Boosting Macadamia Nut Production Sustainably Through Smart Orchard Design

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Figure 1. Honeybee drinking nectar from a macadamia flower. Photo: Mina Anders.

Traditional farming methods have often harmed the environment and reduced biodiversity. To combat these issues, we need more sustainable and environmentally friendly agricultural practices. Bees, which are essential for pollination, play a crucial role in growing many of the world's crops, including macadamia nuts. Finding eco-friendly ways to increase pollination and nut production is vital for environmentally conscious agriculture.

In a recent study conducted in South Africa,[1] our team explored how we can enhance pollination services for macadamia nut trees without breaking the bank. We observed the insects that visit macadamia flowers to find out what increased their number and how their visits affect nut production. Further, we experimentally excluded the pollinators from some flowers with mesh bags in order to see what would happen if there were no pollinators on the flowers at all, and artificially pollinated other flowers by hand to simulate nearly perfect pollination. We did this at two key stages: early nut formation (3 to 5 weeks after flowering), to evaluate pollination success, and later nut development (18 to 20 weeks after flowering), to see how final yields were impacted.

Macadamia trees, as mass flowering plants, are highly dependent on effective pollination. The study showed that insect pollination of the flowers significantly increased both early and final nut production —by 304% and 23%, respectively, compared to the exclusion of pollinators. However, even with insect pollination, there was still room for improvement in nut production, as hand pollination boosted yields by a remarkable 737% for early nuts and 367% for final nuts. This illustrates the potential for improving the pollination performance of insects.

Honeybees proved to be the most important pollinators of macadamia flowers in the farms observed and were responsible for 95% of all flower visits (Figure 1). Interestingly, it was not only the number of managed honeybee colonies that was decisive, but also the presence of natural habitats, such as uncultivated areas with shrubs and trees in the surrounding landscape. These habitats proved to be a more influential factor in increasing these visits than the honeybee colonies. We hypothesized that many of these honeybees were wild and originated from the

References:
1. Anders, M., Grass, I., Linden, V. M. G., Taylor, P. J., & Westphal, C. (2023). Smart orchard design improves crop pollination. *Journal of Applied Ecology*, 60, 624–637.

surrounding habitats. Moreover, we were surprised to find that common agricultural practices such as irrigation did not significantly increase nut production.

"When an orchard is adjacent to a natural habitat, arranging the rows perpendicular to the edge of the orchard results in a more than threefold increase in early nut production."

So, how can we improve pollination services? The solution does not require additional resources after the orchard is planted. It lies in the smart design of the orchards:

1. **Changing the row orientation:** Traditional macadamia orchards are arranged in rows of trees (Figure 2). However, the study found that, when an orchard is adjacent to a natural habitat, a perpendicular arrangement to the edge of the orchard results in a more than threefold increase in early nut production compared to parallel rows (Figure 3A). As most of the bees in the orchards originate from the neighbouring natural habitat, this arrangement makes it easier for them to fly into the orchard, because they prefer to follow the rows of trees instead of crossing them. Thus, on average, we found almost twice as many honeybees on the macadamia flowers in orchards with perpendicular rows compared to orchards with parallel rows.
2. **Mixing macadamia varieties:** The study showed that the initial nut set was larger in orchard blocks with three or more varieties (an average of 4.8 nuts per raceme) than in blocks with only one or two macadamia varieties (an average of 2-2.7 nuts per raceme) (Figure 3B). This difference was slightly lower for the final nut set. In many crops, cross-pollination between different varieties is known to increase the fruit set. This effect has also been observed in macadamia. This is where the honeybees come in: their important role as insect pollinators is to transport pollen between trees of different varieties. The variety investigated in our study was Pahala (also known as 788), a very common macadamia variety in the region.

The study strongly emphasizes the importance of pollination services for successful macadamia nut production. Through thoughtful orchard planning and utilizing the natural landscape surrounding the orchards, we can increase nut production without additional agricultural inputs. This research highlights the potential for ecological intensification through these smart design choices and the preservation of natural habitats. Recognizing the essential role of pollinators and introducing design measures that support their work not only boosts nut production but also contributes to the conservation of vital natural habitats. This approach is an important step towards a more sustainable and environmentally conscious future for agriculture.

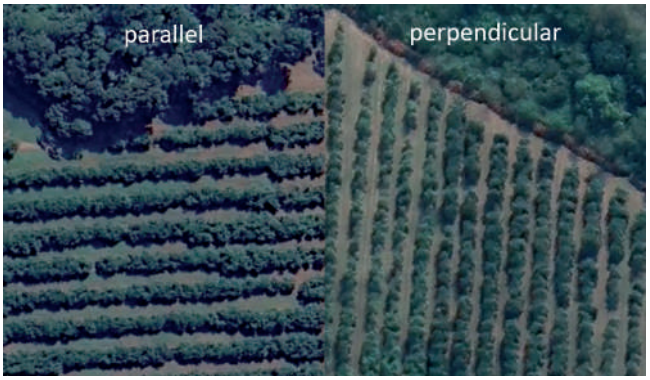

Figure 2. Examples of macadamia tree rows oriented parallel or perpendicular to the edge of the natural habitat. Google Earth Pro, 2020, Image © 2020 Maxar Technologies.

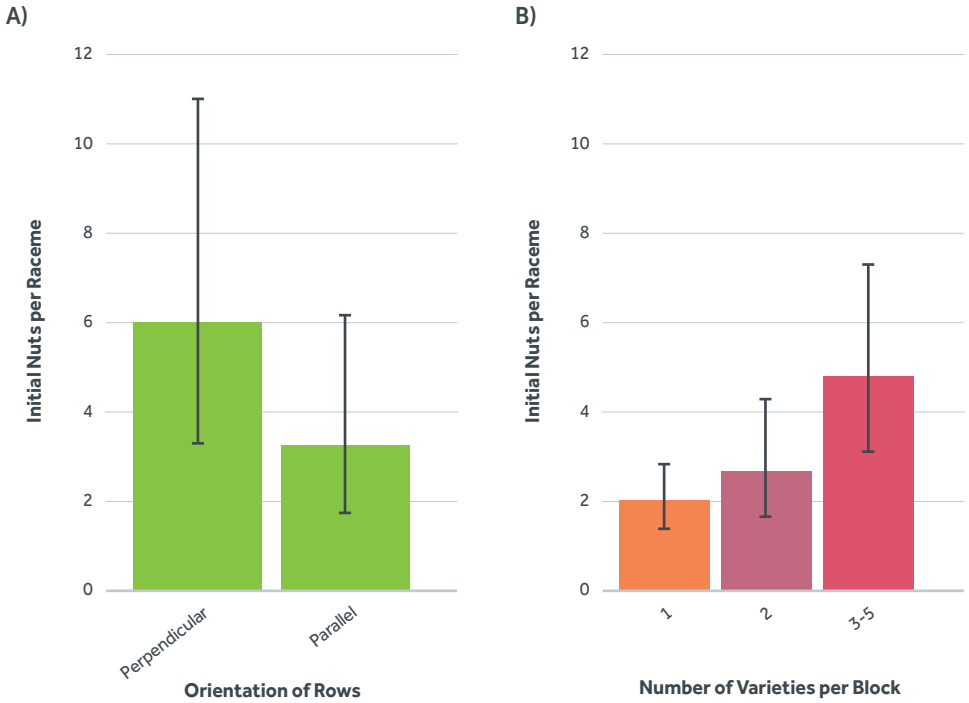

Figure 3. A) Effect of macadamia tree row orientation towards the natural habitat at the orchard edges on the initial nut set (3 to 5 weeks after flowering) and B) effect of the number of varieties in the macadamia block on the initial nut set.