Weed flora: A blessing in disguise to bees

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Weed, whenever we hear the term it comes to our mind a non-remunerative plant competing with our food production. It is a common mindset of people. But if we say weeds can improve crop yield, then it will seem to be counterintuitive but that is the fact. Presence of weeds can enhance the pollination service that can improve the crop yield. As we all know, majority of our important food crops (35%) rely on pollination services. Among different flower visitors, bees (both eusocial and solitary bees) are the leading pollinators and bee pollination to some extent relies on the diversity and abundance of weed flora (Fig.1).

Pollination is an unintentional activity of bees as their main focus is to collect pollen and nectar from the flowers. Usually in agro-ecosystem with predominance of nectar-deficit plants (particularly cereal crops) bees are rewarded mainly with pollen, whereas natural ecosystems with more abundance of wild flora offer them with ample amounts of nectar. Honey bees process the nectar into honey and store it as food reserve to spend harsh winter days. So, the requirement of nectar is quite seasonal (though still required). However, there are certain plant species having no nectaries. Such plants are not able to offer nectar to bees. In such cases bees collect a profuse amount of nectar from wild flora. On the other hand, bees require a continuous influx of pollen as it deteriorates quickly allowing bees to store it in little quantity. However, it is the pollen that provides different kinds of proteins, vitamins, antioxidants, minerals, carbohydrates and other nutrients to the bees. What if a situation arises when there is no mass-flowering crop (such cropping patterns having short blooming periods separated by a long time gap) in the field to provide pollen then what would the bees do as it would not only affect the colony strength but would also threaten their biodiversity? At this point of time different weed flora would stand for the bees providing all the prerequisites to them and protect them from an enforced extinction. In turn pollination of these wild flowers by bees ensures their reproduction (as 78-94 % flowering species depend on insect pollination service) and aids in their survival. It is for sure, if someone performs melissopalynological analysis of raw honey, then he or she would definitely find the presence of at least one weed palyno taxa in that honey (Fig. 2).

How much do bees depend on crops versus weeds varies according to their taxonomic group (*i.e.*, honey bees, wild bees). Being a generalist forager (less selective in floral selection), honey bees always prefer to visit diverse flora to satisfy their need for proteins, vitamins, fats and other nutrients. Though their abundance is higher in mass flowering crops, but a single floral resource will never be able to fulfil that requirement, hence forcing the honey bees to visit diverse flora that can be as many as two hundred species. On the other hand, wild and solitary bees are specialist foragers (due to short activity period) and more rely on weed flora, indicating a strong correlation between wild bee diversity and wild floral diversity. They are more abundant in sub-natural habitats, grasslands and grassy stripes. For both the groups weeds are a limiting factor but for different reasons: quantitatively for honey bees particularly in between mass-flowering seasons and qualitatively for wild and solitary bees that are more selective foragers with major dependency on weed flora. Bumblebees have an intermediate strategy as their foraging preference consists of both mass flowering crops and sub-natural habitats with fairly uniform and low abundance. For bumblebees weeds are also a limiting factor.

Though there is a marked segregation in habitat requirement between wild and honey bees, still they are interconnected through weed factor both directly and indirectly. Indirectly, wild bees interact with the honey bees by pollinating weed flora making them available to the honey bees in between the mass flowering period. Directly, they interact in two different ways. First, competition for floral resources particularly during the period when honey bees forage on weeds. Second, competition through behavioural

Fig. 1. Different weeds are abundant sources of pollen and nectar and are frequently visited by different bee species. (A) *Megachile disjuncta* visiting *Crotalaria* sp., (B) *Apis dorsata* visiting *Polygonum* sp., (C) *Ceratina* sp. visiting *Mimosa* sp. and (D) *Apis dorsata* visiting *Leucas aspera*.

interference where one's behaviour influences other's activity. Therefore, the interaction between wild and honey bees is much complex. It may be antagonistic or mutualistic and depends on season.

Even weed can improve the crop yield indirectly in two ways. First, weed flora harbour these pollinators during the dearth situation and conserve their diversity for the upcoming blooming season of the main crop and increase its yield through pollination. Second, they increase the yield through behavioural interaction. Studies revealed that if sufficient weed communities are growing near the crop fields, then wild bee diversity will be more and as a result of behavioural interference they will push honey bees away to pollinate the main crop, resulting in higher yield. Similarly, foraging activity of honey bees is found to be more effective in orchards with non-*Apis* bees.

So there is a mutualistic relation between the beekeeper and farmer (growing crops that depend on bee pollination) as pollination improves the yield for the farmer and the honey produced from the nectar generates income for the beekeeper. However, this complex web of crop-weed-pollinator creates a trade-off between the stakeholders. Two scenarios may appear. First trade-off situation between the beekeeper and farmer (particularly a cereal grower that doesn't rely on bee pollination) appears as the farmer always considers the weeds as pests that will compete with his crop but for beekeeper weeds are required for survival of his colonies. Second trade-off situation may appear between two farmers, where the first farmer is an oilseed cultivar (like rapeseed, sunflower) who is hoping for increase in pollination through increase in weed diversity and the second farmer is a cereal grower who never allows weeds in his field as it may reduce his crop yield. In addition to that, another trade-off situation between farmers and the general public may appear as weed abundance ensures the survival of wild flora and fauna and thus improves socio economic value of the landscape. Thus increasing weed diversity can enhance the pollination service by maintaining pollinator populations, generate additional income for beekeepers by improving the honey yield and improve aesthetic value of landscape by ensuring the survival of wild flora.

However, an antagonistic relation may also develop between bee pollinators and wild flora. There are

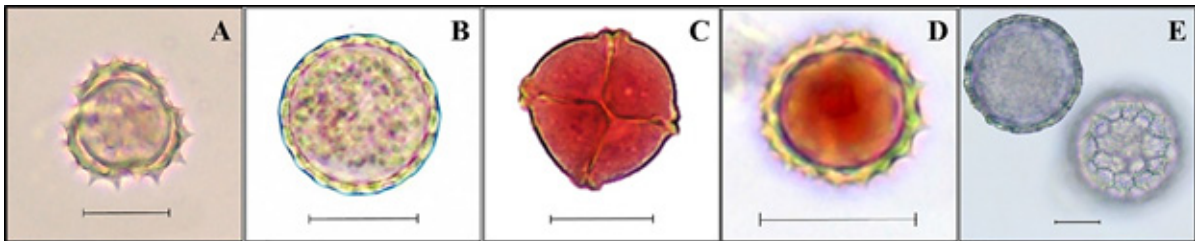

Fig. 2. Light microscopic images of different weed pollens recovered from honey. (A) *Ageratum conyzoides*, (B) *Amaranthus*/*Chenopodium* sp., (C) *Mimosa* sp., (D) *Parthenium hysterophorus* and (E) *Polygonum* sp. Scale bars=10µm

certain cases where flowers trick the visiting bees without providing any kind of reward to them. These flowers mislead the bees by using visual, olfactory, or sexual cues. On the other hand deceptive bee pollinators obtain nectar from the plants without helping them in pollination. Bees may collect the rewards from plant structures (such as extra-floral nectaries) without touching the reproductive parts. Thus nectar robbing without aiding in pollination negatively impact the fitness of the wild flora. Though such cases are very less. So, it is better to focus on the mutualistic pollination relation between wild flora and bees.

However, in the present scenario with agricultural intensification, diversity of many taxa are in a threatened position, especially weeds because of their close association with crop production. Since the middle of 19th century, applications of high amounts of herbicide have reduced the crop-weed competition and eliminated 50% weed diversity in last 70 years. Over the last 30 years there is a significant decrease in weed species like *Chenopodium album, Stellaria media, Sinapis arvensis, Fallopia convolvulus, Polygonum persicaria* and *P. aviculare* which are important food sources for many bees. Moreover, vacancy of that niche may be occupied by certain invasive wild flora that may not have any benefit to bees. It completely shatters the base of agricultural food webs. Decline in weed abundance is strongly linked with decline in wild bee diversity. Statistics revealed that only in Europe, 37-65% of bee species come under conservation concern. In the USA there was 59% decline in honey bees in 61 years. Over the 2021-22 season beekeepers from the USA faced an estimated loss of 39% of their managed bee colonies. In this aspect indiscriminate use of insecticides is a big concern that leads to phenomenon like colony collapse disorder (CCD). Exposure of bumblebees to imidacloprid not only slowed down their colony growth but also resulted in 85% reduction in queen production. With decline in bee population, the economic activity that relies on bees and beekeeping also showed a downward trend.

So from the above perspectives it is fair to say, "weeds are for bees and bees are for weeds". But intensive agricultural practices make this thought bleary. Standing on the present day, intensive weed management strategies is a matter of question. Conservation of biodiversity is now becoming an agronomic concern as long term enhancement of crop production depends on it. Therefore we need to think over the best compromise between food production and societal benefits, instead of focusing on the sole aim of food production. The diversity of weed visiting pollinators can be enhanced by implementing field margins, wild floral stripes, set-aside fields, no-tillage strategy, or by reducing application of pesticides and inorganic fertilizers, and moving towards organic production. A study suggested that an increase from 5 to 20% in organic cropping can improve the diversity of solitary bees by 60% and bumblebees by 150%. At present we are going through a worldwide bee decline phase that needs to be addressed with immediate action and if it is not addressed then we will have to face a situation which Sir Albert Einstein has already visualized, "If the bee disappeared off the face of the Earth, man would only have four years left to live".

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