% of the rows (Figure 3). Glyphosate was applied alone (45%) or in mixture (38%) with other active ingredients (diflufenican + glyphosate, diuron + glyphosate + terbutylazin, and glyphosate + linuron + terbutylazin). Glyphosate was thus always applied. Particular attention must be paid to glyphosate resistance in weeds. Species of the genus *Conyza* and *Lolium* are already resistant to glyphosate in the Alentejo (olive orchard) and Douro (vineyard) regions (Calha and Osuna, 2010; Mendes *et al*., 2011; Calha and Portugal, 2012; Portugal *et al.*, 2012).

Our data show that soil management practices had a clear significant effect on weed communities (Table III, Figure 4). The plant species presented in the communities separated by CCA fitted into one of three categories: ubiquitous among treatments (e.g. *Convolvulus arvensis, Cynodon dactylon, Lolium rigidum; Trifolium glomeratum, Vicia lutea*, among others), hence their position near the origin of the biplot; sporadically present in a given treatment (e.g. *Anagallis arvensis* var. *caerulea; Crepis versicaria* and *Jasione montana*); and dominant in some treatments (e.g. *Bromus madritensis* and *Trifolium repens*) (Table I). Figure 4 and Table I also highlight the fact that the plant species *Scorpiurus vermiculatus* and *Arabidopsis thaliana* were only presented in RNA, while several species of the genus *Trifolium* and *Phalaris aquatica* were associated with RSE. A large number of annual species were surveyed in the soil tillage treatment (MOB).

Despite being ubiquitous among treatments, the perennial species *Cynodon dactylon*, *Convolvulus arvensis* and *Rumex crispus* were more abundant in the vineyards submitted to weed chemical control. Other authors, for different ecosystems and crops, have found a similar effect of soil management practices on weed dynamics – namely an increase in biodiversity because the resident vegetation is retained (Wrucke and Arnold, 1985; Teasdale *et al*., 1991; Naeem *et al*., 1999; Afonso *et al*., 2003; Hiltbrunner *et al*., 2007; Monteiro *et al*., 2008).

In the spring of 2008, most of the surveyed vineyard rows displayed a very good weed control. Weeds were recorded in only 16% of the surveyed vineyards and their abundance was very low. The species *Spergula arvensis, Poa annua, Erodium moschatum, Hypochaeris radicata* and *Cerastium glomeratum* were more frequent in the herbicide row treatment, while *Lupinus micranthus, Vicia lutea, Vicia angustifolia, Cynodon dactylon, Convolvulus arvensis* and *Avena barbata* were favoured by soil tillage.

Winegrower questionnaires also showed that soil tillage was carried out using a cultivator (27%), a disk harrow (18%), a rotary tiller (24%), or a combination of a disk harrow and then a cultivator (31%).

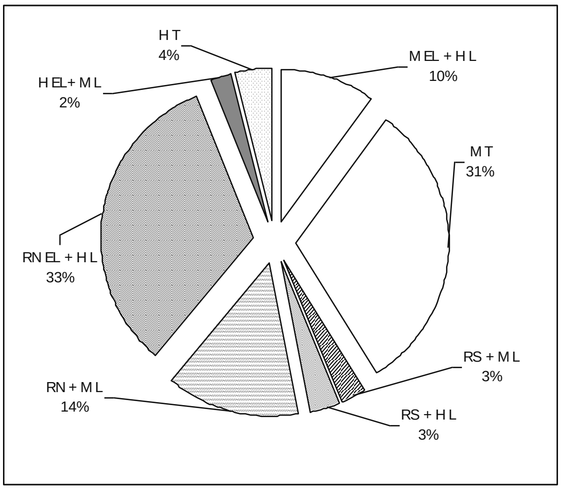


Figure 3 - Vineyard soil management systems in Dão winegrowing region, in 2008 (percentage of the total of 120 vineyards surveyed in the seven sub-regions). MT – total soil tillage; MEL + HL –soil tillage in the inter row + herbicide in the row; HT – total herbicide; HEL + ML – herbicide in the inter row + soil tillage in the row; RNEL + ML – resident vegetation in the inter row + soil tillage in the row; RNEL + HL – resident vegetation in the inter row + herbicide in the row; RSEL + ML – sown cover crop in the inter row + soil tillage in the row; RSEL + HL – sown cover crop in the inter row + herbicide in the row.

Sistemas de gestão do solo em vinhas da Região do Dão, em 2008 (percentagem em relação ao total de 120 vinhas inquiridas nas sete sub-regiões). MT – mobilização total; MEL + HL – mobilização na entrelinha + herbicida na linha; HT – herbicida total; HEL + ML – herbicida na entrelinha + mobilização na linha; RNEL + ML – relvado natural na entrelinha + mobilização na linha; RNEL + HL – relvado natural na entrelinha + herbicida na linha; RSEL + ML – relvado semeado na entrelinha + mobilização na linha; RSEL + HL – relvado semeado na entrelinha + herbicida na linha.

CONCLUSIONS

The present study revealed that changes in weed flora have occurred in the Dão winegrowing region in the last 60 years, with an increase in diversity. More than 200 *taxa* belonging to 31 families were surveyed. Despite the five plant groups separated by CCA, the dominant weed species were found throughout the Dão winegrowing region.

The study also showed that permanent natural cover cropping (RNA) could be an appropriate soil management method, since it increased plant diversity, particularly in terms of the richness of grass and legume plant species and troublesome weeds were not favoured. Nevertheless, studies concerning RNA

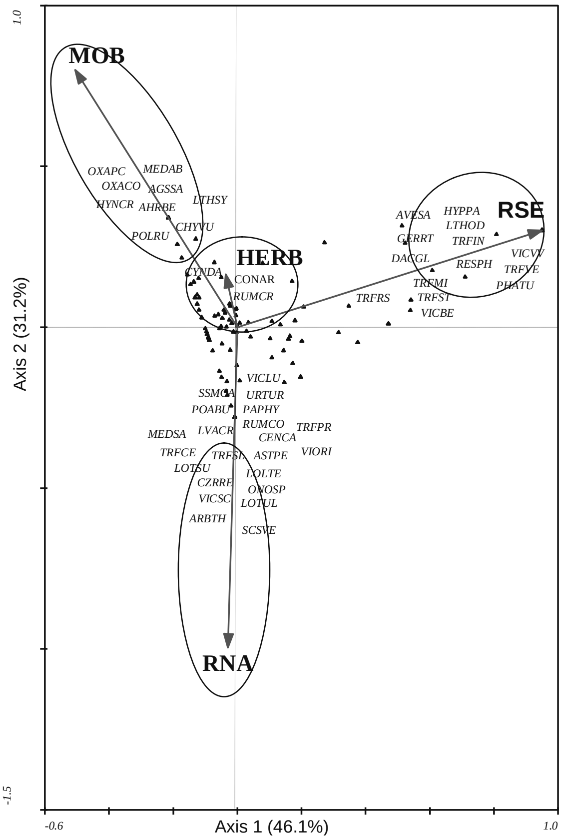


Figure 4 - Vineyard plant species-soil management biplot from canonical correspondence analysis in Dão winegrowing region. Bayer codes for full species names are given in Table I. HERB – herbicide; MOB – soil tillage; RNA – permanent resident vegetation; RSE – permanent sown cover crop.

Ordenação gráfica resultante da análise canónica de correspondências para os táxones identificados em vinhas da Região do Dão e sua relação com as técnicas de gestão do solo praticadas. As espécies são identificadas pelo respetivo código Bayer, referido no Quadro I. HERB – herbicida; MOB – mobilização do solo; RNA – enrelvamento natural permanente; RSE – enrelvamento semeado permanente.

effects on vines should be carried out.

Species of the genus *Ornithopus, Trifolium, Vicia, Lolium* and the species *Poa annua* were very frequent and abundant overall the region and in the four management soil treatments. These *taxa* are annuals with a short life cycle, and are recommended for cover cropping due to the lower risk of water competition with vines and nitrogen assimilation by legumes. Nevertheless, the dynamic of perennial species – e.g. *Convolvulus arvensis* and *Cynodon dactylon* – that were abundant and ubiquitous among treatments, must be carefully evaluated, especially with regard to herbicide use and time of application. Since glyphosate has always been applied in the vineyards, particular attention must be paid to ghyphosate weed resistance in the region.

ACKNOWLEDGEMENTS

The authors would like to thank Vanda Pedroso from the “Centro de Estudos Vitivinícolas do Dão”, Quadrado de Sousa from “Zona Agrária de Gouveia”, José Bernardo from “Oliveira do Hospital”, and the technicians Luís de Sousa, Vítor Figueiredo and Emílio Figueiredo, for their technical support. We are also grateful to the viticultural technicians and winegrowers who kindly responded to the questionnaires. We also thank the anonymous referees for their constructive comments on an earlier version of the manuscript.

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