Title: Increasing pollinator visitation and controlling whiteflies during bloom with kaolin and magnesium oxide.

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Final report

I. Details of the project

A. BACKGROUND

1. Increase in pollinator activity.

Pollination is a limiting factor in the cultivation of cucurbit crops (Sawe et al. 2020, Brett and Sullivan 1972, McGregor 1976). Seeded watermelons require a minimum of 8 bee pollination visits for fruit set, but this number may change for different cultivars (Adlerz 1966). Estimates, still needing verification, of the number of bee pollinator visits required to produce seedless or triploid watermelons range from 16 to 24 (Walters 2005, Wijesinghe et al. 2020). Bee pollinators transfer pollen from the male diploid or seeded melon flower onto the stigma of the female triploid or seedless melon flower (Gillaspy et al. 1993). However, if bees do not adequately transfer diploid pollen, the female triploid flower will abort, resulting in fruit production delays (McGregor and Waters 2014). Therefore, fields growing triploid watermelons must have approximately 20 to 30% diploid melons to ensure fruit set (Fiacchino and Walters 2003, Walters 2005).

Pollination is difficult due to the increasing pressures on managed honeybee hives. The most severe pressure affecting hives in 2021 was Varroa mites, which were present in 50% of managed hives between April and June 2021 (USDA 2022). In addition, between January and March of 2022, the number of honeybee hives lost to colony collapse disorder increased by 12% (USDA 2022). Colony collapse disorder seems to be caused by a complex of stress from pesticide use, declines in flower populations, and parasitism (Goulson et al. 2015). Multiple viruses and the fungus *Nosema* also plague honeybee hives worldwide (Genersch 2010).

Considering the importance of pollination to watermelon production, growers face several issues. First, the limited managed bee populations and declining native bee populations visit the competing floral blooms of weeds, native vegetation, and other commercial crops instead of the watermelon blossoms. For example, in a pollinator study involving seedless watermelons in Georgia, pollinator visits declined in the second and third week in association with the sunflower bloom that occurred in the vicinity (Ellis and Delaplane 2009). Second, there is also some concern that the triploid watermelon blossom, which requires pollination for fruit set, is less attractive than diploid watermelon blossoms. Third, watermelon producers face a dilemma of whether to favor pollinators by limiting insecticides during the blooming period or control yield-reducing insects that may affect yields.

Due to the importance of pollination on watermelon crops and other crops, researchers have made several attempts to increase the attraction of fruit blossoms to bees. The bee attractant Fruit Boost® applied to the triploid seedless watermelon cultivar 'Sugar Heart' did not increase pollinators, fruit-set, or fruit weight (Ellis and Delaplane 2009). In central and southwest Florida, to watermelon fields producing 'Crimson Sweet' and 'Royal Jubilee' cultivars, respectively, the bee attractant Bee-Scent® was applied. The application of Bee-Scent® resulted in an increase in bee activity on only one of the sites and early yield on some of the study sites, although fruit quality was not improved (Elmstrom and Maynard 1990). Bee-Scent® and Beeline® were applied to 'Calypso' cucumber and 'Royal Sweet' watermelon plots and did not increase the number of pollinator visits, yield, or fruit quality. Researchers sprayed a variety of crops with solutions bearing high sugar concentrations to improve pollination. Instead, this tended to distract the bees from pollinating flowers and led them to focus on collecting sugar from the sugar-coated leaves (Free 1965).

2. Protection against whiteflies

In addition to attracting more pollinators, **we know that kaolin combined with limonene is a repellent of whiteflies in tomatoes and squash** (Johnston et al. 2002, Figure 2A). Therefore, a treatment combining kaolin, limonene, and/or magnesium oxide may protect against whitefly infestations. The sweet potato whitefly, *Bemisia tabaci* (Gennadius) B biotype, has become a significant pest of cucurbits. Whiteflies cause damage by direct phloem feeding in the immature and adult parts of their life cycle. Whiteflies also indirectly damage plants by transmitting 50 types of geminiviruses. The most important viruses for watermelon are the Cucurbit leaf crumples virus (CuLCrV), the Cucurbit yellow stunting disorder virus (CYSDV), and the Squash vein yellowing virus (SqVYV). Whitefly populations increase dramatically following mild and dry winters. Mitigating increased whitefly numbers is made more difficult by the rise of pesticide resistance (Horowitz et al. 2020). In north Florida, whitefly populations exploded in 2017 and 2019, while in central and south Florida, whitefly populations were consistently high through the growing season. Begomovirus infections reduce internal watermelon fruit quality through discoloration and reduced sugar content. The earlier a virus infects a crop, the greater the impact on yield. Current traditional pest control practices rely on pesticide treatments that can control nymphs but not prevent continual adult arrivals due to the whitefly's dispersal capabilities. Our lab combined kaolin clay with limonene and obtained effective control of whiteflies in tomato (Johnston et al. 2022) and squash (Fig. 2A). In squash and tomato, the reduction of whiteflies corresponded with an increase in yield (Johnston et al. 2022, Fig. 2B). Limonene scented kaolin does not result in pollinator decline and as a result can control whiteflies on watermelon during the pollinator sensitive bloom period. Notably, a conventional cooperative tomato grower tested the tank mix of kaolin and limonene at a farm scale (Fig. 3). We are therefore confident that this product could be successful in watermelon too.

B. RESEARCH PLAN

Two field experiments were conducted, both at the UF/IFAS/NFREC center in Quincy, FL. Experiments used triploid 'SuperCrisp' plantings with the diploid 'Sidekick' serving as the pollinizer at a 1:3 pollinizer-to-seedless ratio. In both trials, watermelon plants were spaced 3.0 ft in row. Rows were spaced 8.0 ft center-to-center, covered with black polyethylene plastic, and had a 25 ft buffer between replications. Pollinator attractive and repellent treatments were applied in each subplot according to a split-plot design, and there will be five replication per treatment. The main plot treatments consisted of the presence / absence of fake flower lures (Fig. 1) the goal of these colored targets was to provide visual attractant for a pollinator. The sub-plot treatments were A) untreated control with no treatments applied, B) pesticide spray that mitigates pollinator demise and maximizes pest demise, C) Kaolin + limonene + magnesium oxide sprayed as foliar applications, D) foliar applications with Bee-Scent®, a pollinator attractant (positive control).

Number of pollinators was assessed during 4 min observation of each plot. For each visitation the bees were classified either as honeybees, bumblebees, or solitary (wild) bees. The whitefly population were assessed weekly during the fall trial. Ten watermelon leaves were lifted in each plot, and the number of whitefly adults counted. In addition, three 1 cm radius discs of leave were sampled on ten plants per plot, and the number of whiteflies nymphs in these discs were counted in the lab.

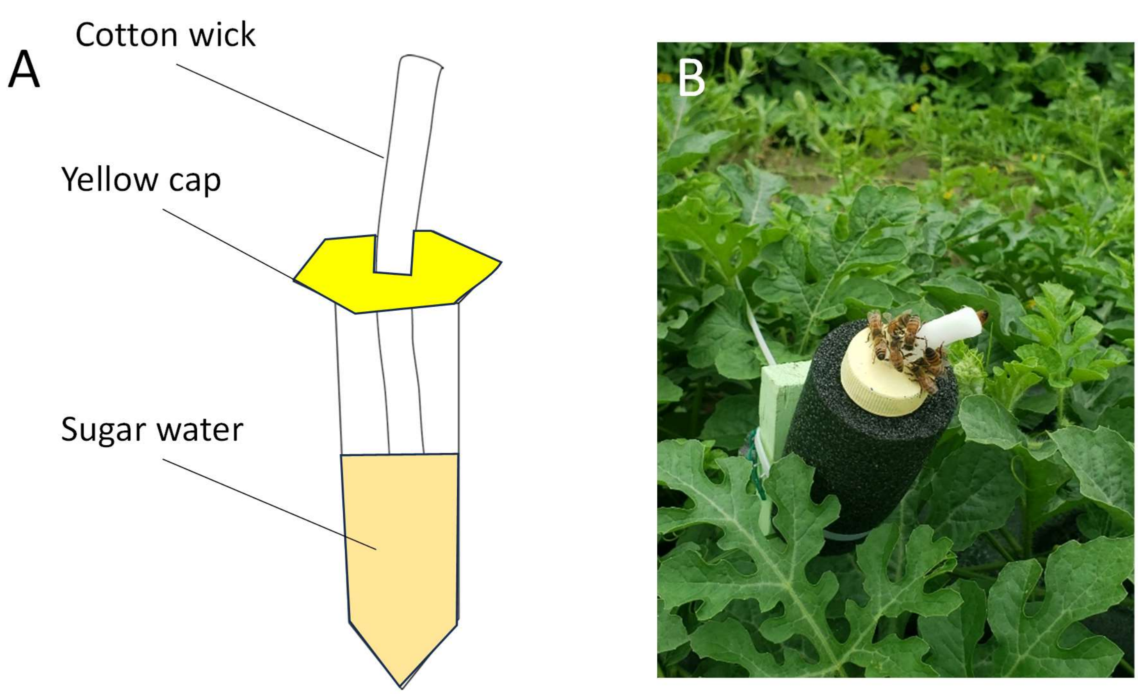

Figure 1: (A) schematic diagram of the fake flower lure, (B) aggregation of honeybees on the lure.

C. RESULTS

1. Increase in pollinator activity (Spring 2023).

The different spray applications did not significantly increase the number of visitors as compared to the control (Fig. 2). The number of visitations during 4 min observation did not differ among spray treatment for either honeybees, bumblebees or solitary bees.

However, the addition of fake flower lures increased significantly the number of visitations for the native bees (+22% increase of the course of the trial, Fig. 3). The number of visitations by honeybees also increased by 10% but this difference was not statistically significant. Fake Flower lures has no effect on bumblebees.

For the spring season the yield was not statistically different between spray treatments (Fig. 4); however, we observed an increase in the number of fruits (+20%) produced in plots with the fake flower lures (Fig. 5). There were no differences however in the total weight of the yield. The spray treatments had no effects on the level of hollow heart and brix level (Fig. 6). There were less hollow heart issues in watermelon from plots with fake flower lures, but this difference was not statistically significant. The brix of the watermelon from plots with the fake flower lures had a slightly lower brix than the control pot (Fig. 7).

Overall, the addition of fake flower lures seems to have positive effect on the attraction of pollinator resulting in higher number of fruits. The experiment should be repeated to confirm the results.

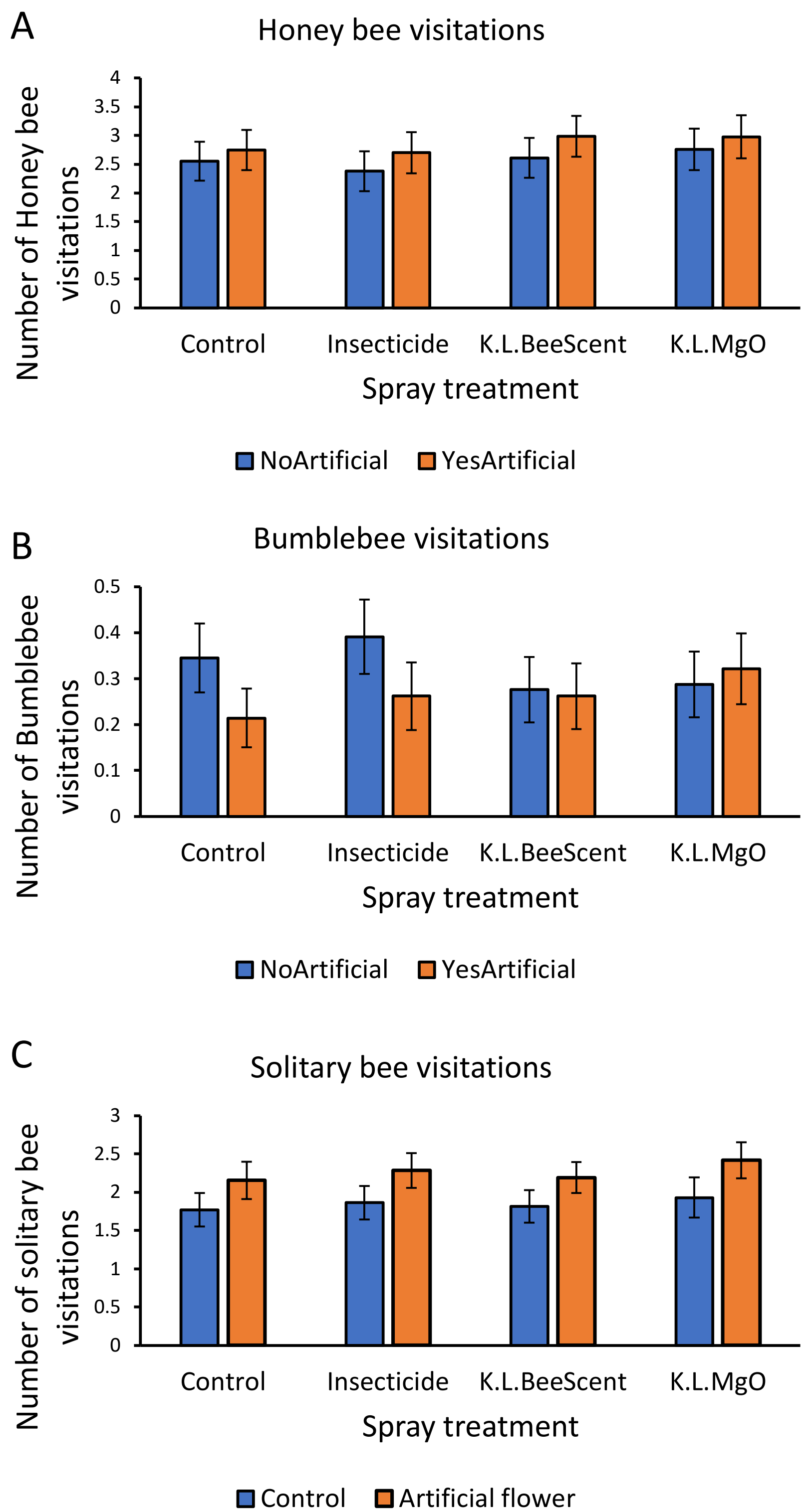

Fig. 2: Average number of visitations for 4 minutes observation for honeybees, bumblebees, and solitary bees.

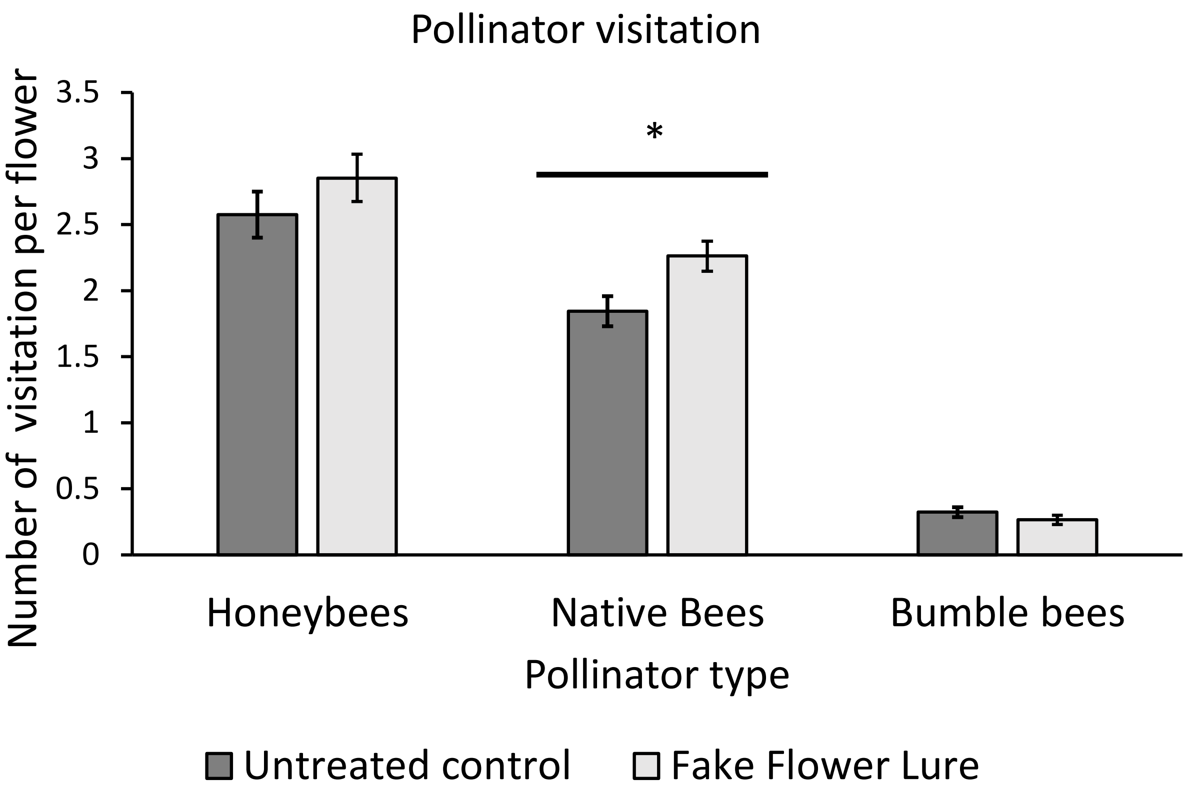

Fig. 3: Number of pollinator visits, depending on the presence or absence of fake flower lures

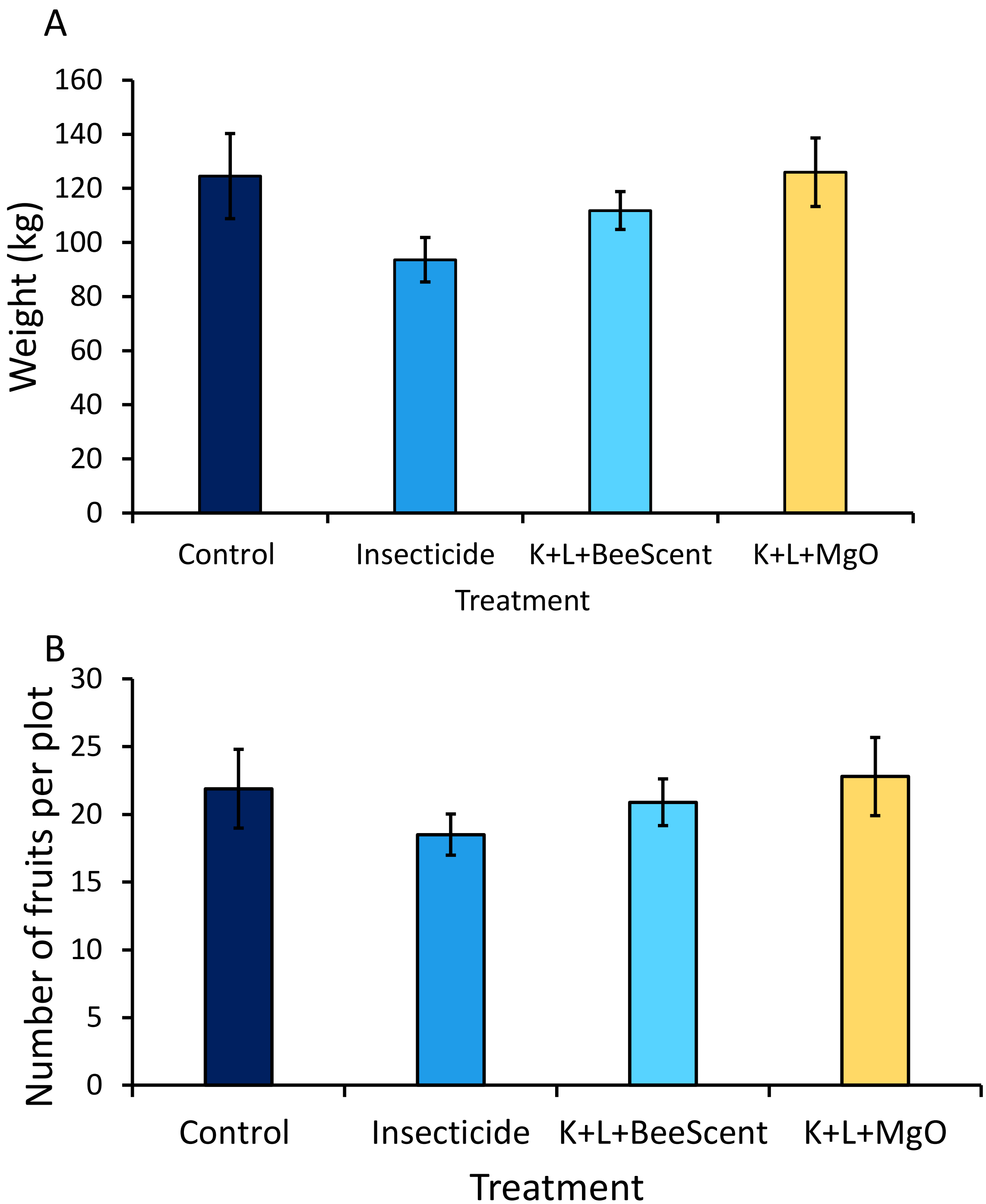

Fig. 4: (A) Number of fruits and (B) total yield produced per plot depending on the spray program.

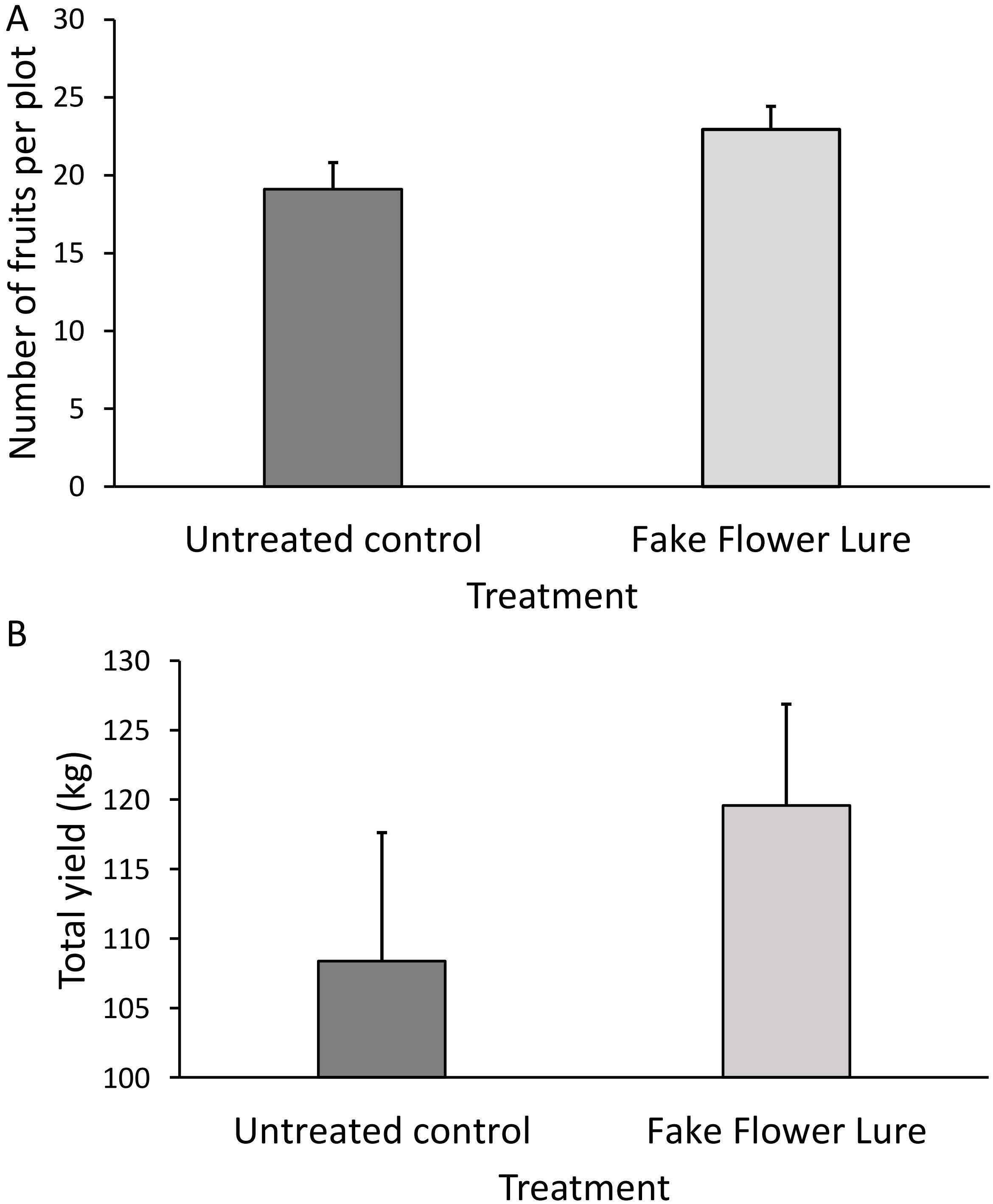

Fig. 5 (A) Number of fruits and (B) total yield produced per plot depending on the presence or absence of fake flower lures.

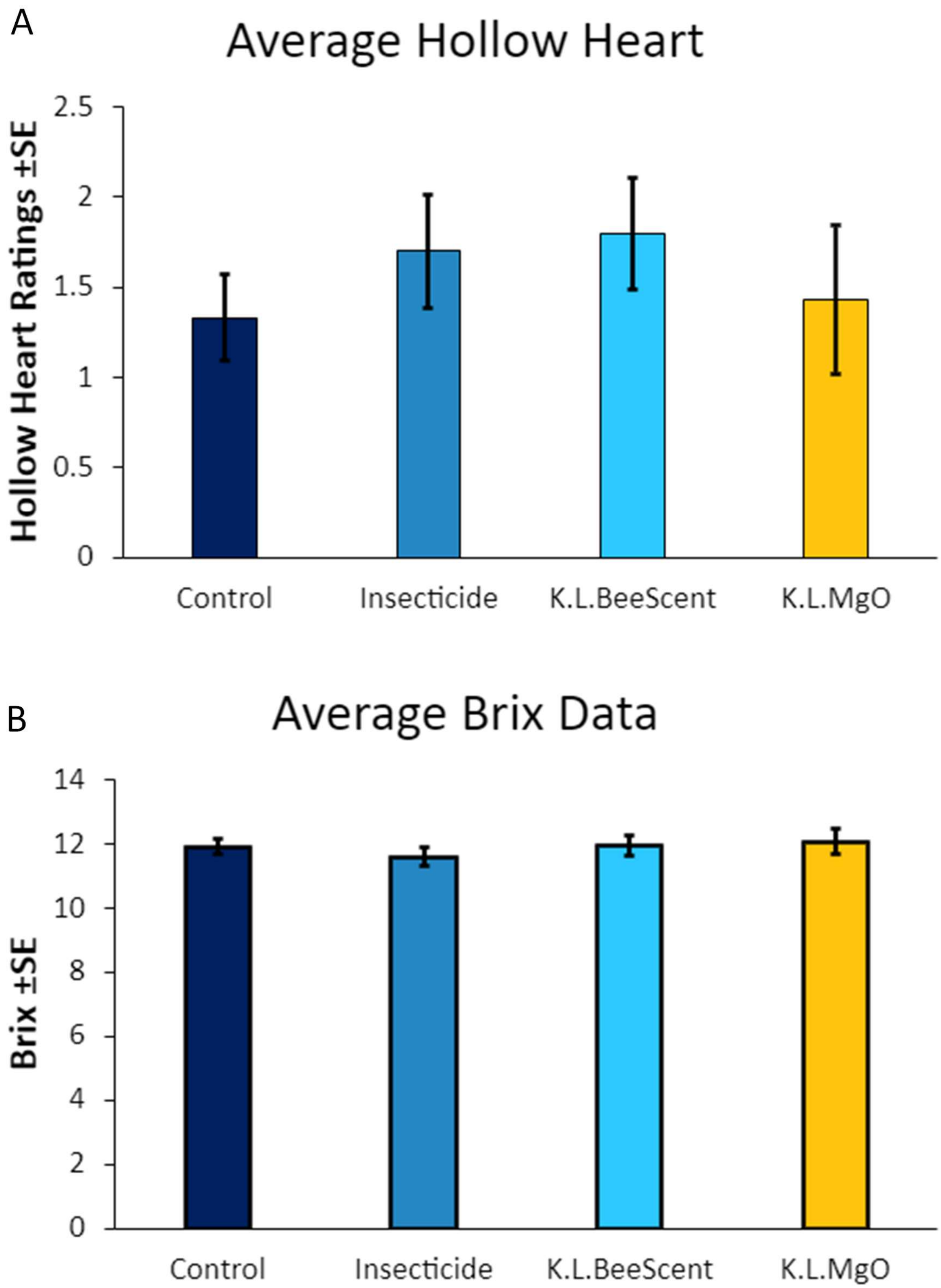

Fig. 6: (A) Brix and (B) hollow heart rating per plot depending on the spray program.

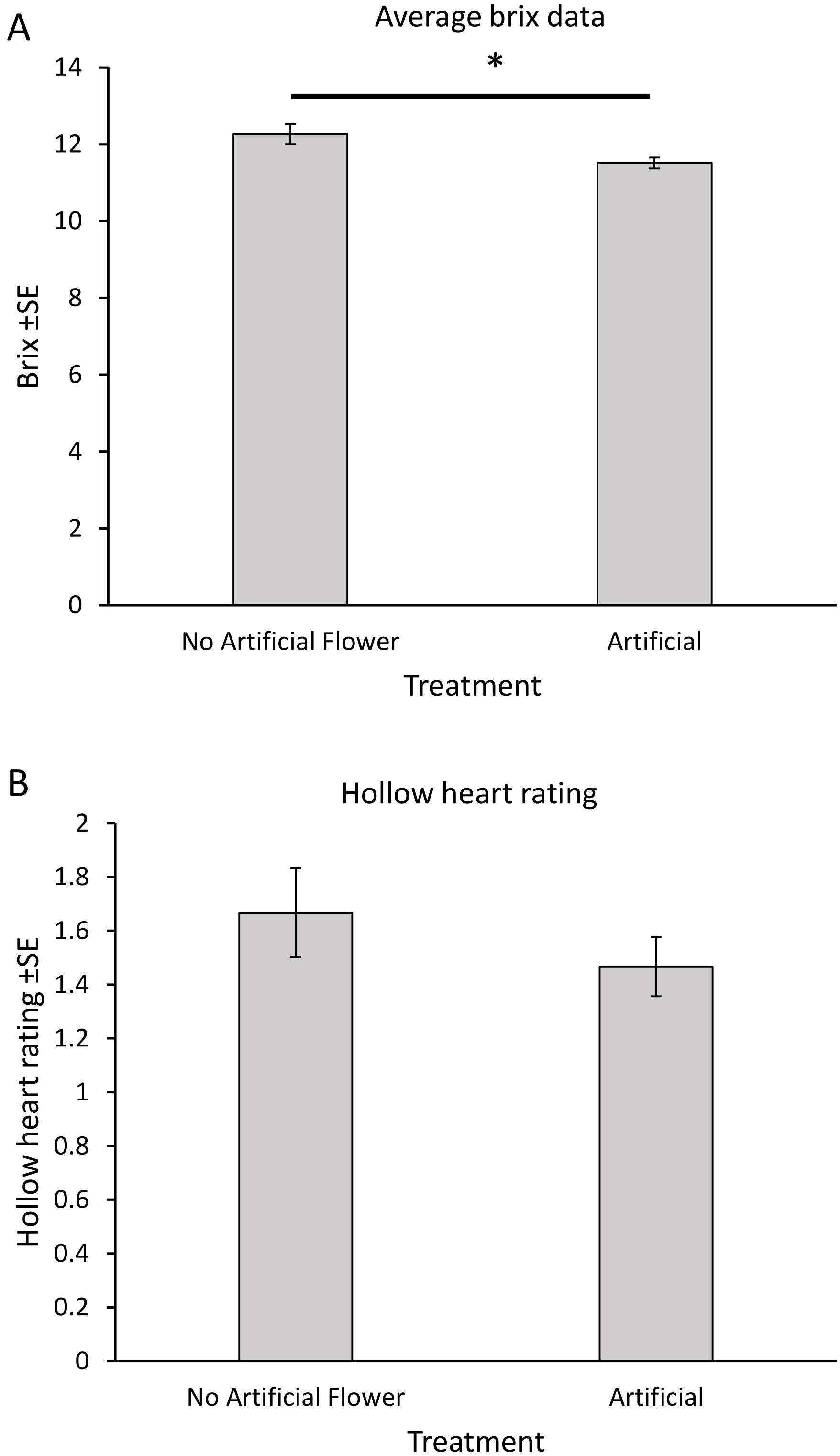

Fig. 7: (A) Brix and (B) hollow heart rating per plot depending on the presence or absence of fake flower lures.

2. Protection against whiteflies (fall 2023)

In fall 2023, our field was severely damaged by deer (Fig. 8) during the blooming stage; therefore, we were able to only collect data regarding the management of whiteflies.

On the different treatments evaluated only the insecticide rotation significantly decreased the number of adult and whiteflies nymphs. ***Therefore, the use of kaolin and limonene in watermelon is not recommended to control whiteflies.*** The main difference with previous studies (Johnston et al. 2022) come from the fact that watermelon is ramping vine, and the underside of the leaves is difficult to reach for spray treatments.

Fig. 8: Deer damage during the fall trial.

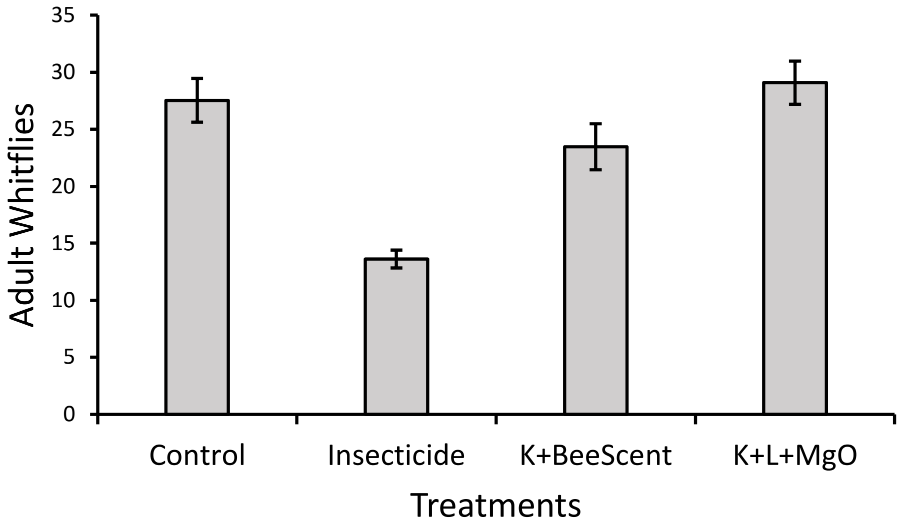

Fig. 9: Number of adult whiteflies per leaf depending on the spray program.

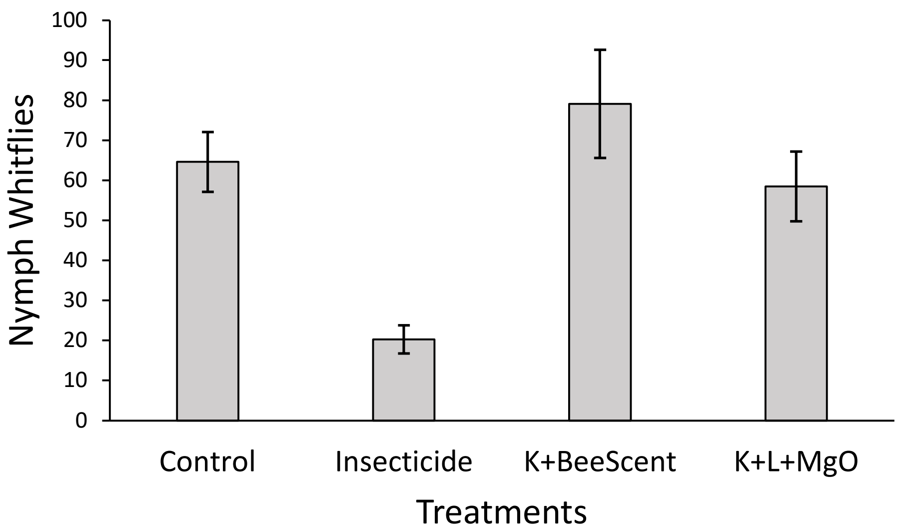

Fig. 10: Number of adult nymphs per leaf sample depending on the spray program.

Products

Martini X., Paris T. *Webinar*. Increasing pollinator activity in watermelon with the use of fake flower lures. NC Watermelon Production Zoom Meeting. Online meeting. January 30, 2024. 100 attendees.

Martini X, Paris T. (2023) Increasing Pollinator Activity in Watermelon with the Use of Fake Flower Lures. The Vineline. Fall 2023: p13.

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Thomson Paris – Postdoc, university of Florida

Adnise Christophe – Internship, Earth University, Costa Rica.

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