



Non-linear responses of functional diversity and redundancy to agricultural intensification at the field scale in Mediterranean arable plant communities



Irene Guerrero, Carlos P. Carmona, Manuel B. Morales, Juan J. Oñate*, Begoña Peco

Terrestrial Ecology Group (TEG), Department of Ecology, Universidad Autónoma de Madrid, C/Darwin 2, Madrid 28049, Spain

ARTICLE INFO

Article history:

Received 16 December 2013
Received in revised form 16 May 2014
Accepted 29 May 2014
Available online 6 June 2014

Keywords:

Agricultural intensification
Weeds
Species richness
Cereal crop
Central Spain

ABSTRACT

Despite their key roles in agroecosystems, species diversity of arable plants is being severely reduced by agricultural intensification, although it remains unclear whether functional diversity is affected in a similar way. We analyzed the response of four functional traits of arable plants (specific leaf area, canopy height, seed mass and flowering onset) to agricultural intensification in Mediterranean arable plant communities. Two intensification gradients were obtained by PCA analysis on variables related either to management practices at the individual field scale or to the surrounding landscape structure and composition. Shifts in the community weighted mean (CWM) and the functional diversity (FD) of each trait along these intensification gradients were explored. The relationship between species richness and the FD of each trait (i.e. functional redundancy) along the same gradients was also analyzed. The responses of species richness and the considered functional traits were driven by intensification at the individual field scale, but not by intensification at the scale of the surrounding landscape. Species richness and FD of all the studied traits decreased with intensification, which favoured tall, heavy-seeded and early flowering species. The decrease of FD was non-linear for specific leaf area and seed mass, with maximum reductions at intermediate levels of intensification. Species richness and FD responses were decoupled, indicating that the functional redundancy in the studied communities responds to agricultural intensification in a non-linear fashion. Along the first stages of intensification, there was an important reduction in species richness that was not accompanied by changes in FD. Further levels of intensification resulted in substantial reductions in FD without changes in species richness. These findings provide new insights on how agricultural management interacts with plant communities through its non-linear effects on functional diversity and functional redundancy.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Species richness and its supporting role in connection to ecosystem functions and services have been the focus of a great body of literature studying the impacts of agricultural intensification on biodiversity (see review by Kleijn et al., 2011). The multifactorial process of agricultural intensification (Chamberlain et al., 2000) involves management changes at the spatial scale of individual agricultural fields (such as the increasing use of high-yielding crop varieties, chemical fertilizers and pesticides, irrigation and mechanization), aimed to maximize yields. Intensification actions also affect the surrounding landscape, with changes in its structure and composition (simplification, homogenization,

artificialisation and abandonment). As a consequence, complex and detrimental effects on biodiversity and agroecosystem properties are usually associated to agricultural intensification (e.g. Donald et al., 2006; Geiger et al., 2010; Guerrero et al., 2012; Kremen et al., 2002 and Stoate et al., 2009).

In the last decades, farmland biodiversity has been the focus of important conservation efforts in Europe, including various common policy tools, such as the Nitrates, Birds and Habitats Directives and agri-environment schemes (Beaufoy, 1998; Buller et al., 2000 and Primdahl et al., 2003). Despite these efforts the negative effects of agricultural intensification on European farmland biodiversity persist (EEA, 2010).

It remains unclear whether changes in species diversity are accompanied by similar changes in the provisioning of associated ecosystem services in agroecosystems (e.g. Letourneau and Bothwell, 2008 and Macfadyen et al., 2009). Recently, researchers' attention has shifted to functional diversity (FD; i.e. the value and

* Corresponding author. Tel.: +34 91 4972780; fax: +34 91 4978001.
E-mail address: juan.onate@uam.es (J.J. Oñate).

range of functional traits of the organisms in a community) as a reliable proxy of the range of functions provided by a community (Díaz and Cabido, 2001 and Hooper et al., 2005). It is generally assumed that the loss of species associated to land use intensification results in a similar loss of functional diversity. However, this assumption has been recently challenged (Mayfield et al., 2010), since changes in species richness and functional diversity after intensification, although often positively correlated, could follow different trajectories, depending on the degree of functional redundancy in the community (i.e. the number of species possessing similar functional traits, see Rosenfeld, 2002) and on how changes in land management affect community assembly processes. In fact, species richness may decline without a corresponding loss of functional diversity in communities with high functional redundancy (Flynn et al., 2009) and it may even be possible for functional diversity to increase without a change in species richness, thanks to changes in the environmental filters favouring the appearance of functionally different species (Mayfield et al., 2010). These models have recently been tested along intensification gradients in grassland ecosystems (Sasaki et al., 2009 and Peco et al., 2012), but not in arable systems.

In this paper we explore the relationships between species richness and functional diversity along agricultural intensification gradients, focusing on wild plants growing on agricultural fields (from now on, arable plants, *sensu* Storkey, 2006). Arable plants are well adapted to disturbed and resource-rich environments such as agricultural fields, thanks to a functional trait composition that makes them good colonizers, reproducers and/or survivors (Sutherland 2004). Due to their position at the base of trophic webs, arable plants play key roles in agroecosystems (Marshall 2003), being essential to other taxa (Brooks et al., 2012; Ebeling et al., 2012; Evans et al., 2011 and Scherber et al., 2010), including species providing important ecosystem services, such as biological pest control and pollination (Kremen et al., 2002; Thies et al., 2011 and Winqvist et al., 2012). They contribute as well to vegetation structure within cropped fields, determining the quality of agricultural habitats for invertebrates, birds and mammals (Benton et al., 2003 and Marshall et al., 2003). Diversity of arable plants at the individual field scale is not only negatively affected by the intensification of practices aimed at combating their potentially negative impact on crop yield (Guerrero et al., 2010 and Storkey et al., 2012), but it also depends on the configuration of the surrounding landscape, with local diversity increasing with landscape complexity (Gabriel et al., 2005).

The response of four arable plant functional traits (specific leaf area, canopy height, seed mass and flowering onset) to agricultural intensification gradients was analyzed, separating field and landscape scales. We also analyzed the changes in the relationship between arable plant species richness and functional diversity of each trait (functional redundancy) along the same intensification gradients. Specifically, we expected that: (i) increased productivity related to agricultural intensification induces changes in functional trait composition of arable plant communities towards trait values associated to faster resource-use strategies, such as higher SLA, as well as trait values associated to increased competition for light, such as earlier flowering, higher canopies and heavier seeds; (ii) intensification of agricultural practices reduces functional diversity, eliminating functional types poorly adapted to high nutrient levels and competition for light.

2. Materials and methods

2.1. Study area

The study was conducted in a ca. 500 km² dry cereal farmland area in central Spain (40°40'N, 3°25'W; altitudes ranging from 600

to 800 m.a.s.l.). Average annual temperature is 14.1 °C with hot summers and mild winters and average annual rainfall is ca. 400 mm, concentrated in spring and autumn (AEMET, 2008). These characteristics define a rather homogeneous area for rainfed cereal cropping (see Table S1, electronic supplementary data). Traditional land use has produced a dynamic agricultural mosaic in the area, with fields of different size (in the range of 0.5–30 ha) and varying development of field boundaries. Non-irrigated winter wheat and barley and annual fallow (fields left unsown in a given year) dominate, covering ca. 86% of total area. The rest is long-term fallow (more than two years old), shrubs and, marginally (0.60% of total area), olive groves and vineyards. Typical rotation on a given field has a two-year cycle, with alternating cereals and fallow. Cereal yield in the study area is around 3000 kg ha⁻¹, lying within the range of central Spanish drylands (average ± SD is 3256 ± 710 kg ha⁻¹; MARM, 2008), but still low enough to consider this system as low-intensity in the European context (Signal and McCracken, 1996).

2.2. Data collection

2.2.1. Field data collection

A total of 78 agricultural fields sown with winter wheat were sampled in spring 2007, an average year regarding temperatures and rainfall in the area (AEMET, 2008). One to five sampling points were distributed in each field depending on field size. To avoid field margin effects on observations, sampling points were placed at 10 m from the margin. Arable plant species were surveyed between May 27th and June 25th. Three 2 × 2 m² vegetation quadrats per sampling point were located parallel to the field side and 5 m apart from each other. Percentage of cover of each species within the quadrat was estimated and averaged for each sampling point. Finally, species richness was calculated as the number of species found on each sampling point, and subsequently averaged to attain a single value for each field, which indicates the average richness at the sampling point scale.

2.2.2. Agricultural intensification data

Three variables related to management practices at the individual field scale and three related to the surrounding landscape structure and composition were considered (Table 1). Information about yield, a frequently used proxy of agricultural intensification (e.g. Green et al., 2005), and farming practices (applied nitrogen fertilizer and sowing density) during 2007 was collected by means of a questionnaire sent out to farmers managing each field. Information on landscape structure variables was obtained from digital maps and measured within 500 m radius circles around the centre of each sampling point and averaged when there were more than one sampling point per field (Guerrero et al., 2010).

2.2.3. Functional traits

Following Westoby (1998), three representative traits of plant strategy for resource capture and allocation were selected: specific leaf area (SLA, mm² mg⁻¹), mean canopy height (cm) and seed mass (mg). Flowering onset (month, ranging from March to September) was further included, a trait that has been frequently used in studies analyzing the response of vegetation to agricultural intensification (e.g. Peco et al., 2012 and Storkey et al., 2010). Functional trait data were extracted from LEDA and e-FLORA-sys databases (Kleyer et al., 2008) for 105 sampled species (see Table S2, electronic supplementary data). Species with trait information represented an average percentage cover of ca. 95%.

Prior to any calculation, the values of seed mass were log-transformed to attain a normal distribution. For each functional trait and sampling point, community weighted mean (CWM) and functional diversity (FD) were calculated. CWM can reveal changes

Download English Version:

<https://daneshyari.com/en/article/2413906>

Download Persian Version:

<https://daneshyari.com/article/2413906>

[Daneshyari.com](https://daneshyari.com)