Optimizing Cover Crop Mixtures for Sustainable Turmeric Production in Hawaii

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As consumer demand for turmeric continues to grow, Hawaii's turmeric growers are seeking more sustainable cultivation methods beyond conventional high-input practices (Kirk et al. 2023; Pant et al. 2013). One promising approach is integrating cover crops between turmeric rows to provide valuable ecological services like weed suppression, nutrient enhancement, and improved soil health. However, guidance on the ideal cover crop species mixtures for intercropping with turmeric in Hawaii's unique tropical environment has been lacking. To address this knowledge gap, researchers at the University of Hawaii's Waimanalo Research Station conducted a comprehensive field study evaluating various cover crop combinations when planted alongside the popular turmeric variety 'Roma'. The overarching goal was to identify top-performing mixtures that local growers can implement to boost turmeric yields while transitioning to more sustainable production systems.

Figure 1. Lead author Alina Wood stands next to a row of turmeric flanked by cover crop treatments.

Study Design

The experiment incorporated six cover crop treatments rotated between turmeric rows over three field trials spanning different seasons during the years 2021-2023 at the Waimānalo Research Station. The cover crop combinations were selected based on the “Three Sisters” model to include a legume, grass and a non-legume broad leaf species.

1) Sudangrass + Sunn Hemp + Radish

2) Millet + Cowpea + Chia

3) Sudangrass + Sunn Hemp + Chia

4) Sudangrass + Cowpea + Sunflower

5) Millet + Sunn Hemp + Radish

6) Bare ground control (plastic weed mat)

Figure 2. Examples of the species mixes comprising treatments 1-5 and the control (weed mat).

The treatments were structured in a randomized complete block design with three replications. Cover crops were drill-seeded into 6-foot wide alleys using regionally-appropriate seeding rates for each species. Data collection included:

- Weekly assessments of cover crop percent ground cover
- Biomass quantity and quality (carbon, nitrogen, C:N ratio)
- Changes in soil chemical properties like nutrients and pH
- Soil respiration as an indicator of biological activity

- Nematode community analysis to evaluate soil food web condition

Results

Cover crop species well-suited to Hawaii's climate, such as sudangrass, sunn hemp, cowpea, and radish, consistently outperformed recommendations from continental seed companies, such as millet and chia. Choosing locally adapted varieties is crucial for maximizing cover crop growth and ecological services. In treatments where only 2 of the three species performed well, total ground coverage was as good or numerically greater than those treatments where all three species thrived.

The mixtures containing Sunn hemp and radish consistently generated biomass with an ideal carbon-to-nitrogen ratio below 20:1 that facilitates rapid nutrient cycling and the breakdown of residues. However, the addition of a high carbon-fixing grass like sudangrass and sorghum x sudangrass hybrids the mixture is recommended if building soil carbon is the goal.

In this study, cover crop residue was moved into the turmeric rows for mulch. Despite promoting vigorous cover crop growth, the intercropping treatments did not clearly optimize soil food web structure compared to bare ground controls. This may underscore the importance of retaining cover crop residues in the field to fully realize soil health benefits rather than removing them. However there were significant differences in beneficial nematode populations among treatments. For example, predatory nematodes were more abundant with higher legume coverage, while fungivores increased alongside broadleaf species. This could have implications for managing pest versus beneficial nematode populations through cover crop selection. While more work needs to be done in this area, it is expected that cover cropping with a diverse range of species and retaining residues in the field will promote beneficial soil biology.

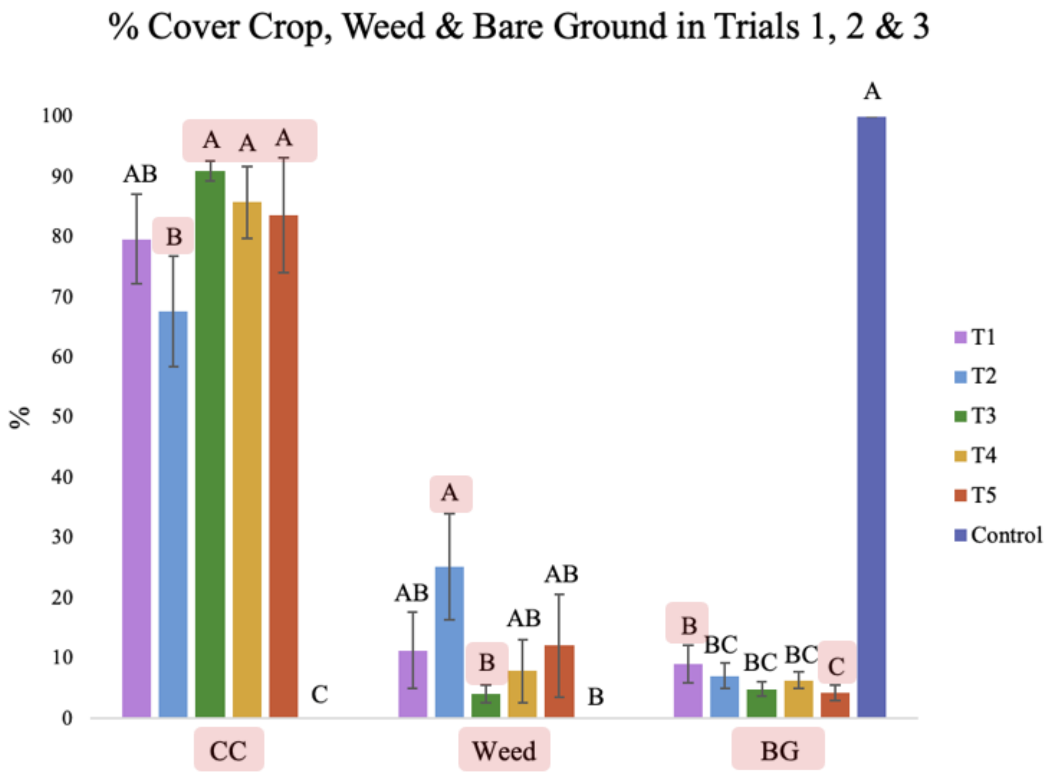

Figure 3.

Figure 3. Treatment effects on the percent of the ground covered by cover crops (CC), weeds and bare ground (BG)

Recommendations

Growers at lower elevations in Hawaii may find the most success with species mixtures that include:

- Sunn hemp + Radish
- Sudangrass + Sunn hemp
- Sudangrass + Cowpea

For added ecological services, a three-species combination like Sudangrass + Sunn Hemp + Radish could also be considered, though it may require lower seeding rates to reduce interspecific competition and maximize total biomass production. For example, in a mix of three well adapted species, you may reduce the seeding rate of each species to 34% of the monoculture rate (Bybee-Finley, 2022). Alternatively, if one of the species is less competitive, a grower may keep the higher seeding rate for that species and reduce the seeding rates of the others in the mix (White et al. 2015). Finally, growers should prioritize retaining cover crop residues in the field maximize the full potential soil health benefits that cover crops can provide.

References

Bybee-Finley, K.A., Cordeau, S., Yvoz, S., Mirsky, S.B. & Ryan, M.R. (2022). Finding the right mix: a framework for selecting seeding rates for cover crop mixtures. Ecological Applications, 32(1): e02484.

Kirk, E., Tavares, K, Radovich, T., Wages, S., Ahmad, A., Uyeda, J, Paull, R.E., Silva, J., Bryant, G., Collier, E., Flanagan, K., Bingham, J.-P., Ellinwood, J. & Sugano, J. (2023). Hawaiʻi turmeric production guidelines. College of Tropical Agriculture and Human Resources.

Pant, A., Radovich, T.J.K., Wang, K.-H., Hue, N.V., Fergerstrom, M., Hamasaki, R., Wung, M. & Robb, C. (2014). Performance and Plant-Available Nitrogen (PAN) Contribution of Cover Crops in High Elevations in Hawaiʻi. Sustainable Agriculture, CTAHR.

Wang, K.-H. & Pant, A. (2015). Cover Crop Chart for Hawaii. CTAHR, University of Hawaii.

White, C., Barbercheck, M, DuPont, D., Hamilton, A., Hartman, D., Hautau, M., Hinds, J., Hunter, M., Kaye, J. & LaChance, J. (2017). Making the most of mixtures: considerations for winter cover crops. PennState Extension. https://extension.psu.edu/ making-the-most-of-mixtures-considerations-for-winter-cover- crops

CRATE

Cover Crop Chart for Hawaii

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← High Elevation → = = = = = = ← Low Elevation →

← Grass → ← Broadleaf → ← Grass →

← Legume →

A **Black Oat** 75 lb/acre						A R* **Sesame** 4 lb/acre	
A **Barley** 90 lb/acre						A **Buckwheat** 20-30 lb/acre	A **Pearl Millet** 15 lb/acre
A **Cereal Rye** 90 lb/acre	A **Canola** 7-10 lb/acre	A **Hairy vetch** 30-50 lb/acre	A **Woolly pod Vetch** 40-60 lb/acre	P **Jack bean** 50-60 lb/acre	('CA Blackeye 5', 'Purple knuckle', 'TS Brown', 'MS Silver') A **Cowpea** R 40-60 lb/acre	A **Mustard** 7-10 lb/acre	A **Oat** 90 lb/acre
A **Oat** 90 lb/acre	A **Mustard** 7-10 lb/acre	A **Bell Bean** 150 lb/acre	B **Yellow Sweetclover** 10-15 lb/acre	SP R* **Velvet Bean** 40 lb/acre	A **Soybean** 50-75 lb/acre	A S **Rape Seed** 7-10 lb/acre	A **Black Oat** 75 lb/acre
A **Winter Wheat** 120 lb/acre	A S **Rape Seed** 7-10 lb/acre	SP **Red Clover** 20 lb/acre	P **White Clover** 20 lb/acre	P **Pigeon Pea** 40-60 lb/acre	P **Lablab** 11-18 lb/acre	A S **Oil Radish** 10 lb/acre	A **Grain Sorghum** 25-30 lb/acre
A **Annual Ryegrass** 100 lb/acre	A S **Oil Radish** 10 lb/acre	A R **Austrian Winter pea** 100 lb/acre	P ('Moapa 69') R **Alfalfa** 15 lb/acre	R **Perennial Peanut** 40 lb/acre	A R* **Sunn Hemp** 30-60 lb/acre	A R **Marigold** 3 lb/acre	A R **Sorghum-Sudangrass** 35-60 lb/acre

* = seedig rate

A = annual; B= Biennial; P = Perennial; SP = Short-term perennial.

R = resistant to root-knot but not reniform nematode; (note: only certain cultivars are resistant to root-knot nematodes for alfalfa and cowpea; cowpea is very susceptible to reniform nematode).

S = suppressive to plant-parasitic nematodes

R*= sunn hemp and velvetbean are resistant to root-knot and reniform nematodes; marigold, Tagetes patula, is resistant to root-knot and reniform, *T. erecta* is only resistant to root-knot; sesame is resistant to southern and peanut root-knot nematode (*Meloidogyne incognita* and *M. arenaria*) but not Javanica root-knot (*M. javanica*).

Wang & Pant (2015)