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Key parameters for the management and design of field margins aiming to the conservation of beneficial insects

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Abstract: Edges of vegetation on crop fields may increase the abundance and diversity of natural enemies and pollinators. This study emphasizes some aspects on plant management. Germination, coverage and blossoming were registered on several plant species. Germination and plant emergence showed a great variation among species. High coverage plants (e.g. *Coriandrum sativum*) relegates small ones (e.g. *Salvia verbenaca* and *Silene vulgaris*) to the understory. *Borago officinalis* and *Echium vulgare* had extended blossoming periods, while *Coriandrum sativum* and *Vicia sativa* had short and peaked ones; *Diplotaxis catholica*, *S. verbenaca* and *S. vulgaris* showed an intermediate pattern. Guidelines for the choice and management of plant species are provided.

Key words: floral margins, beneficial insect, natural enemies, bees, biodiversity

Introduction

The management of natural vegetation in agricultural land is utterly important because wild plants may serve both as eco-systemic service providers (e.g. pest control or pollination), and as reservoirs for crop pests and diseases (Willmer, 2011). The services plants provide vary with species, depending on factors such as their fitness and phenological state. In spite of the importance of plants as service providers, little information is available for their management and the design of vegetation margins. This work aims to emphasize some key parameters (e.g. germination rates, coverture and blossoming) to take into account when designing vegetation margins for the conservation of natural enemies and pollinators.

Material and methods

The germination of eight plant species (Table 1) was assayed in laboratory and field conditions. This plant mix aimed to provide abundant floral resources, different floral structures and extended blossoming periods. In the laboratory assay, 30 seeds of each plant species were set up in eight Petri dishes with moist cotton and placed in a plant growth chamber (Binder KBWF-750, Tuttlingen, Germany) at 25 °C and 75% RH. The plates were checked every 3-4 days during 30 days and the emerged seeds were counted and removed. This experiment was repeated three times for each plant species. The assays of germination in field conditions were conducted in four localities in the Region of Murcia (SE Spain). In each locality, a strip of approximately 100 m^2 was sown manually in autumn using the eight plant species (Table 1). Enough seeds were used to achieve densities of about 5 plants per square meter for the medium size species and 10 for the small size, using germination rates from preliminary trials (Table 1). The emergence of plants in each strip was estimated by counting the number of seedlings in a 1 x 1 m square on the first week of January. This procedure was repeated three times randomly on each of the four margins. Three more assessments were carried out in every locality, from February to April, to assess the abundance of each plant species using the same procedure as for the plant emergence. The percentage of coverage and individuals in bloom of each plant species was estimated every one or two weeks from January to July within a 2 x 2 m square. The sampling was repeated three times for each margin at each date.

Table 1. Plant species assayed. Parameters used for the sowing of plant species to obtain the desired plant densities (Plants/m^2). *Experimental field emergence from preliminary trials.

Plant species	**N seeds/g**	**Grams/m^2**	**N Seeds/m^2**	**%Emergence***	**Plants/m^2**
Borago officinalis L.	51	0.230	12	42.3	5
Chrysanthemum coronarium L.	600	0.023	14	36.0	5
Coriandrum sativum L.	64	0.489	31	32.0	10
Diplotaxis catholica (L.) DC.	11,583	0.022	250	4.0	10
Echium vulgare L.	280	0.298	83	6.0	5
Salvia verbenaca L.	526	0.317	167	6.0	10
Silene vulgaris (Moench.) G.	1,353	0.064	86	11.6	10

Results and discussion

All plant species showed a higher percentage of germination in the laboratory than of emergence in the field (Figure 1). In general, the emergence in the field was reduced from 16% to 95% in relation to the germination values registered in the laboratory. *Silene vulgaris*, *Coriandrum sativum*, *Vicia sativa*, *Salvia verbenaca* and *Borago officinalis* were the plants with the highest emergence. *Echium vulgare* and *Diplotaxis catholica* showed a low emergence both in the laboratory and in the field trials. The number of plants emerged in the field was similar to the predicted density according to the parameters in Table 1, with some extreme exceptions such as *S. vulgaris* that almost tripled the expected densities and *C. coronarium* that did not emerge in the field (Figure 1).

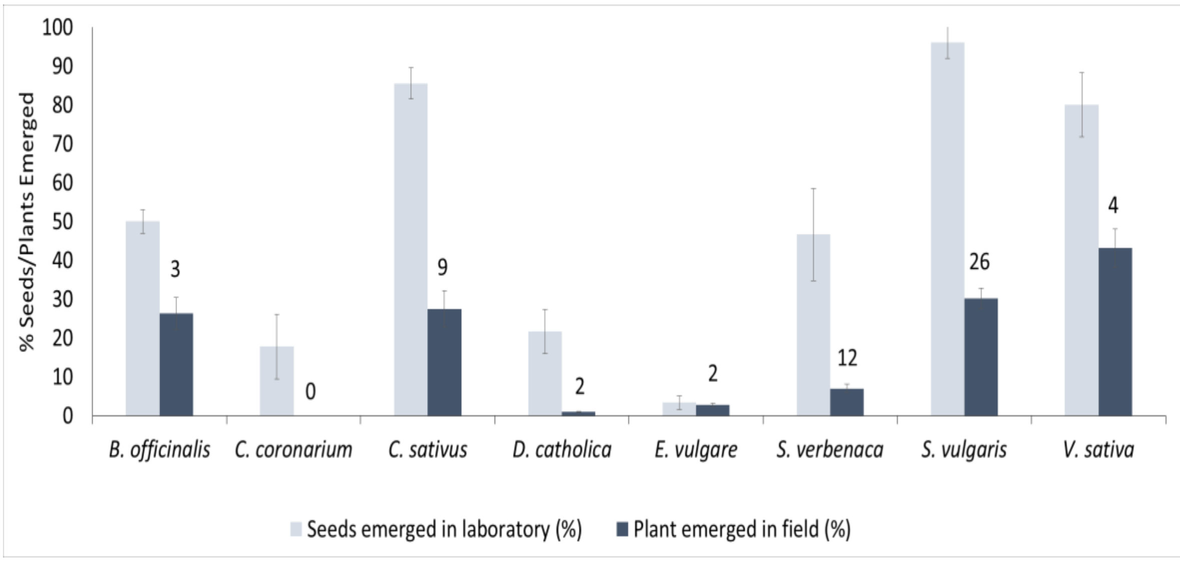

Figure 1. Percentage of seeds germinated in the laboratory and emerged in the field (Number of seeds emerged/Number of seeds sown). The figures on top of the bars represent the average number of plants per m^2 emerged in the field.

During the field trial, the number of plants in mixed edges generally decreased over time, although in some species (i.e. *B. officinalis*, *E. vulgare* and *Salvia verbenaca*) it stayed almost constant (Figure 2). *Coriandrum sativum*, *B. officinalis* and *V. sativa* were the species with the highest coverage; in contrast, *D. catholica* and *E. vulgare* had the lowest values. *Silene vulgaris* was relegated to the understory by the bigger plants and its coverage did not increase until the rest of the species started to recede (Figure 3A).

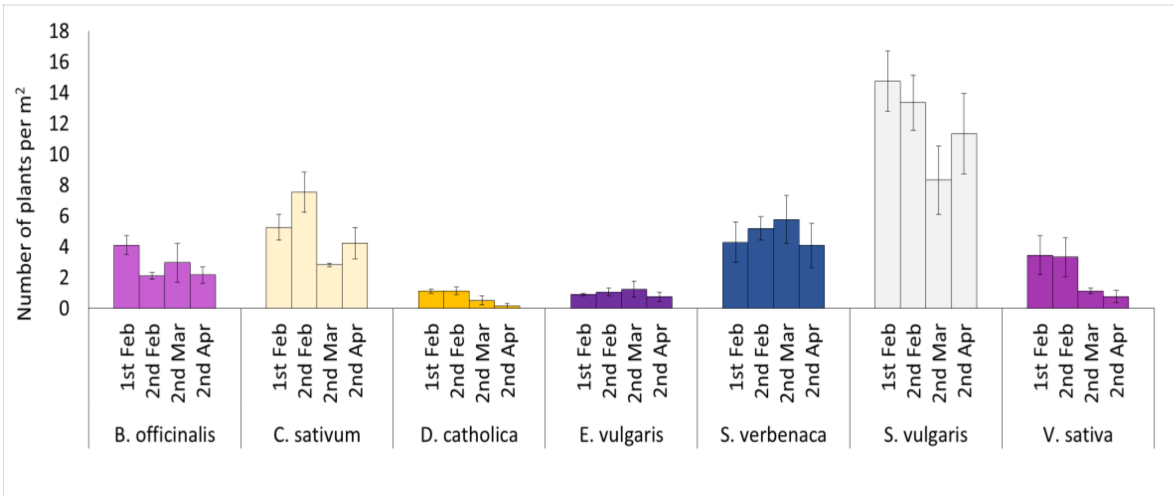

Figure 2. Abundance per m^2 (Number of plants/SE) of each plant species on several sampling dates (1st and 2nd are first and second week of the month).

Some plant species such as *B. officinalis* and *E. vulgare* had extended blossoming periods, while others (i.e. *C. sativum* and *V. sativa*) had short and peaked ones. The percentage of individuals of *S. verbenaca* and *S. vulgaris* in bloom started to increase when the rest of the plants lowered their coverage (Figure 3B).

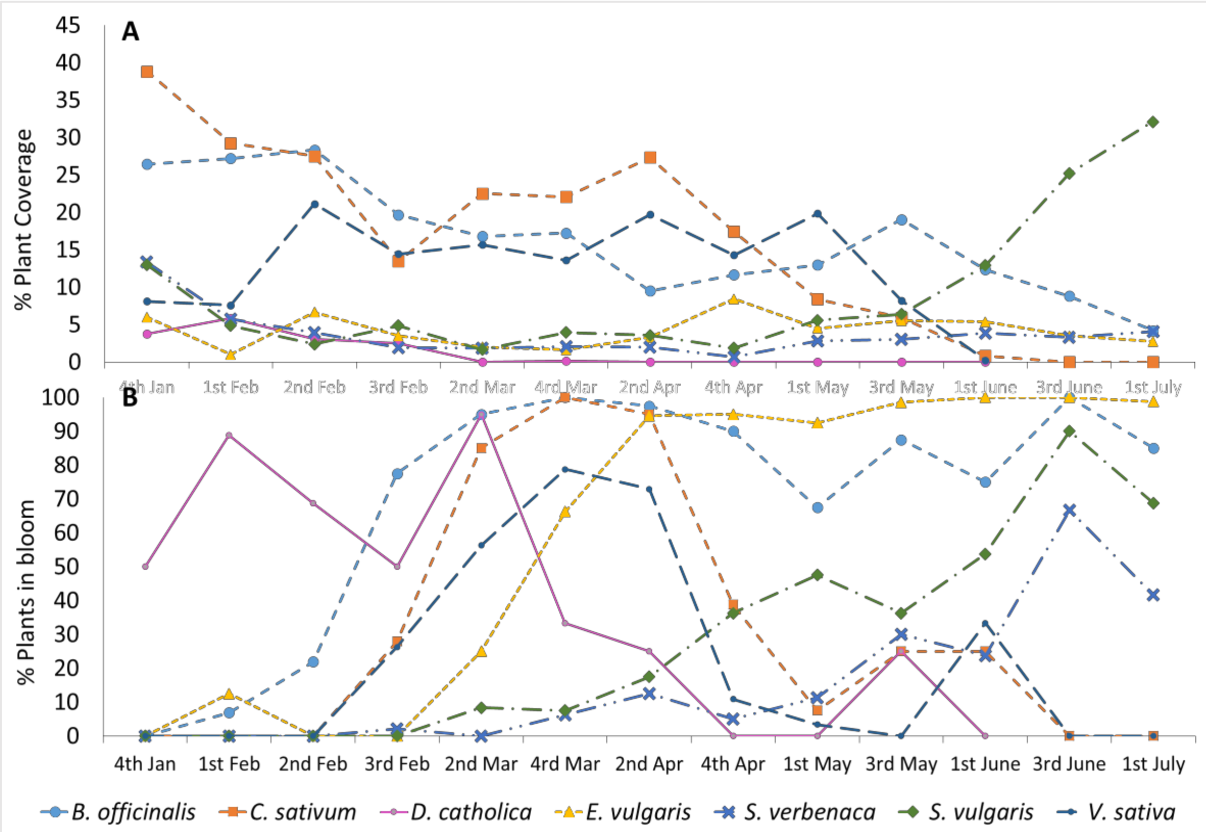

Figure 3. A) Percentage of plant coverage over time. B) Percentage of plant blossoming over time.

From the results of these assays, our own experience (Sanchez *et al.*, 2014) and the literature (e.g. Sheperd *et al.*, 2003), we conclude outlining some of the aspects that we consider should be taken into account in relation to the choice of plants when designing margins of vegetation for the conservation of beneficial insects and other arthropods:

- Take into account the viability of seeds and plant emergence in the field in order to predict the density of each plant species on the margin.
- Do not use excessively high plant densities (e.g. 10 individuals per square meter for small and 5 for medium size plants).
- Do not mix plants that are very different in size or growth rates because smaller and less vigorous plants will be displaced. For instance, *S. verbenaca* and *S. vulgaris* are relegated by bigger plant species.
- Use plants with extended periods of blossoming (e.g. *B. officinalis* and *E. vulgare*).
- Use plants with different floral structure to cover the requirements of a broad range of beneficial organisms (Willmer, 2011; Nichols & Altieri, 2012).
- Use a mixture of plants species that increase eco-systemic services but do not compete with the crop or serve as pest or disease reservoirs.

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