USING LEGUME GREEN MANURES IN MORINGA AND MAIZE PRODUCTION SYSTEMS

Research Findings from ECHO South Africa Program

Presentation Outline

I. Introduction to ECHO South Africa Research Program

II. Legume Green Manure Cover Crops: Benefits, Top Performers

III. ECHO South Africa Moringa Leaf Powder Production Project

IV. ECHO South Africa Maize Legume Green Manure Intercropping

Introduction to ECHO South Africa Research Program

- Rainy Season: November to April
- Rainfall: 635 mm
- Temperature: 13-29°C

South Africa Research Farm Soil Texture

Sand: 89%

Silt: 7%

Clay: 4%

Very high sand content:

- Low water-holding capacity
- Low nutrient-holding capacity

ECHO South Africa Project Site Soil Properties

Baseline Soil Properties							
	pH	SOM	NO_3^-	P	K	Zn	Mn
Start	5.8	0.6	3.2	25	64	6	6
Goal	6.5-7.0	2	25	37-53	>80	25-200	>12

SOM – Soil organic matter measured as percent, all nutrients measured in parts per million

How Can We Improve Soil Fertility On These Poor Soils?

Legume Green Manures

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

Benefits of Legume Green Manures

Improve long-term soil fertility	▪ Increase soil nutrient levels-Nitrogen fixation ▪ Add to soil organic matter ▪ Improve soil biological activity (bacteria, fungi, protozoa)
Longer-term Ground Cover	▪ Soil erosion control ▪ Reduced weed pressure ▪ Soil moisture conservation ▪ Lower soil temperature
Increase in food and fodder production	▪ Human food (cowpea, lablab, pigeon pea, etc…) ▪ Nutritious fodder for animals

Selected Legumes from ECHO South Africa Program

Lablab purpureus
13 tons/ha @ 6 months
250 kg N/ha @ 6 months

Mucuna pruriens
10 tons/ha @ 6 months
190 kg N/ha @ 6 months

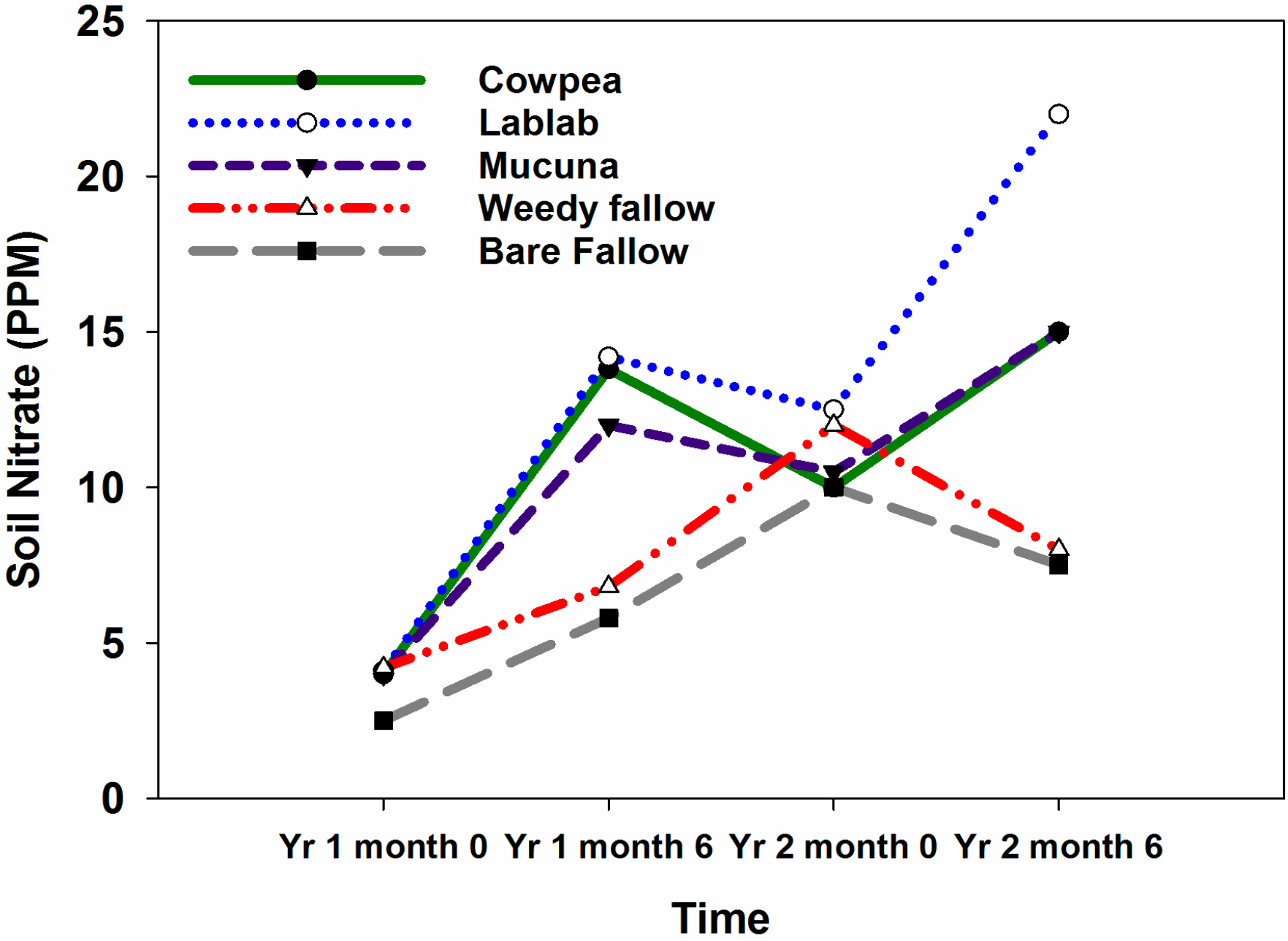
Vigna unguiculata
4.3 tons/ha @ 4 months
130 kg N/ha @ 6 months

Cajanus cajan
3.7 tons/ha @ 6 months
80 kg N/ha @ 6 months

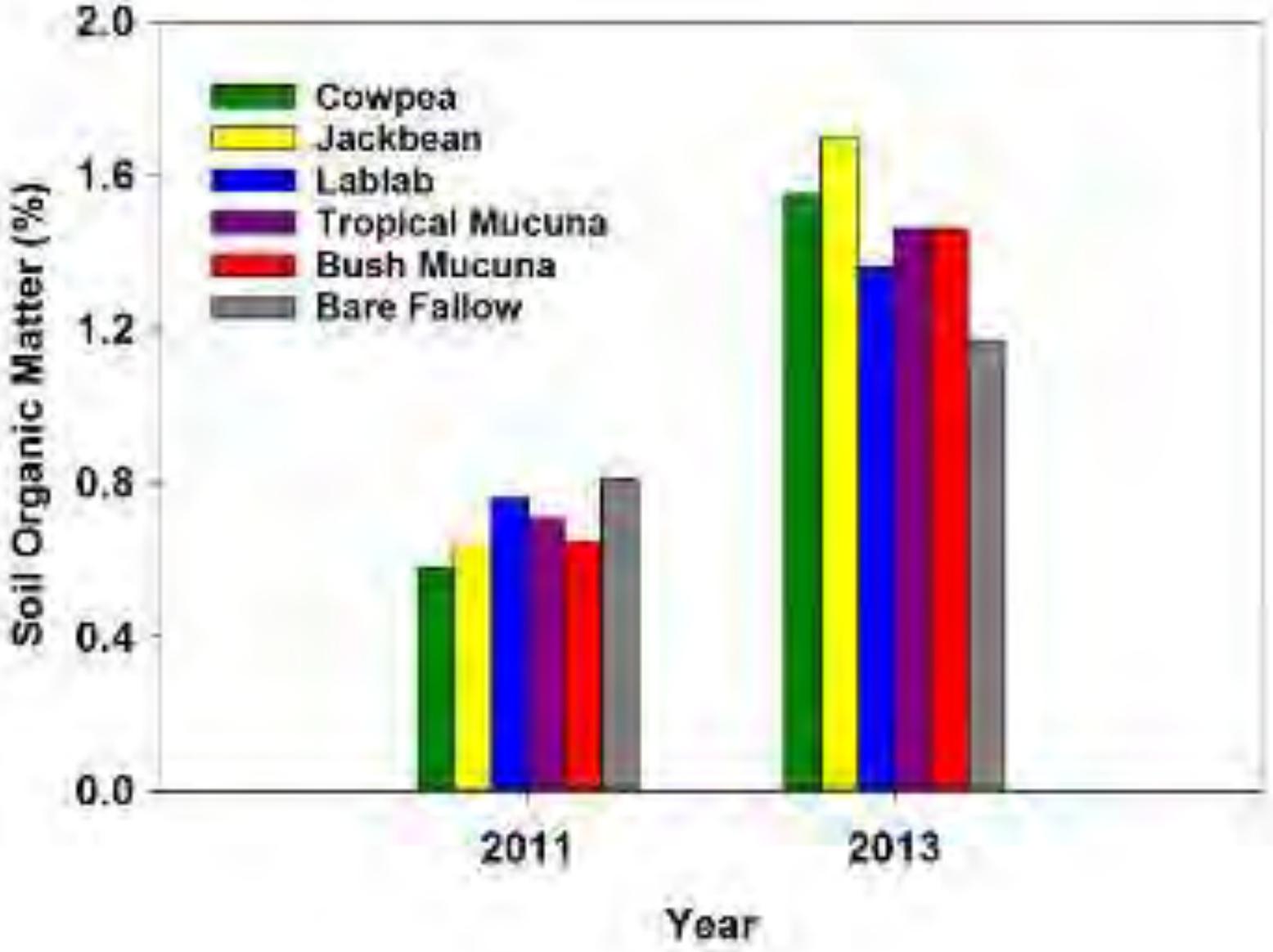
Canivalia ensiformis
4 tons/ha @ 6 months
50 kg N @ 6 months

Mucuna pruriens "Bush"
6 tons/ha @ 6 months
175 kg N/ha @ 6 months

Legume Green Manures Increase Soil Nitrogen Over Time

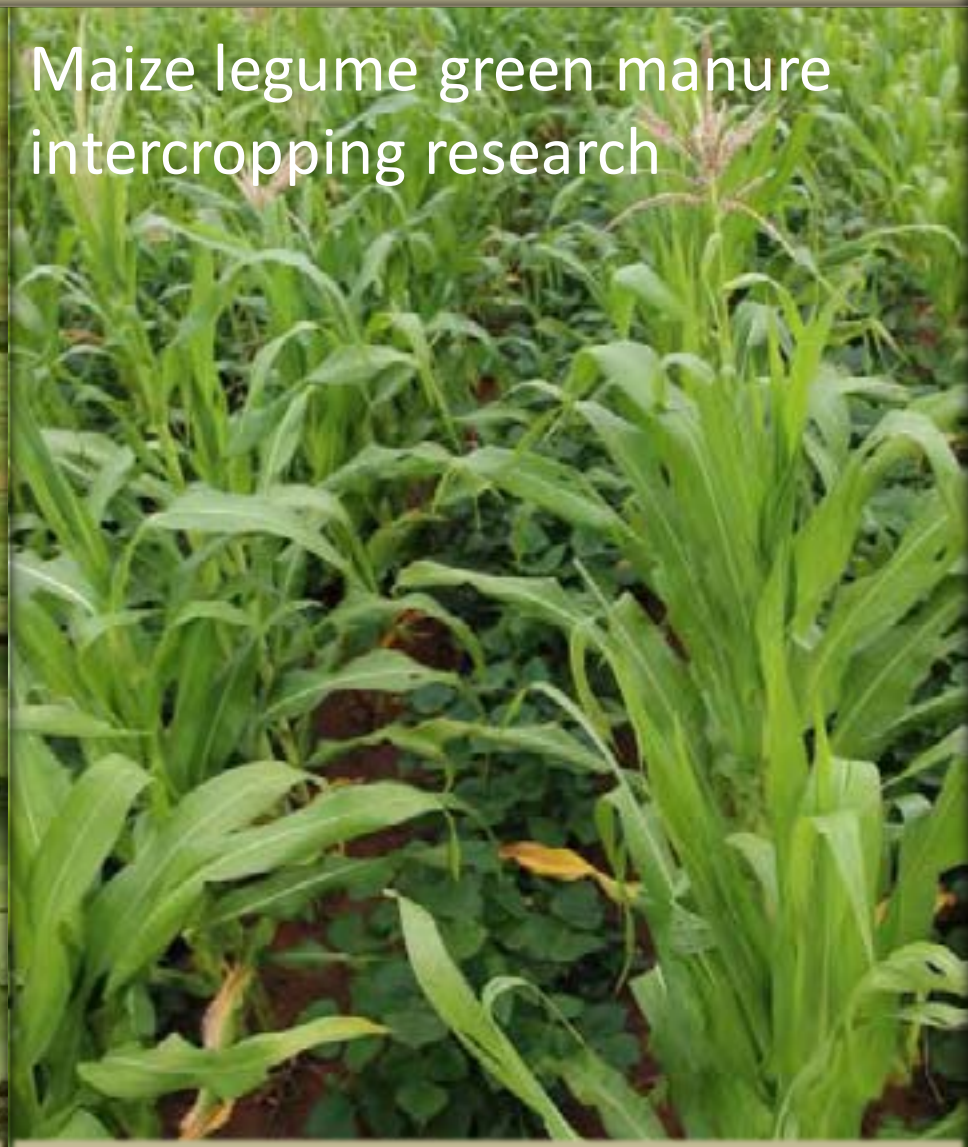


Green Manures Increase Soil Organic Matter Over Time



Integrating Legume Green Manures in Moringa and Maize Production Systems

Canivalia ensiformis “jackbean”



Lablab purpureus “lablab”

Moringa Research Objectives

Objective 1: Determine if legume green manures can be successfully intercropped with Moringa to increase leaf powder production, improve soil fertility, and provide fodder and beans.

Objective 2: Determine if vegetables can be successfully intercropped with Moringa to produce additional marketable crops

Pounding Moringa

Moringa powder

Possible Locations for Large Scale Moringa Production

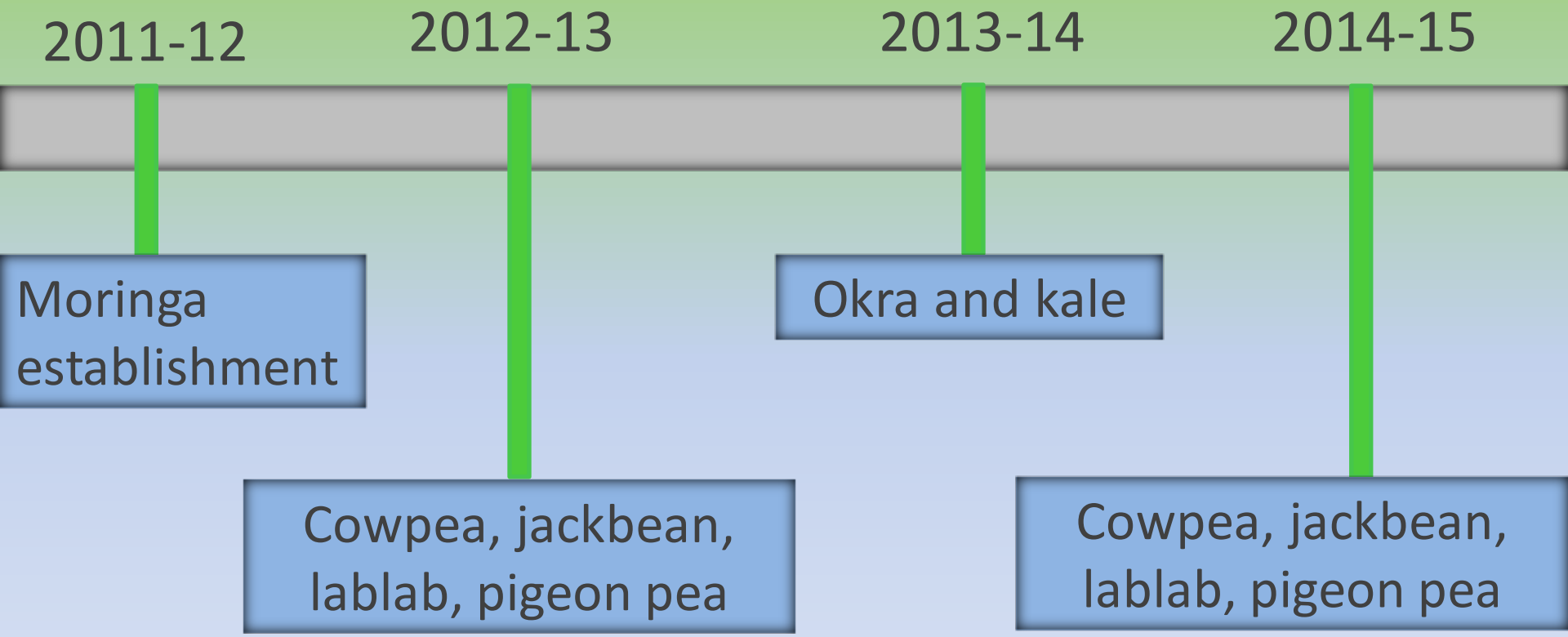
- Hospitals: HIV patients, malnourished children, pregnant women, nursing mothers

- School Gardens: Nutritional supplement to school lunches, diversify gardens

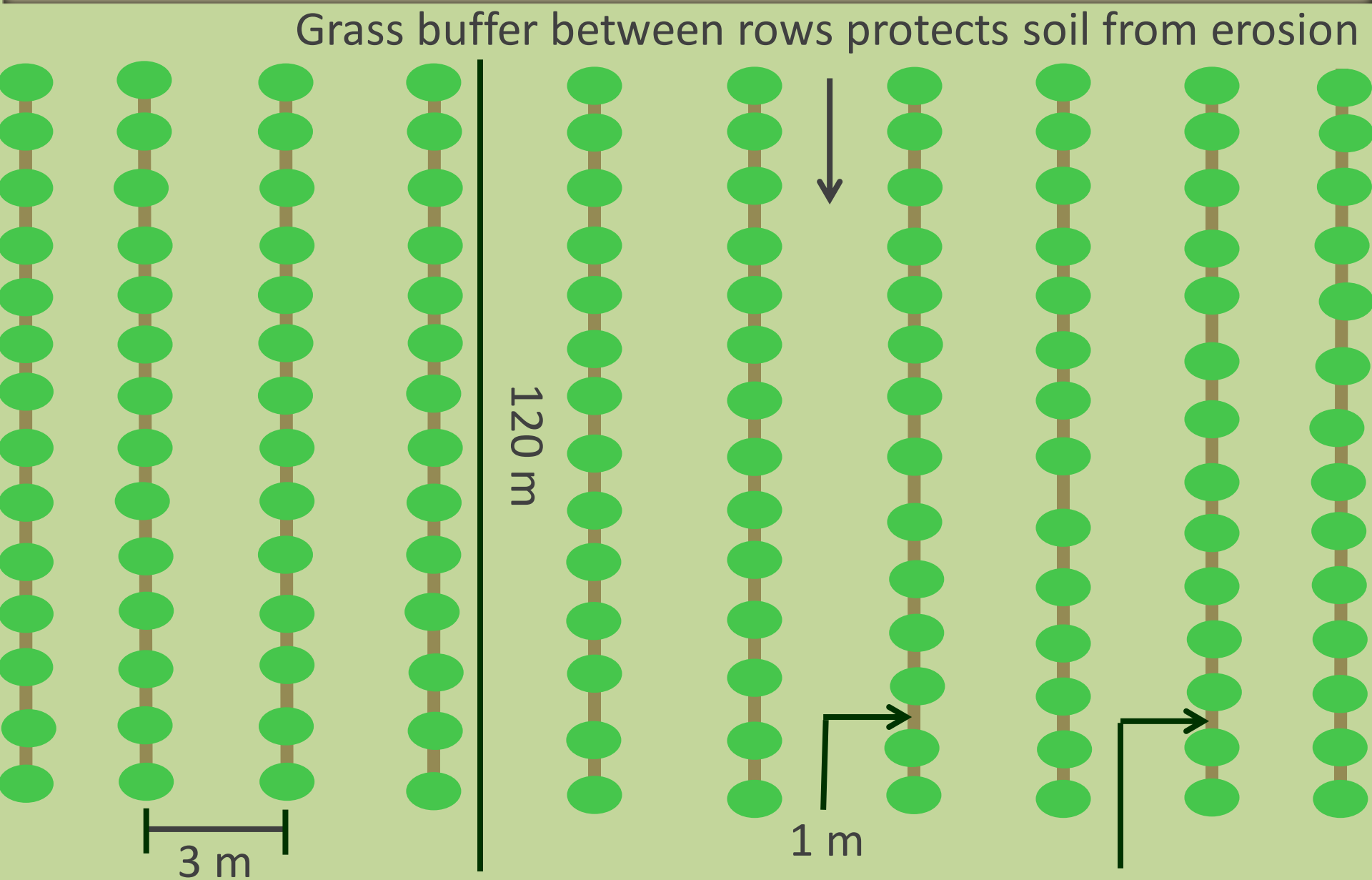
School Garden
Kumasi, Ghana

ECHO South Africa Moringa Intercropping Study History

Legume green manures and vegetables are rotated each year



ECHO South Africa Moringa Field Design



Establishment of Young Trees: 2011-2012 Season

Moringa-Legume Green Manure Intercropping, January 2015

Selecting Legume Green Manures For Moringa Intercropping

Factors to consider:

- Some species will climb up Moringa and must be cut back
- Fodder can be provided from cutting back climbing species

Lablab climbing Moringa

Moringa-Legume Green Manure Intercropping

Legume green manures compete well with Moringa and provided excellent groundcover

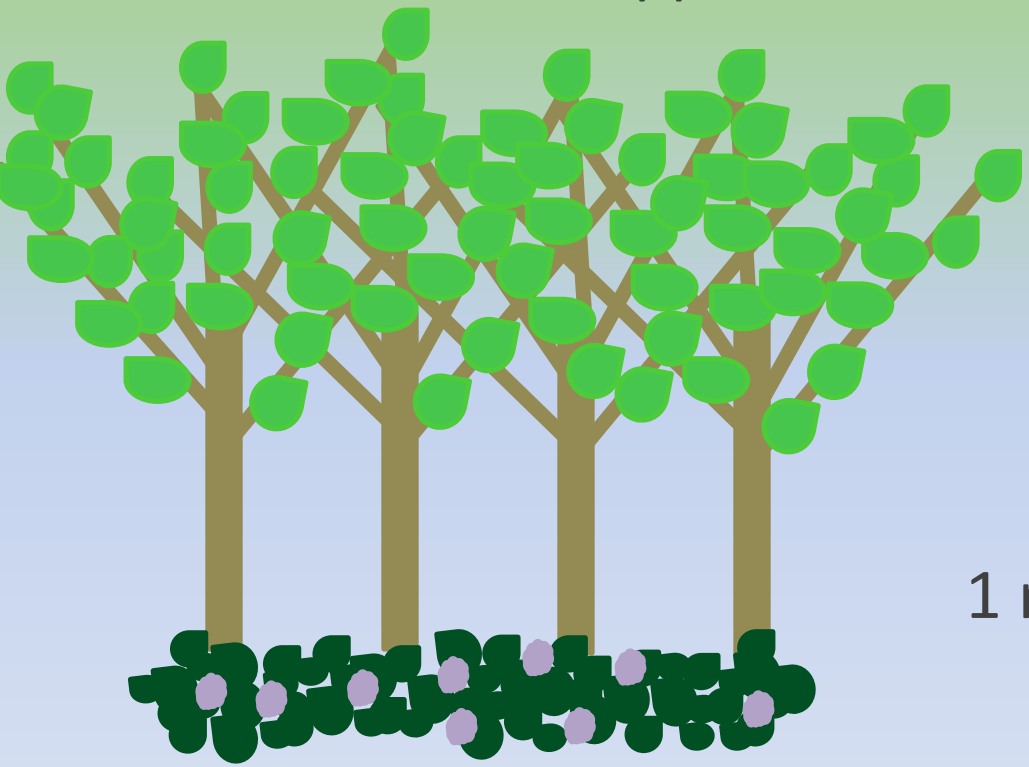

No Legume Green Manure

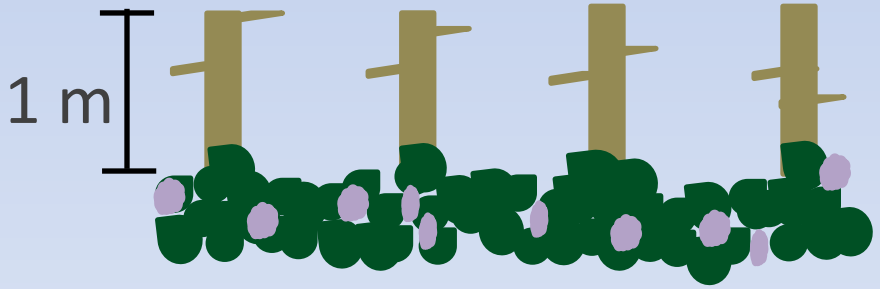

Jackbean under Moringa


Lablab under Moringa

Moringa Leaf Harvest Schedule

- Moringa leaves harvested twice during rainy season
- Trees cut to 1 m in height when leaves are harvested
- Chicken manure applied at base of trees @ 5 tons/ha





Legume green manures grown under Moringa canopy

First Moringa Harvest of 2014-15 Season

Moringa placed in dryer @ 55°C for 1.5 days

Moringa Leaves Can Also Be Dried in Shade

- Moringa leaves can be dried in the shade in a dry area. Fancy dryer is not needed
- After drying, Moringa can be pounded with traditional mortar and pestle

Senegal

Senegal

Moringa Field After First Harvest, January 2015

Two Weeks After Harvesting Leaves

- Harvesting leaves provides additional light for legume green manures
- Aggressive legume green manures can be trimmed back and used for fodder

Lablab under Moringa

Bush mucuna under Moringa

2013-14 Season: Vegetables Grew Poorly Under Moringa Canopy

Problem: Vegetables planted late and did not compete well with Moringa for light. Insects and animals also ate young plants

Possible Solutions: Plant earlier and try different vegetables that might compete well with Moringa

Okra under Moringa canopy

Kale under Moringa canopy

Key Findings: Moringa-Legume Green Manure Intercropping

Total leaf powder yield increased from 249 kg/ha in 2012-13 season to 366 kg/ha in 2013-14 season

	Dry Leaf Powder		Vegetable Yield (kg/ha)	
Legume	g/tree	Kg/ha	Okra	Kale
None	97	308	24.7	8
Cowpea	92	275	33.3	10.7
Jackbean	104	316	20.7	4.7
Lablab	90	276	29.9	11.1
Pigeon Pea	115	372	31.2	6.8
P Value	0.259	0.137	0.637	0.508

One hectare of this system would provide enough Moringa powder for a year's supply of 5 grams per day for **136 people by season 2** and **200 people by season 3**

Key Findings: Moringa-Legume Green Manure Intercropping

Legume green manures provided additional benefit of bean production for cowpea (360 kg/ha) and lablab (413 kg/ha) in 2012-13

Cowpea pods under Moringa canopy

Lablab pods under Moringa canopy

Legume green manures also produced > 5 tons/ha biomass for fodder and soil fertility improvement

Applying ECHO South Africa Moringa Leaf Powder Production Research to Conditions in West Africa

Factors to consider:

Local Climatic Conditions:

- total rainfall/distribution affects # Moringa harvests

Legume Green Manures and Vegetables

- Determine which species perform best in region
- Think about the market value of different crops

Trial and Error

Maize-Legume Green Manure Intercropping Research

Research Objectives and Treatments

Objective 1:

Determine if lablab and cowpea can be successfully intercropped with maize to produce additional food, fodder, and biomass.

Objective 2:

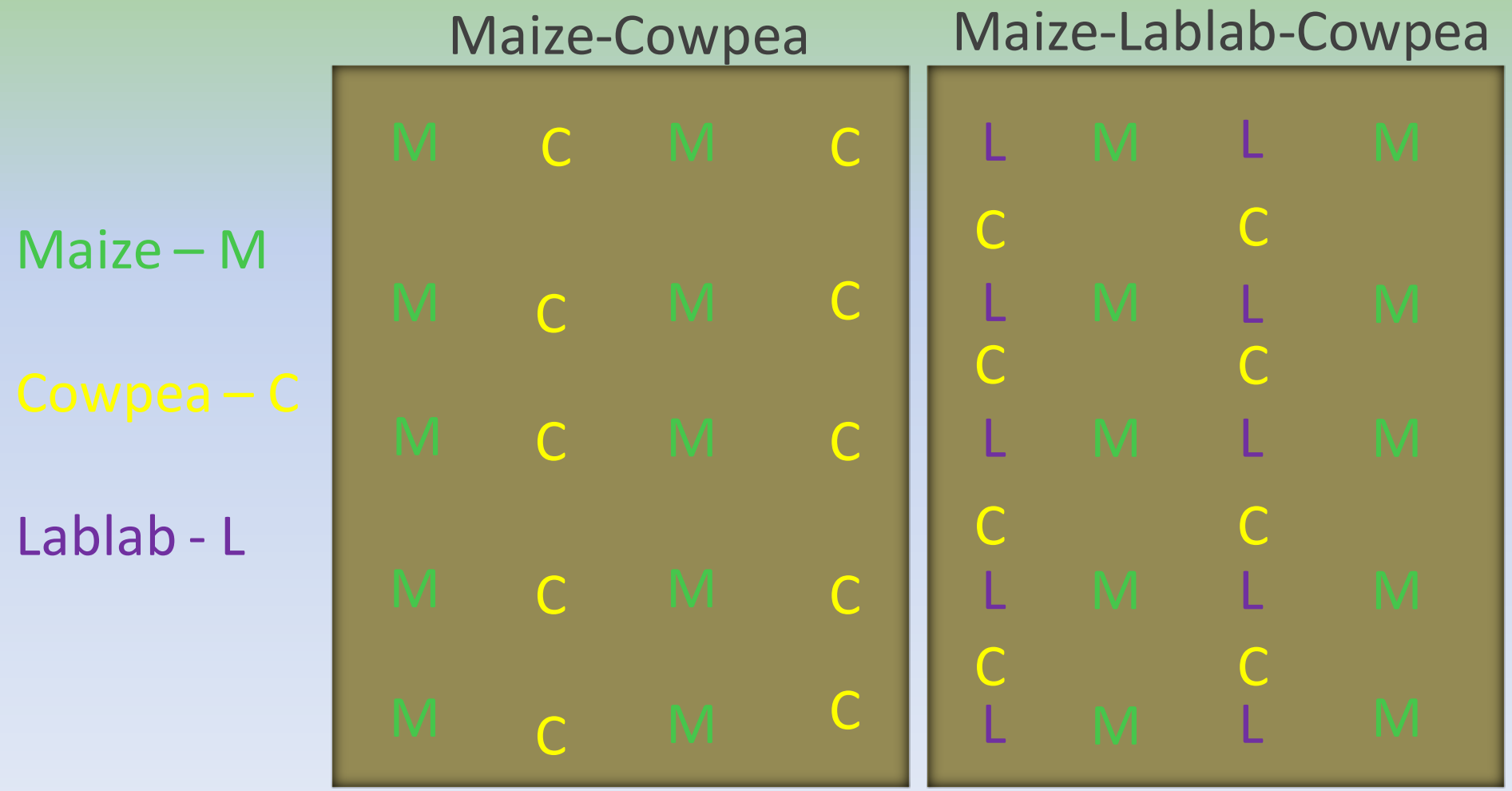
Determine the best time to plant lablab into maize or a maize-cowpea intercropping system

Treatments

1. Lablab planted in plots with a) only maize or b) maize-cowpea intercrop
2. Lablab planted in plots 0, 2, 4, or 8 weeks after maize and cowpea

ECHO Maize-Legume Green Manure Intercropping Method

- Maize and cowpea planted at same time
- Lablab added to half of plots at week 0, 2, 4, 8, and 12



Intercropping Legumes with Other Legumes

Why?

Legumes with different growth habits and life cycles can grow well together.

Longer period of ground cover to protect soil

Larger quantity of biomass and fodder

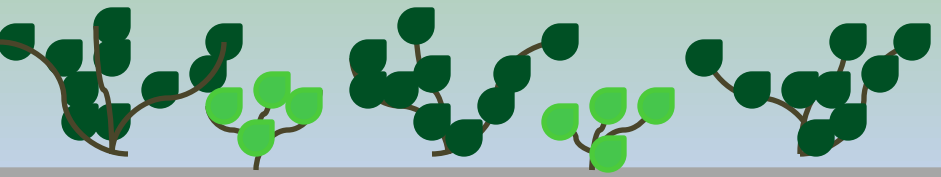
Greater nutrient addition to improve soil fertility

Week 4

Cowpea

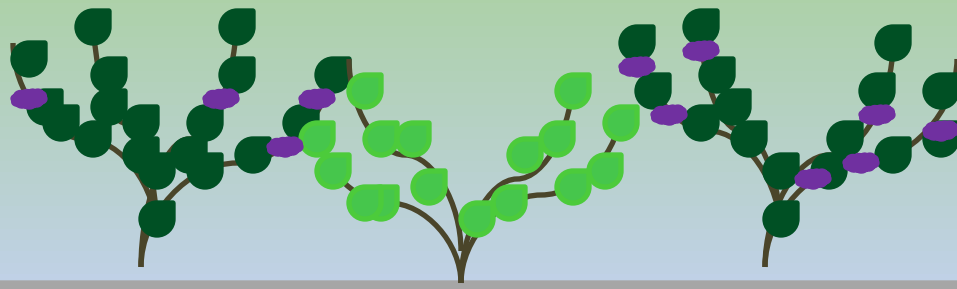
Lablab

Initial cowpea growth is faster than lablab



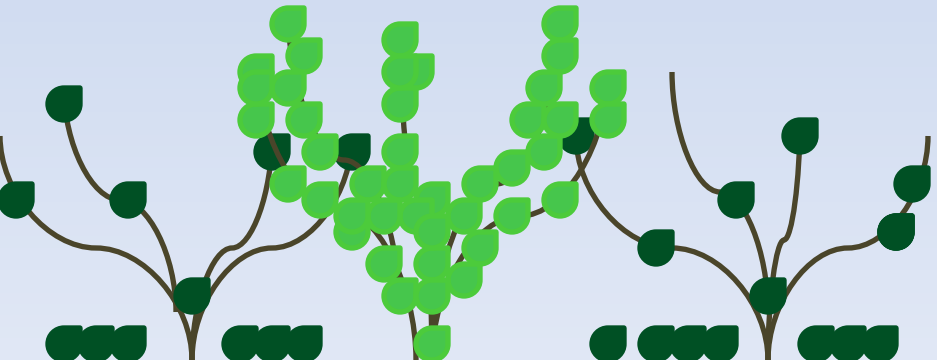
Week 8

Cowpea flowering and producing pods, while lablab growth rate is increasing



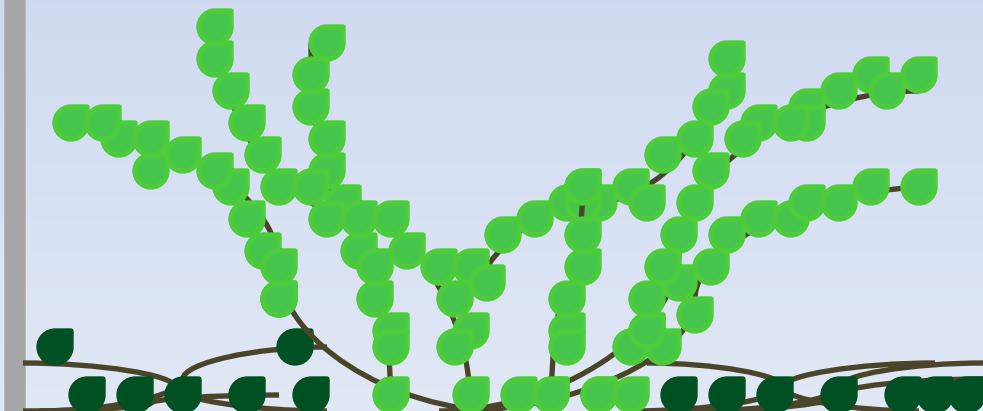
Week 12

Cowpea is in decline just as lablab is growing rapidly



Week 16

Cowpea is decomposing as lablab takes over



Cowpea-Lablab Intercropping

Lablab is slower than cowpea at the beginning, but grows rapidly after cowpea harvest is finished

Cowpea-Pigeon Pea Intercropping

- Cowpea spreads as ground cover, while pigeon pea is erect
- Cowpea harvest after 2 to 3 months, while pigeon pea harvest after 6 months

Maize-Legume Green Manure Intercropping Methods

Be On Time

- Field preparation
- Planting
- Thinning
- Weeding

Permanent Planting Stations

- Concentrate nutrients around crops
- No broadcasting manure
- Reduced soil compaction over time

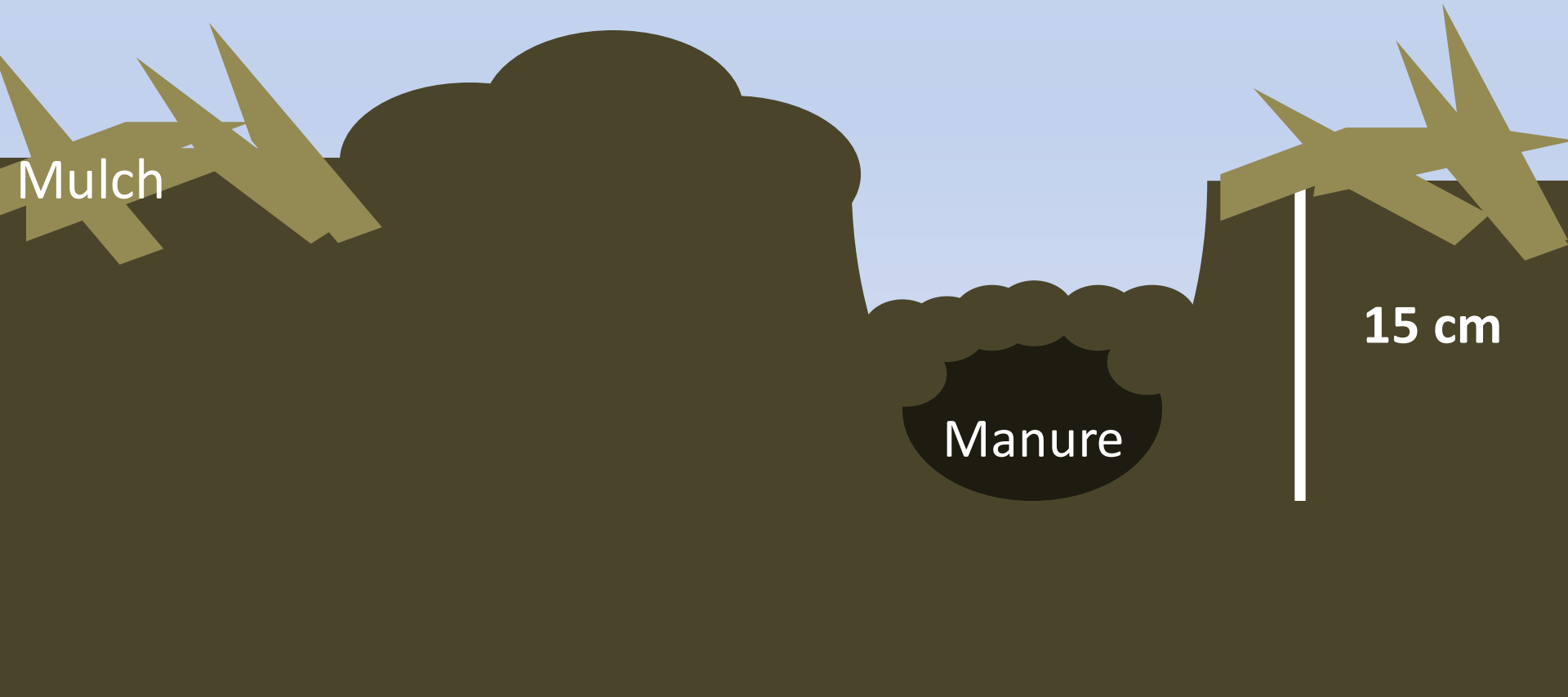
Surface Mulch

- No burning residues!
- Protect soil from erosion
- Conserve soil moisture
- Reduce soil temperature

Permanent Planting stations with Surface Mulch

Permanent Planting Stations Benefits:

- Manure in planting stations only feeds crop
- Soil in planting stations becomes softer
- Nutrients build up over time



Digging Planting Stations During Dry Season

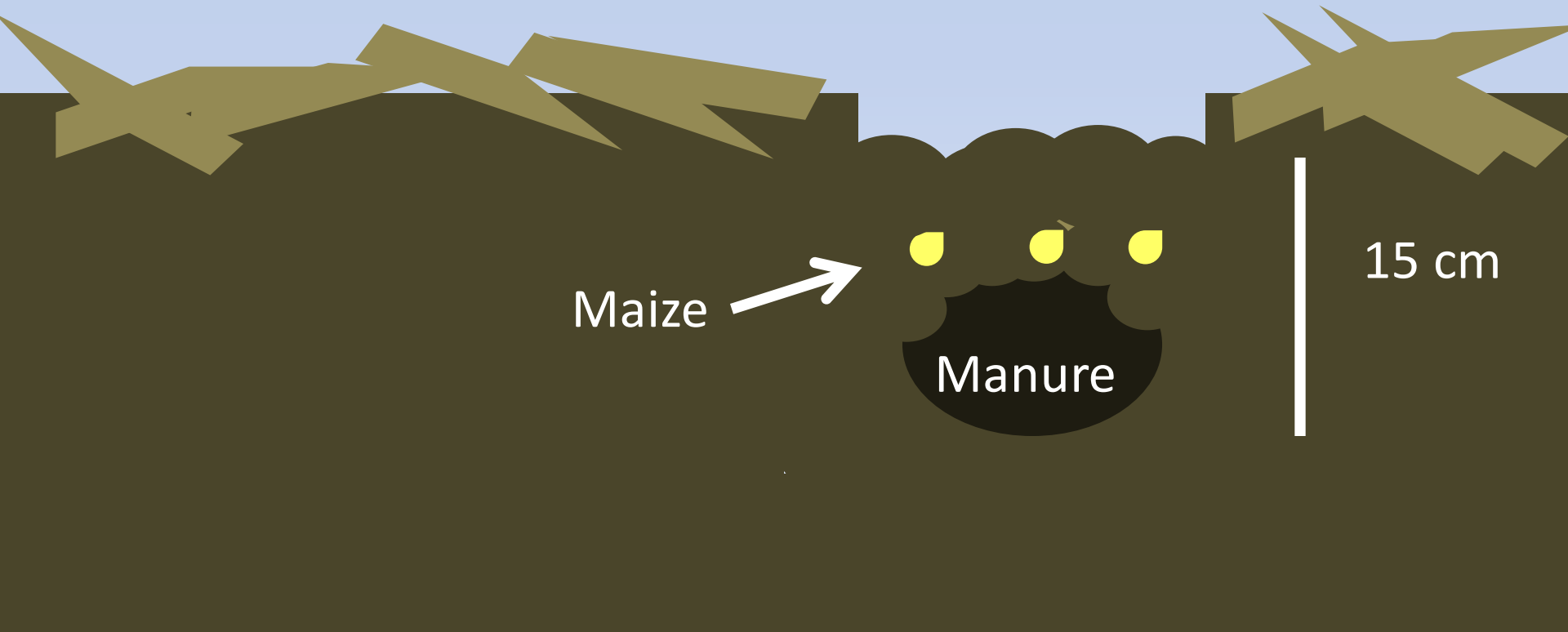

I’m tired!!

Planting Stations with Manure. Mulch Is From Last Season

Permanent Planting stations with Mulch on Field

Planting Method for Cereals:

- Plant 3 seeds of maize per hole. Thin to 2 plants 2-3 weeks after planting.
- For millet or sorghum, plant 6 seeds and thin 3 plants 2-3 weeks after planting.



ECHO Maize-Legume Green Manure Intercropping Method

- Planting multiple crops in same field each year
- Rotate rows: Do not plant same crops in same rows each year
- Spacing: 50 cm between rows and 60 cm with row

Maize – M

Cowpea – C

Lablab - L

Maize-Legume Green Manure Intercropping Results From 2013-2014 Season

Cowpea and Lablab Grow Very Well Together

- Cowpea and lablab have different growth habits and life cycles and grow well together
- When cowpea growth declined @ week 12, lablab growth accelerated and provided long-term groundcover
- Intercropping lablab with cowpea did not lower cowpea biomass production or yields

Cowpea Rate of Growth

- Cowpea canopy closed 8 weeks after planting maize
- Harvest of cowpea began 10 weeks after planting
- After 12 weeks cowpea growth began to decline

Lablab Rate of Growth

- Lablab grows slow for first 4 weeks, but canopy closed 12 weeks after lablab planting
- Lablab planted 4, 8, and 12 weeks after maize did not compete well with maize
- Lablab must be removed from maize stalks if it begins climbing and choking plants

Effect of Legume Canopy on Soil Temperature

- Soil temperature was lower when both lablab and cowpea were intercropped with maize @ weeks 10 and 12

Soil temperature (°C)				
Legume planted with maize	Wk 4	Wk 8	Wk 10	Wk 12
Lablab	26	28	**34**	**31**
Lablab + Cowpea	26	28	**29**	**26**
P value	0.151	0.034	< 0.001	< 0.001

Effect of Legume Canopy on Soil Moisture

- Cowpea and lablab conserve soil moisture more effectively than just lablab @ weeks 10 and 12

Soil Moisture (%)				
Legume planted with maize	Wk 4	Wk 8	Wk 10	Wk 12
Lablab	6.7	6.9	**7.5**	**4.1**
Lablab + Cowpea	6.7	7.1	**7.9**	**5.1**
P value	0.762	0.485	0.002	<0.001

Changes in Soil Organic Matter Over Time

- It is very difficult to build soil organic matter in sandy soils
- Soil organic matter from all treatments increased from the initial baseline value of 0.6%.

	Organic Matter (%)			
Lablab Planting Time	4 Sept	4 Dec	21 Jan	31 March
Week 0	1.92	1.68	1.08	1.17
Week 2	1.88	1.75	1.08	1.14
Week 4	2.22	2.15	1.01	1.01
Week 8	2.07	1.95	1.11	1.08
Control	2.11	1.75	0.89	1.19
P-Value		0.15	0.62	0.57

Measurements of Soil Microbial Health

- Sampling taken one month after planting
- Desired ranges in parts per million (ppm): bacteria- 1000-3000, fungi- 100-300, protozoa > 20,000

	Soil Microbial Health (ppm)		
Lablab Planting Time	Bacteria	Fungi	Protozoa
Week 0	2280	128	24773
Week 2	2482	100	27955
Week 4	2446	104	22482
Week 8	2198	117	32862
Control	2361	117	32900
P-Value	0.78	0.23	0.88

Maize and Cowpea Yield Data

- Cowpea and lablab intercropping did not affect maize yields
- Cowpea yield was not affected by presence of lablab
- Legume green manures provide fodder and grain without negatively affecting maize yields

Treatment	Yield (kg/ha)		
Lablab Planting time	Maize	Cowpea	Total
Week 0	1900	650	2550
Week 2	1300	497	1797
Week 4	1600	804	2404
Week 8	1500	781	2281
Week 12	1700	702	2402
P Value	> 0.05	0.202	

Challenges to Maize-Legume Green Manure Intercropping

Insect Pest Problems On Cowpea

- Cowpea has major pest problems
- With no crop rotation, pest pressure builds up
- More pesticides needed on cowpea

Aphids

Giant Coreid Bug

Spiny Brown Bug

Brown Spiny Bug On Lablab Pods

Pest and Disease Problems of Maize

- Maize stock borer damage
- *Erwinia* species stalk rot

Lablab Must Be Cut Back To Protect Maize

ECHO South Africa Maize Legume Intercropping Summary

Cowpea and lablab grow well together and provide long-term ground cover and fodder

Intercropping cowpea, lablab, and maize in same field every year can lead to increase in pest and disease pressure

Farmers will have to take time to cut lablab vines during season to prevent damage to maize

Applying Maize-Legume Green Manure Intercropping Research to Farming Systems in West Africa

Challenges of Intercropping Lablab with Millet or Sorghum

- Millet and sorghum stalks are weaker than maize stalks. Lablab vines can break or push down millet and sorghum plants.

- Lablab cannot be allowed to break millet and sorghum stalks. They have important uses.


Senegal


Aggressive lablab

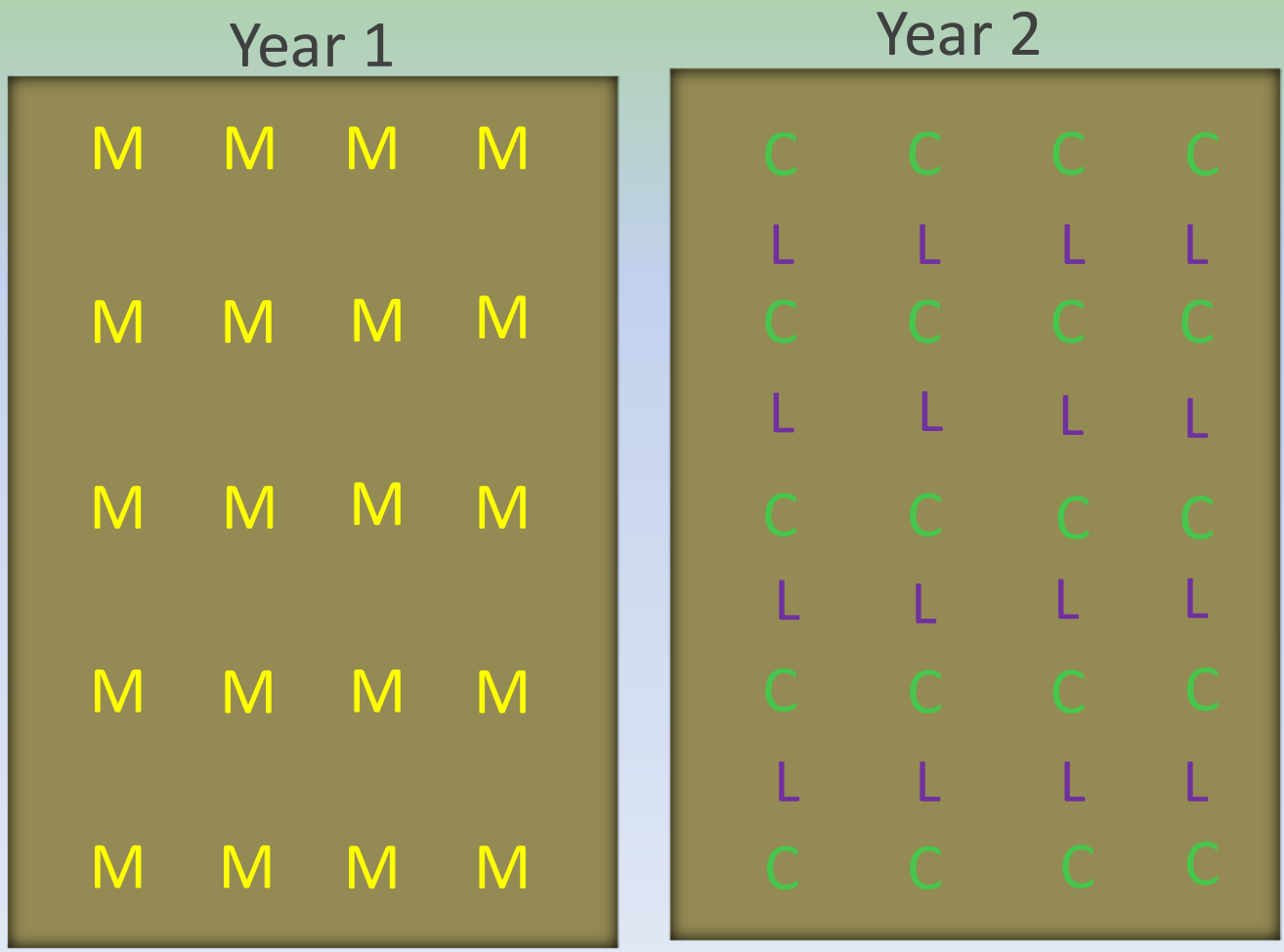
Possible Solution: Crop Rotation of Cereals and Legumes

- Crop Rotation: grow millet one or two years followed by cowpea-lablab intercropping
- Advantage: Additional fodder and bean production, less pest pressure

Millet – M

Cowpea – C

Lablab – L



Closing Thoughts

Legume green manures grow very well under Moringa trees. More research is needed for integrating vegetables into Moringa.

Cowpea and lablab grow very well together and can provide food, fodder, and biomass for soil fertility improvement

If maize, cowpea, and lablab are intercropped in the same place every year, there may be pest and disease incidence

It is important to consider local climate and market conditions. Try modifying this research to meet local conditions

Thank you! Questions?

Arun Jani
adkjani@gmail.com