

Functional plant, *Cnidium monnieri*, facilitates the conservation and the biocontrol performance of natural enemies

Zhuo Li,^{1,2} Chunyan Chang,¹ Yiyang Yuan,¹ Xingrui Zhang,¹ and Feng Ge^{1,*}

¹Institute of Plant Protection, Shandong Academy of Agricultural Sciences, Jinan 250100, China

²State Key Laboratory of Integrated Management of Pest Insects and Rodents, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China

*Correspondence: gef@ioz.ac.cn

Received: October 31, 2023; Accepted: December 4, 2023; Published Online: December 5, 2023; <https://doi.org/10.59717/j.xinn-geo.2023.100045>

© 2023 The Author(s). This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Citation: Li Z., Chang C., Yuan Y., et al., (2023). Functional plant, *Cnidium monnieri*, facilitates the conservation and the biocontrol performance of natural enemies. The Innovation Geoscience 1(3), 100045.

Functional plants, including crops and non-crops, can play ecological roles, either alone or through multifactor interactions. These roles include soil-water conservation, biological nitrogen fixation, biodegradation, weed management, biological control, pollination, habitat, and food supply. Accord-

ing to their ecological functions, the plants are categorized as nectar plants, habitat plants, and attractor plants. Functional plants, as a valid ecological control method, have important characteristics, such as providing suitable habitat and food for natural enemies and preventing pests from feeding on

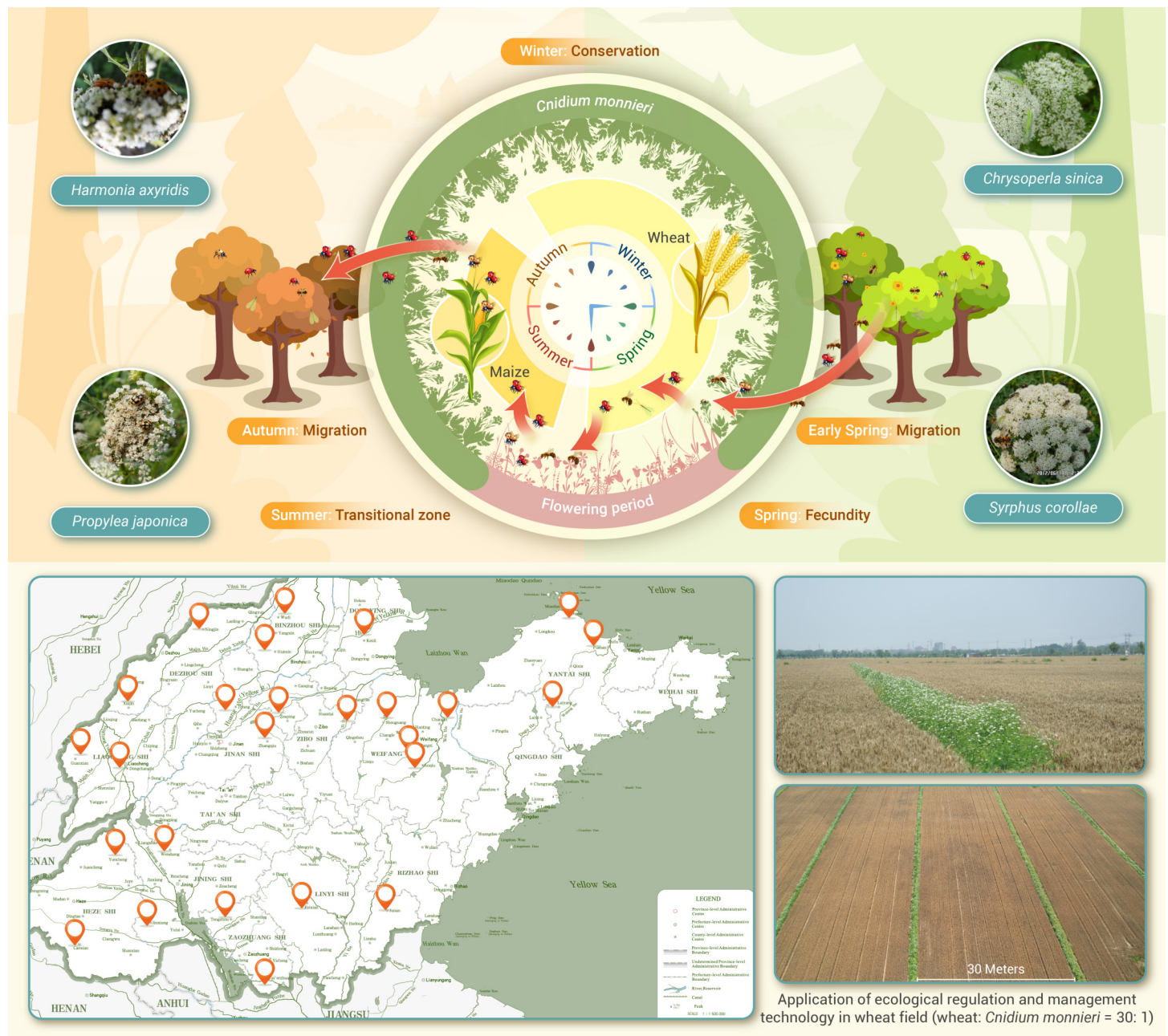


Figure 1. The schematic diagram of action modes of natural enemies on *Cnidium monnieri* to biocontrol the pests in wheat-maize rotation field in 26 districts of Shandong province, China.

crops.¹ For example, *Vetiveria zizanioides* has been found to attract rice borers in the rice region of southern China.² Further, *Medicago sativa* L. was planted around cotton fields for conserving natural enemies to control cotton aphids (*Aphis gossypii* Glover) in the cotton region of northern China.³ Since 2012, our screening experiments have shown that *Cnidium monnieri* can conserve and propagate the natural enemies *Propylaea japonica* and *Harmonia axyridis*, outperforming other functional plants in Yucheng, Shandong (Figure 1).⁴ In this paper, we systematically exposit the characteristics, action modes, and application of *C. monnieri* to demonstrate its use in the conservation and biocontrol of natural enemies.

INTRODUCTION AND DISCOVERY OF *C. MONNIERI*

Cnidium monnieri is a native annual herb belong to the Umbelliferae family that grows wild in humid areas, such as East and Southeast Asia, North America, and some European countries. It grows throughout China, and in North China, it blooms from April to July and fructifies from June to October. *C. monnieri* has pharmacological effects, and has been shown to have anti-inflammatory, analgesic, antibacterial, anti-itching, antioxidant, and neuroprotective properties. It has been widely used to treat gynecological inflammation, eczema, arthritis, atopic dermatitis, and cardiovascular and cerebrovascular diseases.⁵ In our experiments, that based on characteristics of functional plant and screened 62 plants in Yucheng through 12 years, we identified it as an economically valuable flowering plant in farmland ecosystems that attracts many natural predators, such as ladybeetles (Coleoptera: Coccinellidae) and hoverfly larvae (Diptera: Syrphidae). This finding provides a foundation for the development and utilization of this flowering plant species in the biocontrol of insect pests. Our previous studies showed that planting *C. monnieri* adjacent to wheat and cotton fields increased the abundance of predatory enemies of aphids, including ladybeetles, lacewings, and hoverflies (Figure 1), and thus reduced the abundance of aphids.⁴

CHARACTERISTICS OF *C. MONNIERI*

As an ecological control method, *C. monnieri* can aid in the conservation and propagation of pollinators that are the natural enemies of pest species, without becoming a food source for pests. The ecological functions of *C. monnieri*, as a "pollination, food, shelter and transport service," have opposite effects on beneficial and harmful insects. As a potential functional plant, it has many advantageous characteristics. As a source of food and shelter for natural enemies and pollinators, *C. monnieri* supports their survival and propagation, which encourages them to migrate into crops, where they pollinate plants and contribute to the biological control of pests. These effects can last for many years after the plant is established, without requiring special fertilizers or water management. *C. monnieri* has strong adaptability throughout Shandong, such as cold resistance, ability to grow in low-fertility soils, and salinity and drought tolerance. However, it will not become a weed owing to its weak diffusion and emergence. Because the plant can be used as a pharmaceutical herb, it can have a higher value than crops, increasing the farmers' returns and preferences. In addition, with a long flowering period lasting almost 3 months, that sustainably conserving the natural enemies and pollinators into low occurrence of pests and having a high value for beautification and appreciation, to build the beautiful villages. Finally, natural enemies moving and controlling the pests around *C. monnieri* within 16.5m, limited the landscape configuration and effective distance of biocontrol and pollination.

ACTION MODES OF *C. MONNIERI* IN WHEAT-MAIZE ROTATION FIELD

Semiaphis heraclei, which belong to Hemiptera and Aphididae, intensively and exclusively occur on umbelliferous and honeysuckle plants, such as *C. monnieri* and *Lonicera japonica* (Figure 1). These pests induce secondary volatiles (1,2-diethylbenzene and *p*-diethylbenzene) of *C. monnieri*, which were found to attract predatory lady beetles, such as *Harmonia axyridis* and *Propylaea japonica*, to wheat fields in early spring.⁵ *C. monnieri* conserves natural enemies, as Coccinellidae (76.87±5.77 /m²), Chrysopidae (14.67±1.61 /m²) and Syrphidae (52.46±6.02 /m²), by providing them with food (*Semiaphis*

heraclei and pollens) and suitable shelter and enabling them to propagate prolifically to control the wheat aphids into low occurrence in the spring and summer. During the period between the wheat harvest and maize emergence, *C. monnieri* serve as a transitional zone to provide food and suitable shelter for natural enemies before migrating into maize in the summer. After the maize harvest, natural enemies migrate from maize to *C. monnieri* in the autumn, and are conserved on the surrounding bushes and trees through the winter. Obviously, the phenology of *C. monnieri* matches the occurrence of pests in northern wheat-maize rotation fields, which can support the sustainable conservation of natural enemies for the ecological control of pests (Figure 1).

APPLICATION OF *C. MONNIERI*

At present, selecting suitable functional plants for the regional farmland landscape design presents an important ecological control method through conserving natural enemies to continuously control pests. The regional planting of *C. monnieri*, as a valid functional plant with many characteristics, has been applied with good results in northern wheat-maize rotation fields, such as in Shandong, Hebei, Henan, Jiangsu, Anhui, and Shanxi provinces. For example, 4,500 ha of wheat-maize rotation fields in 12 cities (26 districts) of Shandong, which ensured crop production safety and biocontrol effect more than 85% with different landscape configurations and annual climatic conditions, have had regional application of *C. monnieri* (Figure 1).

CONCLUSIONS

Regional farmland landscape design based on *C. monnieri* not only conserves natural enemies for continuous ecological control of pests, but also produces huge economic, ecological, and social value. As a functional plant with important pharmaceutical and economic value, *C. monnieri* can be planted around wheat-maize fields to reduce the input of chemical pesticides. Pollution-free agricultural products without environmental costs are favored by consumers and increase farmers' returns. Regional application of *C. monnieri* can reduce chemical pesticide pollution and improve biodiversity of the agricultural ecosystem. Meanwhile, *C. monnieri* has wide adaptability and can be planted in saline-alkali land for soil-water conservation and modification to contribute to ecological civilization. In addition, regional use of *C. monnieri*, which has a 3-month flowering period, is conducive to enhancing the appearance of villages and contributing to rural revitalization, improving farmers' ecological protection consciousness, and thus realizing social value.

REFERENCES

1. Zhao, Z.H., Ouyang, F., Men, X.Y., et al. (2013). Habitat management in biological control. *Chin. J. Appl. Entomol.* **50**, 879–889.
2. Gao, G.C., Li, J., Zheng, X.S., et al. (2015). Effects of extracts from *Vetiveria zizanioides* on growth and development, activities of protective enzymes of *C. Suppersalis*. *Bull. Sci. Tech.* **5**, 97–101.
3. Chen, M., Luo, J.C., and Li G.Q. (2011). Evaluating alfalfa cutting as a potential measure to enhance predator abundance of *Aphis gossypii* (Homoptera: Aphididae) in cotton-alfalfa intercropping system. *Acta Agrestia Sin.* **19**, 922–926.
4. Yang, Q.F., Men X.Y., Zhao, W.L., et al. (2021). Flower strips as a bridge habitat facilitate the movement of predatory beetles from wheat to maize crops. *Pest Manag. Sci.* **77**, 1839–1850.
5. Cai, Z.P., Ouyang, F., Su, J.W., et al. (2020). Attraction of adult *Harmonia axyridis* to volatiles of the insectary plant *Cnidium monnieri*. *Biol. Control.* **143**, 104189.

ACKNOWLEDGMENTS

This research was supported by the National Natural Science Foundation of China (grant no. 32202405), the Shandong Provincial Natural Science Foundation, China (grant no. ZR2020QC134), the State Key Laboratory of Integrated Management of Pest Insects and Rodents (grant no. IPM2001), and the Agricultural Scientific and Technological Innovation Project of Shandong Academy of Agricultural Sciences (grant no. CXGC2023F04).

DECLARATION OF INTERESTS

The authors declare no competing interests.