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Editorial

Special Issue "Pollinator Diversity and Pollination in Agricultural Systems"

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Animal-mediated pollination and the subsequent fertilization of plants is the most important eco-physiological process that occurs during the production of many fruit, vegetable, and nut crops. It has been estimated that the economic global value of animal-mediated pollination is 9.5% of the value of the world agricultural production [1]. This is sobering in light of the documented global decline of pollinators [2–4]. Of the animals performing pollination services, bees are considered the most significant [5,6]. Pollination by bees is one of the more complex insect–plant interactions in agriculture. This is because of the behavioral, ecological, and physiological dynamics of pollinating bees (involving thousands of species worldwide), the ecological and physiological dynamics of crop plants, and the complex dynamics between the interacting bees and plants involving both of their behaviors, ecologies, and physiologies. While there have been recent advances in the pollinator diversity and community ecology associated with crop plants, much remains to be learned about crop plant pollination, the specific roles of crop plant reproductive syndromes, and the temporal and spatial dynamics of pollinator diversity and abundance. In addition, the effectiveness and economics of relying upon native pollinators and/or commercially managed pollinators such as the honey bee need to be better resolved. In most crop production systems dependent upon animal pollination, other areas that have not been well researched are the effectiveness of pollinator reservoirs; the competition of the pollen from neighboring flowering plants with crop bloom; the longevity of stigma receptivity; within-crop-species pollen compatibility; planting designs to maximize fruit sets; the insect efficacy of pollen vectoring; the effects of agricultural chemicals on insect visitation, fruit sets, and yields; and the effect of plant resource constraints on flower development, all of which are compensatory mechanisms that reduce fruit size.

Eight articles that provide insight into some of this complexity across a variety of vegetable, fruit, nut, and fiber crops have been published in the Special Issue of *Agronomy* entitled "Pollinator Diversity and Pollination in Agricultural Systems". The research covered in this Special Issue spans a diversity of topics from plant physiology to bee community diversity. The molecular signaling by plants that imparts self-incompatibility or, through a lack of signaling, self-compatibility affects cross pollination. This is of great interest to crop plant breeders, as it directly impacts crop quality and yields. Kämper et al. [7] show that the yields of standard cultivars of almonds that are self-incompatible relied entirely on cross pollination and that the paternity of the pollen had little effect on yield or quality. However, they also determined that the yields in some of the newer self-compatible cultivars were due to self-pollination, but varied significantly, suggesting that some of these new cultivars may be good candidates for the establishment of single cultivar orchards. Drummond and Rowland [8] also looked at open pollination and the yield of both self-incompatible and self-compatible genotypes in a wild blueberry agroecosystem. They found that early blooming genotypes tended to have high levels of self-compatibility and that these genotypes also had the highest fruit sets and berry weights. This research showed that the ecological interaction of bloom phenology, self-compatibility, and bumble bee foraging behavior shaped the levels of fruit set and yield that occurs in wild blueberry fields and that early occurring bees at the beginning of bloom are critical to high yields. Plant phenology and energetics were also shown to affect the dynamics of pollination in single cultivar olive orchards when artificial cross-pollen applications were performed throughout the bloom period [9]. The authors found that when trees had a heavy flower load, fruit set and yield increased with the number of cross-pollen applications. However, in years when trees had a low level of flower abundance, the number of pollen applications had no effect on fruit set or yield. Therefore, tree energetics determine the number of flower resources in the tree, which determines the tree's yield response to the level of pollination. Crop plants can also show a physiological response in retaining fruit that appears to be dependent upon the level of pollination. Drummond [10] shows that fruit drop in wild blueberry has a genetic basis, and that it can be either proportional to flower abundance or due to resource limitation. Fruit drop, over a three-year period, ranged from 23.3% to 49.4% of the total set fruit and was found to be an interaction of genetic, environmental, and pollination level as represented by seed set. Therefore, pollination can explain yield not only by setting fruit from flowers, but also by resulting in fruit drop due to low levels of flower visitation and sparse deposition of pollen on stigmas.

Pollinator abundance and diversity are also related to crop fruit set and yield [11–13]. Most of the time, the pollinators associated with crops are generalists, as reported in this Special Issue by Parys et al. [14] in southern US cotton fields. The fitness of these pollinators in agricultural landscapes has received limited attention. In this issue, Eckerter et al. [15] found that bumble bee colony growth and fitness was not explained by floral resource abundance in agricultural landscapes, but instead by distance from surrounding forest landscapes. They found an inverse relationship in colony growth and fitness and distance from forest edges. Their findings suggest that conservation of forest landscapes is beneficial to embedded agricultural landscapes in Europe by providing pollinator communities with higher population growth and fitness. Bee community diversity, abundance, pollination efficacy, and crop plant reproductive biology in wild blueberry fields is reviewed by Bushmann and Drummond [16]. They provide insight into a rich bee community (>120 spp.) associated with this crop and its unusual non-reciprocal outcrossing dynamics along with limited but important autogamy [8]. Their research also shows that while bee diversity is high in this crop system, only two major taxa were observed to explain variation in fruit set and yield, *Bombus* spp. and *Apis mellifera* (L.). The importance of the native bee community was best estimated by showing that a hypothetical total disruption in the supply of honey bees for pollination of this crop would result in a 30% reduction in yield. The reason that this yield loss is not expected to be more is from buffering by the native bee community.

In summary, the pollination of crops is a complex interaction between pollinator behavior, ecology, diversity, and abundance; and crop plant physiology, phenology, and ecology. This Special Issue, Pollinator Diversity and Pollination in Agricultural Systems, has attempted to shed light on some of this complexity.

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