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Flower reservoirs in organic stone fruit orchards to promote functional biodiversity: Monitoring plant establishment and flower availability

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Abstract

Flower strips are an established technique to promote beneficial insects in orchards, yet their integration between tree rows remains limited due to management constraints. This study tests an alternative approach—so-called flower reservoirs, i.e., flower areas placed at orchard edges—to enhance habitats for natural enemies and pollinators. A tailor-made perennial seed mixture, attractive to aphid antagonists and pollinators and adapted to nutrient-rich orchard soils, was developed and implemented in three commercial organic cherry orchards across different Swiss regions in 2024. Plant establishment and flowering were monitored in 2024–2025. First results indicate site-dependent establishment success of flower reservoirs: at the best-performing site, mean vegetation cover of sown species reached 70 % and floral cover over 16 % during peak bloom (June–August 2025) and 22 out of the 24 sown species were recorded. In contrast, control orchards without reservoirs showed consistently low floral cover (< 2 %). Across all sites, Daucus carota L. showed consistent and robust growth within the first two years. These first-years results suggest that flower reservoirs can represent a practical and ecologically valuable complementary approach or alternative to inter-row flower strips, enhancing floral resources for natural enemies and pollinators in organic stone fruit orchards. Further monitoring in the coming years on more sites will verify their potential for pest regulation benefits.

Keywords: Functional biodiversity, flower strips, stone fruits.

Introduction

Flower strips in orchards are a well-known management strategy, especially in apple orchards (Cahenzli et al., 2019), providing habitats for beneficial insects and enhancing natural pest control and pollination services (Campbell et al., 2017; Pfiffner et al., 2018 and 2019; Jacobsen et al., 2019). However, their mid-term establishment between tree rows remains limited and challenging (Gilg & Holliger, 2023) mainly due to logistical challenges, lack of adapted machinery and high disturbances by machinery (Howard et al., 2025). In modern cherry production, orchards are increasingly enclosed with insect nets and rain roofs to reduce pest and disease infestation and maintain fruit quality. These physical barriers, however, modify the orchard microclimate—creating warmer and more humid conditions that favour aphid population growth, particularly of the black cherry aphid *Myzus cerasi* FABRICIUS (Hemiptera: Aphididae). As a standard practice in organic cherry orchards, fundatrices of this species are controlled using paraffin oil after bud swelling and neem oil at later stages (Häseli & Daniel, 2009; Cahenzli & Boutry, 2022) showing side-effects on natural enemies. Nets also restrict the movement of beneficial insects such as hoverflies, lacewings, and ladybirds, which are key aphid predators, while access to flowering plants outside the orchard is limited, reducing nectar and pollen resources essential for these species. To counterbalance these effects, we tested whether flower reservoirs—flower areas established at orchard edges within the net-covered area and adjacent to tree rows—can provide floral resources and habitats for aphid antagonists and pollinators inside

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enclosed orchards. These flower reservoirs should be easier to integrate into management routines and require less maintenance and are barely affected by orchard practices in contrast to inter-row flower strips. They can also act as efficient complementary measure to strips in the alley. A tailor-made perennial seed mixture was developed and sown on-farm. Ongoing monitoring evaluates plant establishment and flowering dynamics as a basis for assessing whether this approach can enhance functional biodiversity and in consequence the natural pest regulation and farmer acceptance in organic stone fruit production.

Material and Methods

To enhance functional biodiversity in orchards, we developed a tailor-made flowering mixture based on a literature review and previous FiBL trials focusing on flower mixture design (Pfiffner et al., 2019) in collaboration with UFA-Samen (Winterthur, Switzerland). The selection of plant species followed specific criteria: (i) attractiveness to natural enemies of aphids (hoverflies, lacewings, ladybirds, parasitoids) as well as to pollinators; (ii) tolerance to nutrient-rich orchard conditions; (iii) use of Swiss ecotypes; (iv) perennial growth; and (v) extended flowering period throughout the growing season. A total of 24 species (22 herbs and 2 grasses) were selected for the flower reservoir mixture, primarily from the families Asteraceae (8 species), Apiaceae (4 species), and Lamiaceae (5 species). Most selected species are characteristic of meadow-type plant communities. The designed seed composition followed a ratio of 85:15 between dicotyledonous species and grasses.

The study included six commercial organic cherry orchards located in three different Swiss regions (hereafter referred to as zones), with one test orchard (with a flower reservoir) and one control orchard (without a flower reservoir or flower strips) per zone. Flower reservoirs were established within the net-covered area, near anchoring poles and perpendicular to the tree rows, to facilitate traffic and minimize disturbance to beneficial insects. The three flower reservoirs were sown in spring 2024 with dimensions depending on the orchard, measuring approximately 2 m in width and 20 to 60 m in length. To assess germination and growth success, two visual vegetation surveys were conducted in July and October 2024. In 2025, the further plant development, spontaneous vegetation and flower availability were monitored monthly from April to October both in flower reservoirs and in controls. In each orchard, four 1 m × 1 m vegetation plots were assessed for sown and spontaneously occurring species. The ground cover of each species and the proportion of bare soil were visually estimated (%), and approximate vegetation height (cm) was recorded. Flower reservoirs were mown once per year, in September or October. Due to poor establishment, two flower reservoirs were resown in autumn 2024. In one orchard, instead of sowing it directly into the local soil, we sowed the mixture in 14 boxes (pallet frames, 120 x 80 x 20 cm) filled with “Bio-Universalerde” (Ökohum, Switzerland) and placed them in the orchard where the flower reservoir had been planned. The boxes were watered manually by the farmer.

Results

The establishment and development of sown species varied among zones. Zone Three represented the most successful site, exhibiting the highest cover of sown species, with an average of 50 % in 2025 and a maximum exceeding 75 % in June and July (Figure 1). In total, 22 of 24 sown species were recorded, with most observed throughout all assessments, indicating successful establishment. Only *Anthriscus sylvestris* (L.) Hoffm. and *Pastinaca sativa* L. were not detected. Vegetation was largely dominated by *Daucus carota* L., *Centaurea jacea* L., and *Cichorium intybus* L.

In zone One, the cover of sown species was on average 20 % in 2025 and exceeded 30 % during the summer (Figure 1). Eighteen out of the 24 sown species were recorded with *Daucus carota* L. again being dominant. Spontaneous grasses and dicotyledonous plants maintained high soil cover throughout 2025.

In zone Two, the flower mixture was sown in boxes. Germination was generally successful, with 21 out of the 24 sown species observed, resulting in over 60 % cover between April and June 2025 (Figure 1). However, due to water shortage during the summer, most species desiccated, and plant cover decreased to approximately 25 %. Only *Daucus carota* L. and a few individuals of *Achillea millefolium* L., *Origanum vulgare* L., *Tanacetum vulgare* L., and *Trifolium pratense* L. survived. From that time onward, spontaneous grasses markedly increased in cover.

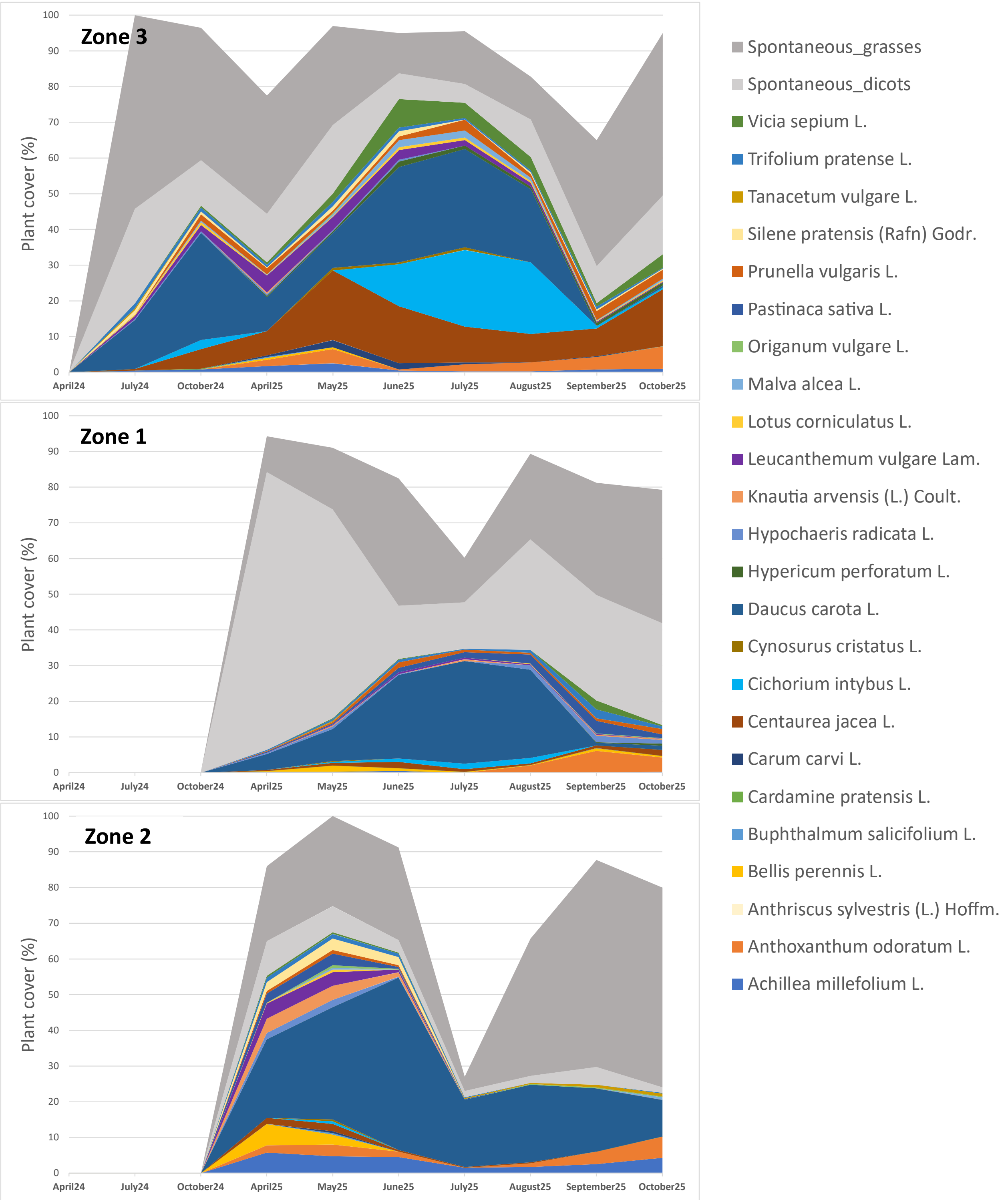

Figure 1: Temporal development of plant cover (%) of sown flower reservoir species, spontaneous dicots, and grasses in flower reservoirs of zone 3 sown in April 2024, zone 1 sown in September 2024, and flower reservoir of zone 2 sown in boxes in September 2024.

In addition to plant cover, floral cover was assessed in the flower reservoirs and in the control orchards (Figure 2). Floral cover in control orchards remained very low throughout the season (< 2 % at peak bloom, April–June), whereas flower reservoir orchards showed a pronounced floral peak from June to August, reaching up to 16 % of soil coverage (Figure 2).

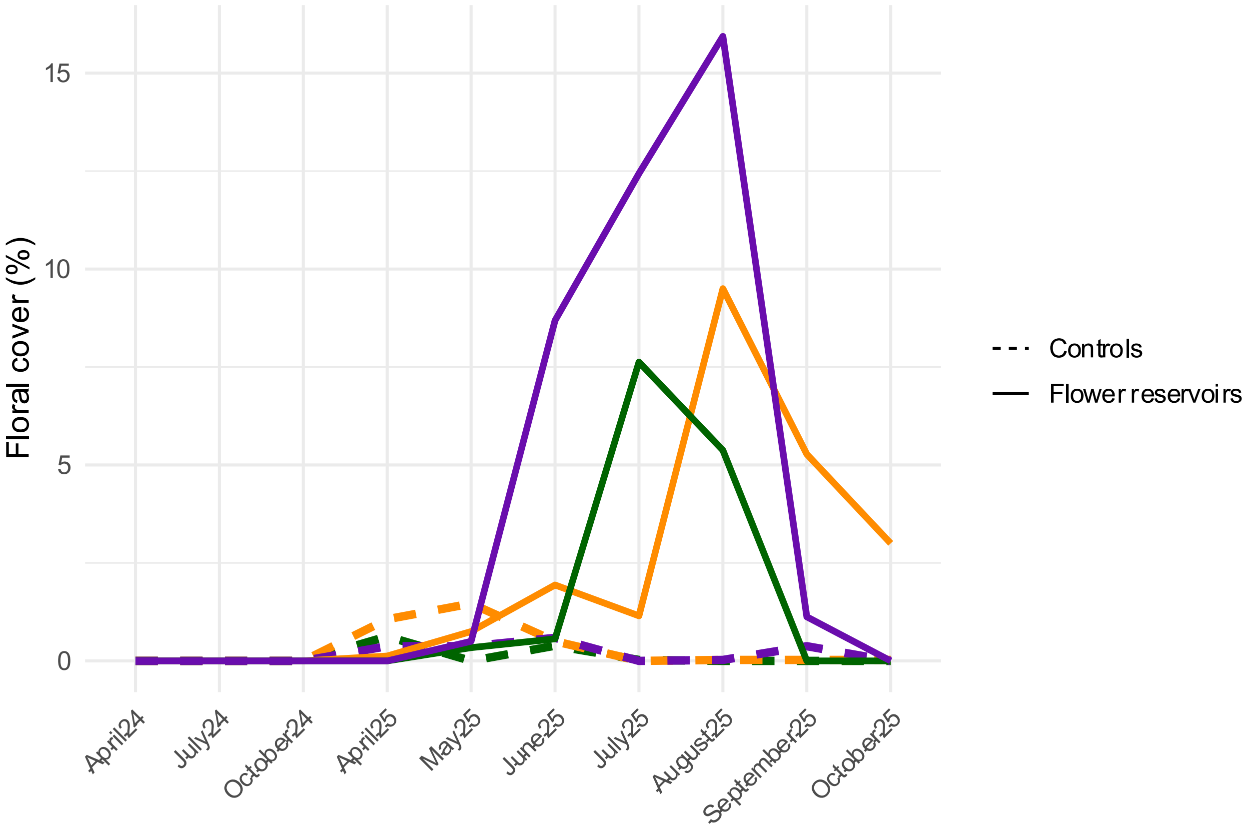

Figure 2: Temporal dynamics of floral cover (%) of sown species in flower reservoirs or in boxes (solid lines) and of spontaneous vegetation in control orchards (dashed lines). Colors denote experimental zones: zone 1 reservoir sown in September 2024 (green), zone 2 reservoir sown in boxes in September 2024 (orange), zone 3 reservoir sown in April 2024 (violet).

Discussion

Results revealed differences in plant growth and establishment success among the three sites during the first year after sowing. Variation in germination and growth success can be attributed to multiple factors, including presence of rain shelters, soil type, soil preparation, and weather conditions. Notably, spring 2024 was exceptionally cold and wet—conditions unfavourable for wildflower germination and growth, except for *Daucus carota* L., which performed well across all sites. Despite the limited number of study sites and differences in sowing dates, the observed patterns offer promising insights that warrant further investigation. Additionally, the findings highlight the generally poor floral resource availability in organic stone fruit orchards and underscore the need for floral structures to support beneficial invertebrates. Despite a slight temporal mismatch between the onset and peak of black cherry aphids, typically occurring in April–May, and the peak flowering of the flower reservoirs in June–August, providing flower resources throughout the season is crucial to sustain and establish beneficial insect communities over the long term, supporting increased pest regulation in subsequent years. Given their limited area relative to the total orchard surface, the establishment of flower reservoirs is expected to entail only minor additional costs, mainly related to seed purchase and sowing; however, their implementation may not be feasible in all orchards, as it depends on orchard structure and the availability of space at orchard edges. If implementation is feasible, flower reservoirs could provide a practical strategy to enhance beneficial insect populations, supporting natural pest regulation and contributing to more sustainable organic stone fruit production. The development of the flower reservoirs will continue to be monitored and evaluated during 2026 and 2027. Furthermore, to assess the impact of the flower reservoirs on natural enemies and their contribution to pest regulation, additional evaluations will be conducted, including surveys of natural enemies and pollinators abundance, and aphid infestation levels.

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