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ECHO Development Notes

BIOCHAR CARBON CREDITS AS A DEVELOPMENT OPPORTUNITY FOR SMALL-SCALE FARMERS

This article introduces the structure, benefits, and tradeoffs of biochar carbon credit systems for small-scale producers and shares two case studies.

MBRLC 50 YEARS OF SALT EXTENSION: LESSONS LEARNED FROM FARMERS' ADAPTATION

MBRLC staff reflect on 50 years of SALT extension in the Philippines and share reasons behind farmer adoption and adaptation of the system.

SEED SAVING FOR LOCAL ADAPTATION

Adaptive breeding focuses on increasing genetic diversity within populations to improve resilience, stress tolerance, and long-term food security. This article provides an introduction and examples on this topic.

Upcoming Events

ECHO is a non-profit Christian organization.

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Editorial Team:
Managing Editor: Tim Motis
Design Editor: Stacy Swartz
Proofreader: Elliott Toevs

The potential of biochar carbon credits as a development opportunity for small-scale farmers

Case studies contributed by Samuel Gyasi (Chairman of Asaasepa Food Systems Limited, and CEO of Climate Innovation Limited) and Evelind Schecter (Co-Founder and Treasurer, Warm Heart Worldwide)

Edited by Shaun Snoxell and Robert Walle

This article introduces the potential for small-scale farmers to earn income through carbon credits from biochar production. Some organizations are helping farmers turn waste biomass into both valuable soil amendment and carbon credit income. However, there are significant challenges that development practitioners should consider before participating in this carbon credit market. This article briefly covers how carbon credit systems work, the opportunities they present, and the challenges farmers face in gaining access to these systems. It then presents two organizational case studies before concluding with some guidance for development workers.

Biochar is the product of pyrolysis (low-oxygen heating) of biomass such as wood or bamboo. Biochar can have a beneficial effect on soil fertility when used as a soil amendment, largely through increasing soil pH (of acidic soil) and improving soil structure. Carbon in biochar is highly stable, degrading very slowly and thereby delaying the release of carbon for centuries. This makes it a tool for carbon sequestration. ❶ Biochar can be produced with simple techniques suitable for small-scale farmers (Figure 1). As a result, there is rising global interest in biochar for the potential for small-scale carbon capture.

❶ Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide to reduce greenhouse gases.

Global biochar accreditation system

The global carbon credit market exists to measure, verify, and reward activities that remove carbon from the atmosphere. When carbon is removed (such as by making and using biochar), producers can earn carbon credits that they can sell. Organizations that produce biochar can earn carbon credits based on carbon captured through their activities. They can then offer those credits for sale. The global system is complicated. In simplified terms, the industry consists of standard-setting organizations, validation and verification bodies, biochar project operators, and biochar producers. Some organizations overlap these functions.

Figure 1. Training on different small-scale biochar kilns at ECHO Asia site. *Source*: ECHO Asia staff

Standard-setting organizations

Standard-setting organizations set out methodologies to account for carbon capture and build carbon credit registries. Producers need to prove that they meet their standards (set forth by standard-setting organizations) to be eligible for tradeable carbon credits. Carbon Standards International (CSI)❷ is the standard-setting organization used in the case studies, but there are other actors such as Puro [http://edn.link/puro] and Verra that cover some of the same functions. CSI manages biochar standards like the World Biochar Certificate and the Global Artisan C-Sink Standard. Puro issues biochar removal certificates (CORCs), and Verra has approved biochar methodologies (e.g., VM0044 [http://edn.link/verra]) for issuing Verified Carbon Units.

❷ Carbon Standards International provides a good explanation of their biochar standard at Carbon Standards – Services [http://edn.link/ccinkstandards], where they also provide an overview of their process and endorse digital Monitoring, Reporting, and Verification providers.

Validation and verification organizations

Validation and Verification Bodies are third-party auditors (for example, Ceres-cert.de) who confirm that the claimed biochar is actually produced and sequestered, ensuring that the project follows the methodology required. They perform annual on-site audits to monitor production and provide independent reports. Digital Measurement, Reporting, and Verification (dMRV) systems are required to collect the data on the daily production. C-Sink managers employ local verifiers to confirm that the production and usage are completed per the guidelines, and that the data is captured correctly. CSI's website contains a registry of C-Sink managers.

Project operators

These organizations take responsibility for developing and running certified carbon-removal projects. They go through a rigorous certification process with one of the standards organizations. Each project they start must be audited before production starts, and an on-site audit is required annually.

Under CSI's system, the project operator is called a C-Sink Manager. A C-Sink Manager may or may not produce biochar directly. Often, they organize groups of farmer-producers, handle data collection and record-keeping, and oversee all monitoring and reporting requirements. They are responsible for project planning, data management, coordinating verification, and stakeholder engagement. The C-Sink Manager is the entity that receives the issued carbon credits, which they must then sell (usually via broker platforms or marketplaces). Finding buyers for these niche removal credits can be challenging, and sales often happen through specialized exchanges or brokers.

Producers

Producers are the individuals or groups that make the biochar. Under CSI's system, small-scale producers fall under the Global Artisan C-Sink Standard, which is tailored for lower-tech production by individual smallholder farmers. Within this framework, a producer making biochar at a higher, specified volume, can be certified as an Artisan Pro. In all cases, small-scale biochar producers must participate in a project organized by a C-Sink Manager to have their production verified and registered for carbon credits – they cannot earn credits independently. The same is true for small-scale biochar producers operating under standards set by other standard-setting entities like Verra or Puro.

Opportunities and challenges for small-scale farmers

The opportunity in this system is that small-scale farmers can turn waste biomass into biochar at minimal cost using simple methods. This biochar can earn carbon credits under the right conditions. Farmers can convert what was formerly agricultural waste into both a valuable soil input and a potential income stream. Mechanisms now exist (through standards and programs described above) to register even small batches of biochar production for credits, and there are real-world projects demonstrating payments reaching farmers for their carbon sequestration efforts.

The challenges are significant, however. An intermediary (such as the C-Sink Manager) is required to aggregate and register small-scale farmers' biochar production. Individual farmers cannot directly participate due to the complexity of the certification process. The necessary Measurement, Reporting, and Verification (MRV) efforts carry high fixed costs, which become inefficient and costly when spread across many dispersed small producers. The time and expense required to achieve and maintain a C-Sink Manager registration is high, meaning much of the carbon credit revenue often goes toward covering compliance and transaction costs (i.e. the project developers) rather than going directly to farmers. In practice, small-scale farmers may receive only a fraction of each credit's sale value once auditing, certification, and management fees are paid.

Network case studies

Asaasepa in the Ghanaian Cocoa Sector

Mr. Samuel Gyasi, Chairman of Asaasepa Food Systems Limited, described the following case study from his firm's work in the Ghanaian cocoa sector. Asaasepa has worked as an Artisan Pro producer of biochar, alongside other consulting roles in the cocoa value chain.

Figure 2. A Kon-Tiki kiln (left) and dMRV process in Ghana (right). The image on the right shows the Greenbox device from Planboo, a thermal IoT sensor installed on each kiln to monitor the pyrolysis process. *Source*: Samuel Gyasi

Ghana produces over 700,000 tonnes of cocoa beans per year. Cocoa beans make up just 10% of the entire cocoa fruit. As a result, there are large amounts of waste cocoa pod biomass at cocoa processing stations. The large amounts of biomass present an opportunity for biochar production. Cocoa processing stations often are run as cooperatives, which allows revenue from biochar production to be paid back to cooperative members.

Asaasepa's cocoa biochar and carbon credit model works in three main stages: sourcing biomass, producing biochar, and earning and sharing carbon credit income.

First, Asaasepa identifies cocoa pod husk waste sites and sets up basic infrastructure, such as collection points, production sheds, and raised drying platforms. Cocoa pod husks are collected from these points and transported to the production site, then dried on raised mats until the moisture content is about 15%. The dried husks are loaded into a Kon-Tiki kiln and pyrolyzed at controlled temperatures (Figure 2). After cooling, the biochar is measured using a bulk density method, then either bagged (for example, in 100-liter bags) or mixed with poultry manure to be distributed back to cocoa farmers. Some of the biochar is applied directly on cocoa farms to improve soil structure, water-holding capacity, and nutrient retention (Figure 3).

Figure 3. Biochar ready for application back to fields in Ghana. *Source:* Samuel Gyasi

Asaasepa worked with a C-Sink manager for project design, certification, and compliance. Planboo provided digital MRV software and equipment to record key data on biochar production and application. Based on verified carbon stored in soils, Asaasepa receives carbon credit revenue, and a share of this income is paid to cocoa farmers and their cooperatives.

However, payback to farmers is constrained and often not very transparent, because leading rural service companies bear high upfront compliance and certification costs. For example, when Asaasepa first set up a production unit in Diaso, Central Ghana, total costs exceeded 30,000 USD. This included registration with CSI, feasibility work, laboratory bulk density tests, on-site training, MRV setup, third-party audits (from Certification of Environmental Standards GmbH – CERES), consultancy, and other expenses. Traditional cocoa cooperatives typically have weak institutional and financial capacity, which makes it difficult for them to independently take on such large investments.

Mr. Gyasi highlighted that high compliance costs, and a lack of transparency and good governance from value chain actors were major constraints. He also highlighted opportunities for the use of digital platforms to reduce monitoring costs,[3] and the potential presented by large volumes of waste biomass.

[3] Climate Innovation Ltd is the commercial provider of a dMRV platform branded as eK Oboafo. For more information see Services – Climinno Ghana Limited (Services – Climinno Ghana Limited; http://edn.link/tgtkpa). Mr Gyasi is availbe for inquiries on the Ghanaian biochar sector at samuelgyasi@climinnoghltd.com.

Biochar Life

Biochar Life was established to address the market access challenge for small-scale farmers in the biochar carbon credit market. Biochar Life grew out of the non-profit, Warm Heart Worldwide [http://edn.link/yz6fa9], but operates as a Public Benefit Corporation (PBC) to manage the sales and certification process.

Biochar Life acts as the C-Sink Manager. It sits between the global carbon market and the rural farmer. Warm Heart (and other local NGOs) focuses on training and community mobilization (Figure 4). Biochar Life focuses on compliance, certification, and sales. Biochar Life works in Kenya, Malawi, Indonesia, and Thailand.

Figure 4. Warm Heart biochar training with Top Lit Updraft Kilns in Malawi.
Source: Warm Heart Worldwide

The model is designed to maximize farmer revenue. Approximately 75% of the net proceeds from carbon credit sales are returned to the farmers and their local communities. Biochar Life retains around 15% for administration/verification overhead and another 10% for future project development.

One metric tonne of biochar produces around 1.9 tonnes of CO_2 equivalent. This varies by feedstock. A critical challenge is the payment lag. Credits are issued and sold 60 to 90 days after production. To bridge this gap, Biochar Life and its partners must often seek "production financing" to pay farmers closer to the time of work, rather than making them wait months for the credit sale.

Farmers are trained to use simple "Kon-Tiki" soil pit or trough kilns (Figure 5). Farmers pyrolyze crop waste (corn stocks, cassava rhizomes) that would otherwise be conventionally burned. Pyrolyzing crop waste produces minimal smoke and results in biochar that can be used as a soil amendment.

Figure 5. Biochar Life biochar supplier using a simple trench kiln in Malawi.
Source: Warm Heart Worldwide

Using the PlantVillage app [http://edn.link/plantvillage], farmers scan a QR code linked to their specific farm and upload photos of the production phases. Biochar Life's team reviews the data. Once approved and audited, credits are issued by CSI. Biochar Life sells the credits on platforms (e.g., Carbonfuture, CIX) and transfers the funds back to the local cooperative or farmer mobile wallets.

Biochar Life mentioned five key requirements for a successful small-scale farmer carbon credit program:

1. **Secured market demand:** Before buying biochar from farmers, the project must have a buyer or a sales partner confirmed. Overhead certification is too high to speculate on future sales.
2. **Aggregation & cooperatives:** Individual farmer verification is very expensive. Success requires aggregating farmers into cooperatives or hubs so that one verification visit can cover dozens of producers.

3. **Production financing:** Farmers need cash for immediate needs. A mechanism to provide bridge loans or partial upfront payment is vital, as they cannot wait 3 to 6 months for carbon credit checks to clear.
4. **Proximity to biomass & water:** Transporting biomass is typically not economically feasible. Production must happen within 50 to 100 km of the feedstock source, and water must be available on-site to quench the biochar (stop the burning) at the precise moment.
5. **Strict quality control to ensure dry biomass:** Wet biomass produces more smoke and greenhouse gases and lowers biochar yield. Projects must have strict protocols for drying feedstock before carbonization to meet the clean production standards required by CSI.

Guidance for development practitioners

Obtaining registration to earn carbon credits, such as by becoming a C-Sink Manager, takes a lot of time and investment. If you are a biochar producer, consider partnering with existing C-Sink Managers rather than obtaining your own registration. If you decide to become a C-Sink Manager, ensure that you have sufficient time and financial resources.

Commercial-scale biochar production is more feasible when large amounts of biomass are already aggregated and free. This reduces production and monitoring costs. Work with existing institutions, such as processing mills or cooperatives, to maximize access to large amounts of biomass. Access to aggregated supplies of biomass streamlines and thereby reduces the cost of production and monitoring.

For those interested in earning carbon credits to provide revenue to small-scale producers, weigh the opportunities in light of alternative livelihood support strategies. Ensure that the carbon price, and the resulting income, is high enough to justify the time and effort to engage in the carbon credit market.

Echoes from Our Network: MBRLC 50 years of SALT extension: Lessons learned from farmers' adaptation

by Jethro P. Adang and Henrylito D. Tacio, Director and Former Information Officer of the MBRLC, respectively

Introduction

The Mindanao Baptist Rural Life Center (MBRLC) Foundation [http://edn.link/mbrlc] is a non-government organization based in the southern part of the Philippines and founded in September 1971. It is located at the rolling foothills of Mount Apo, the country's highest peak.

When American missionary Harold R. Watson and his two Filipino counterparts – Warlito Laquihon and Rodrigo Calixtro – were trying to figure out why farmers were complaining about the low production from their farms, despite the fact they were using fertilizer and certified seeds, they discovered the root cause of the problem: soil erosion. They wanted to know how to solve the problem. And so, they had a brainstorming session at the office. After consultation and thorough research, they came up with a technology that addresses not only the problem of soil erosion but other aspects of farming like production, crop rotation, sustainability, and income.

That's how Sloping Agricultural Land Technology (SALT; http://edn.link/tn72) came to be. It is a system that requires meticulous management of the space between rows of trees and shrubs (Figures 6 and 7). It is advisable to implement a combination of permanent, semi-permanent, and annual crops to restore the ecosystem and optimize yields, while also allowing farmers to effectively organize their work schedules.

Figure 6. Okra grown between Calliandra hedgerows on MBRLC's campus in Bansalan, Mindanao. *Source:* MBRLC staff

Within the SALT farm, one can observe a variety of permanent crops such as cacao, coffee, bananas, and other fruit trees, alongside cereals like upland rice, corn, or sorghum, as well as vegetables including bush sitao (*Vigna sesquipedalis* × *Vigna unguiculata*), winged beans (*Psophocarpus tetragonolobus*), sweet pepper (*Capsicum annuum*), tomato (*Solanum lycopersicum*), and eggplant (*Solanum melongena*).

Typically, every third strip of the available land is allocated to permanent crops, while the remaining two strips are used for a mix of different cereals and vegetables. Each strip is designated as a specific growing area, to facilitate seasonal rotation of crops.

Figure 7. Some farmers in Luzon, Philippines are using contour farming – part of the concept of SALT farming. *Source:* MBRLC staff

In 1985, Watson was named by the Ramon Magsaysay Award Foundation as recipient of one of five prestigious awards – that of International Understanding, the category open to non-Asians but working in Asia. He was recognized for international utilization of SALT and other farming techniques which the MBRLC has developed over the years.

In the beginning, MBRLC shared the technology among adjacent farmers. But since the problem of erosion was common throughout the region, Watson and his associates decided to extend the technology to other parts of Mindanao. This led to the creation of its extension program.

Advantages of SALT

There are several techniques for controlling soil erosion, but MBRLC believes SALT has several advantages. To name a few:

- SALT technology promotes soil protection as a sustainable method of farming well-suited to small-scale rural farmers living in upland areas.
- SALT sustains the farm while potentially providing income to the farmer.
- Crop diversity on SALT farms helps address malnutrition. Malnutrition poses a significant challenge for farming families residing in upland regions.
- Based on experiments carried out at the center, SALT farming has been shown to reduce soil erosion, improve soil quality, and enhance long-term production.

- SALT restores natural vegetation, which helps to balance the absorption of released carbon dioxide and generates oxygen for living organisms to use.
- SALT represents a suitable agricultural technology for the present circumstances as it can alleviate the impacts of global warming, climate change, and food scarcity.
- Once SALT farms are fully established, farmers begin to see indications of land regeneration such as improved soil health and resilience to floods.

Why do Filipino farmers adopt SALT?

When extension workers from the MBRLC started their work in various parts of Mindanao, they asked why farmers were adopting the SALT scheme. These are some factors that contributed to farmer adoption:

- A clear understanding about the need for sustainable agriculture practices in the uplands, which is foundational to farmer adoption of the technology.
- An appreciation of the long-term benefits for the next generation, based on an understanding of the advantages of the technology.
- Exposure to model farms (Figure 8) as a motivating factor to adopt the technology, building on continued education and awareness of the advantages of SALT as a sustainable solution to the problems of soil erosion and low production.
- Farm ownership is also a big factor. Filipino farmers want to own their own farm after seeing how suitable SALT is as a way of farming and the long-term benefits it offers to their children, grandchildren, and the land.

Figure 8. MBRLC 50 years SALT model farm, planted with bush beans. *Source:* MBRLC staff

Why farmers don't adopt SALT

Most farmers today are focused on production and profit; they mostly practice intensive ways of monocropping, exhausting and depleting the soil and its nutrients. They find it hard to adopt SALT because some aspects do not align with their way of thinking about farming. They don't see the potential and sustainability of the technology. Other contributing factors are:

- Massive influence of chemical-based farming that encourages fast and quick crop production.
- A lack of concern on the part of most farmers about the long-term effects of chemical farming and conventional farming.
- Land ownership issues, with tenants leaving the decision of whether or not to adopt the technology to the landowners.
- Lack of knowledge of sustainable farming and passion to do it. The ability to sustain the maintenance of a SALT farm may also be a factor.

- Spaces occupied by contour hedgerows are perceived as a loss of production space that farmers could use for additional income if planted in vegetables instead of hedgerows. The long-term effect of reduced soil erosion, with contour hedgerows, is often not considered.

Recommendations

MBRLC holds the view that a flawless farming system does not exist. This perspective also applies to the advancement of technology. In order for the SALT scheme to be completely embraced and tailored by farmers via the extension program, the following recommendations are proposed:

1. Partner with different government and non-government organizations for continuous engagement with farmers. Impact on upland farmers can be maximized by training through local organizations people are familiar with.
2. Raise community-based awareness, on a regular basis, about sustainable and organic farming for farmers so they see the importance of sustainable farming.
3. Establish model farms in strategic areas within communities for farmers to see and observe the long-term effects of SALT farming.
4. Enlist the assistance of governmental agencies in promoting and implementing technology, particularly in upland communities and designated nationally protected upland areas.
5. It is essential to educate and influence the younger generation so that they become aware of the potential risks associated with the future of upland farming systems if they do not adopt technologies that safeguard these regions. The establishment of the SALT system should be demonstrated in schools to provide an additional learning example for students to observe.
6. Encourage collaboration between government agencies and NGOs, as such cooperation is necessary to develop policies, training programs, educational initiatives, and ongoing monitoring to encourage farmers to adopt the SALT system.
7. Ask both government agencies and NGOs to offer incentives or subsidies to farmers to facilitate the initial setup of SALT farms. Continuous monitoring and evaluation must be rigorously implemented to guarantee the sustainability and success of the project and program.

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From ECHO's Seed Bank: Seed saving for local adaptation

by Stacy Swartz, Emma Mudd, content contributed by Faith Juma, Fabienne Tiendrebeogo, Julia Dakin, and Joseph Lofthouse

Introduction

Traditional seed banking emphasizes uniformity, stability, and controlled pollination.[4] Most of us who are multiplying or regenerating crop cultivars or varieties do not think of ourselves as crop breeders, since we are managing a crop to retain desired traits over generations. We hand-pollinate Cucurbita species to maintain soft skin, flesh color, flavor, or other expected and valued characteristics. But in some ways, all seed savers are breeders. When we remove a seed lot from storage and expose it to current soil, weather, and management conditions, the plants respond and adapt to those surroundings as they grow. We naturally select the strongest plants to save seed from, and therefore the most fit, given the seasonal and management conditions in which we are multiplying the seeds. This is why it is an important seed bank practice to regrow seeds that have been in storage for a long time, ensuring they can still survive and thrive amid changes in the agroecosystem (climate, management system, pest pressures, etc.).

Adaptive breeding differs from traditional seed banking by intentionally introducing or reintroducing genetic diversity within a species, followed by natural selection that enhances adaptability to local conditions. Seed lots generated from highly diverse plantings, often referred to as "ultra-crosses,"[5] are useful sources of germplasm for adaptive breeding. Both traditional seed banking and adaptive breeding approaches are complementary and valuable for long-term food resilience. If consumer preferences rely on traits that may be lost, these situations are not suitable for adaptive breeding, and you should maintain them through traditional seed multiplication and selection practices. Table 1 shares examples of scenarios for which certain crops fit better with traditional seed saving or adaptive breeding methods.

[4] The term "open pollinated" can be a bit misleading. While farmers can reliably save seed from open pollinated varieties (OPVs) and expect consistent crop traits over generations –unlike hybrid seed in which the next generation produces variable traits – pollination of OPVs is often highly controlled. Potentially better terms for describing pollination for the purposes of genetic uniformity or diversification are discriminate and indiscriminate pollination, respectively.

[5] An ultra-cross is the first generation of an extremely diverse planting– typically multiple varieties/lines of the same species. These are sometimes also referred to as "mass cross."

Table 1. Examples of crops with varying suitability for breeding techniques for unique contexts.

Crop	Context	Breeding suitability
Corn	Consumers expect a yellow and/or red-kernelled variety of corn to meet local culinary preferences because of their sweet taste.	This context is not well-suited to adaptive breeding. Genetic resources used for any variety out-crossing should all have yellow/red kernels. Consider traditional seed saving practices.
Corn	Average production-season temperatures are higher than farmers have historically experienced, and plants are prone to wilting and desiccation. White or yellow kernels are both acceptable to consumers with culinary preferences.	Adaptive breeding may be suitable for those who can endure the production risks associated with these processes. Practitioners who have land area that can be dedicated to crossing varieties with genetic potential to produce in high-heat contexts with local varieties could be good intermediaries to develop these adaptive lines.
Squash	Many colors, shapes and sizes of squash are grown. Varieties with preferable taste are available but perform poorly. Taste and shelf life are the most preferable traits to consumers.	This context is well-suited to adaptive breeding. Tastier varieties can be crossed with traditional ones; the seeds can be saved from fruits that store longer and have superior flavor. Consider that planting the poorer-performing varieties carries some risk.

Table 1. Examples of crops with varying suitability for breeding techniques for unique contexts.

Vegetable amaranth	Vegetable amaranth is grown for household use, with seed often saved from plants that were previously harvested for leaves. Therefore, local varieties over time go to seed quickly and have smaller leaves. Varieties that have larger, more palatable leaves are desired.	This situation is well-suited for adaptive breeding to improve local varieties which are likely climate-resilient already but need crop improvement for consumption attributes. Crossing local varieties with large-leafed and/or highly palatable varieties could help meet local variety demands.
African eggplant	Some varieties have small fruits, others have big, round fruits, while others have oval fruits. The most preferred ones for market and food are varieties that produce oval-shaped fruit; they are not bitter but the plants are attacked more by pests. The wild variety with small leaves has very bitter tasting fruit but high pest tolerance.	Adaptive breeding may be suitable to improve the most preferred oval shaped African eggplant to help with pest resilience by crossing it with traditional varieties with pest resilience.
Sorghum	Rainfall is irregular and insufficient. Some varieties yield well but are not drought-resistant. Local varieties are more resilient but do not always produce high yields.	Well-suited for adaptive breeding. Use (or save) seeds from plants that are both drought-resistant and high-yielding to gradually improve a line that yields well under local conditions.

Adaptive breeding (Figure 9)

Genetic diversity within a species and/or variety helps populations resist pests, diseases, nutrient deficiencies, and climate stress over time. Adaptive seed breeding focuses on increasing genetic diversity within populations to improve resilience, stress tolerance, and long-term food security. The approach supports farmers, especially in challenging climates, by enabling crops to adapt naturally through exposure to local environmental conditions.

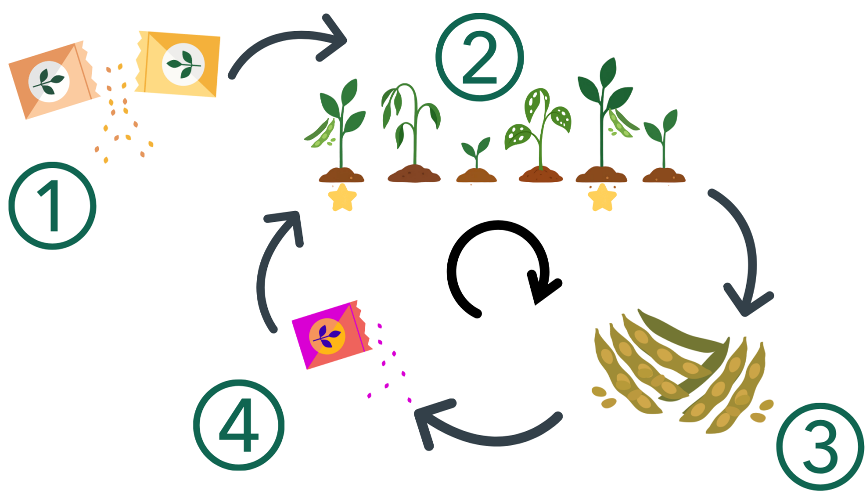

Figure 9. Steps for adaptive breeding. 1: collect diverse germplasm for the species of interest. 2: allow for natural selection. 3: harvest from plants that thrive. 4: sow selected and saved seed from the previous season. Repeat 2-4 until you achieve local adaptation.

The natural ecosystem performs much of the selection work. Growers observe which plants thrive without intervention and save seeds only from vigorous individuals. Weak plants are naturally eliminated, reducing labor and improving long-term adaptability.

From the first season of growing multiple varieties of a species to having seed that is well adapted to the region can take as little as three years for crops such as melons, corn, gourds (Figure 10), or annual leafy vegetables. It takes much longer for crops that don't readily outcross, like most beans, or perennials that take years to produce fruit, like avocados and mangoes.

After the first year of environmental selection, human selection pressure becomes an important factor: the grower saves seeds from the plants that have the best flavor, or other traits important to the community.

Figure 10. Pumpkins (*Cucurbita moschata*) from the ECHO Global seed bank production plots. *Source:* Holly Sobetski

To improve success starting in the first year, choose germplasm that is already growing successfully locally or in similar climates. Adaptive breeding is not appropriate for contexts in which farmers depend on a crop success for household consumption or market sales from a single variety. Thus, for more ambitious or uncertain projects (adapting crops outside of their comfort zone), adaptive breeding is best conducted by practitioners, co-ops, or local organizations who can appropriately evaluate and mitigate the risks of crop failure as well as account for the multi-season investment of adaptive breeding. If a small-scale farmer wants to engage with adaptive breeding, start small and use more marginal land area for seed production plots. Increasing species diversity by mixing varieties that already grow well is a best management practice.

Guidelines for implementation

- Start with crops that already grow well in the region and that, if diversified, will still remain acceptable to the end consumer.
- Grow more than one variety together in the first year to increase the genetic base of the species, locally. Growing as many varieties as possible increases the total gene pool in the population and, therefore, the potential diversity. However, it's fine to start with your two favorite varieties and add additional germplasm in following years.
- Save seed only from the healthiest 30–50% plants. If time management allows, you can rogue plants that are underperforming or do not produce traits that you want to retain during the growing season.
- Avoid management that would inhibit resilience, including application of pesticides, synthetic fertilizer, and row cover, to allow environmental selection to guide improvement.[6]
- Maintain transparency about mixed or diverse seed lots to those receiving seed.
- Use place-based names when sharing adaptive populations so that the location of the adaptive breeding is clear.

[6] In adaptive breeding, view plant loss as part of the adaptation process rather than a failure. The focus shifts from saving every plant to supporting the long-term health of the species. This reduces stress and fosters a more resilient, ecological approach to seed saving.

Seed saving and evaluation are strengthened through community involvement. Shared seed lots with diverse ancestry enable growers across regions to adapt populations further. Programs like seed shares [see Further resources section] facilitate broad distribution and exchange of adaptive varieties.

Highly diverse populations often adapt well when moved to new regions because they carry broad ancestral diversity. However, results vary by crop. Some species may need multiple seasons to acclimate to new climates or soils.

Further resources

Going to Seed offers a free Adaptation Gardening course, facilitated by Joseph Lofthouse. Although the course features largely temperate crops, the concepts and practices are relevant to plant breeding globally. Going to Seed also has an Adaptation Resource Guide [http://edn.link/adaptationguidegoing2seed] that is openly available.

Potential sources of genetically diverse seed

Experimental Farm Network [http://edn.link/hgjxca]– A great source of rare crop varieties and information on plant breeding. EFN supplies dozens of landraces and breeding stock [http://edn.link/exnznd] for local crop development.

Fedco Seeds [http://edn.link/z6t2y3] – A longtime supplier of seeds for the Global Seed Bank, Fedco now offers a number of "gene pool [http://edn.link/wmn264]" varieties of lettuce, mustards, beans, and more for increased diversity.

Going to Seed– In addition to their Adaptive Gardening course, Going to Seed runs a seed share program [http://edn.link/teqehm] where growers receive seeds of diverse mixes and send back a portion of those that grow well. Currently only available in the US and Canada.

Southern Exposure Seed Exchange [http://edn.link/z92kpx] – A supplier of many Global Seed Bank varieties over the years, SESE offers diverse mixes [http://edn.link/h4pt3z] of collards, radishes, swiss chard, beets, and lettuce.

Ujamaa Seeds [http://edn.link/3tjtx3] — Supports the Ujamaa Cooperative Farming Alliance. Offers ultra-crosses of collards, okra, and cowpea as well as a number of variety mixes.

Upcoming Events

See the full calendar on ECHOcommunity.org/events

Syntropic Agroforestry

April 21-24
ECHO North America | FL, USA

Symposium on Seed Systems

Strengthening Community Resilience in Central America and the Caribbean

May 12-14
ECHO Central America and Caribbean | Sololá Campus, Guatemala

Seed Banking

May 20-22
ECHO North America | FL, USA

Tropical Agriculture & Development (TAD) Course

June 1-6
ECHO Asia | Chiang Mai, Thailand

Sustainable Agriculture Symposium

June 23-25
ECHO East Africa | Ethiopia