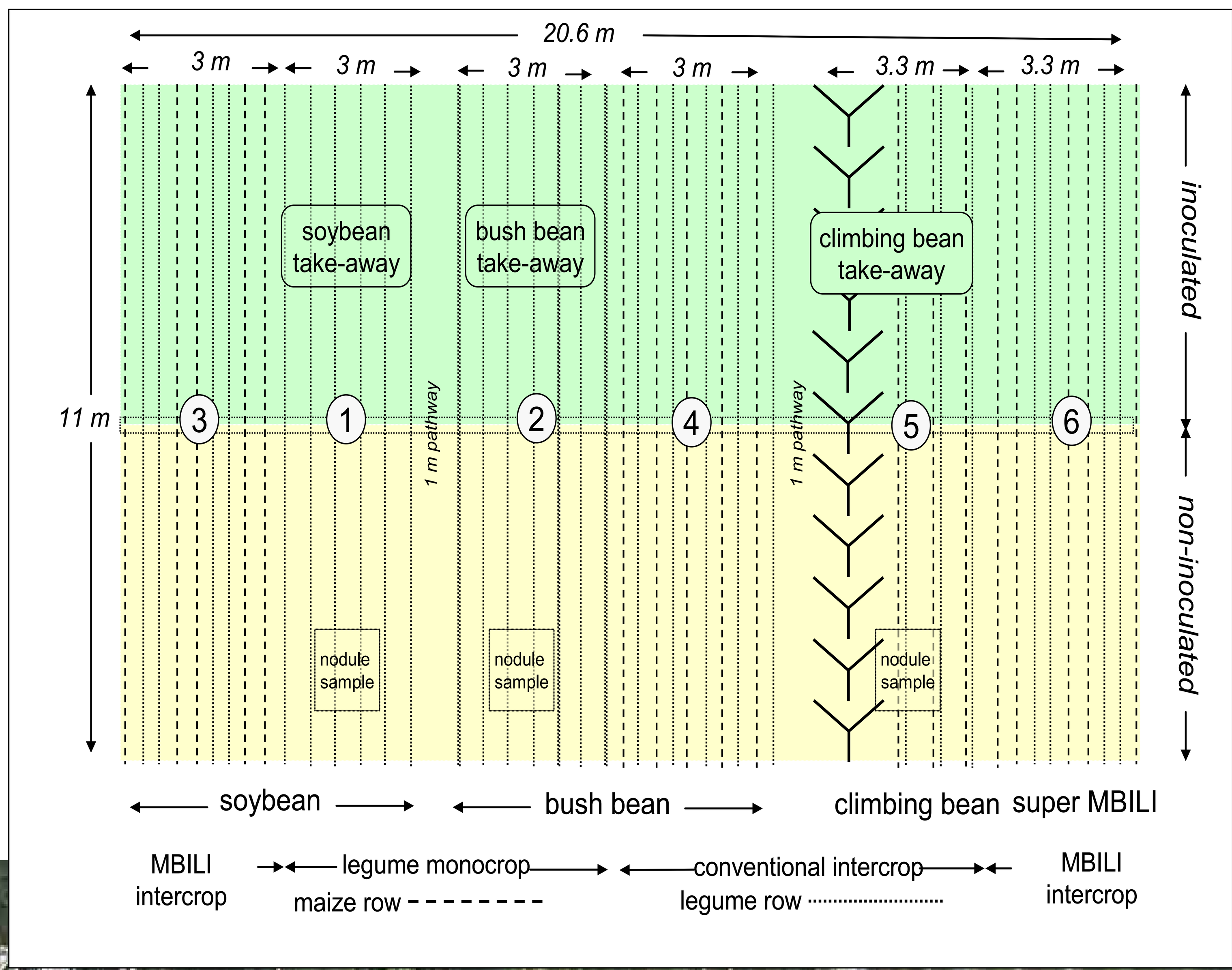
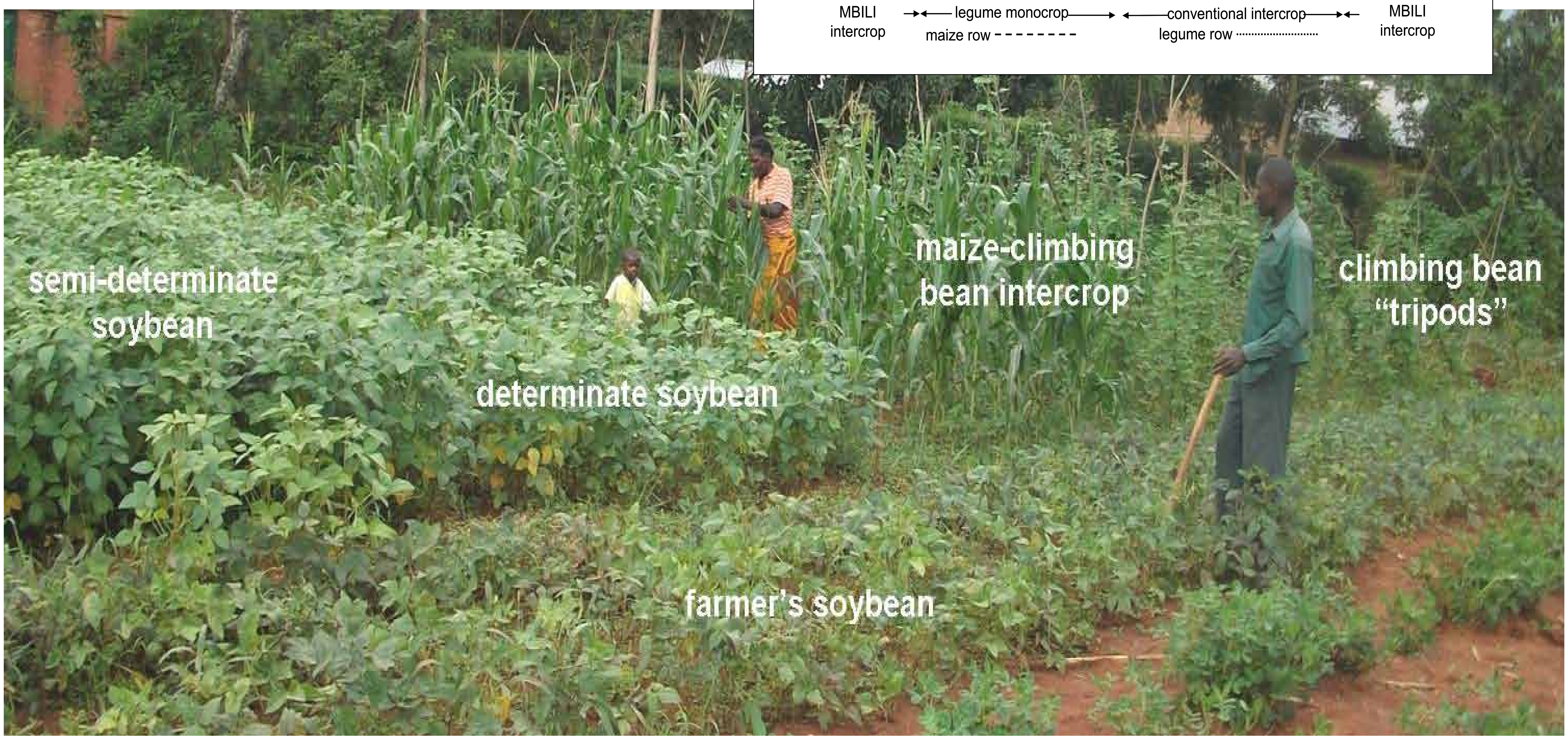
A PARTNERSHIP APPROACH

N2Africa uses a step-wise approach to deployment of legume and inoculants technologies with strong BNF capacity, focusing initially on “quick wins”- employing existing proven technologies based on success feedback from researchers, farmers, extensionists and other partners.

Effecting change at farm level

- Package proven technologies with available inputs
- Work through established grassroots groups (positive peer pressure, collective action)
- Develop diagnostic skills through extension campaigns, field demonstration and farmer field days





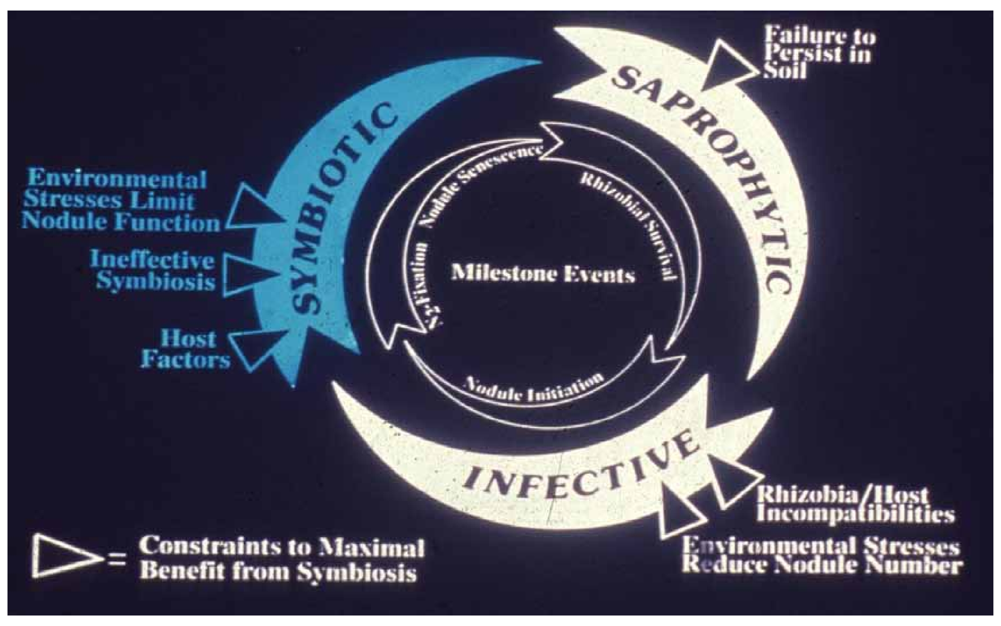
Rhizobiology

Soil samples from different agro ecological zones are collected and and assessed for their rhizobial populations as well as "need to inoculate" in order for nitrogen fixation to occur.

Several rhizobiology laboratories have been renovated and new equipment purchased to enable them to conduct quality analyses. Several NARS staff as well as N2Africa Research Officers have undergone training in rhizobiology so as to gain new skills and expertise.

Several M.Sc. and PhD students sponsored by N2Africa are pursuing rhizobiology topics at respective levels

The life cycle of rhizobia consists of three phases, each with their own milestone events and constraints to achieving effective symbiotic nitrogen fixation

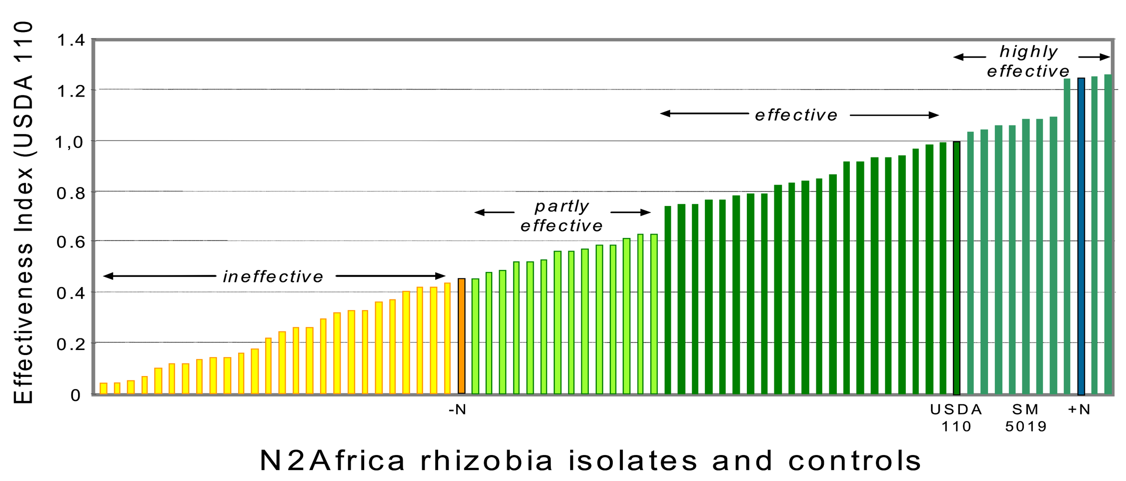


The **saprophytic phase** of the cycle, rhizobia may persist in the absence of the legume hosts either in the bulk soil, the decaying root nodules from previous symbiosis, or in the rhizospheres of non-host plants

The **infective phase** in the cycle of rhizobia represent a series of events involving both symbiotic partners. The infection process is sensitive to stresses of the environment, particularly soil acidity and salinity.

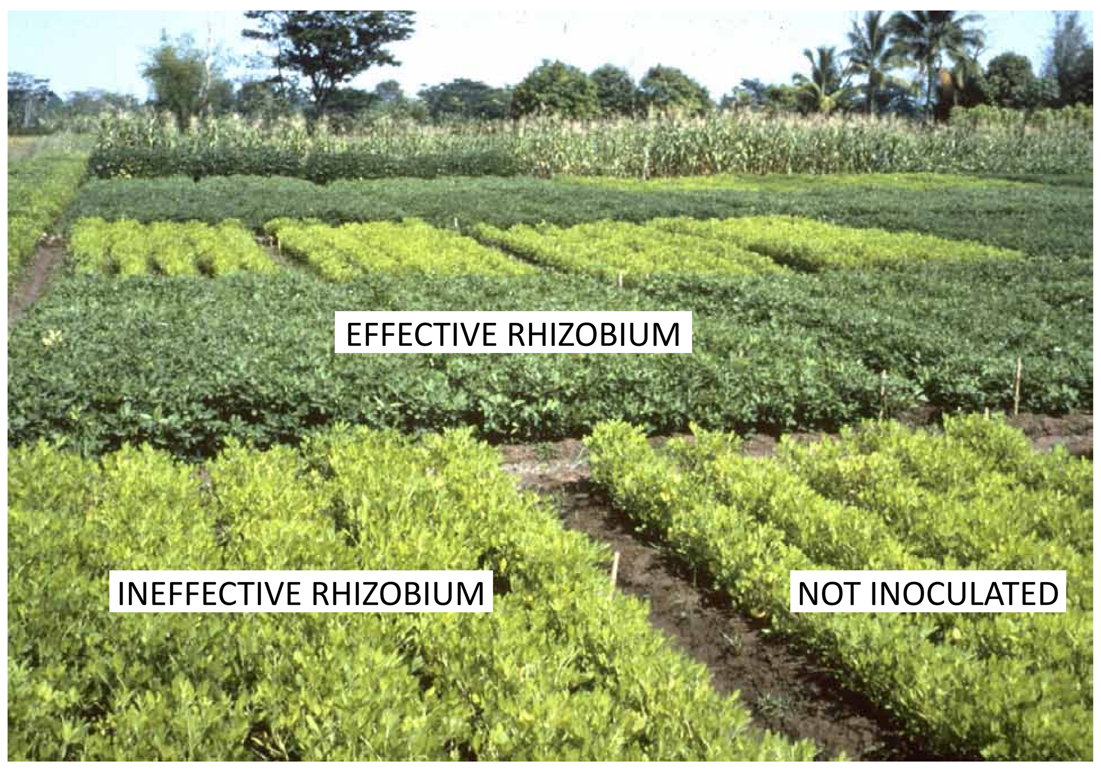
The **symbiotic phase** of the cycle refers to the development and function of root nodules. This phase is also subject to environmental factors that affect the host plant.

High numbers of **native rhizobia** present a competitive barrier to the successful establishment of introduced rhizobia.



Effectiveness testing of isolates from Kenya has identified several candidate elite strains for field testing.

Testing Rhizobium Strains in the Field



Parameters included on the Kenyan Rhizobium Isolate Database

Source country: NA = N2Africa, K = Kenya

Entry: strain number in chronological order

Contributor: Organization holding isolate, MIR = Nairobi MIRCEN

Alternate Code: strain designation of contributing organization

Longitude and Latitude

Host Sub-family: M = Mimosoideae, P = Papilionoideae

Host Tribe: taxonomic group of host legume at Tribe level

Host Genus: Original host legume genus

Host Species: Original host legume species

YMA Growth rate: S = slow, I = intermediate, F = fast

CR YMA: colony characteristics on Congo Red

BTB YMA: Reaction on bromothiol blue

Test Host: legume host used in effectiveness testing

Reference: reference rhizobium strain in effectiveness testing

Performance: ratio of isolate to reference strain

GH95: is isolate among the top 5% in greenhouse, 0 = no, 1 = yes

F98: is strain among the top 2% in field testing, 0 = no, 1 = yes

Candidate: candidate elite strain for inoculant production, 0 = no, 1 = yes

Inoculation Responses

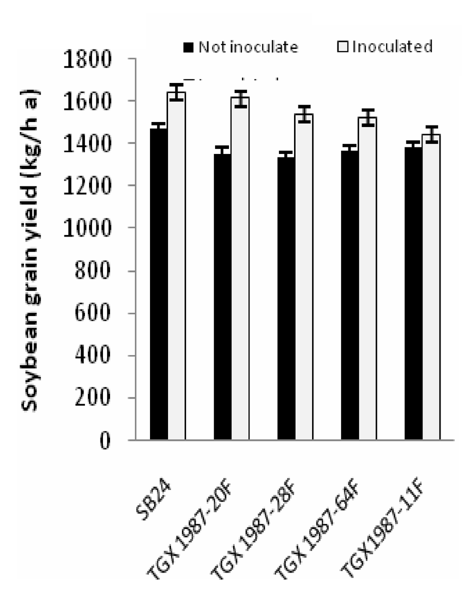


Figure 1. Inoculation response of five soybean varieties as observed at Bughore site in DR Congo during 2011 long rains growing season.

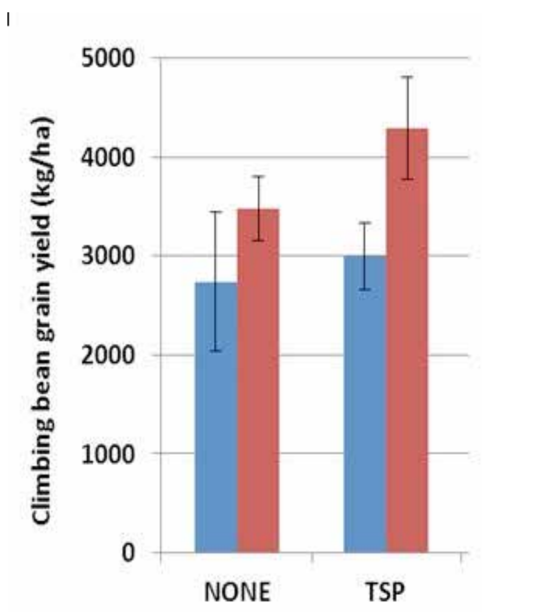
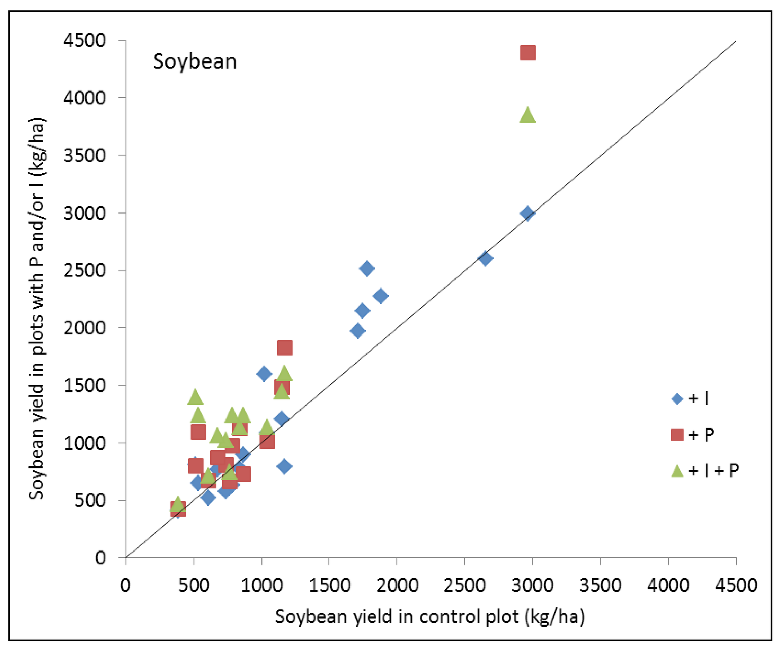
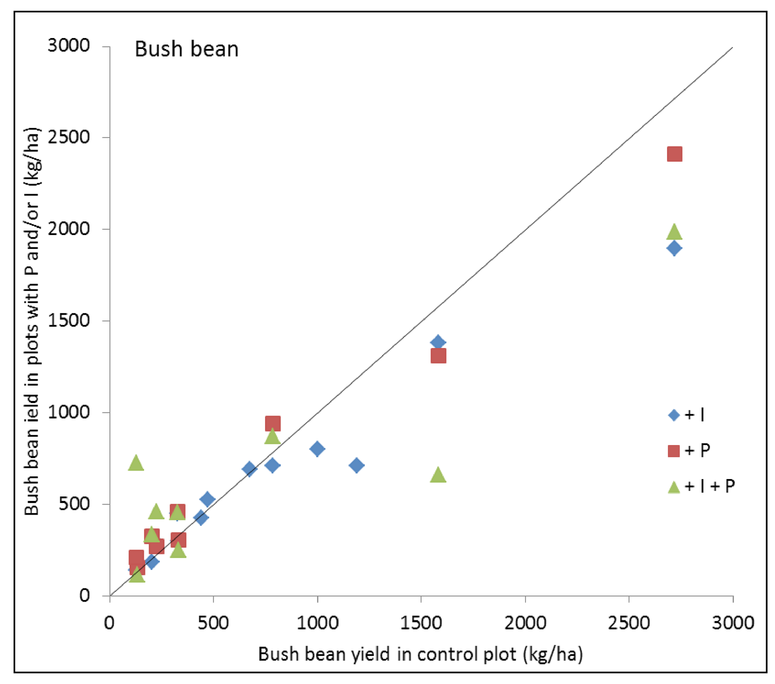
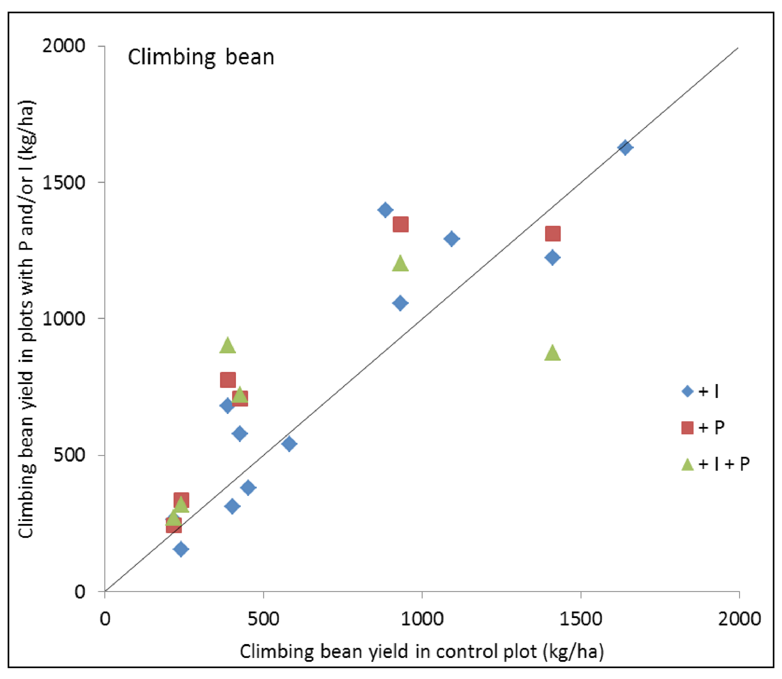


Figure 2. Interaction between inoculation and phosphorus addition to climbing bean at Nemba site in northern Rwanda (red is + inoculum) during 2010 long rains season.

Response of soybean, bush bean and climbing bean grain yield to inoculation (I) and/or P fertilization (P), relative to the yield in the control plot without inputs, in the agronomy trials in Western Kenya in 2010 long rains and short rains and 2011 long rains.





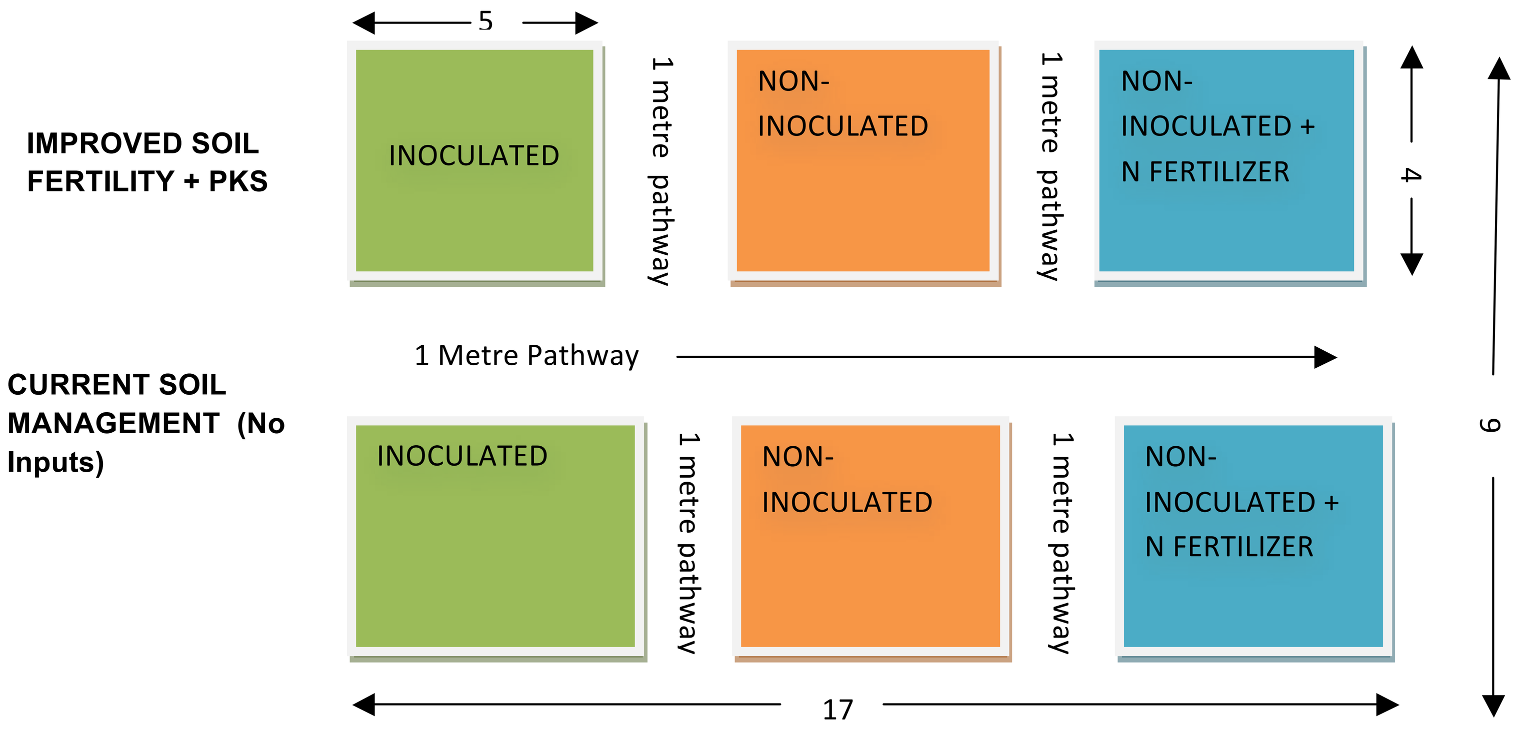


Agronomy

When the situation is not known, a field test to determine the need for inoculation is recommended. Three basic treatments are needed:

- Inoculated plants with the best inoculant available.
- Non-inoculated plants receiving no fertilizer treatment.
- Non-inoculated plants furnished with fertilizer nitrogen

These three treatments may be examined at two soil fertility levels.



Soils representing different agro-ecological zones sampled from across chosen sites

Agronomic trials set-up and underway to find best fit varieties and inputs of N2Africa mandate legumes in the different N2Africa mandate

Capacity has been built through working with government extension workers, researchers, master farmers, follower farmers and other partners like AGRA and TL II for agronomic research and data collection.

Field days and demonstrations are conducted on N2Africa agronomy trial sites. Effective demand is created for N2Africa technologies (especially seeds, inoculants and fertilizers) from local farmers involved in the research in particular, and the surrounding local communities in general. Data collection entry and subsequent analysis are for be done for best-fit variety and input trials.

Number of varieties by legume type that are undergoing evaluation for BNF potential in different countries.

country	soybean	bean	cowpea	groundnut	total
DR Congo	10	12	0	4	26
Ghana	7	0	9	6	22
Kenya	14	18	0	0	32
Malawi	6	2	2	2	12
	6	0	0	4	10
Nigeria	11	0	8	4	23
Rwanda	13	10	0	0	23
Zimbabwe	6	6	2	2	16
Total	74	47	20	22	1647

Agronomy

N2Africa is establishing a baseline of BNF status, niches for N2 fixing legumes, and a system of monitoring, evaluation and impact assessment in all its focus working areas

Monitoring Implementation: Example Case Story

Mrs Hassan from Malawi: a success story since the first season of N2Africa, handling one full soybean variety trial with three replications on her own, her trial is one of the most well managed in the 2011/2012 season and is expecting to give one of the highest yields. Having undergone two N2Africa trainings on inoculants technology and field management under both research and dissemination, she is now an advocate for inoculants technology in her community, and many people are interested in N2Africa technologies because of her good and highly visible N2Africa trials.

Farmer Hassan helping with the implementation of soybean agronomy trials conducted on her farm.

N2 Africa Project Outcomes

- Diversification of N2-fixing legume species that are integrated into smallholder farming systems in sub-Saharan Africa;
- Expansion in cultivation of grain and forage legumes, greater productivity in legume-based farming systems, and enhanced family incomes;
- Selection of efficient rhizobial inoculant strains and improved grain legume varieties with enhanced BNF capacities adapted to various environmental stresses;
- Establishment of a state-of-the-art laboratory and culture collection of elite strains of rhizobia for target legumes; and
- Establishment of rhizobial inoculant production in countries of West, East and Southern Africa, through partnership with the private sector.

Original and revised dissemination targets over the project's four years.

Year	Original Dissemination Targets		------------ Revised Targets[1] ------------				
	per year	cumulative	cumulative	WA	SA	Kenya	CA
1	18000	18000	11000	3000	0	3000	1000
2	24000	42000	56500	13000	2000	13000	5750
3	51000	93000	159834	37500	9000	29000	14417
4	132000	225000	225000	37500	25000	37500	18750

[1] WA = both Ghana and Nigeria, SA = Malawi, Mozambique and Zimbabwe and CA = DR Congo and Rwanda.

Training of Lead Farmers (Master Farmers), and their subsequent grassroots training, the training ratio and initial training of agro-dealers through Year 2.

Country	--- Farmer Training ---		Training	Agro-dealers
	Lead Farmers	Grassroots	ratio	trained
Ghana	60	10800	180:1	5
Nigeria	519	11594	22:1	0
Malawi	525	10500	19:1	13
Mozambique	271	11637	43:1	0
Zimbabwe	240	6588	27:1	0
DR Congo	29	3025	104:1	0
Kenya	62	10515	169:1	7
Rwanda	127	2450	19:1	0
Total	1788	67109	94:1	25
Expected	320	56500	132:1	80
Achieved	559%	119%	72%	31%

N2Africa Action Sites, legume varieties, BNF technologies and farmer participation over two years of project activities (2011 Project Progress Report).

Country	Impact Zones identified	Action Sites	Legume varieties evaluated	BNF technologies promoted	Farmer
DR Congo	South Kivu	15	22	6 (R,P,F,I,E,M)	5757
Ghana	Northern	30	22	6 (R,P,F,N,M,O)	11160
Kenya	West Kenya	25	32	9	16722
Malawi[c]	Central Malawi	7	12	3 (R,P,F)	10500
	West and Central	17	6	4 (R,P,L,N)	11637
Nigeria	Central Northern	15	23	5 (R,P,F,RP,M)	13980
Rwanda	N, E & S of Kigali	12	23	5 (R,P,F,I,L)	5320
	Central Zimbabwe	7	19	5 (R,P,F,L,G)	8615
Project-wide	**8**	**128**	**159[a]**	**13[b]**	**83691**

[a] total variety x country combinations, some varieties were tested in more than one country. [b] BNF technologies include: R = rhizobium inoculation, P = phosphate fertilization, F = fertilizer blends, I = intercropping or rotation systems, S = staking systems, M = micronutrients, N = starter N, L = soil liming, RP = rock phosphate addition, E = seed bed establishment, O = organic fertilizers, G = gypsum (for groundnut pod set), D = disease management (for soybean rust control). [c] includes households in Southern Africa carrying over into Year 3.

MSc Students Sponsored by N2Africa

Country	Name	Status
DRC	Bintu Ndusha Nabintu	Field work
	Eric Sika Torroma	Coursework
	Fidel Barhebwa Bnagaliza	Coursework
	Balume Kayani Isaac	Field work
Ghana	Jacob Ulzen	Coursework
	Abdul-Aziz Abdul-Latif	Coursework
Kenya	Maureen Waswa	Fieldwork
	Anne Wekesa	Field work
	John Okoth Omondi	Fieldwork
Malawi	Esnart Nyirenda	Coursework/fieldwork
	Donald Siyeni	Coursework/fieldwork
	Mônea Lina Mucavêa	Admitted
	Fernando João Sualei	Admitted
Nigeria	Fatima Jibrin Abubakar	Coursework
	Vida Peter	Coursework
Rwanda	Domitile Mukankubana	Coursework
	Alfred Rumonge Tabaro	Coursework
Zimbabwe	Tatenda Kainga	Fieldworkk
	Sibonginkosi Dunjana	Fieldwork

Research topics and status of PhD students participating in the N2Africa Project as of Month 30 (April 2012)

Country		Research Topic[1] and Status[2]			University
	(no)				
Ghana	1		1 (D)		Kwame Nkrumah University of Science and Technology/WU
Kenya	1				Murdoch university
Malawi	1			1(C)	Wageningen University (WU)
	1				Londrina, Univ. Brazil
Nigeria	1				Murdoch university
Rwanda	1		1(E)		Wageningen University (WU)
	1				Murdoch university
Project-wide	7	0	6	1	1 African university, 6 foreign universities

[1]Research topics primarily related to Legume Agronomy (Objective 2), Rhizobiology and Inoculant Production (Objective 3) and BNF Technology Dissemination (Objective 4). [2] Graduate student status: E = enrolled, R = reported, C = undertaking coursework, T = undertaking research topic, D = delayed.

Additional students that were partially supported by N2Africa to conduct research on topics to support the objectives of the project.

Name	Location of Research	Nationality	Relationship to N2Africa
Moritz Reckling	Rwanda	German	MSc research / internship
Greta van den Brand	Malawi	Dutch	Msc research
Brenda Manenji	Zimbabwe	Zimbabwean	MSc research
Kondwani Khonje	Malawi	Malawian	Internship
Lotte Klapwijk	Rwanda	Dutch	Internship
Samson Foli	Nigeria	Ghanean	Msc research / internship
Wiestke van der Starre	Zimbabwe	Dutch	MSc research
Myriam Mujawamarya	Rwanda	Rwandese	Msc research / internship
Elie Parachini	Malawi	French	Attachment

Performance of the N2Africa Project based on 29 quantitative parameters through Year 2.

Goal	Unit	Source			
Conduct Master Farmer workshops	no	Milestone 5.3.2	320	1766	552%
Identify promising soybean varieties	no	Milestone 2.1.1	10	27	270%
Conduct three extension events per season	no	Milestone 4.4.3	66	175	265%
Identify promising bean varieties	no	Milestone 2.2.1	6	12	200%
Identify promising gnut & cowpea varieties	no	Milestone 2.3.1	12	21	175%
Conduct annual events on human nutrition	no	Milestone 4.5.3	32	53	166%
Develop dissemination tools	no	Milestone 4.2.1	24	39	163%
Engage Action Sites (communities)	no	Milestone 1.2.2	80	128	160%
Conduct adaptive reserarch campaigns	no	Milestone 2.5.1	27	43	159%
Increase BNF by grain legumes	kg N/ha	Vision Statement	46	66	144%
Conduct grassroots training	no	Milestone 5.4.1	56500	67109	119%
Train MSc candidates	no	Milestone 5.2.1	16	19	119%
Reach rural house-holds by Year 2	no	Activity 1.2	56500	67273	119%
Involve women in all farmer-related activities	%	Milestone 4.5.2	48	50	96%
Conduct three media events per year	no	Milestone 4.4.4	48	46	96%
Communities produce improved legume seed	%	Milestone 4.3.2	50	44	88%
Upgrade rhizobiology laboratories	no	Milestone 3.4.2	8	7	88%
Communities linked to legume markets	%	Milestone 4.3.3	50	44	87%
Explore tree & forage legumes	no	Milestone 2.4.1	18	14	78%
Train technical staff in rhizobiology	no	Milestone 5.1.1	32	23	72%
Increase legume grain yield	kg/ha	Vision Statement	954	630	66%
Conduct annual short courses (participants)	no	Milestone 5.1.2	30	13	43%
Train agro-dealers in BNF products	no	Milestone 5.4.3	80	25	31%
Isolate and screen native rhizobia	no	Milestone 3.1.3	2000	624	31%
Train PhD candidate	no	Milestone 5.2.1	8	2	25%
Commercialize inoculant distribution	no	Milestone 3.4.3	150000	31759	21%
Increase income	$/yr	Vision Statement	130	20	16%
Conduct MPN counts	no	Milestone 3.1.2	400	59	15%
Select candidate strains for field testing	no	Milestone 3.1.3	100	8	8%
Average performance					120%

FIELD/ENVIRONMENTAL MANAGEMENT

How to increase the inputs from biological nitrogen fixation

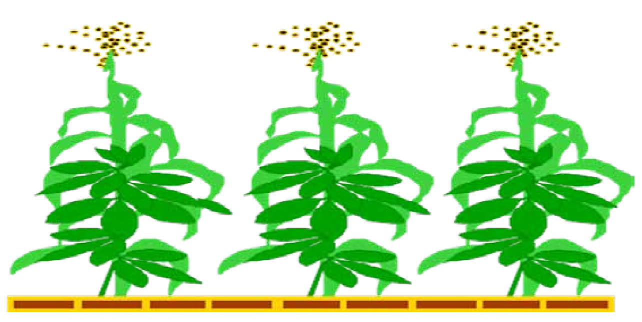
- Increase the area of land cropped with legumes (targeting of technologies)
- Increase legume productivity through better management and fertilizer
- Select better legume varieties
- Select better rhizobium strains and inoculate
- Link to markets and create new enterprises to increase demand for legumes

Grain legume production strategies

1. Intercropping

Traditional Intercropping of Maize and Bean: Alternate rows

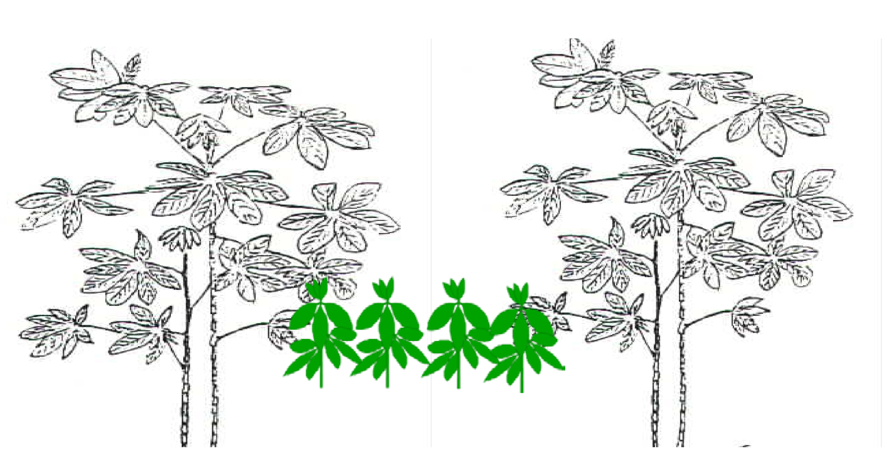
Staggered intercropping of Maize and Bean: Laini Mbili



Intercropping Maize with climbing legumes

- Simple innovations in maize-legume intercropping permit farmers to grow a wider range of food legumes as under-storey intercrops with cereals.
- The most common intercropping practice is to alternate maize and bush beans or cowpeas, either between or within rows. These legumes mature quickly and can tolerate shading, but yields are low.
- Alternatively, cereals may be planted at their recommended population, but every-other row is shifted to provide a wider alternate inter-row to the legume or strip-cropped by lowering maize populations but maintaining similar yields.

Conventional maize-bean, (upper left), upland rice-soybean (upper right), MBILI with groundnut (lower right), out of control lablab with maize (lower left)



Intercropping Cassava and grain legumes

- Different approaches permit more productive intercropping with groundnut, green gram, soybean and other higher-value food legumes that are not otherwise intercropped with maize because of excessive shading
- Intercropping also permits cultivation of legumes that suppress *Striga* such as *Lablab* and *Desmodium*
- Another useful example of intercropping is upland rice and soybean where soybean reduced bird damage to rice.
- When maize and pigeon pea are intercropped, maize is harvested first and pigeon pea grows for several more months, producing a complete canopy cover and yields of up to 1.5 t ha^{1}.

2. Rotation

- Legumes may be grown in rotation with other crops one in three or four seasons (e.g. L-M-M-M-L-M-MM) in monomodal climates or every other season in bimodal rainfall conditions (M-L-M-L)
- Cereal-legume rotation replenishes soil nutrients and improves the availability of organic resources, particularly when legume varieties have traits appreciated by farmers.
- Strong commercial demand for legumes further justifies targeted investment into crop rotation.
- Promiscuous soybean and the dual-purpose cowpea lines available to farmers in West Africa produce about 2.5 t of grain, 2.5 to 4 t of forage, fix between 44 and 103 kg N and have a positive N balance of 43 kg N ha^{-1}. Growing maize after soybean improves grain yield 2.5-fold.
- Legume rotations may be intercropped at both stages, such as maize-cowpea followed by groundnut-pigeonpea
- Widespread adoption of cereal-legume rotation is supported through farmer collective action, development of underlying value-added cottage industries, product development and branding, information exchange and development of rural savings and banking systems

Climbing beans in Rwanda (upper left), soybean in Nigeria (upper right), pigeonpea-groundnut in Malawi, (lower right), Striga Smother in Kenya (lower left

3. Relay Cropping

A second crop of beans may also be planted but this risks pest and disease. Note how the dried lower leaves of maize were removed (lower right)

Inoculant packets deployed by the project through Year 2.

country	hub	status	Target (n)	Realized (n)	Achieved (%)
Ghana	WA	imported	25000	2304	9.2
Nigeria	WA	imported	25000	1200	4.8
Malawi	SA	imported	16667	140	0.9
Mozambique	SA	imported	16667	550	3.3
Zimbabwe	SA	produced	16666	1230	7.4
DR Congo	ECA	imported	12500	8806	70.4
Kenya	ECA	produced	25000	15784	63.1
Rwanda	ECA	imported	12500	1745	14.0
total			150000	31759	21.2%

management	seed & inoculant	fertilizer & fungicide	labor	bagging	total
	------------------------------ $ ha^{-1} ---------------------------				
SB19 spraying only	40	46	87	5	178
SB19 SSP no BIOFIX	40	107	90	6	243
SB19 SSP w/ BIOFIX	62	107	91	8	268
SB19 Sympal w/BIOFIX	62	119	93	11	285

Estimated production costs of soybean in west Kenya during the 2011 long rains growing season.

management	SB19 yield kg ha^{-1}	gross return	net return	benefit: cost ratio	labor days per ha	grain: seed ratio	AE fertilizer ratio
		------ $ ha^{-1} -----					
SB19 spraying only	758	444	266	2.50	33	13	na
SB19 SSP no BIOFIX	970	568	325	2.34	36	16	2.1
SB19 SSP w/ BIOFIX	1310	767	499	2.86	37	22	5.5
SB19 Sympal w/BIOFIX	1680	983	699	3.45	39	28	9.2

management	SB19	gross	net	benefit:	labor	grain:	AE
	yield	return	return	cost	days	seed	fertilizer
	kg ha^{-1}	------ $ ha^{-1} -----		ratio	per ha	ratio	ratio
SB19 spraying only	758	444	266	2.50	33	13	na
SB19 SSP no BIOFIX	970	568	325	2.34	36	16	2.1
SB19 SSP w/ BIOFIX	1310	767	499	2.86	37	22	5.5
SB19 Sympal w/BIOFIX	1680	983	699	3.45	39	28	9.2

Grain yield and economic returns to soybean production in west Kenya during the 2011 long rains growing season (based on 26 farms).