COOPERATIVE EXTENSION
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COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES

Cacao Living Cages: A Proof-of-Concept Trial for Alternative Cacao Establishment

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Cacao (*Theobroma cacao*) cultivation is expanding in Hawaii along with the nascent chocolate industry. Young cacao trees are vulnerable to defoliation, especially due to feeding damage from Chinese Rose Beetles (*Adoretus sinicus*) and from wind burn. It is common practice for wire cage tree shelters to be placed around each tree at planting or transplanting to protect the young plants in the field (Bittenbender 2014). Constructing these cages is simple (Isele et al. 2018), but the materials including wire, shade cloth, plastic sheeting, or other mateirals, are costly, and cage assembly is time consuming on a large scale. As cacao orchards increase in size, there is interest in finding alternatives to using wire cages for each tree. One alternative that is being proposed is to use cover crops planted around the young trees as "living cages" to protect the cacao from rose beetle and wind damage. Similar to wire cages, the living cages will also provide the additional benefit of partially shading the young trees. Additionally, the use of leguminous cover crop species will provide a source of nitrogen, through the symbiotic relationship with Rhizobium bacteria in the roots, as well as provide organic matter when the living cages eventually die back. Pigeon pea (*Cajanus cajan*) and sunn hemp (*Crotalaria juncea*) have been selected as two legume cover crop species of interest that will grow tall enough to act as living cages.

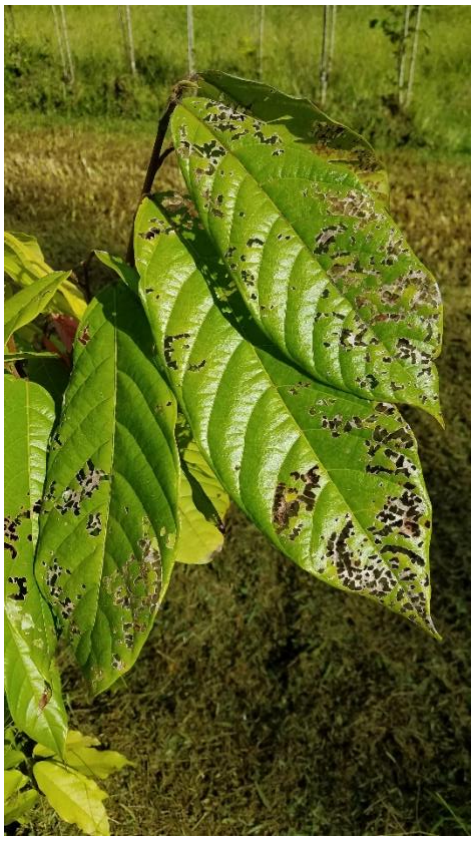

Figure 1: Chinese Rose Beetle (*Adoretus sinicus*) feeding damage on cacao leaves.

In this trial, single-species cover crop treatments were compared to conventional wire cages and uncaged treatments. The objective of this experiment was to determine as proof of concept if it is possible to use cover crops, either broadcast or planted in rings, to replace the conventional wire cages in protecting young cacao trees during orchard establishment.

Methods:

The trial was conducted from February to September 2020 at the Kauai Agricultural Research and Extension Station in Wailua, Kauai, and was managed using organic practices. This experiment was a randomized complete block design (RCBD) with 5 treatments and 7 blocks (n=7). Each plot was 10'x10' and consisted of a single UH-4 cacao tree grown from seed. Trees were seeded in the greenhouse December 2019 and grown for six months prior to transplanting. Cover crop seedlings (sunn hemp and pigeon pea) were initially started in the greenhouse in

February 2020 and transplanted to the field when they were large enough to form rings approximately 2ft diameter, planting at ~2" spacing. However, the transplanted pigeon pea and sunn hemp both showed significant stunting after transplanting, evident by comparison of the transplanted sunn hemp (average height 13in) to the broadcast sunn hemp (average height 36in) as measured two months after planting. The original cover crop plots were cut down and re-established directly from seed in the field at this time for uniformity. Netting was used over the cover crop plots during establishment to protect the seeds from birds.

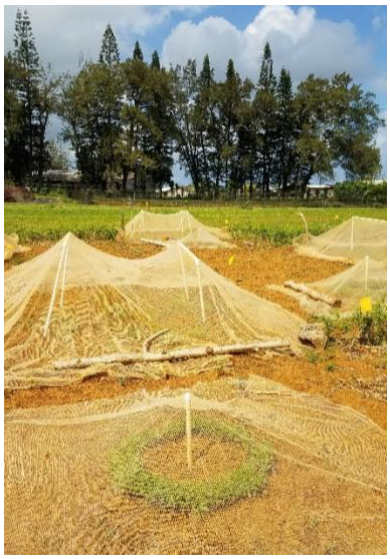

Figure 2: Cover crop plots with netting to prevent bird damage.

Cacao trees were transplanted on 1 July 2020 to the center of each plot when the cover crop was tall enough to protect the cacao trees. An organic, slow-release fertilizer was included in the planting hole for each tree. The initial plan was to rate Chinese Rose Beetle damage based on a grading scale following Spafford et al. 2016; however, no beetle damage was observed on the cacao trees during the experimental period.

Treatment	Description
Uncaged – No Cage, No Cover Crop (NCNC)	Unprotected tree planted in the open
Conventional wire cage (CG)	Wire cement mesh wrapped with 50% black shade cloth
Sunn hemp broadcast (SHB)	Sunn hemp seed broadcast and incorporated at 75lb/ac (Wang 2015)
Sunn hemp ring (SHR)	Direct seeded to form ring ~2ft diameter
Pigeon pea ring (PPR)	Direct seeded to form ring ~2ft diameter

Table 1: Descriptions of the five treatments used in this trial.

Figure 3: Trial field on planting day, 7.1.2020

Results and Discussion:
Wind damage was very evident on cacao trees within 3-4 weeks after transplanting on the unprotected cacao trees in the "no cage, no cover crop" treatments, as shown in Figure 6 below. Note that the trees in the cover crop plots are much greener and do not show signs of defoliation, even nearly 3 months after transplanting (Fig. 4 and 5).

Figure 4: Pigeon pea ring with cacao tree in the center, 9.21.2020.

Figure 5: Sunn hemp broadcast plot with cacao tree in the center, 9.21.2020.

Figure 6: Severe wind damage and defoliation on "no cage, no cover crop" cacao tree, 7.24.2021.

The trial was terminated at the end of September 2020, as it was observed that trees in the "no cage, no cover crop" (NCNC) treatment were almost fully defoliated and dying back primarily due to wind damage, and overall the trees were not growing well. The sunn hemp was also mostly dead by this time. No Chinese Rose Beetle damage was observed on any of the trees, though some beetle feeding damage observed on cover crop at both sides of experimental area, indicating that the pest was present but preferentially feeding on the cover crop instead of cacao.

There were several confounding limitations in this trial including that the cacao seedlings were stunted by initial wind damage in greenhouse that weakened them prior to transplanting, the delay in planting as the cover crop was reseeded, and weed pressure that was not well managed in this trial. While there were some visual differences among the five treatments, there were no significant differences in the cacao tree heights at the point of final data collection (Fig. 7).

Though this trial was not successful in measuring the effect of various cover crop techniques on the impact of Chinese Rose Beetle during cacao establishment in this field, it did provide some useful insights regarding the potential for this approach as an alternative to conventional wire cage tree shelters for young cacao trees. The use of pigeon pea seems particularly promising because it is longer lived than the sunn hemp, but in future trials we would recommend wider spacing as the pigeon pea can grow quite large and bushy. For future trials, it is also suggested to focus on timing the cover crop and cacao seedlings to ensure they are both vigorous and well-established for transplanting at the time they are needed, or considering direct seeding both the cover crops and the cacao. Further work would be helpful to determine the feasibility of this orchard establishment approach for large-scale plantings.

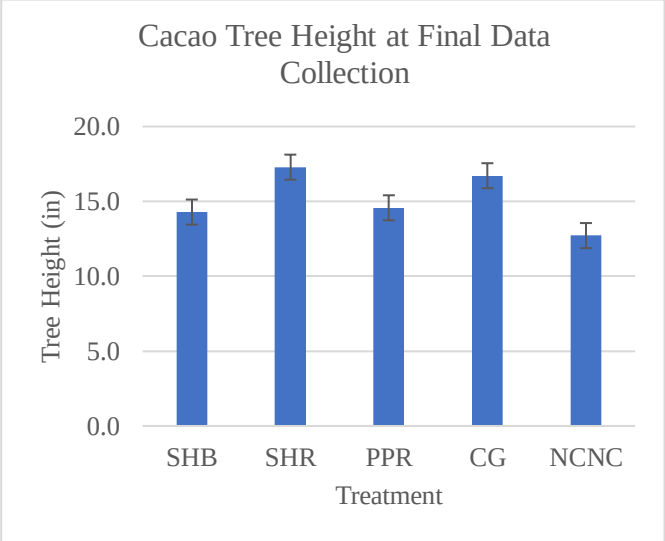

Figure 7: Cacao tree height averages for each treatment at the final data collection on 9.21.2020 (n=7). The error bars denote the standard error of the mean.

References and Further Reading

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