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Wildflower strip establishment for the delivery of ecosystem services in sweet cherry orchards

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Summary

The practice of introducing wildflower habitats in cropped areas is an approach that can be used to enhance ecosystem services. The value of such an approach will be affected by the establishment success of the sown species. To investigate this, 12 strips of wildflower habitat were established in alleyways between rows of cherry trees at three sites in the West Midlands (UK). The establishment of plants in sown strips was compared to six untreated alleyways that received conventional management. Eight forb species and one grass species was sown in strips measuring 1 m × 95 m. The establishment success of the sown species and their contribution to the vegetation of the alleyway was determined using percentage cover assessments in replicate quadrats. *Dactylis glomerata*, *Leucanthemum vulgare*, *Prunella vulgaris* and *Lotus corniculatus* established most consistently and with greater cover values in the sown strips. However, the sown strips were also associated with a greater abundance of unsown species, some of which are classed as weeds.

Key words: Establishment success, occurrence, percentage cover, quadrat sampling, unsown wildflowers, West Midlands

Introduction

Agricultural intensification and landscape change are two key drivers for the reduction and fragmentation of natural habitats that support beneficial species on farmland (Blackmore & Goulson, 2014). As with many crops, sweet cherries are highly dependent on pollination services to maintain yields and fruit quality (Holzschuh *et al*., 2012). Cherry production in the UK has increased dramatically due to land use intensification (Lang & Schoen, 2016) and the adoption of modern orchard systems (Cahn *et al*., 2000). To underpin yields, growers rely heavily on the use of managed pollinators (Hansted *et al*., 2015). However, due to a combination of higher visitation rates and greater pollen transfer (Garibaldi *et al*., 2013), wild pollinators may provide a more effective pollination service to cherry, resulting in better fruit set and fruit quality (Holzschuh *et al*., 2012).

If a greater reliance is to be placed on wild pollinators to deliver pollination services, it is essential that their resource demands are met outside of the cherry blossom period, which is typically in April. By providing wildflower habitat in alleyways between rows of cherry trees, wild pollinators are likely to benefit from the extended provision of resources, sustaining them throughout the year leading to an enhanced delivery of services during the cherry blossom period.

Cherry production is also affected by pests and diseases. As a consequence, growers use a number of different Plant Protection Products (PPPs) to protect their crops. Two major pests of sweet cherry are cherry blackfly (*Myzus cerasi*) (Stutz & Entling, 2011) and spotted wing drosophila (*Drosophila suzukii*) (Beers *et al*., 2011). It is standard practice to control both species using PPPs (McLaren & Fraser, 2002; Van Timmeren & Isaacs, 2013), which can have negative consequences for beneficial insects and the environment (Beers *et al*., 2011).

Increasingly, growers are adopting Integrated Pest Management (IPM) strategies, but the number of options available to cherry growers is limited. To improve the sustainable production of sweet cherry in the UK, there is potential for Conservation Biological Control (CBC) measures to be implemented (Begg *et al*., 2016) and introducing wildflower habitat is one strategy. The overall aim of the study is to investigate the benefits of introducing wildflower strips into cherry orchards for the delivery of pollination and pest regulation services. The aim of this study is to investigate the establishment success of the species sown in modern sweet cherry orchards.

Material and Methods

Study sites

The study was carried out at three sites in Herefordshire (UK), with two orchard blocks at each site. In each orchard block (defined as a separate parcel of land), three alleyways were randomly selected to be studied. The studied alleyway strips measured 1 m wide and 95 m long, starting at the beginning of the alleyways to the centre of the orchard. The length of strips used enabled standardization between orchard blocks, which varied in size from 1.3–3.6 ha. Two alleyways per orchard block were established with wildflower interventions, whilst the third was an untreated control, which consisted of the original alleyway vegetation.

Wildflower establishment

In autumn (September/October) 2016, a total of 12 randomly selected alleyway strips were sprayed with the broad-spectrum, systemic herbicide Roundup™ (glyphosate) to kill off existing vegetation in preparation for sowing. At least six days after spraying, the strips were cultivated to create a fine seed bed and sown with the wildflower mix within 24 hours. The mix consisted of eight forb species and one grass species, sown at a rate of 2.0 g m^{-2} (Table 1). All forb species were sown at a rate of 200 seeds m^{-2}, and 100 seeds m^{-2} for *D. glomerata*, between the 5–14 October 2016. Prior to sowing, seeds were mixed with sand to ensure an even sowing by hand. After sowing, the strips were rolled to ensure contact of seed with the soil. Due to poor establishment, probably owing to the late autumn sowing, all sites were re-sown the following year in March/April 2017 after a light cultivation. During the establishment year (2017), the wildflower strips, along with the six unsown (untreated) alleyways, were cut regularly to a height of approximately 10 cm and cuttings were left *in situ*.

The seed mixture was designed specifically to support arthropod functional groups (Blake *et al*., 2012; Carrié *et al*., 2012). The forb species were included to provide forage resources and shelter for pollinators and natural enemies, whilst *Dactylis glomerata* (a tussock forming species) was chosen to provide refuges for natural enemies (Pywell *et al*., 2005).

Table 1. *Seed mix composition and sowing rate used to establish the wildflower strips*

Scientific name	Common Name	Sowing Rate (seeds m^{-2})	Sowing Rate (g m^{-2})	% By Weight
Achillea millefolium	Yarrow	200	0.033	1.69
Centaurea nigra	Knapweed	200	0.444	22.60
Leucanthemum vulgare	Ox-eye daisy	200	0.100	5.08
Leontodon hispidus	Rough hawkbit	200	0.222	11.30
Lotus corniculatus (wild type)	Bird's-foot trefoil	200	0.400	20.34
Prunella vulgaris	Selfheal	200	0.200	10.17
Silene dioica	Red campion	200	0.200	10.17
Trifolium pratense (wild type)	Red clover	200	0.267	13.56
Dactylis glomerata (wild type)	Cock's-foot	100	0.100	5.10

Vegetation sampling

In September 2017, quadrat sampling was carried out to determine the contribution of each sown and unsown species to the composition of the alleyway vegetation in both treatment and control strips. Ten quadrats measuring 0.5 m × 0.5 m were randomly distributed and assessed in each alleyway. All plant species were identified and assigned a percentage cover value, except for the unsown grasses, which were assessed collectively as grass. Unsown grasses have therefore been excluded from calculations of species richness and Shannon Diversity. Values of bare ground and moss were also recorded. Differences in values of Shannon Diversity, and the number of unsown species between alleyway treatments were analysed using One-way ANOVA in SPPS (Version 23). Values of species number were log transformed prior to analysis.

Results

Species richness and diversity

In total, irrespective of treatment, 31 different species were recorded in the 180 quadrats sampled. On average, 3.5 (± 0.2) sown species and 4.0 (± 0.4) unsown species were recorded in the wildflower alleyways (Table 2). None of the sown species were recorded in the control strips, which on average contained 2.3 (± 0.1) unsown species. The only sown species not recorded was *Leontodon hispidus*. In the control strips, up to nine unsown forb species were recorded, compared to 23 in the wildflower strips. The wildflower strips contained significantly more unsown species than the control alleyways that were not sown and managed conventionally ($F_{1,10} = 16.5$, $P<0.01$). Shannon diversity was also significantly higher in the wildflower strips than those not sown ($F_{1,10}=206.7$, $P<0.001$) (Table 2).

Percentage cover of sown and unsown wildflowers

In the wildflower strips, the average cover of sown species (including *D. glomerata*) was 26.0% (± 1.0) (Fig. 1), compared to a contribution of 57.9% (± 2.3) from unsown forb species. Unsown grass species accounted for 22.9% (± 2.0%), and moss 0.7% (± 0.1). In the untreated control strips, the unsown forb species provided an average cover of 44.7% (± 3.6), compared to 66.9% (±

3.4) for unsown grasses. No moss was recorded in the control strips. Mean values of bare ground for the wildflower strips was 9.4% (± 1.1), compared to 1.6% (± 0.4) in the control strips.

Of the sown species, *Dactylis glomerata* had the greatest establishment cover, with an average of 7.6% (± 1.7), followed by *Leucanthemum vulgare*, *Prunella vulgaris* and *Lotus corniculatus* with values of 4.7% (± 1.1), 4.4% (± 0.9) and 3.9% (± 1.4), respectively (Table 3). Cover values of *Silene dioica* and *Centaurea nigra* were negligible; *S. dioica* was only recorded in 6.7% of quadrats surveyed, compared to 1.7% for *C. nigra* (Table 3). In contrast, *P. vulgaris*, *L. vulgare,* and *L. corniculatus* were recorded in 69.2%, 60.8%, and 49.2% of quadrats and the sown grass, *D. glomerata*, was recorded in 80.0% of quadrats.

Table 2**.** *Values of total species number and Shannon diversity (± SE) according to strip type and whether sown or unsown components*

	Species Number	Shannon Diversity
All Species		
Wildflower Strips	7.5 (± 0.5)	1.47 (± 0.06)
Control Strips	2.3 (± 0.1)	0.44 (± 0.04)
Sown Species		
Wildflower Strips	3.5 (± 0.2)	0.93 (± 0.07)
Control Strips	0.0 (± 0.0)	0.00 (± 0.00)
Unsown Species		
Wildflower Strips	4.0 (± 0.4)	0.91 (± 0.09)
Control Strips	2.3 (± 0.1)	0.44 (± 0.04)

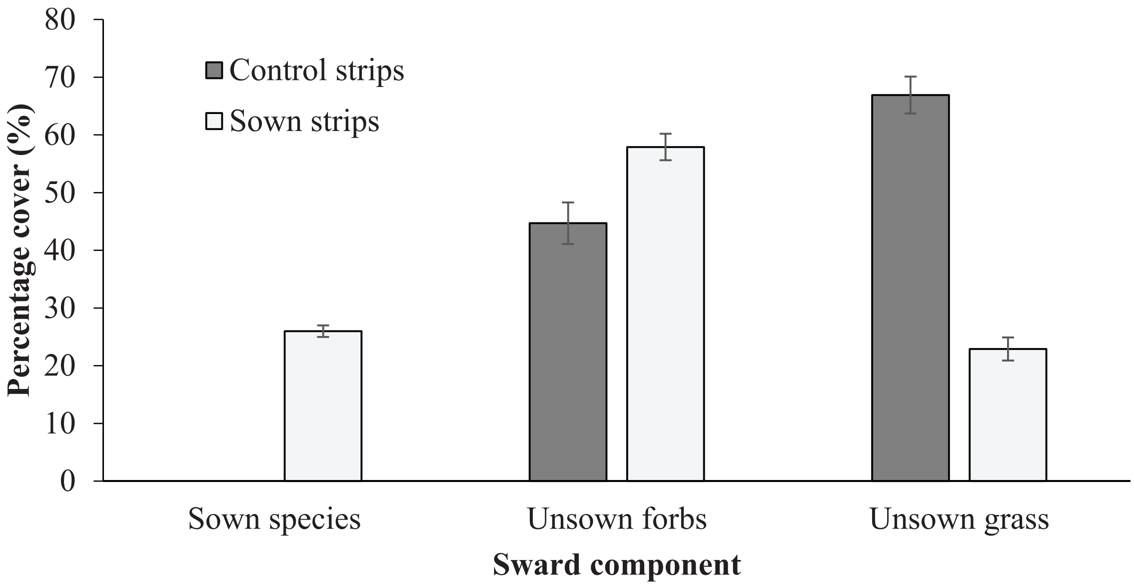

Fig. 1. Percentage cover (± SE), of sown wildflowers, unsown forbs and unsown grass according to alleyway treatment.

The most abundant unsown forb species in the wildflower strips were *Ranunculus repens*, *Taraxacum officinale*, *Trifolium repens*, *Rumex obtusifolius*, and *Polygonum aviculare*, which accounted for 17.2% (± 10.1), 12.0% (± 4.9), 7.6% (± 3.4), 7.4% (± 2.0), and 4.8% (± 3.6), respectively. However, in the control strips, the most abundant forbs were *T. officinale*, *R. rep*ens and *T. repens*, with cover values of 16.6% (± 8.7), 12.5% (± 5.5) and 10.6% (± 6.5), respectively.

Table 3. *Average percentage cover values (± SE) and percentage occurrence (in quadrats) of the sown species across all 12 wildflower strips*

Sown wildflowers	Percentage cover (%)	Percentage of occurrence (%)
Dactylis glomerata	7.6 (± 1.7)	80.0
Leucanthemum vulgare	4.7 (± 1.1)	60.8
Prunella vulgaris	4.4 (± 0.9)	69.2
Lotus corniculatus	3.9 (± 1.4)	49.2
Trifolium pratense	2.8 (± 1.3)	35.8
Achillea millefolium	2.4 (± 0.9)	43.3
Silene dioica	0.2 (± 0.1)	6.7
Centaurea nigra	0.03 (± 0.02)	1.7
Leontodon hispidus	0.0 (± 0.0)	0.0

Discussion

Based on values of percentage cover and percentage occurrence of the sown species, overall, the establishment of the sown wildflowers in the cherry orchards can be deemed a success (Carvell *et al*., 2004; Blackmore & Goulson, 2014). However, it is evident that species differed in their performance, and *L. hispidus* was never recorded in quadrats, although it was observed in the sown alleyways. Establishment success is influenced by a number of factors (Aldrich, 2002), and persistence and frequency of species would be expected to change as the project progresses (Blackmore & Goulson, 2014).

Of the sown forb species, *L vulgare*, *P. vulgaris* and *L. corniculatus* established most consistently and with greater cover values across the 12 wildflower strips. Such a finding is supported by Pywell *et al.* (2003), although they also found that *Achillea millefolium* performed well in sown mixes. In the current study, *A. millefolium*, was not recorded with high values of cover, but it was frequently recorded in the quadrats, being present in 43.3% of those assessed. Despite being sown at a lower sowing rate than the forbs (100 *vs* 200 seeds m^{-2}), *Dactylis glomerata* was the most frequently recorded sown species, in addition to being the species with the greatest average percentage cover (7.7%). Given the successful establishment of *L. vulgare*, *P. vulgaris* and *L. corniculatus*, and secondarily *A. millefolium* and *T. pratense*, we expect the wildflower strips to provide a suitable habitat for beneficial species during this on-going study (Balzan *et al*., 2016).

It is evident that the establishment protocol resulted in an increased abundance of unsown species; some of these, including *T. repens* and *T. officinale*, also have potential to enhance beneficial arthropods (Altieri *et al*., 1977). Ultimately, combined with the sown species, the diversity and abundance of unsown species in the sown strips could provide a greater range of opportunities, for a greater range of beneficial species (Blaauw & Isaacs, 2012, 2014).

The successful establishment of the wildflower strips suggests that this approach has the potential to support the sustainable production of sweet cherry through enhanced pest regulation and pollination services.

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