

Assessment of host plant species for a trap cropping approach in integrated pineapple mealybug (*Dysmicoccus brevipes*) management

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Abstract

For pineapple [*Ananas comosus* (L.) Merr.] producers fighting the pineapple mealybug [*Dysmicoccus brevipes* (Cockerell 1893)], a pest that causes major damage globally, choosing the appropriate crop management plan is essential for agricultural success. Mealybugs are tiny, soft-bodied insects that may seriously harm crops by secreting honeydew, a sticky substance that hinders photosynthesis and encourages the formation of mould (Palma-jiménez and Blanco-meneses 2018). By sucking sap and dispersing viruses, the pineapple mealybug is infamous for limiting development and even destroying plants (Lisnawita et al. 2023). Their broad host range makes them difficult to manage. Chemical control techniques, such as the use of synthetic pesticides like organophosphates (like malathion), neo-nicotinoids, and chitin-biosynthesis inhibitors, have historically been the main means of managing pineapple mealybug infestation in plants (Wallingford et al. 2015, Lembaga Perindustrian Nanas Malaysia 2020). Despite their initial effectiveness, excessive use of these compounds may be harmful to people and animals as well as the environment. Nevertheless, frequent use of these substances may result in insect resistance, which might eventually reduce these insecticides' effectiveness (Leong et al. 2020). Alternative approaches are being investigated to lessen reliance on chemical pesticides. Leveraging the host selection behaviour of mealybugs for control has been the subject of recent study. Growing non-crop plants in a designated area to draw pests away from primary crops is known as "trap cropping," and it has shown to be a successful and long-term solution (Sarkar et al. 2018). Without the drawbacks of using chemicals, this technique, which takes advantage of pests' preferences for certain plants, has been effective in lowering pest populations and minimising damage (Popp et al. 2013, Dara 2019).

Introduction

Nevertheless, further investigation is required to pinpoint certain plants that successfully draw pineapple mealybugs. By better understanding these preferences, trap cropping techniques may be improved, providing a more sustainable means of pest control for the world's pineapple sector (Cotes et al. 2018). By examining the pineapple mealybug's predilection and selection for various host plant species, our research seeks to close this gap and advance the creation of more efficient and ecologically acceptable pest control methods.

Nine plant species were used in this study: banana (*Musa* spp.), pumpkin (*Cucurbita moschata* (Duchesne) Duchesne ex Poir.), roselle (*Hibiscus sabdariffa* L.), hibiscus (*Hibiscus rosa-sinensis* L.), okra (*Abelmoschus esculentus* (L.) Moench), java grass (*Cyperus rotundus* L.), goose grass (*Eleusine indica* (L.) Gaertn.), and rhodes grass (*Chloris gayana* Kunth.). Based on reports by Mani and Shivaraju (2016), O'Hearn and Walsh (2018), and Lopes et al. (2019), the host plant species was chosen. All of the host plants were placed in 16-by-16-inch polybags filled with a soil mixture that included organic matter, sand, and topsoil at a ratio of 3:2:1. The plant was watered in accordance with routine operating procedures until it reached a height of two to three feet. Insects: Sweet pumpkins were used to raise the pineapple mealybug (Carabali-Banguero et al. 2013). An insect cage with a fine mesh net covering the whole enclosure was used for the rearing, and the temperature was maintained at 27°C (Mani and Shivaraju 2016). Before the host plant experiment started, thirty adult pineapple mealybugs were raised on the pumpkin for two months to establish their population (O'Hearn and Walsh 2018).

Experiments using host plants: Pineapple mealybug host plant choice was assessed between August 2022 and January 2023. Three 9 m² study plots were set up. To lessen pest assaults on the host plant, especially grasshoppers and leaf-eating beetles, each plot was made open at the top and covered with black netting that permits 50% light penetration. Each plot is around ten meters apart. A fully randomised design (CRD) with three replicates (plot) was used for the experiments. The effectiveness of each of the selected trap crops was assessed using no-choice settling tests (Schoeny et al. 2019). The ground portion of the allotment is covered with plastic mulch, often called silvershine, to prevent the development of new weeds. Before the experiment started, nine host plant species (banana, pumpkin, roselle, hibiscus, okra, ground fig, java grass, sambau grass, and rhodes grass) were easily planted at a height of two to three feet. A circle was formed by the host plant

species. The pineapple mealybugs' reservoir, a pumpkin, is positioned in the middle, one metre away from the host plant type (Schoeny et al. 2019). The host plant species are separated by 60 centimetres. Standard operational procedures and plant needs were followed while watering and fertilising each plant. This research did not use any pesticides or herbicides. For six months, the host plant and the pineapple mealybug were observed every two weeks, and each host plant's pineapple mealybug population was determined. In later field research, the host plant crops that draw the most pineapple mealybugs are thought to be the most successful. Analysis of data: Minitab version 20.0 software's One-way Analysis of Variance (ANOVA) technique was used to analyse the data. The Origin Pro 2022 software was used to create a heatmap that visually depicted the relative number of pineapple mealybugs drawn to certain trap crops. Additionally, a bar graph was used to compare and evaluate the total number of pineapple mealybugs in various trap crops. Microsoft Excel was used to analyse the bar graph. Host choice and performance: According to our research, pineapple mealybugs clearly prefer bananas to other plant species that were investigated (Table 1). ANOVA statistical study demonstrates the influence of host species on mealybug attraction by confirming a considerable variation in mealybug dispersion across several plants ($F=26.87$, $P<0.00$). The plants are then divided into groups according to average mealybug numbers using Tukey's Pairwise Comparisons. Bananas are the best attractor in group A, with an average of 621.7 mealybugs. Roselle, hibiscus, and ground fig have averages of 155.0, 120.0, and 81.3, respectively, in Category B, which is started by pumpkin (average 237.0). Okra (27.0), Java grass (20.0), Goose grass (10.0), and Rhodes grass (2.0) have the lowest averages, making up group C. Statistical significance is indicated by the grouping letters. There is no discernible difference in the host plants' capacity to draw mealybugs when they share a letter. Bananas so do far better than any other crop. On the other hand, crops such as okra and other types of grasses are not very appealing. Bananas are the best option for successful trap cropping techniques, highlighting the significance of host plant selection in the strategic control of pineapple mealybug populations.

Pineapple mealybug populations vary across a variety of host plants, with bananas showing the greatest infection level (Fig. 1). This suggests a clear preference

Table 1 Pineapple mealybug adults observed on plants; mean no. of adults observed on all 9 host plant species

Species of host plant	Mean $\pm$ SD
Banana	621.7 $\pm$ 172.7 ^a
Pumpkin	237.0 $\pm$ 45.6 ^b
Roselle	155.0 $\pm$ 22.5 ^{bc}
Hibiscus	120.0 $\pm$ 70.0 ^{bc}
Ground fig	81.3 $\pm$ 17.5 ^{bc}
Okra	27.0 $\pm$ 17.3 ^c
Java grass	20.0 $\pm$ 27.2 ^c
Goose grass	10.00 $\pm$ 12.49 ^c
Rhodes grass	2.00 $\pm$ 2.65 ^c

Note: Means that do not share a letter are significantly different.

of mealybug for bananas compared to other examined plants, although rhodes grass is noticeably less appealing to these pests.

Larger error margins indicate that mealybug prevalence varies on ground fig and hibiscus, indicating that their effectiveness may change depending on situational or environmental circumstances. Conversely, narrower error bars imply that mealybug populations are more stable in plants like banana and pumpkin. Tukey's technique places pumpkin in Group B and bananas in Group A due to their better attractiveness. Roselle, hibiscus, and ground fig are grouped together in BC, indicating that they may be as appealing to mealybugs as pumpkin but less so than bananas. Group C includes less favoured plants that have lower mealybug numbers, such as okra and other types of grasses.

These results demonstrate the strategic value of choosing certain host plants for agricultural mealybug control. Bananas are a viable alternative for a trap crop because of their attraction to mealybugs. However, the discrepancy seen in certain species suggests that further research is needed to confirm their dependability in various situations. Using colour intensity to indicate mealybug abundance, Fig. 2's heatmap illustrates the interactions between pineapple mealybug and a variety of host plants across fortnightly intervals. The heatmap's mostly light hues indicate that most plants

are not very appealing to mealybugs. On the other hand, *Cucurbita moschata* is a close second because of its many darker segments, whereas *Musa* spp. regularly display dark tones, making them the most visited by mealybug. The varying attraction of other plants is highlighted by the fluctuation in colour intensity; some exhibit intermittent dark patches, suggesting momentary heightened attractiveness. The heatmap's vertical gradient variation indicates varying attraction levels over time, perhaps as a result of mealybug lifecycle phases, environmental changes, or other causes. Bananas were shown to be the most effective attractant in this research, which examines the effectiveness of several trap crops in controlling pineapple mealybug. These outcomes

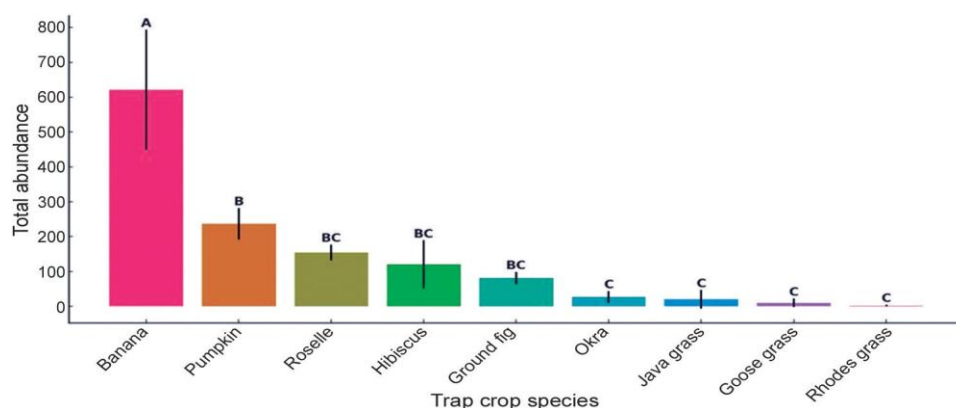


Fig. 1 Total abundance of pineapple mealybug for each host plant species.

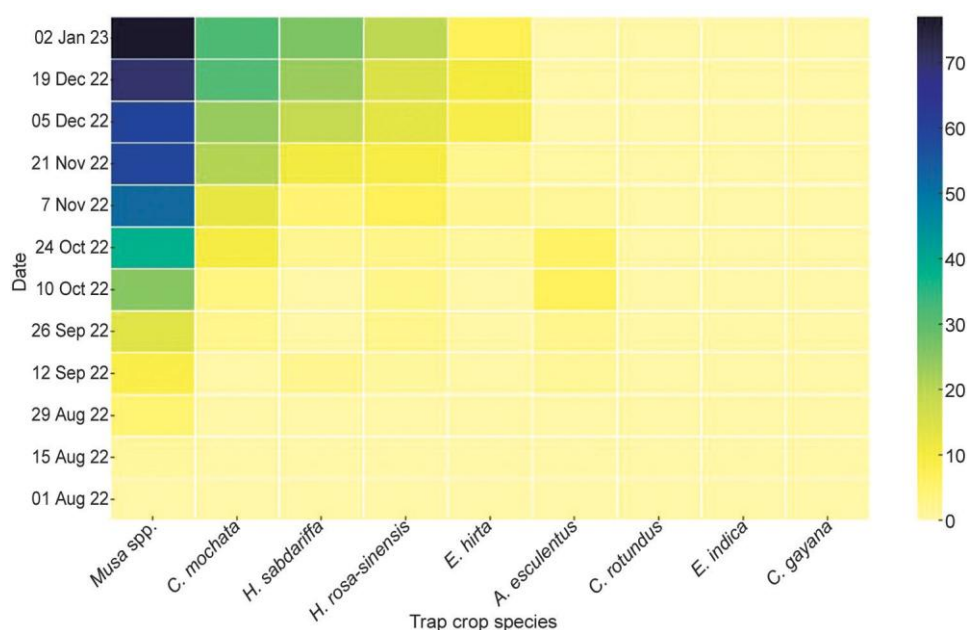


Fig. 2 Heatmap of pineapple mealybug attracted to each host plant species.

Furthermore, crops that have been shown to be fairly successful include pumpkin, roselle, hibiscus, and ground fig (Mani and Shivaraju 2016, Lopes et al. 2019), which may be used in conjunction with bananas to improve the overall efficacy of mealybug control techniques. This might be helpful when bananas are not a practical trap crop. This analysis confirms previous research demonstrating species-specific differences in trap cropping effectiveness (Sarkar et al. 2018). On the other hand, okra, java grass, goose grass, and rhodes grass had less appeal (Lopes et al. 2019), suggesting that they may play a part in more comprehensive pest control frameworks but have limited use as main trap crops. In addition to regulating crop-weed dynamics to reduce pest harbourage, the research highlights the need of strategic selection based on crop effectiveness, pest resistance, and environmental compatibility (Hooda and Chauhan 2023, Maybery-reupert et al. 2023). The results of Kabi et al. (2016), who observed lower mealybug population densities in pineapple-banana intercrops than in a single pineapple crop across seasons, are consistent with an all-encompassing approach, which emphasises the variable effectiveness of trap crops. The Common Fruit-Piercing Moth (*Eudocima phalonia*) is kept away from the primary crop in New Caledonia by planting bananas alongside other crops, demonstrating the adaptability of bananas as trap crops in a variety of agricultural contexts (Leroy et al. 2021). Furthermore, vulnerable banana cultivars and residues may function as trap crops in multi-cultivar stands, according to a research by De Graaf et al. (2008). Bananas' unique qualities, like their

aroma, which Schiestl (2010) points out is essential for attracting pollinators, their eye-catching bright colours, as discussed by Long et al. (2011), and even their leaf texture, which Salerno et al. (2020) suggest may affect insect preferences, may be the source of their allure. However, assessing agriculture factors and local adaptation is also necessary for bananas to be fully successful (Kumar and Singh 2023). comprehensive pest control strategies. The current study emphasises how crucial trap crop selection is in controlling pineapple mealybug outbreaks. Notably, compared to other assessed crops, bananas were shown to be the most effective at drawing mealybugs. On the other hand, other crops, such as okra and different grasses, were not very successful. The effectiveness of trap cropping as a mealybug control strategy is supported by these data. Future research should look at the particular characteristics of these crops that attract mealybugs, with an emphasis on examining the impact of sensory elements including texture, colour, and aroma. Furthermore, it is worthwhile to look at the possible simultaneous impact of using a variety of trap crops. Even if less successful crops may not be the major draws, they nevertheless have a useful place in a comprehensive framework for managing pests, either as backup choices or in crop rotation techniques. This study emphasises the need of continuing research in agricultural pest management tactics and advances the hunt for more sustainable pest control techniques.

SUMMARY

Pineapple wilt disease and the consequent spread of the pineapple disease virus are caused by pineapple mealybugs. The purpose of this research was to assess the alternative host plants as possible pineapple mealybug trap crops. For the investigation, nine different host plant species were chosen: banana, pumpkin, roselle, hibiscus, ground fig, okra, java grass, goose grass, and rhodes grass. For two months, thirty mature female pineapple mealybugs were raised on a pumpkin. A plot (a 3 m x 3 m rectangle covered with black netting) was set up in three repetitions. The pumpkin was surrounded in a circle by nine host plant species, each measuring about two to three feet in a 16-by-16-inch polybag. Calculating each plant species' infestation over a six-month period (with two-week observations) allowed researchers to assess the host plant species' efficacy. According to our research, bananas have the highest mean and SD value (621.7 ± 172.7) for the pineapple mealybug, followed by pumpkin (237.0 ± 45.6) and rhodes grass (2.00 ± 26.5). The host plant species vary significantly, according to the ANOVA findings (F-value of 26.87 and a P-value < 0.00). According to the findings, bananas may be used as pineapple mealybug trap crops and may be taken into account in an IPM plan for pineapple mealybug management.

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