

Building Soil Fertility with GMCCs

*Much of this content drawn from "A proven alternative to shifting agriculture: worldwide experience with green manure/cover crops"
(Roland Bunch)*

Stacy Swartz

What are Green Manures? Cover crops?



What are Green Manures? Cover crops?

"A species of plant, often but not always leguminous, whether a tree, bush, vine or crawling plant, which is used by a farmer for one or several purposes, at least one of which is that of maintaining or **improving soil fertility** or **controlling weeds**."

Roland Bunch

- Green manures are those used for the primary purpose of improving soil fertility
- Cover crops are those crops used for the primary purpose of controlling weeds

Mucuna puriens

Velvet bean

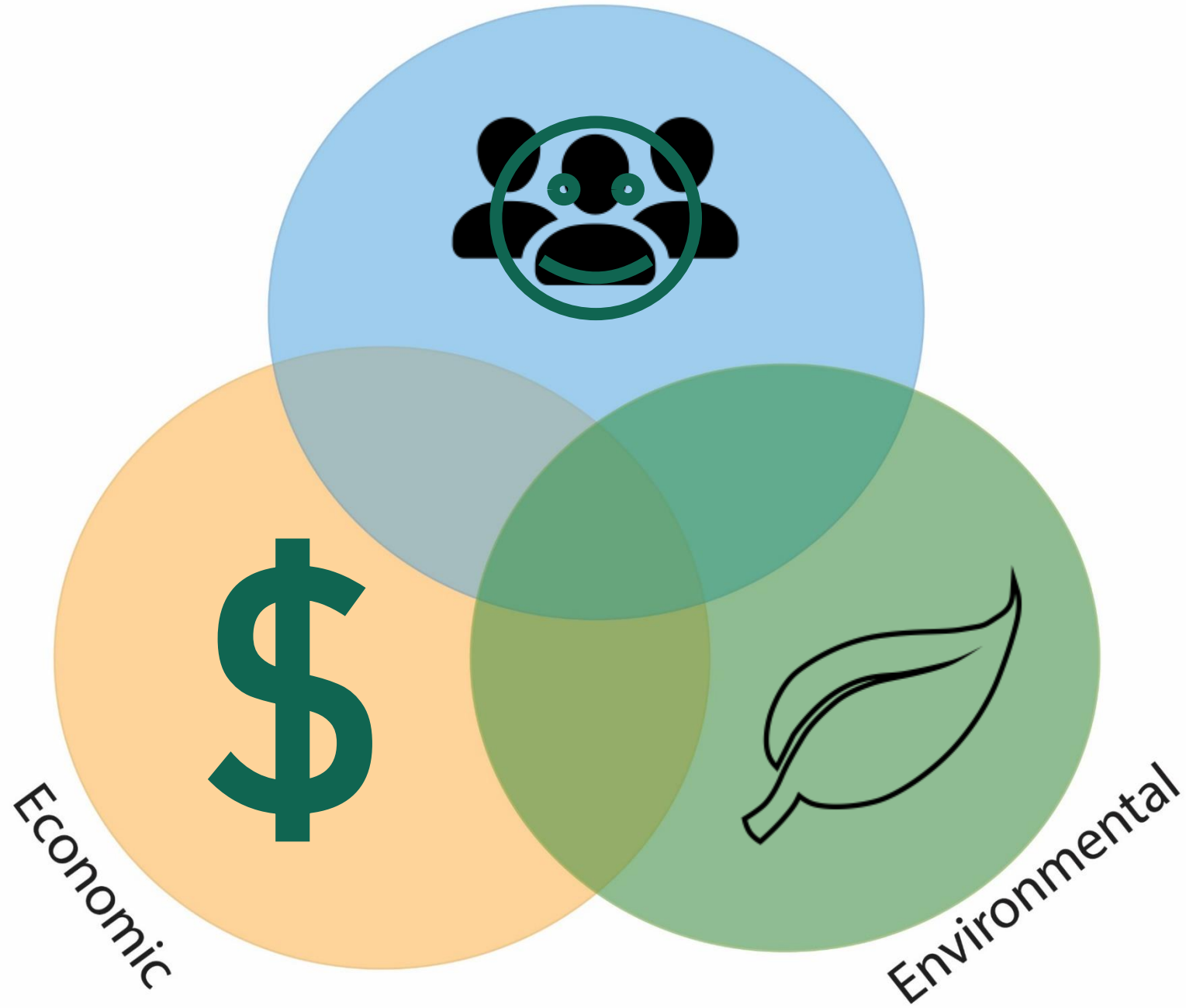
Community Gathering

Soil advocate

Farmer advocate

Concerned advocate – No GMCCs

Social





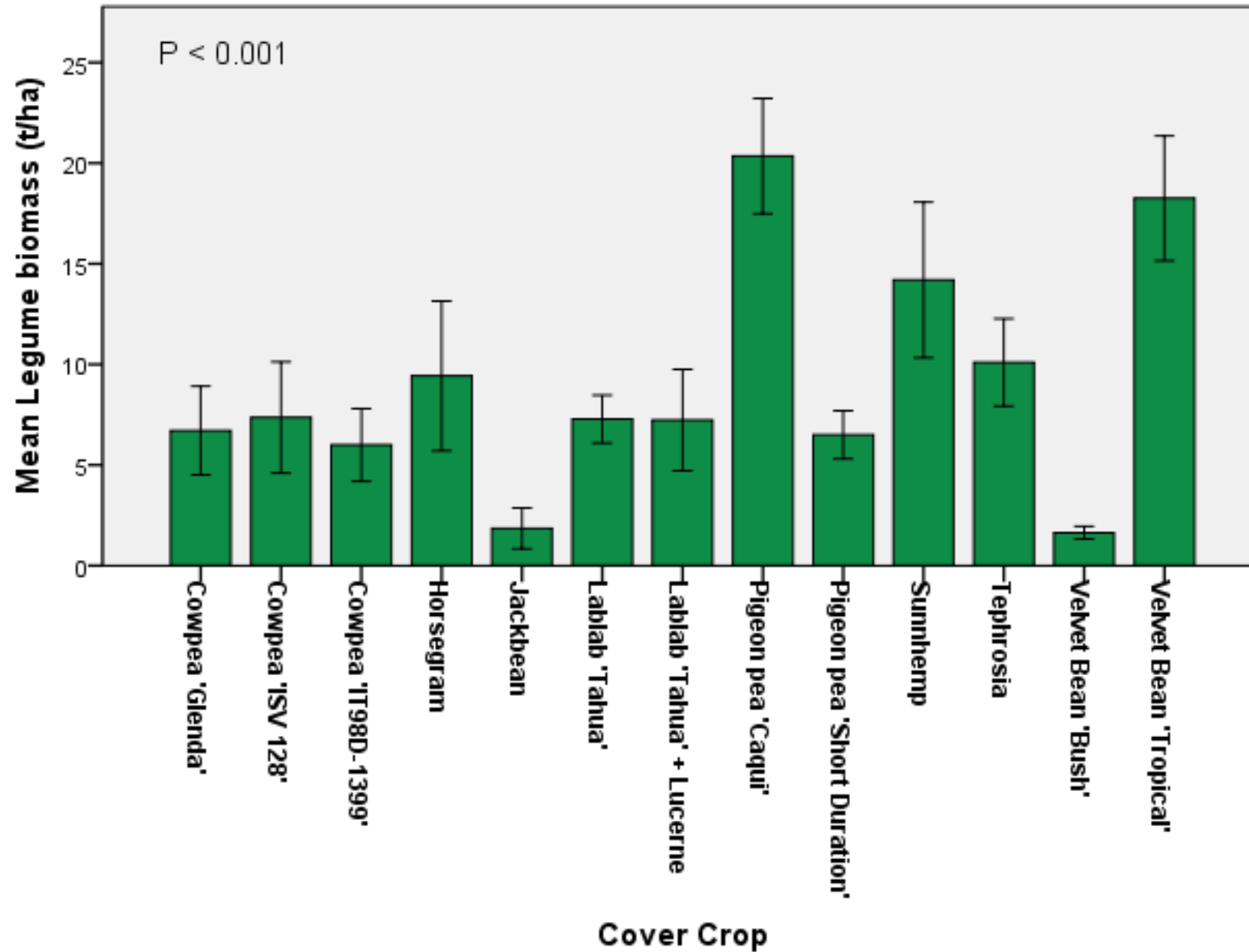
Community Gathering

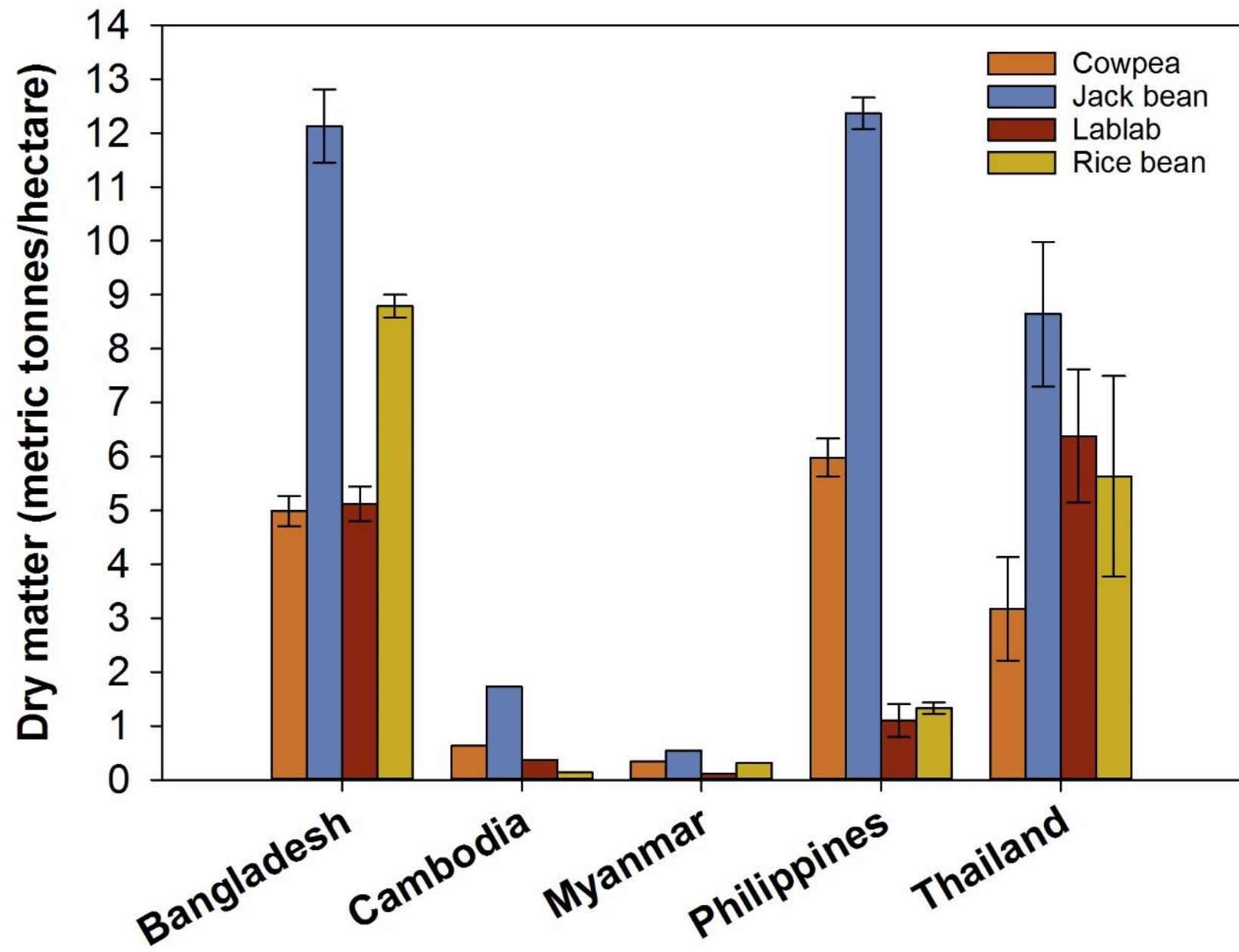


Vigna unguiculata

Cowpea/niebe

Biomass of leaf/stem tissue of legume cover crops 24 weeks after planting.





Lablab purpureus

Hyacinth bean

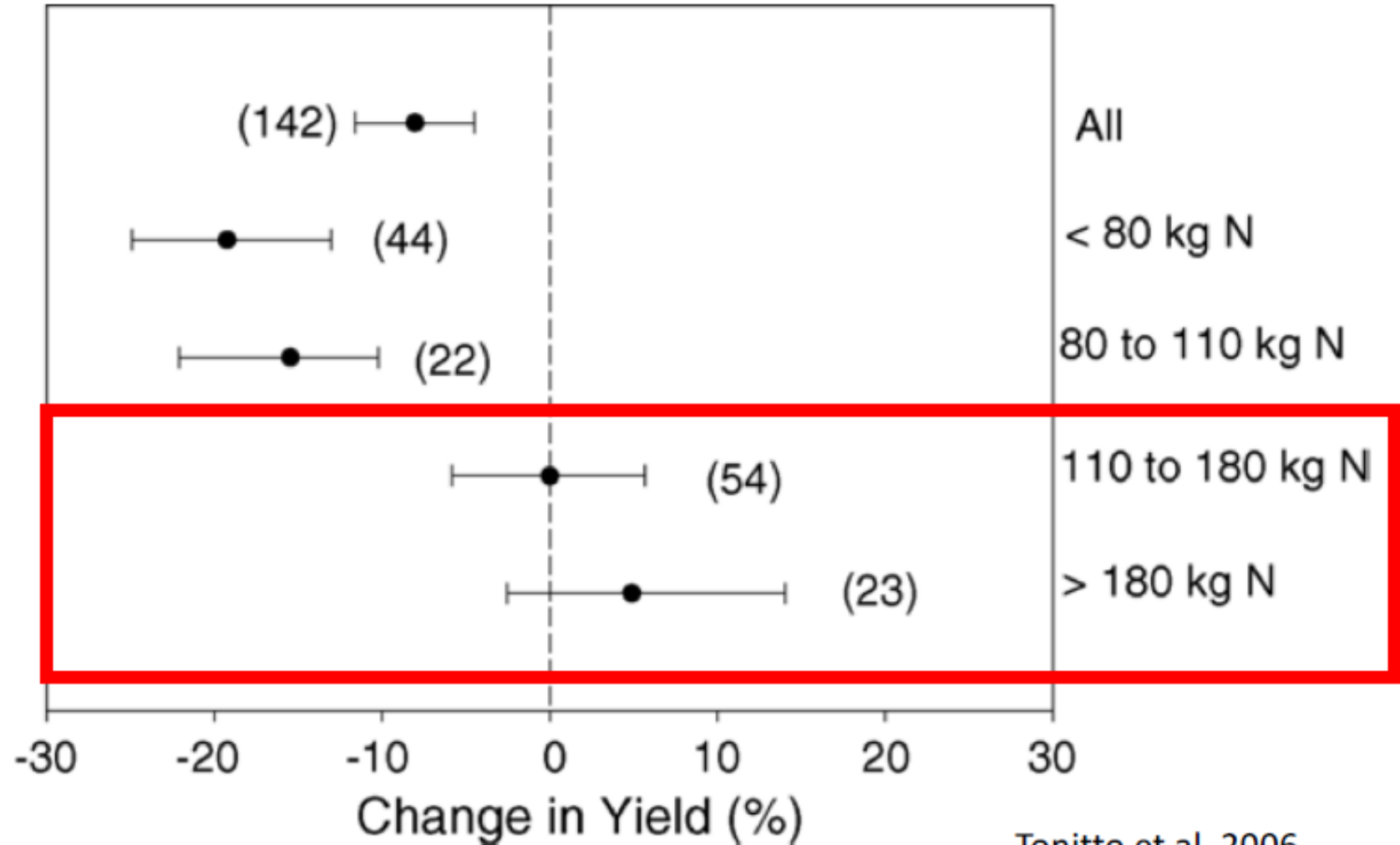


Community Gathering



How much N fixation do you need for a yield benefit?

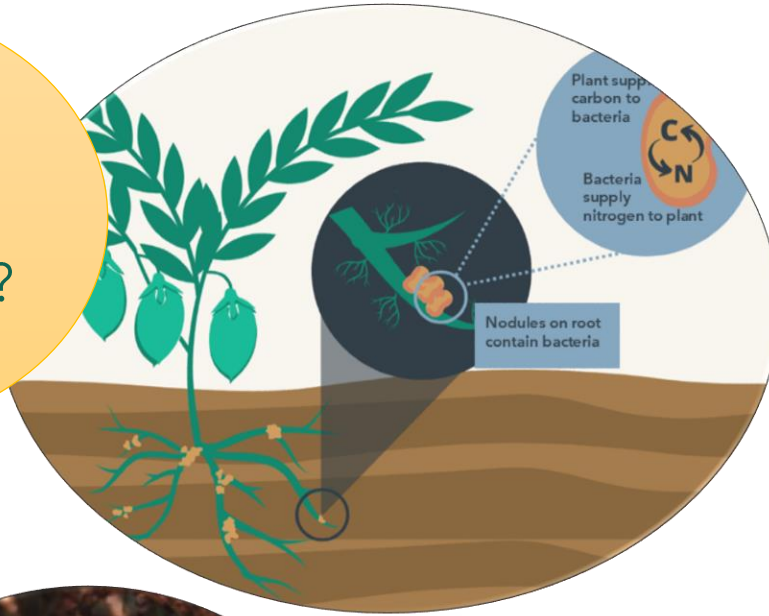
Comparable yields if cover crop N uptake is $> 110 \text{ kg N ha}^{-1}$



Tonitto et al. 2006

Root Nodules

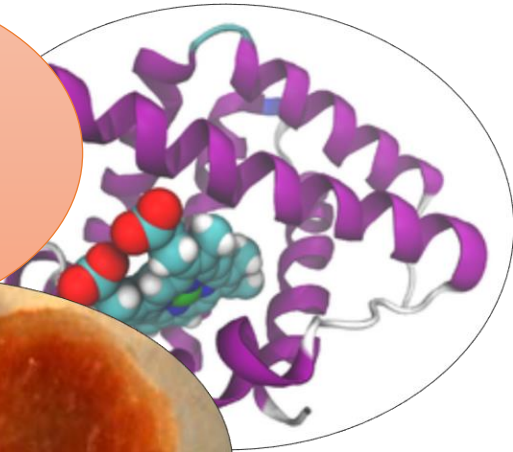
What is a symbiotic relationship?



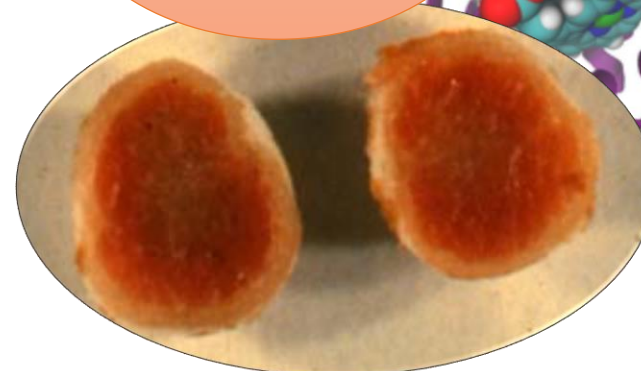
What is a root nodule?



How do we know if it's beneficial?



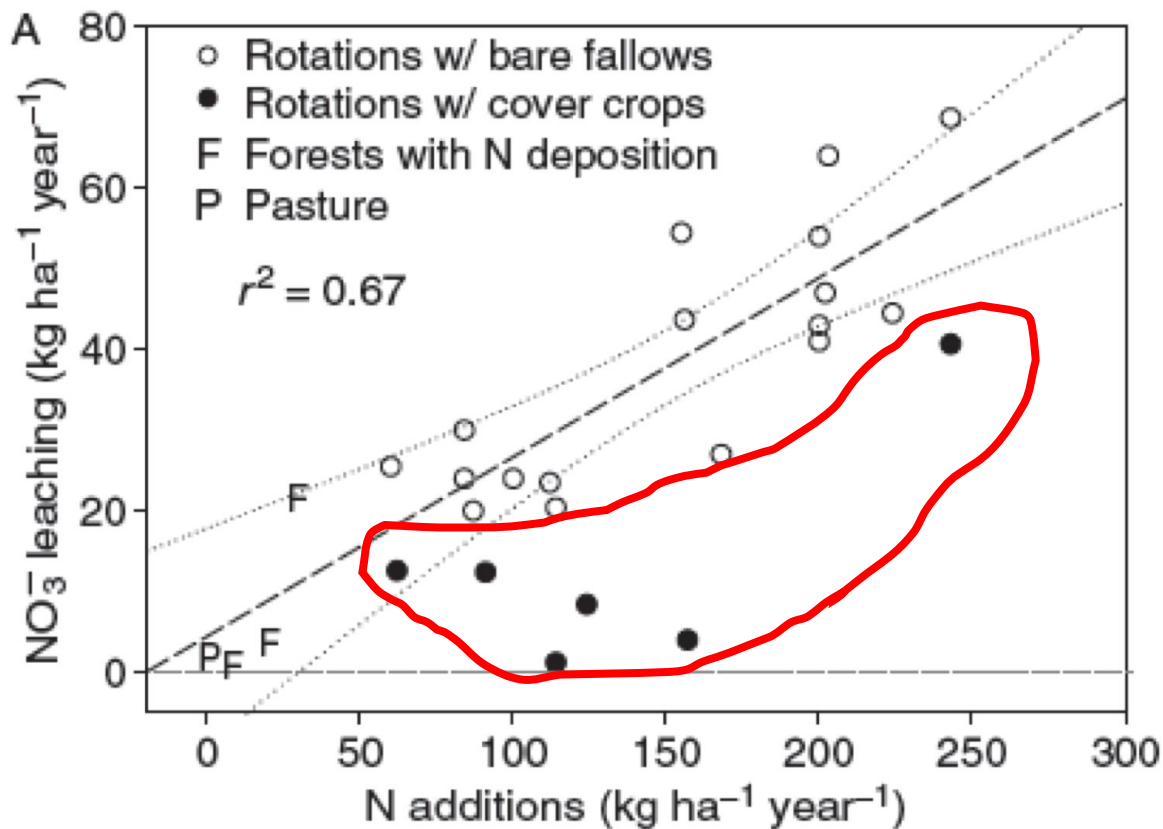
What's the difference between a nodule and galling?



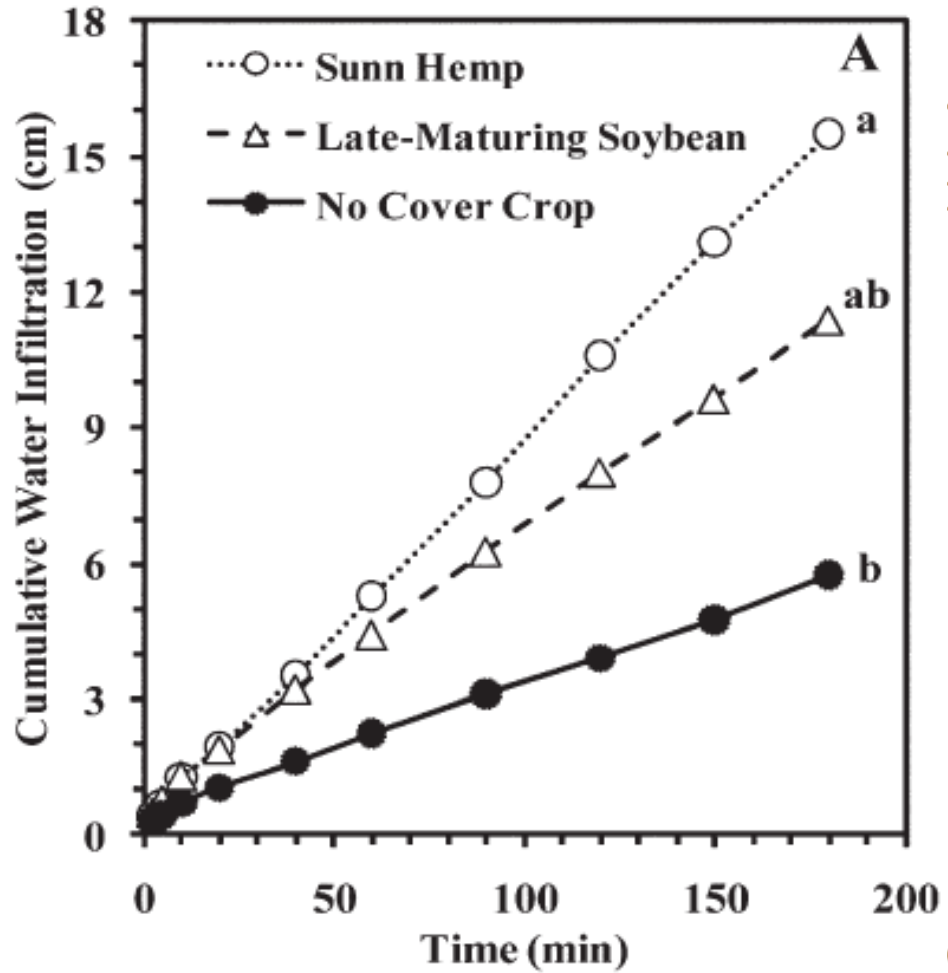


Do GMCCs really...

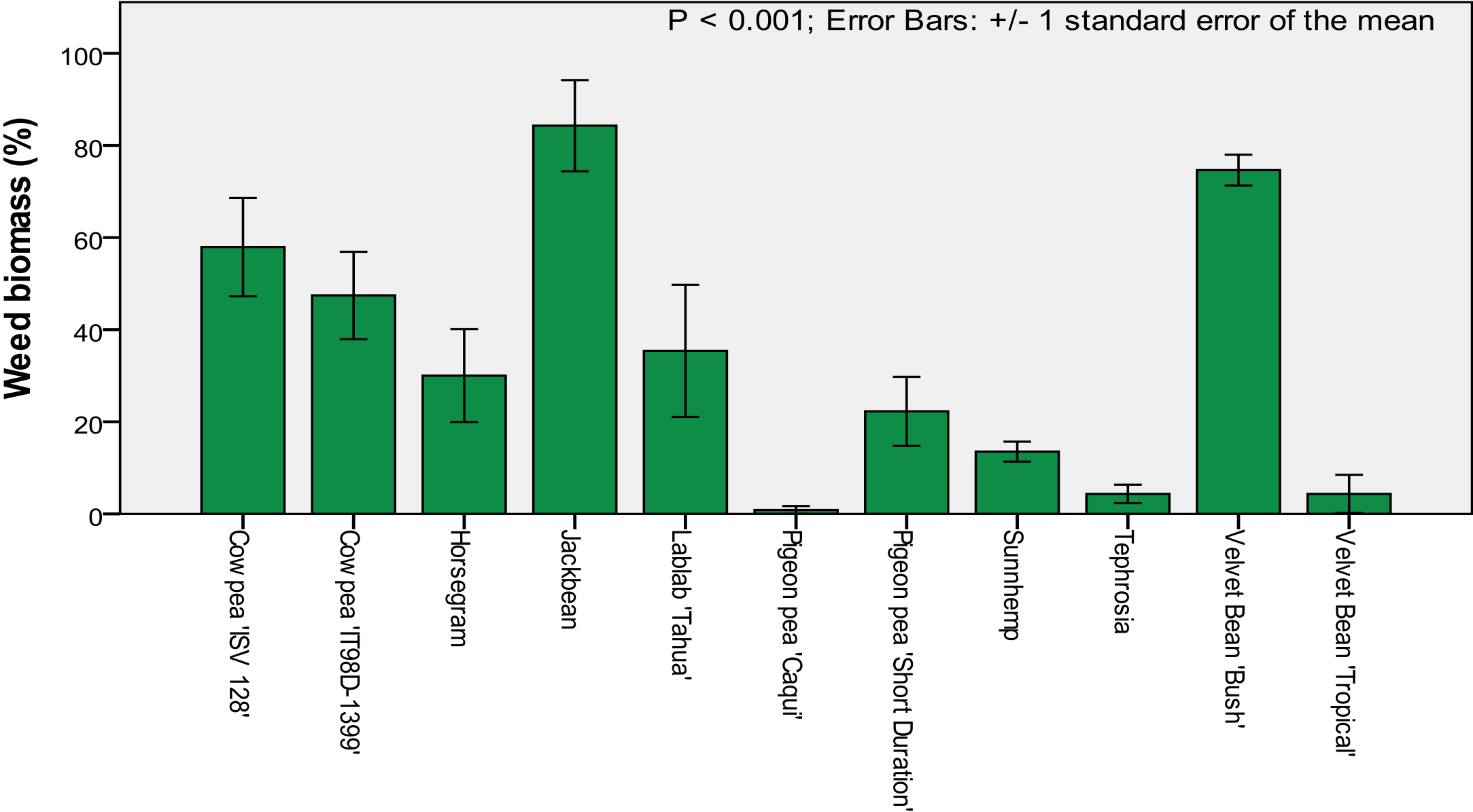
reduce nitrate leaching



Increase water infiltration



Percentage of above-ground biomass (legume + weed), within one square meter, comprised of weeds. Data taken 6 months after seeding the leguminous green manure cover crops in the field on 14 October 2010.



Sorghum biocolor
var. sudanense

Sorghum
Sudan Grass

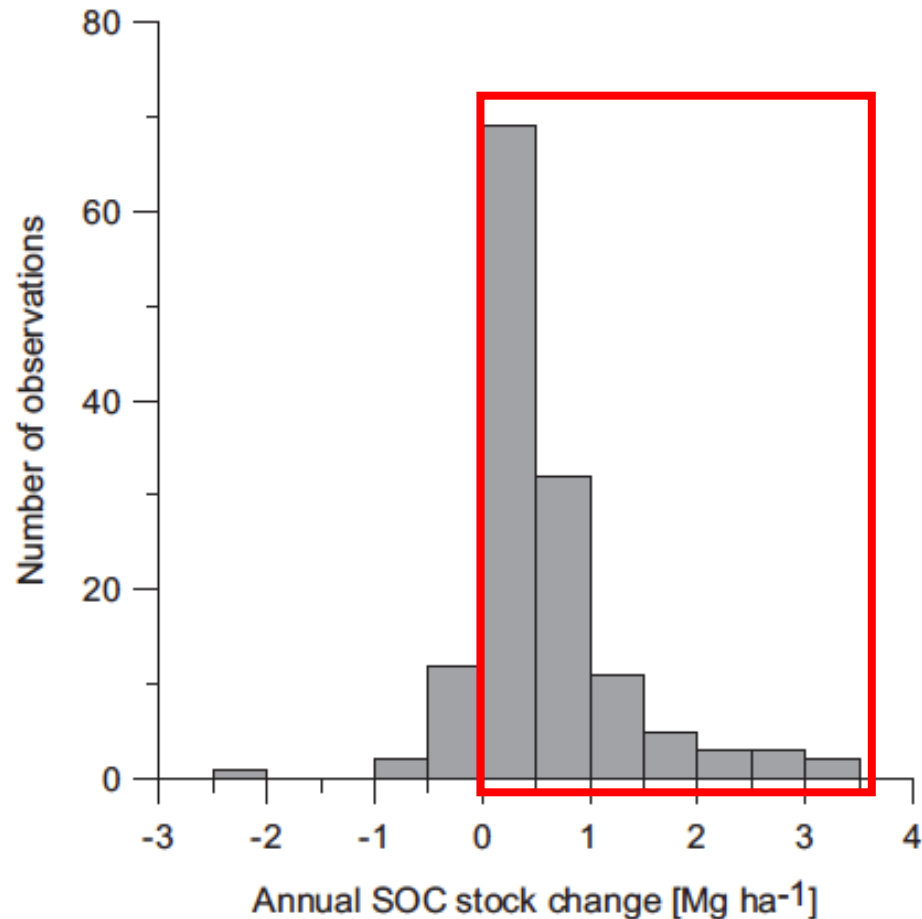


Community Gathering

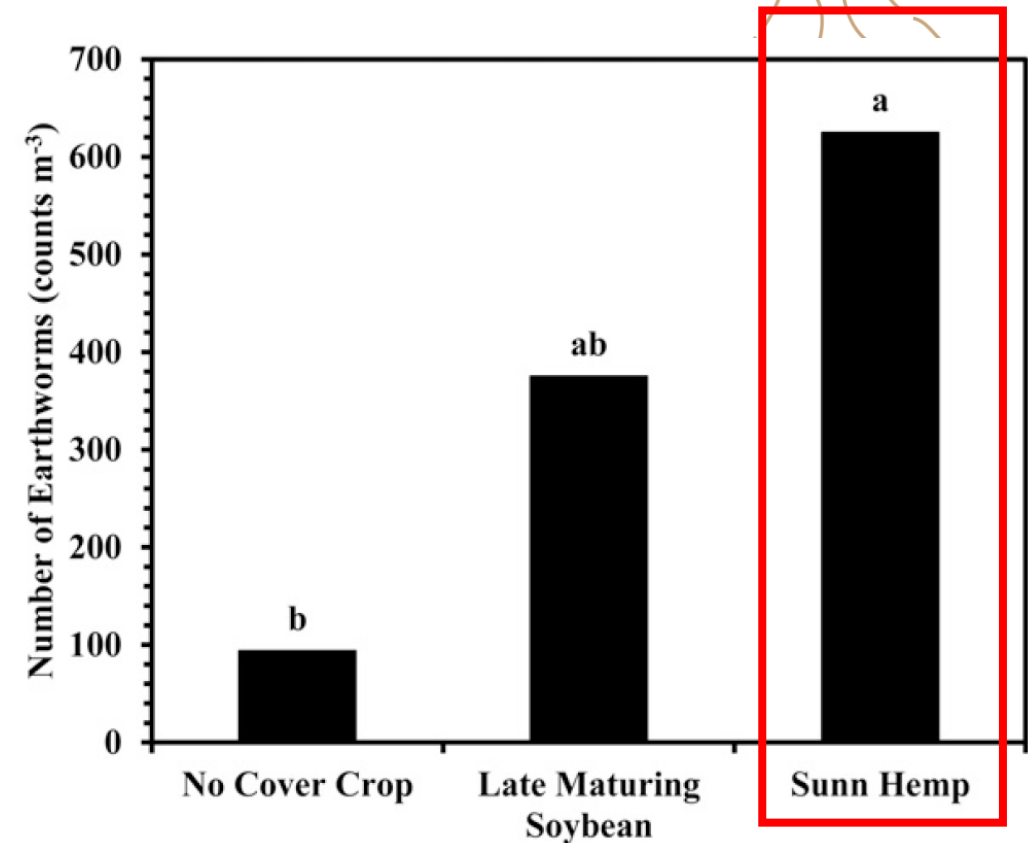


Do GMCCs really...

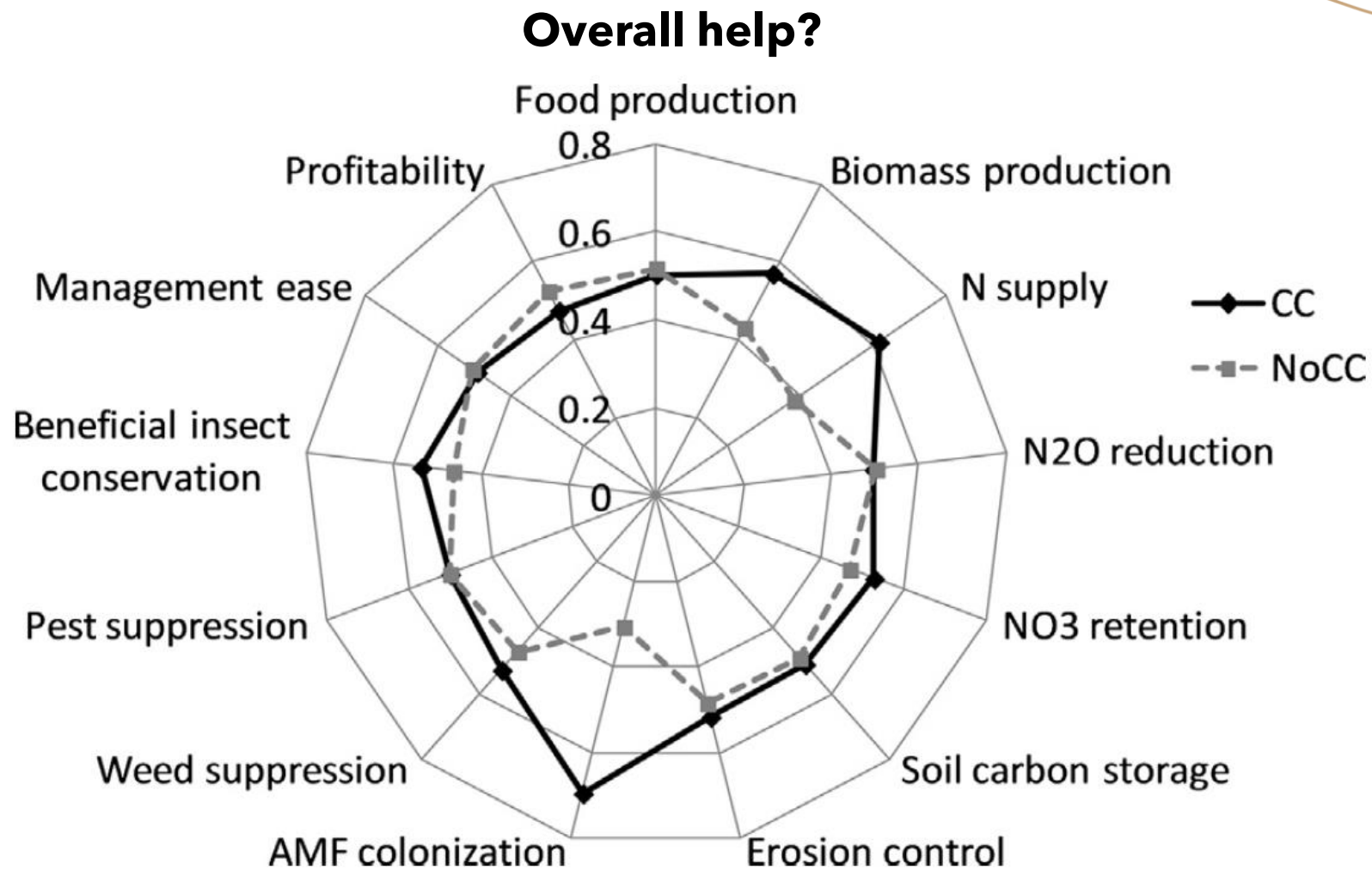
Increase soil organic Carbon



Increase soil life



Do GMCCs really...



Minimizing Risk, Maximizing Benefit

Keys to Success

- Minimize opportunity cost
 - Pick ones that are edible
 - Intercrop (e.g. with coffee or maize)
 - Rejuvenate wasteland
 - Grow with fruit trees
- Minimize inputs
 - Produce own seeds
 - Avoid using inoculants
- Must have low labor cost
 - Less labor in weed control
- Must fit into existing farming systems
- Must have one major benefit besides improving soil
- Choose one sure success for niche/context
- Be sure not to introduce pests/invasives



Soil surface cover vs. soil incorporation

- **Soil incorporation:** plowing in the organic biomass while N concentration is at its highest
 - Common practice in temperate areas
 - Prevents losses of N to the atmosphere
 - Lose the possibility of seed harvest for grain
- **Soil cover:** leave residues on soil surface
 - Recommended for tropical soils
 - Protects against intense heat
 - Lose N to volatilization



Research plot in South Africa illustrating biomass
(in this case 13 metric tons/ha dry)

Crotalaria juncea

Sunn hemp

Intercropping with legumes - competition

- Both legume and cereal crop plants need light as well as soil moisture and nutrients
- Legume crop can act as a "weed"
- Ways to minimize competition
 - Adjust plant spacing
 - Adjust planting time of cereal crop vs. legume
 - Plant crops that utilize resources at different times or zones in the soil profile



TROPICAL COVER CROP SELECTION CHART

Recommendations: 15 results found
Sorted by potential amount of biomass produced

Pigeon Pea <i>Cajanus cajan</i>
Velvet Bean <i>Mucuna pruriens</i>
Hairy Vetch <i>Vicia villosa</i>
Sunn Hemp <i>Crotalaria juncea</i>
Lablab <i>Lablab purpureus</i>
Slender Leaf Rattlebox <i>Crotalaria ochroleuca</i>
Bush Velvet Bean <i>Mucuna pruriens</i>
Faba Bean <i>Vicia faba</i>
Siratro <i>Macroptilum atropurpureum</i>
Cowpea <i>Vigna unguiculata</i> subsp. <i>unguiculata</i>
Jack Bean <i>Canavalia ensiformis</i>
Rice Bean <i>Vigna umbellata</i>
Horse Gram <i>Macrotyloma uniflorum</i>
Runner Bean <i>Phaseolus coccineus</i>
Mung Bean <i>Vigna radiata</i>



What are the benefits of leguminous GMCCs?

By integrating legumes into cropping systems, small-scale farmers in low-resource settings can invest in the long-term health and resilience of their soils. Success or failure depends largely on choosing the right legume(s). With that in mind, this document presents insights on legume selection that ECHO has learned from comparing legumes across parts of Southeast Asia and through five seasons of legume screening and intercropping trials in South Africa. References to ECHO publications, available at www.ECHOcommunity.org, are abbreviated as AN (Asia Notes), BPN (Best Practices Notes), EDN (ECHO Development Notes), and TN (Technical Notes). Numerous other sources of information are mentioned in the References and Further Reading sections of this document.

GMOCs, but this document focuses on legumes—plants belonging to the Fabaceae family. They are known for their ability, in conjunction with soil bacteria, to convert nitrogen from the atmosphere into fixed nitrogen that plants can take up. This process is called biological nitrogen fixation.

THEY THRIVE IN POOR SOILS

Land available to small-scale farmers is often characterized by difficult growing conditions. Depending on the location, for example, farm lands may be too wet, dry, steep, eroded, acidic, alkaline, saline, or infertile for optimal growth and yield of food plants. Where possible, land that is marginal for crop production should be used for other purposes such as pasture for livestock. However, many farmers have little choice but to produce their staple food plants on less-than-ideal soils.

One of the most commonly deficient nutrients on marginally degraded land is nitrogen. Because of their ability to utilize atmospheric nitrogen, legumes are often able to grow in nitrogen-deficient soils. Many tropical legumes also have extensive root systems that are able to draw moisture and nutrients from deep in the soil. Moreover, tropical legumes are diverse, with some adapted to humid climates and others to more arid zones. For these reasons, tropical legumes are recognized for their potential to grow under a range of difficult growing conditions.

What is a GMCC?

Green manure/cover crops (referred to hereafter as GMCCs) are plants used to cover and improve the soil, as well as to positively impact the ecology of the land and other crop plants. Many plants can be used as

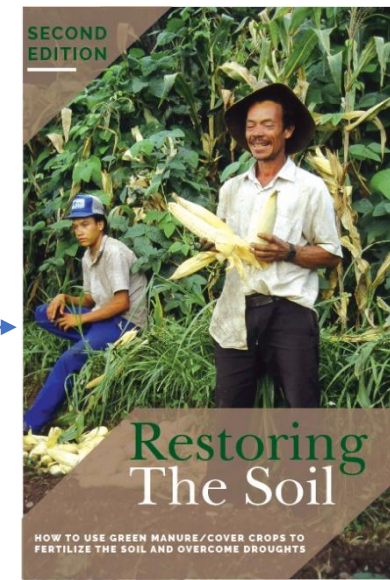
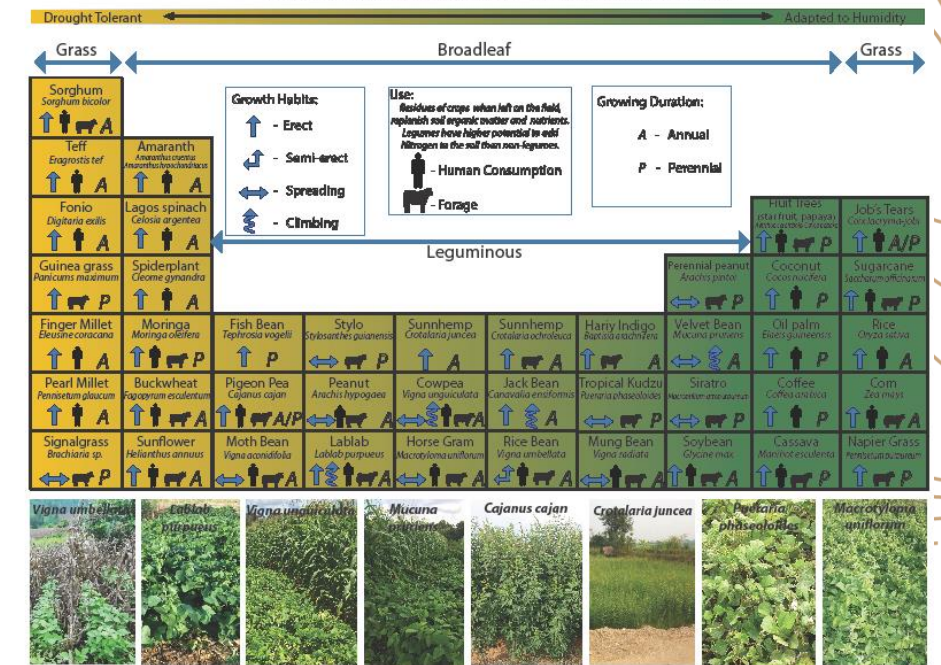
THEY ADD ORGANIC MULCH TO THE SYSTEM

Soil preservation is key to farmers' capacity to produce enough food for their families over time. This, in turn, depends to a large extent on maintaining soil organic

What's Inside:
by ECHO staff
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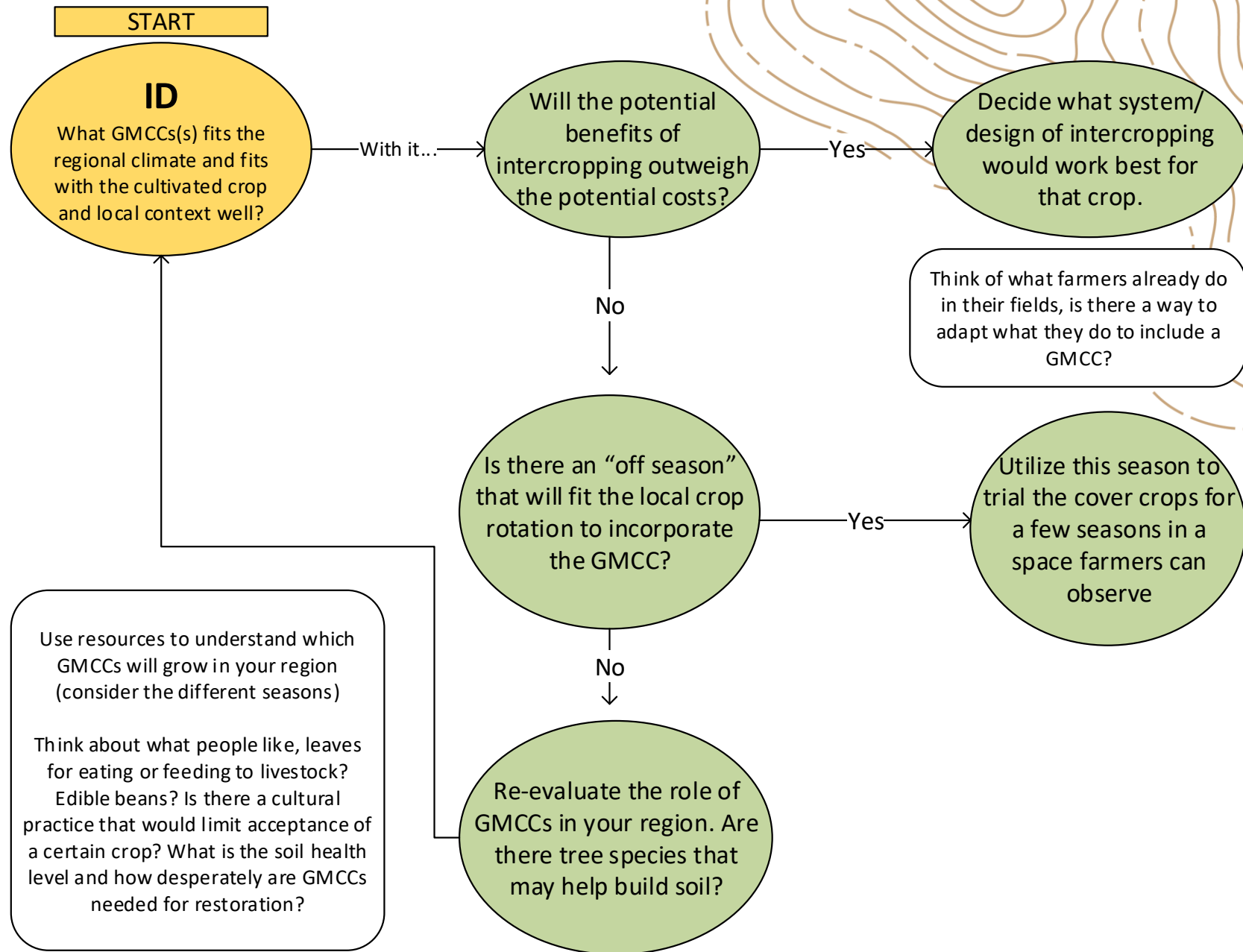


ECHO GMCC Tools and Resources!





Incorporating GMCCs in your context



Resources

General information

Green Manure Crops ([ECHO Tech Note 10](#))

An Introduction to Soil Fertility ([ECHO Tech Note 57](#))

Nutrient Quantity or Nutrient Access? A new Understanding of How to Maintain Soil Fertility in the Tropics ([EDN 74](#))

The Use of Green/Manure Cover Crops for Relay Cropping in Northern Thailand ([AN 10](#))

Vegetative and Agronomic Technologies for Land Husbandry ([EDN 89](#))

Roland Bunch, Five Years in Africa ([EDN 131](#))

Techniques utilizing GMCCs

A "2:4:2" Maize/Legume Intercropping Pattern ([EDN 133](#))

Conservation Agriculture in East Africa: An Update ([EAN 1](#))

Conservation Agriculture in Areas with High Rainfall ([EDN 127](#))

Use of Legume Cover Crops in Orchards or Plantations ([EDN 46](#))

Inoculation of Leguminous Crops and Trees ([EDN 101](#))

Cornell University website, [Conservation Agriculture: Global Research and Resources](#)

Farooq, M. H. Kadambot, and M. Siddique (Editors). 2015. [Conservation Agriculture](#). Springer International Publishing Switzerland

[Save and Grow](#), a book (available as a PDF download) on an ecosystem approach to sustainable agricultural intensification that encompasses CA

Matusso, J.M.M., J.N. Mugwe, and M. Mucheru-Mana. 2012. [Potential](#)

Crop-specific information

Cowpea: Spotlight on Multi-Purpose Varieties ([EDN 122](#))

Crotalaria juncea, a promising green manure crop for the tropics ([AN 3](#))

Lablab purpureus: A new Staple Crop for the Sudano Sahel ([TN 73](#))

Dolichos lablab: A Legume that Feeds People, Animals and the Soil ([EDN 82](#))

Further Support for the Use of Lablab in Dry Areas ([EDN 119](#))

Tephrosia: A Multipurpose Tree for Gm/CC, Soil Conservation and IPM ([EAN 2](#))

Cowpea: Living Mulch under Maize ([EDN 123](#))

Rice Bean - *Vigna umbellata*: Another amazing green manure/cover crop ([EDN 83](#))

Success with Velvet Bean in the Republic of Benin ([EDN 43](#))

Sesbania rostrata: A green manure production system for rice ([EDN 75](#))

[Various Plant Information sheets for individual gm/cc](#)

Fact sheets on many legume species available online through [Grassland Species](#)

[Profile](#), [Tropical Forages](#), [Winrock](#) (nitrogen-fixing trees), [Ecocrop](#) (FAO), and [Feedipedia](#)

Soil fertility, soil life and GMCCs

Bunch, R. 2012. [Restoring the Soil: A Guide for Using Green Manure/Cover Crops to Improve the Food Security of Smallholder Farmers](#). Canadian Foodgrains Bank

Marjatta E., J. Mureithi, J. Mureithi, and R. Derpsch. 2004. [Green manure/cover crop systems of smallholder farmers: experiences from tropical and subtropical regions](#). Kluwer Academic Publishers.

Anderson, S., S. Gundel, B. Pound, and B. Triomphe. 2001. [Cover crops in smallholder agriculture: lessons from Latin America](#). London: ITDG (Intermediate Technology Development Group).

Hoorman, J.J. and R. Islam. [Understanding Soil Microbes and Nutrient Cycling](#). Ohioline (Ohio State University Extension)

Dick, W.A., and J.L. Hatfield. 2001. [Sustaining soil fertility in West Africa: proceedings of a symposium sponsored by Divisions S-4, S-8, and A-6 of the Soil Science Society of America and the American Society of Agronomy: the papers were presented during the annual meeting in Minneapolis, Minnesota, 5-9 November, 2000](#). Madison, WI: Soil Science Society of America.

[Handbook for Integrated Soil Fertility Management](#), Africa soil health consortium. 2012. Edited by Thomas Fairhurst.