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# edn

## ECHO Development Notes

**MORINGA PRODUCTIVITY WITH LEGUME INTERCROPPING**

*This article is an outworking of ECHO research in Limpopo Province of South Africa, from 2010-2015, supported by the Howard G. Buffett Foundation.*

**INSECT PEST MANAGEMENT: EVALUATION AND ASSESSMENT**

*This is the last article in an IPM series. It discusses considerations for evaluating and assessing pest managment strategies.*

***GLIRICIDIA SEPIUM* AGROFORESTRY IN TANZANIA**

*ECHO network member Will Caswell shares an agroforestry system using gliricidia along with annual crops.*

 Selected material from *EDN* 1-100 is featured in the book *Agricultural Options for Small-Scale Farmers*, available from our bookstore (www.echobooks.net) at a cost of US$19.95 plus postage. Individual issues of *EDN* may be downloaded from our website (www.ECHOcommunity.org) as pdf documents in English (1-153), French (91-152) and Spanish (47-152). Issues 1-51, in English, are also compiled in the book *Amaranth to Zai Holes*, available on our website.

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# Moringa Productivity with Legume Intercropping

by Tim Motis

*This article is an outworking of ECHO research in Limpopo Province of South Africa, from 2010-2015, supported by the Howard G. Buffett Foundation. It summarizes findings published in a scientific journal by Motis et al. (2017). The original article can be found at https://doi.org/10.17660/ActaHortic.2017.1158.11. An author-created draft of the full paper is available on ECHOcommunity.org [http://edn.link/9nkm2y]. This EDN article expands on the findings of the research to include insights about establishing and maintaining moringa plantings.*

Moringa (*Moringa oleifera*) is a fast-growing tree with nutritious leaves eaten fresh or dried and converted to powder that can be added to traditional foods as a nutritional supplement. Farmers in the warm tropics can easily grow moringa. Its primary requirements are plenty of sunlight and well-drained soil. Here we address plantings of multiple rows of moringa trees, applicable to clinics, hospitals, orphanages, schools, or individual farmers producing moringa leaf powder at larger-than-household scale (Figure 1). In Niger, where there is a strong market for moringa products, plantings range in size from 0.2 to 1 ha (Pasternak *et al.*, 2017). This article contains information on how to establish and diversify such plantings. It also addresses questions such as:

**Figure 1.** Moringa grown with legumes planted 50 X 50 cm in a double row under the moringa trees (spaced 1 m apart). *Source*: Tim Motis

- How much leaf powder do moringa trees produce?
- What are the benefits and tradeoffs of intercropping moringa with tropical legumes?

## Description of the moringa orchard trial

### Plant spacing

Trees planted in rows are easier to manage than randomly placed trees. We chose to space trees 1 m apart within rows, with 3 m between rows. An in-row spacing of 1 m worked well for managing the trees as a hedge, keeping the leaves within easy reach for harvesting. With 3 m between the tree rows, we had enough space to access the trees and accommodate a second crop (in our case, a legume or vegetable).

We considered using the entire space between tree rows for the second crop. Instead, we opted to plant the second crop at the base of the moringa trees as shown in Figure 1. That way, we only had to weed, water, and fertilize a 1-m wide strip of ground below each tree row (Figure 2).

**Figure 2.** A plot with no legumes under the trees, illustrating the 1-m wide band beneath moringa trees that was weeded, irrigated, and fertilized. *Source*: Tim Motis

You could certainly try other spacings for the moringa trees. Pasternak *et al.* (2017) suggested a 2 X 2 m spacing for moringa trees grown in combination with other crops.

## Legumes grown with moringa

In thinking about what could be grown under moringa, we selected legumes because of their ability to thrive in a variety of soils, shade weeds and provide soil-enriching mulch. Many legumes also produce edible beans. Legumes in the trial included cowpea (*Vigna unguiculata*), jack bean (*Canivalia ensiformis*; inedible without processing), lablab (*Lablab purpureus*), and pigeon pea (*Cajanus cajan*). We also included a treatment with nothing planted under the trees (Figure 2), so that we could compare moringa harvests with and without legumes. We replicated each treatment four times, with treatments randomly assigned to plots.

## Planting and maintenance

Moringa trees and legumes were established with seeds planted directly into the soil. An alternative approach to planting moringa would have been to sow the seeds into plastic pots or sacks and then transplant resulting seedlings into the field. Transplanting works well but requires nursery space. Water was supplied as needed via drip irrigation. Fertility inputs consisted mainly of composted chicken manure applied three times per year at an application rate of 16 kg per 10-m length of tree row. Because of its deep roots, moringa usually grows well without fertility inputs (Palada and Chang, 2003), but we have found that moringa leaf production increases with added fertility (Motis and Reader, 2019). Options for fertility inputs include animal manure, compost, and/or NPK fertilizer.

We devoted Year One to establishing the trees. Over the next three years, we grew legumes (Year Two and Four) or vegetables (Year Three) at the base of the moringa trees. The vegetables grown in Year Three were a mix of kale and okra. They were damaged by hail soon after planting, so we learned the most from the legumes, which are the focus of this article.

The space between the tree rows was maintained as grass (Figure 1), which we mowed as needed. The most labor-intensive activities were, therefore, limited to the area directly beneath the trees.

**Figure 3.** Moringa trees pruned to a height of 1 m at harvest. *Source*: Tim Motis

## Harvest and pruning

Beginning in Year Two, moringa trees were harvested twice per year. At each harvest, the trees were pruned to a height of 1 m, to stimulate leaf production and keep leaves within easy reach.[1]

[1] Pasternak *et al.* (2017) suggest that, if you want a few trees to produce seeds, refrain from pruning one tree every 6 to 8 m.

We placed a thick layer of straw at the base of the trees shortly after the second harvest each year. This was done to protect them from freezing temperatures during the winter. We removed the straw each spring, so that it would not be a factor affecting moringa growth during the growing season.

During Years Two and Four, we harvested legume pods every two weeks, from the time that mature pods were first observed until the final moringa harvest (the beginning of winter). At the final moringa harvest, we also collected and weighed above-ground legume growth from 1 square m in each plot.

❷ Convert 255 kg to g: 255 kg x1000 g/kg = 255,000 g

Calculate total number of 5-g doses: 255,000 g x dose/5 g = 51,000 doses

Calculate number of people supplied with a daily dose over a year (there are 365 days in a year, so each person needs 365 doses):

51,000 doses x person/365 doses =139.7 (round down to 139)

## What we learned

### About moringa productivity without legumes

People often ask how much leaf powder to expect from their moringa trees. Table 1 shows the sum of our two harvests during each year. During the second year after seeding, with no legumes, the moringa trees produced a total of 76 g/tree of leaf powder, the equivalent of 255 kg/ha. That means that, during a second year after seeding, 1 ha of a moringa planting like ours can produce a year's worth of leaf powder for 139 people consuming 5 g of powder per day. ❷ Witt (2013; [http://edn.link/ern1]) provides the nutritional content for 5 g (15 mL or 1 tablespoon by volume) of moringa powder, an amount described as a realistic serving size.

**Table 1.** Outputs of a moringa-legume planting in South Africa (Motis *et al.*, 2017).

| | Moringa leaf powder yield (kg/ha) | |
|---|---|---|
| **Legume** | **Year 2*** | **Year 4*** |
| None | 255 | 473 a |
| Cowpea | 235 | 274 bc |
| Jack bean | 253 | 206 cd |
| Lablab | 223 | 191 d |
| Pigeon pea | 279 | 340 b |
| P value** | 0.8725 | <0.0001 |

| | Dry, above-ground legume biomass (kg/ha) | |
|---|---|---|
| **Legume** | **Year 2*** | **Year 4*** |
| Cowpea | 762 d | 1047 b |
| Jack bean | 1180 c | 4753 a |
| Lablab | 6380 a | 3961 a |
| Pigeon pea | 2860 b | 1588 b |
| P value** | <0.0001 | <0.0001 |

| | Dry grain yield of legumes (kg/ha) | |
|---|---|---|
| **Legume** | **Year 2*** | **Year 4*** |
| Cowpea | 360 b | 212 c |
| Jack bean | 634 a | 1466 a |
| Lablab | 316 b | 525 b |
| Pigeon pea | 34 c | 1 d |
| P value** | <0.0001 | <0.0001 |

*The published manuscript refers to seasons. The term "year" is used here since there was only one growing season per year. Year two and year four correspond to the first and second years of legume intercropping, respectively.

**Within each column, at least two values for a measured parameter (e.g., second-year moringa yield) are statistically different if $p < 0.05$, in which case any two values are statistically similar unless they share no letters in common.

Each year's moringa leaf production came from regrowth of stems close to the ground, due to winter freezes that killed growth above the straw mulch. Expect more productivity where year-round growth is possible. For example, moringa trees at the ECHO Global Farm in Florida, following a year of establishment after seeding, produced 51 to 108 g/tree of dry leaf matter every three months (Motis and Reader, 2019 [3]).

With no legumes, moringa powder production increased from 255 kg/ha in Year Two to 473 kg/ha in Year Four. This shows that moringa leaf production can increase with time, over a period of at least four years. In Niger, the 'PKM 1' cultivar of *Moringa oleifera* (the same cultivar grown in this trial) is said to grow well for four years, after which the trees need to be replaced (Pasternak *et al.*, 2017). Replacement of trees is something to consider if your older trees no longer produce as much leaf material as they did in previous years. Instead of replacing all of the trees at once, you could replace under-performing trees on a yearly basis, thereby avoiding major disruptions in leaf production.

[3] In this trial, average per-harvest moringa leaf yield (on a dry weight basis) increased from 51 g/tree with no fertilizer to 108 g/tree with a quarterly application of 75 g/tree of nitrogen from NPK (8% nitrogen; 2% phosphorus; 8% potassium) fertilizer. When grinding dry leaves into powder, the weight of the powder should be nearly the same as the weight of the dry leaves; some leaf material may fall to the ground during the grinding process.

### About moringa productivity with legumes

We realized that the legumes could compete with moringa for resources such as light, nutrients and water. This was indeed the case when legumes were intercropped with moringa for the second time (Year Four of trial). We think higher early-season rainfall in Year Four than Year Two benefitted the legumes more than moringa, making the legumes more competitive. Year-Four legume canopies were generally the same height (1 m) as the moringa trees after first-harvest pruning; thus, they were tall enough to shade new moringa growth. That was not the case in Year Two when the legume canopies were only about 0.5 m tall.

Of the four legumes, lablab reduced Year-Four moringa productivity the most. Moringa leaf yields were 59% less with lablab than with no intercrop. Lablab vines climbed the moringa trees, competing with the trees for light. Cowpea and pigeon pea had the least impact on Year-Four moringa powder production, but reduced moringa yields that year by 42% and 28%, respectively. These results shed light on a few ways to minimize moringa/legume competition:

- Avoid legumes that are strong climbers.
- Time the planting of legumes so that they are least likely to compete with your trees.
- Prune your moringa trees higher than 1 m (perhaps try 1.25 m or 1.5 m).
- Cut the legume biomass for fodder before they reach the height at which trees are pruned.

### About the productivity of legumes under moringa

Lablab and jack bean produced more biomass than cowpea and pigeon pea. Biomass could be a source of mulch for the moringa trees or nearby gardens, or it could be cut and carried to livestock. Legumes that produce a lot of biomass shade weeds but are also the most likely to compete with your main crop.

Jack bean produced the most grain. Jack bean seeds, however, are not edible without careful processing (Hall, 2019). Of the remaining legumes, cowpea and lablab were the best grain producers. Our cowpea yield of up to 360 kg/ha was comparable to production levels of 300 kg/ha in Niger, but lower than the global average of 610 kg/ha (Rawal and Navarro, 2019). Our highest lablab grain yield of 525 kg was within the range of 327 to 612 kg/ha of grain yield reported for lablab in Tanzania (Nord *et al.*, 2020).

## Concluding thoughts

Moringa grows fast and competes with underlying crops for light. Managing rows of moringa trees as a hedge, through periodic pruning, reduces shading of any underlying crop. We saw that tropical legumes thrive at the base of moringa hedgerows, to the point that they reduced total moringa powder production during one of two seasons. I suggest growing moringa alone, until the trees are established. You could then try growing one or more other crops under your trees that you think could be useful. There may well be tradeoffs. For example, you may be willing to accept some loss in moringa productivity in exchange for weed suppression, mulch, and extra grain from legumes.

If you want to grow legumes under moringa, try growing the legume(s) you are interested in under a few trees until you know their effect on moringa leaf production. Take previously-mentioned steps to minimize competition. You could also consider growing non-legumes under moringa. Others have succeeded with lemon grass (C*ymbopogon citratus*; Palada *et al.*, 2008) and vegetables (Pasternak *et al.*, 2017). If you try vegetables, consider species such as those in the Brassica family that tolerate shade. We trust the information in this article is helpful in planning your moringa planting.

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# Insect Pest Management: Evaluation and Assessment

*by Stacy Swartz*

*Part 4 of 4 in a series on integrated pest management*

This article is the fourth and final segment of ECHO's Integrated Pest Management (IPM) series focusing on insect pests. The first three articles about pest prevention [http://edn.link/prevent], monitoring [http://edn.link/ipm2], and control [http://edn.link/ipm3] are available on ECHOcommunity.org. This article will focus on evaluating pest management strategies and assessing which ones to include and prioritize for future implementation.

## Monitor pest populations after strategy implementation

After attempting to prevent or control a pest, farmers should monitor pest activity to accurately evaluate the effectiveness of their interventions and overall management approach. Monitoring pests and evaluating the effectiveness of a preventative strategy may require time and patience as many preventive strategies take weeks, months, or even years of implementation. Monitor preventative strategies intensively at the beginning of a cropping season to determine if the strategy keeps pest populations from building up or entering the field. To evaluate the efficacy of a suppressive strategy meant to control existing pests, monitor pest populations in the short-term—within a few days of the intervention to ensure crop protection. If utilizing a chemical intervention to control a pest, begin monitoring pests only after it is safe to reenter application areas. Restricted entry intervals (REIs) [4] should be listed on product labels or found by researching the pesticide's active ingredient or common name. Table 2 lists some examples of different control strategies and some estimated timelines for monitoring.

Monitoring pest levels can be done with the same techniques as overviewed in the second article [http://edn.link/ipm2#sampling] (e.g., various traps, nets, etc.). Pest activity may differ depending on what

[4] REIs are time periods required for an applied pesticide to decompose, dissipate, or settle enough to be safe for an agricultural worker to re-enter the cropping area that a pesticide was applied to. A person needs specialized training and possibly extra protective gear to enter a cropping area before the REI expires.

**Table 2.** Monitoring timeline considerations for four insect control strategies.

| Strategy | Type of control | Category of control | Monitor timeline |
|---|---|---|---|
| Trenches (e.g. beetle control) | preventative | cultural | Monitor within the first season, especially the beginning of the pests' life cycle in the region. |
| Attracting beneficial insects | preventative | biological | Monitor over several years, including during the off-season when crops are not growing. |
| Systemic* pesticide spray | suppressive | chemical | Monitor in the following 3-10 days after spraying. Systemic pesticides can take several days to travel to all parts of the plant after uptake to be effective. |
| Soap and oil spray | suppressive | mechanical/ physical | Monitor after the soap and oil dry (within 2 days). Soap and oil act on the exterior of the pest- suffocating it or breaking down outer tissues. The spray is only effective as long as it stays wet and makes contact with the pests. |

* Systemic pesticides are those that a plant absorbs then distributes throughout plant tissues to reach all plant parts.

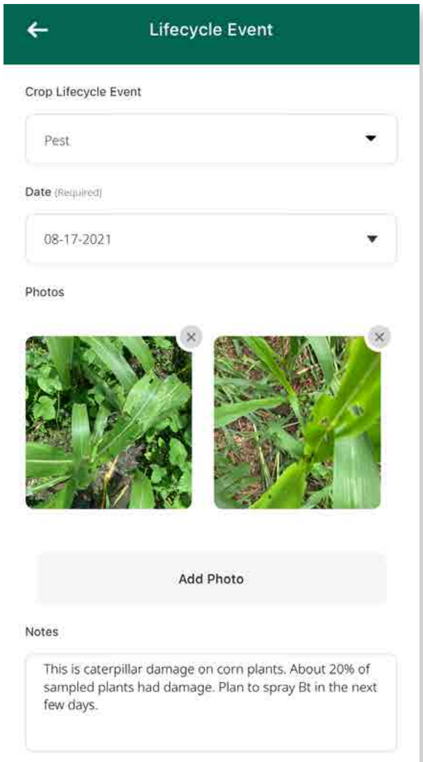


**Figure 4.** A screenshot of the ECHOcommunity app after entering pest management observations into the life cycle event feature. *Source*: ECHOcommunity app

interventions are used. Some interventions are toxic, causing the death of a pest at one or more life stages. Others are deterrents, which cause pests to leave the crop. Still others cause changes in pest behavior, such as the inability to molt or feed, and take more time to have a lethal effect than toxic interventions. Therefore, it is helpful to know how a strategy affects a pest when monitoring.

When monitoring, record observations about how well pest management interventions are working, and what factors might be influencing their effectiveness.

- Which life stage(s) of targeted pests are being impacted?
- How lethal/deterring is the intervention for each life stage?
- How long does it take to affect the pest?
- Is anything unique about the weather or environment that may impact the effectiveness of a strategy?

These notes are helpful when assessing which interventions to include or exclude from an IPM plan. The ECHOcommunity app (Figure 4) allows the user to track and record information under the "My Plant Records" feature. Select 'Add a Lifecycle Event' -> 'Pest' and record information in the notes section. Useful notes to record are the management strategy, monitoring notes (both before and after implementing the strategy), and other observations. The feature also allows photos to be added to the entry.

Monitoring is essential not only for evaluating the effectiveness of an intervention but also for the continued protection of a crop. If a strategy does not control a pest population, repeat or use another strategy.

## Evaluate strategies

Many factors impact how effectively a pest management strategy works. Rain shortly after a foliar application may limit how much of a product remains on the plant to control the pest. Air temperature and sunlight intensity can impact how quickly a pesticide (natural or synthetic) breaks down and, therefore, how long a pest is exposed to it. Pest exposure to a pesticide is also influenced by how evenly it is sprayed, with what size of droplets, and what surface (e.g., undersides, top of the leaves, or entire canopy) of the leaf was sprayed.

A farmer's considerations are vital to a successful and meaningful IPM plan. A sustainable, long-term investment in pest mitigation is only as good as it is acceptable to a farmer or farming community. Therefore, it must be the farmer's assessment that determines the value of a strategy. Acceptable damage to a crop is dependent on a number of factors, many of which are unique to a specific farmer's context. Factors farmers should consider in evaluating the merit of a strategy are overviewed in table 3.

Development workers, extension agents, and other practitioners can help guide farmers by asking questions about their satisfaction with a strategy they used or simply monitoring the crop alongside the farmer and asking them to share about the successes and challenges of the cropping season.

**Table 3.** Farmer considerations impacting valuation of IPM strategies.

| Factor | Explanation |
|---|---|
| Intended use of crop | Pest damage on a fodder crop such as napier grass (*Pennisetum purpureum*) is generally more acceptable than pest damage on an ornamental crop such as hibiscus (*Hibiscus* spp.). |
| Maturity of the crop | Plants are more susceptible to damage when young, so interventions are often more beneficial when applied earlier rather than later in a crop's life cycle. |
| Resource availability | If a farmer must travel a far distance or cannot find the materials needed for a strategy, it will lessen the value of the strategy. |
| Resource accessibility | If a farmer cannot travel to get materials due to infrastructure limitations or weather conditions, or cannot afford materials, it will lessen the value of the strategy. |
| Information availability | If a farmer cannot find information about a pesticide or strategy, it will lessen the value of the strategy. |
| Information accessibility | If a farmer is illiterate and the information available is all written or if strategy instructions are not in their native language, it will lessen the value of the strategy. |
| Cost of strategy | The ratio of cost to effectiveness of a strategy must be economically favorable for the farmer. |
| Time constraints | If a farmer does not have time to spray a pesticide multiple times, a strategy that requires repetition would be less valuable. |
| Labor constraints | If a farmer does not have enough energy or laborers to implement a strategy (trenches), it will lessen the value of the strategy. |
| Toxicity | If a strategy is highly toxic (high lethal rate) to the pest, a farmer may value it more. If a strategy is highly toxic to non-target species, such as bees, a farmer may value it less. |
| Environmental impact(s) | If a strategy negatively impacts the environment, a farmer may value it less. |
| Societal opinions | If the community does not accept, value, or feel safe with a strategy, a farmer may value it less. |
| Traditional practices | If a strategy goes against traditional practices, it may be difficult for a farmer to switch and go against cultural norms. |

## Make Goal-Oriented Adjustments to IPM Plan

Setting goals can come at any point in the IPM decision-making process, but a good time to reevaluate them is after intervening to control a pest population. As much as possible, consider sustainability as the overarching goal for pest management plans. A plan's economic, social, and environmental sustainability are all important for the continued long-term control of agricultural pests. Having and readdressing a set of goals can solidify a pest management plan around core ideas that are important to a farmer or farming community.

An example set of goals is:

1. Mitigation of crop loss (no less than a minimum number of kg/acre)
2. Long-term reduction of pest presence and pressure
3. Low impacts on the environment
4. Acceptability by the surrounding community

Now it is time to close the loop of IPM by assessing which strategies to use for future seasons, including modifications learned or adopted as well as lessons learned from previous seasons. As discussed in earlier articles, IPM is a continual process (Figure 5) that should improve over time as you gain experience, observe pests, implement strategies to control pest populations, and evaluate the decisions you have made.

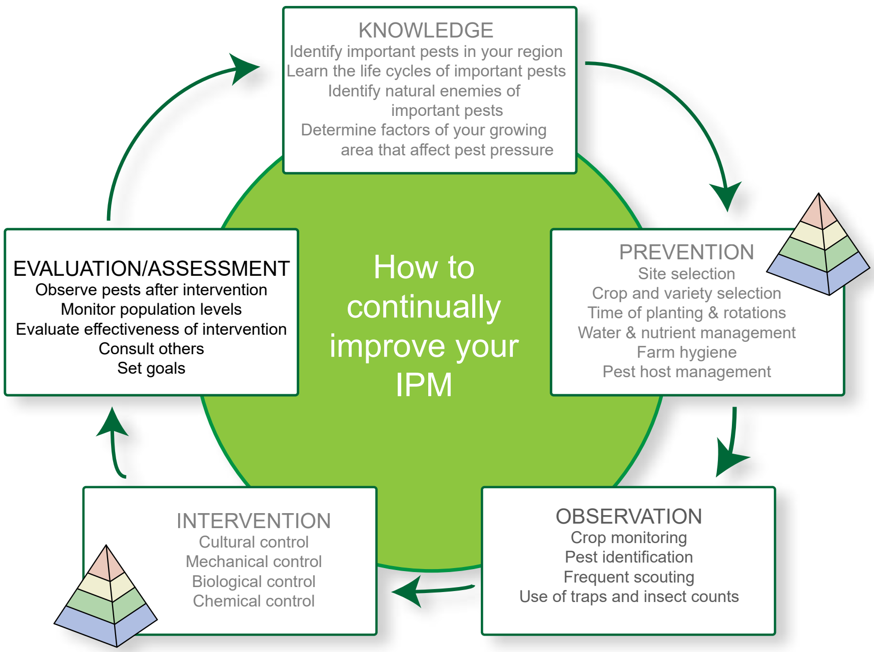


**Figure 5.** Stages of an example IPM cycle. Planning can start at any stage of the cycle, and the order of stages is flexible. The pyramid icon indicates strategies that prevent or suppress insect pests. Source: Adapted from farmbiosecurity, Creative Commons Attribution 3.0 license

By learning, observing, and acting, you can evaluate outcomes and determine if pest management decisions are in line with your goals. This process is strategy assessment.

One approach to assessment is to list strategies under each goal that they address in order of effectiveness. More frequently listed and higher-ranked strategies should be kept/added to a pest management plan. Delete strategies that you will no longer implement, noting why they will be discontinued. For example:

1. Rotate through different modes of action for stink bug chemical sprays.
2. Establish white-flowering plants with nectaries for beneficial predators of stink bugs.
3. Communicate with neighboring farmers about the timing of interventions to control stink bugs so that we are more synchronous in our control efforts.
4. ~~Companion plant sunflowers to attract stink bugs away from main crop:~~ too labor-intensive and didn't seem to make that big of a difference for how much labor it required. May not have timed the planting correctly to effectively trap stink bugs.

## Concluding thoughts

Farmers can take other approaches to assess the value of keeping versus removing a strategy from an IPM plan, including implementing and measuring the impact of each strategy in isolated areas of a field. Farmers know and understand their fields and crops best because they are present in their fields the most and know the seasonal history of regional crop production. Farmer's inherent creativity to solve pest problems has the potential to bring IPM strategies forward and should be encouraged. Look for opportunities to glean insights from farmers on how to effectively control pests and enhance the overall balance of agroecosystems.

# Echoes from our Network: Gliricidia-Annual Intercropping System

*by Will Caswell*

## Context and rationale

Where we live in Northern Tanzania, it is common to see fields prepped and planted year after year with little to no harvest. The ground does not yield as it did for previous generations, and many farmers we talk to cannot explain why. Agroforestry systems have the potential to improve crop production by rehabilitating the soil, increasing water retention, and reversing the effects of erosion.

Agroforestry combines agriculture and trees to enhance agroecosystems. Each agroforestry system has its own timeline, combination of species, and management strategy that helps maximize the system. At the Mavuno Village Farm in Mwanza, Tanzania, we have observed the impact of one specific agroforestry system using gliricidia (*Gliricidia sepium*) trees. As a leguminous species, gliricidia roots can be colonized by soil microbes that fix atmospheric nitrogen into plant-usable forms, resulting in increased soil nitrogen as the plant biomass is returned to the field[5], therefore reducing the need for fertilizer application when intercropping annuals such as maize or sunflower.

[5] Editors note: Bray *et al.* (1993) report a range of 3.00-4.15% nitrogen content of gliricidia leaves on a dry matter basis.


**Figure 6.** Pruning gliricidia trees and stripping leaves (A). Dry mulch layer to plant into (B). *Source:* Will Caswell

## How we grow annual crops with gliricidia

1. Plant the glricidia trees at a spacing of 2x2 meters (we planted our trees in 2017 from seed).
2. Establish the trees by allowing them to grow without pruning for 2 years.
3. Prepare the field for planting by pruning the trees at a height of roughly 0.5 meter. This can be accomplished with a sharp machete, although a good pair of pruners or loppers is helpful (Figure 6a).
4. Cut removed plant material into shorter sections and strip the leaves off. Spread the leaves and small stems/branches evenly on the ground as mulch. Place thicker branches off to the side. These larger branches[6] are left in the field (Figure 6b).
5. Plant the first annual crop of maize with the short rains in September (our first planting of maize happened in September 2019). Buds on the gliricidia trees will sprout and grow along with the crop.
6. Harvest maize in late December or early January.
7. Prepare the field again as described in steps 3 – 4.
8. Plant a short-season crop (e.g., beans) in January.
9. Harvest the beans in March.
10. Prepare the field again as described in steps 3 – 4 and plant another maize crop or a third crop (e.g., sunflower). In Tanzania, we

[6] Field preparing tip: Don't let the gliricidia branches get too big and woody. They are much easier to prune when they are green and about a thumb's width.

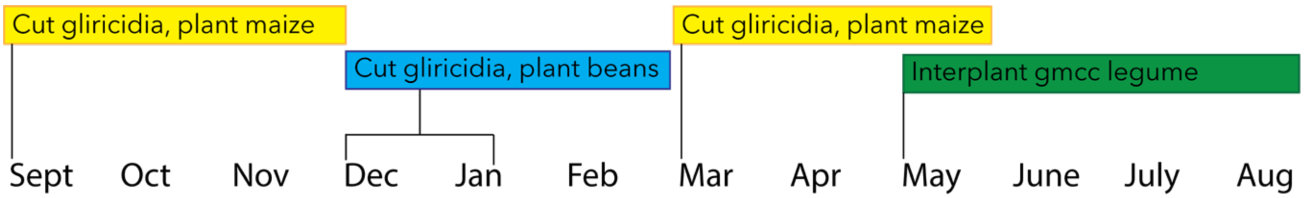


**Figure 7.** Cropping cycle calendar for one whole year of the gliricidia system. *Source*: Stacy Swartz

aim to interplant a green manure cover crop in April or May during the long rains and harvest in June/July at the beginning of the dry season. But the trees are not pruned again until September when the short rains begin (Figure 7).

It should be noted that we are set up to irrigate with sprinklers to supplement rainfall, which makes it possible to raise three crops per year. Without irrigation, I doubt more than two crops would be feasible.

### Disadvantages/constraints

Because gliricidia has soft wood, poor pruning (rough cuts resulting in open wounds) will invite disease and shorten the lifespan of the tree. This also means that it makes poor firewood. Because of the trees' ability to access water with deeper root systems, the trees will have the advantage over the intercropped annual species. Therefore, adequate rainfall and/or irrigation during the first couple weeks after planting is important for initial growth of the annual crops. Without enough water shortly after planting, it is possible that the plants closest to trees will be outcompeted. Another downside to this system is that it requires much more time during field preparations to prune trees and strip leaves.

### Advantages/benefits

One of the advantages of this system is the opportunity to provide shade for the field in the dry season. Even without much rain the trees, at our spacing of 2 X 2 m, will regrow to shade everything below (Figure 8). This shade, along with mulch, helps maintain soil moisture and soil life throughout the dry season. Another advantage of adding gliricidia trees is the reduced weeding time. Once the trees are established and


**Figure 8.** Gliricidia regrowth at different points in the year. Tree regrowth as the maize crop matures (A) and at about one month before the first pruning of the year (B).
*Source:* Will Caswell

you've planted the first crops, you should see that there is very little initial weeding required before planting out the next crop. This benefit is provided by the trees' ability to shade out and outcompete weeds. After trees are established, farmers experience reduced inputs towards weeding, spreading fertilizer, and watering throughout the cropping cycle.

While we have not recorded data from this plot and yearly managment has varied, it is clear through observation that crop health and vigor has improved and the quality of maize is better with gliricidia trees. Although the amount of rainfall was similar between the last two seasons, the maize health and yield were much better this year than last year. The difference is especially clear in the lower rows of the field, where a greater slope has caused erosion in the past. Once the gliricidia trees were established there, the topsoil started accumulating and the crops planted in these rows are now much healthier and productive. Improvements, therefore, could be due to a combination of soil-related benefits including increased soil moisture (a result of shade and mulch from the trees), improved soil health, (from the nitrogen-containing leaf mulch), and reduced soil erosion.

## Future considerations

Gliricidia can be planted from seeds or stem cuttings. While planting by seed ensures that the plant has a tap root, cuttings also work well in our experience. Since we are irrigating to supplement rainfall, there is little worry that a tree planted from a cutting would die from lack of water once its root system is developed. If dependent on rainfall alone, you might opt for seedlings. An unknown is how long the trees will withstand continuous pruning before biomass yield declines.

In order to optimize this system, we have incorporated two pieces of machinery this year: a chainsaw and a wood chipper. The chainsaw allows for faster, cleaner cuts to the trees and enables us to prepare the field in less time than with a machete. The wood chipper saves us the steps of stripping leaves and cutting the branches into smaller sections. Instead, the whole branch is processed, leaving small wood chips behind. This is ideal mulch and easier to plant into. However, even without these tools you can manage this agroforestry system on small plots. I trust this article gives you an idea of how gliricidia can be integrated into annual crops, as well as variables such as tree spacing and tools that can be selected for your situation and context.

### Reference

Bray, R.A, T. Ibraham, B. Palmer, and A.C. Schlink. 1993. Yield and quality of *Gliricidia sepium* accessions at two sites in the tropics. *Tropical Grasslands* 27:30-36.

# From ECHO's Seed Bank: 'Lacinato' Kale for Home Gardens

*by Tim Motis*

Consider growing kale if you are looking for a nutritious, leafy vegetable that you can easily incorporate into your garden and eat in a variety of ways. Kale (*Brassica oleracea* var. *acephala*) is in the same family of plants as cabbage, broccoli, and collards. Kale is a low-calorie food high in essential minerals (Thavarajah *et al.*, 2016) and vitamins (Šamec *et al.*, 2018).

**Figure 9.** Example of growing greens (mustard pictured) under shade structures. You can moderate the amount of shade with the amount of branches added to the top of the structure. *Source*: Stacy Swartz


**Figure 10.** Lacinato kale plant (top) and example of growing it in a keyhole garden (bottom). *Source*: Evan Clements, Creative Commons Attribution 3.0 license (top) and Stacy Swartz (bottom)

Kale cultivars differ in leaf color, shape, and texture. Here we focus on a cultivar called 'Lacinato' which has unique narrow, blue-green, rough-textured leaves known for their sweetness. The following traits make it a versatile garden plant:

- Seeds can be sown in small containers or trays and then transplanted, or they can be sown directly into garden beds. Aim for a final spacing of 30 to 46 cm between plants. Seedlings can be eaten as they are removed to obtain the desired spacing.
- Immature as well as older leaves can be harvested. If interested in eating the leaves of young seedlings, sow seeds 5 cm apart to achieve a denser planting.
- Leaves can be eaten fresh or cooked in various ways (e.g., boiled, steamed, fried).
- Kale is a cool-season vegetable that also has some heat tolerance. Temperatures between 10° and 25°C are optimal for growth of kale and related plants (e.g., cabbage, broccoli; McCormack, 2005). Cooler temperatures result in the best flavor. If you want to grow it in warmer conditions, try growing it under partial shade (Figure 9).

ECHO staff member, Stacy Swartz shared the following, based on her experience with Lacinato kale in Tanzania:

- Maximize harvest by retaining only the top three to five leaves. Harvest the lower leaves to increase leaf production. If you intensively harvest like this, you can space plants closer together (30 cm instead of 46 cm).
- Remove all of the leaf petiole (stem) when harvesting, as parts that remain can rot (which can lead to disease problems).
- It takes longer to cook Lacinato kale than other leafy greens like mustard and collard greens. This is because of leaf thickness. Thicker leaves, however, also make Lacinato kale more resistant to most of the pests that eat those greens (mostly caterpillars and aphids).
- It grew well in keyhole gardens (Figure 10) or beds (raised in the rainy season, sunken in the dry season) but the crop grows too tall for sack gardens, shading out plants below
- It grew well at high elevation (Arusha is about 1,400 m).

### References

McCormack, J.H. 2005. Brassica seed production: An organic seed production manual for seed growers in the Mid-Atlantic States. Version 1.1

Thavarajah, D., P. Thavarajah, A. Abare, S. Basnagala, C. Lacher, P.Smith, and G.F. Combs Jr. 2016. Mineral micronutrient and prebiotic carbohydrate profiles of USA-grown kale (*Brassica oleracea* L. var. *acephala*). *Journal of Food Composition and Analysis* 52:9-15

Šamec, D., B. Urlić, and B. Salopek-Sondi. 2018. Kale (*Brassica oleracea* var. *acephala*) as a superfood: Review of the scientific evidence behind the statement. *Critical Reviews in Food Science and Nutrition*. DOI: 10.1080/10408398.2018.1454400

# Books, Websites, and Other Resources

*by Steve Snyder*

## Food Plant Solutions

ECHO partners with organizations around the world to gather and share resources with small-scale farmers and agricultural development workers. ECHO has shared Food Plant Solutions' (FPS) publications within ECHOcommunity.org for about a year and recently signed an agreement with FPS to extend our cooperation to improve the visibility of FPS-resources.

Their publications highlight the importance of selecting plants that are both high in nutrition and well-adapted to local conditions. Their materials consist primarily of country-specific field guides. You can find a guide book for each of over 35 countries, with each guide containing information about nutritious food plans found in those places.

FPS is connected, through Rotary, with Food Plants International (FPI). Bruce French, who established FPI, has created a database of over 30,000 edible plants. The information contained in FPI's database is foundational to FPS resources. The work of FPS compliments ECHO's desire to provide information about useful plants and agricultural techniques.

## Downloadable Books are now available on the ECHOcommunity App

Many of the books recommended by ECHO staff and network members are freely available on the internet and can be downloaded from ECHOcommunity.org [http://edn.link/downloadable].

We are excited to announce that numerous books are now available through the ECHOcommunity mobile app. You can find them by navigating to "Resources" -> "Network Publications and Videos" and selecting "Downloadable Books." Included in the list are subsets for books from FAO, Heifer International, Food Plant Solutions, Haiti Network, SWISSAID, and others. Approximately 500 additional resources are now available through the app.

Any resource on the app - including books, articles, and videos – can be downloaded to the user's local device for offline viewing and can be shared using the normal smart device sharing options on both iOS and Android.

Find the app in your App Store by searching for "ECHOcommunity" or check out the links below:

http://edn.link/android

http://edn.link/apple

# Upcoming Events

### ECHO East Africa Event

**Virtual ECHO East Africa Symposium on Sustainable Agriculture and Appropriate Technologies**

ONLINE EVENT
September 28-30, 2021

### ECHO Florida Event

**ECHO's 28th Annual International Agriculture Conference**

ECHO's Global Farm in Florida, USA
November 16-18, 2021