National Training on
Carbon Sequestration and Carbon Trading

6–17 February 2012

Indian Council of Agricultural Research (ICAR)
NATIONAL AGRICULTURAL INNOVATION PROJECT (NAIP)

ICRISAT
Science with a human face

UF UNIVERSITY of FLORIDA

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Carbon Sequestration and Carbon Trading

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Proceedings on National Training on Carbon Sequestration and Carbon Trading

Introduction

A two-week national training course on Carbon Sequestration and Carbon Trading supported by National Agricultural Innovation Project (NAIP) and Indian Council for Agricultural Research (ICAR) was held at ICRISAT-Patancheru from 6 to 17 February, 2012. Sixteen participants representing ICAR institutions, State Agricultural Universities (SAUs), and ICRISAT participated in this course which was jointly offered by the ICRISAT, India and University of Florida, USA (Figure 1). The training was comprised of theory and hands-on experiences by renowned faculty trainers from ICRISAT, the University of Florida, Virginia Tech University and the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur. The course was coordinated and directed jointly by Drs Suhas P Wani, ICRISAT; K Ramesh Reddy of the University of Florida, with Dr Rosana P Mula, Coordinator, Learning Systems Unit.

Figure 1.Group photograph of C Sequestration and C Trading training program

Details of Training

The inaugural session was on 6th February and Dr Dave Hoisington, DDG-R in his inaugural message on 6th February stressed the importance of carbon sequestration and the need for identifying potential areas of collaboration. Dr Peter Craufurd, Director-RDS, in his special remarks emphasized the role of good practices in checking some of the C, N losses and increasing carbon sequestration. Dr Suhas P Wani, Course Director and Assistant Research Program Director-RDS welcomed the participants and oriented about the workshop framework and the objectives. He told that the focus of the training was designed on refreshing the knowledge on the importance of soil carbon and its relationship with global warming and climate change. The other objectives were to acquaint with methods of measuring carbon sequestration under different management practices, introducing simulation modeling tools and carbon management research protocols to formulate clean development mechanism (CDM). All were also apprised in the beginning of the most important output expected from the training in making a winning proposal on carbon sequestration representing different agro-ecological zones to be written and presented by the participants in consultation with the trainers.

Pre-course evaluation of all the participants to assess their needs and strengths was conducted using the set of questions on the topic of C sequestration and marketing. The results of pre-course evaluation revealed that 12 participants scored , 50 per cent marks and only three trainees scored in the range of 51 to 75 per cent (Figure 2).

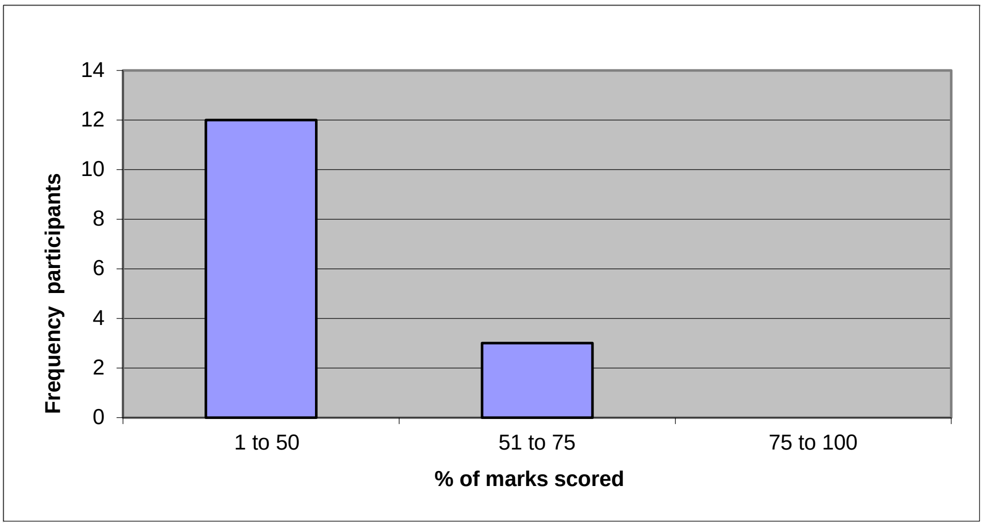

Figure 2. Frequency distribution of pre-course evaluation of C-sequestration course trainees

Starting with technical sessions, Dr. Suhas P. Wani told that global warming is now a well-established fact and highlighted the severity of the issue from projected C emissions to 26 G t C y^{-1} from 7.4 G t C y^{-1}, mainly through CO_2 as the principal greenhouse gas. Agriculture and global warming induced climate change have very strong and close relationship. He stressed on two fold strategy to manage CO_2 levels in reducing emissions and increasing C sequestration. Also, soil organic C is essential to maintain a good physical condition and to absorb, retain, and supply water and nutrients to crops. However, growing population, increasing incomes and food demand in developing tropics poses a great threat for carbon stocks. In addition to benefits of sequestered C in soil, C-financed development was also focused i.e. income from the sale of C saved and used in community development which is enshrined in the international agreement called 'Kyoto Protocol'. The carbon income is slated to be a tiny portion of projects but can serve as additional source of finance, and so livelihood development should not be ignored in such projects. The clean development mechanism (CDM) can help poor farmers through watershed, agroforestry interventions. The successful case study has been from Chalpadi through *Pongamia pinnata* plantation in waste lands where extracted oil is used in power generators managed by women group and 900 t CO_2 eq was sold to Germany. Similar other examples were shared from Powerguda, Kammuguda, Aliguda villages. In summary, the presentation highlighted a need to innovate C sequestering systems to produce more food, reduce poverty and protect the environment. The coordinators, Dr Suhas P wani and K Ramesh Reddy, oriented participants on the very 1st day to prepare eco-region wise projects based on the learnings during the training.

Dr K Ramesh Reddy in his topics tried to develop among trainees an understanding of basic issues related to C sequestration, including those of chemical reactions involved and their relevance. Beginning with the presentation, major components of C cycle were described. He threw light on organic/inorganic, solid/gas C forms and operationally defined terminology related to C. C sequestration could be biotic (Primary production – Respiration) or abiotic (Calcium carbonate – Precipitation). Participants learnt the chemistry of organic carbon formation and breakdown and $CaCO_3$ formation and dissolution. He shared global soil organic and inorganic C maps and importance of soil organic matter as major C reservoirs (30-50 X 10^{14} kg). He highlighted the challenge in integrating C sequestration at spatial and temporal scale.

The training highlighted the C cycle processes. The training increased knowledge about the forms, pools and chemical constituents of C. The participants understood about the microbial biomass C and enzyme activities and techniques for measurement of microbial biomass and enzymes. The importance of Carbon was shown for living systems because it can exist in a variety of oxidation states (-4, 0, +4) and serves as a source of electrons for microbial processes. Organic matter is a source (short term and long term storage) of nutrients for plants and soil microbes. Participants learnt the functions of organic matter viz. source of nutrients for plant growth; source of energy for soil microorganisms; provides long-term storage for nutrients; strong adsorbing agent for toxic organic compounds; complexation of metals etc. and also that its decomposition is regulated by many factors like substrate quality, hydrology, file, electron acceptors (who, how many), limiting nutrients, and temperature. During the day, soil sampling design was also discussed in detail.

As per orientation earlier to prepare projects based on the learning from the trainings, all the participants were divided into 4 groups. It was decided to prepare projects on 4 systems i.e. mulberry-based, groundnut/agroforestry-based, rice-based and Cassava-based (see Appendix 1). Out of four proposals by the participants, one proposal on "Mulching and nutrient management in cassava based system" was awarded as best proposal followed by "Biochar use in rice based system".

The participants learnt about the use of stable isotopes in agronomic and environmental studies, microbial processes and plant studies and Dr K Ramesh Reddy shared findings on it. The instructor discussed about C sequestration in agricultural systems which can potentially contribute to mitigate GHGs and which is strongly linked to soil quality and sustainable agriculture. The lectures also highlighted that C sequestration also means N and P sequestration, the most limiting nutrients in agricultural systems.

Dr Suhas P Wani discussed about the C sequestration through agricultural systems to mitigate the impacts of climate change. He shared the findings of historic watershed experiment at ICRISAT where he shared that improved management increased soil organic C, microbial biomass C, soil respiration, mineral N as compared with the traditional practices. He highlighted the importance of legume based systems for increased C sequestration. He also shared the findings from benchmark locations in India for C sequestering management systems and about the best production systems for C sequestration in different regions in India. He shared that CENTURY model was identified to assess carbon stocks at all locations targeted by this project. APSIM and DSSAT models are the crop growth models to assess the changes in soil productivity associated with changes in soil carbon. He highlighted the management practices which increase C sequestration viz. Conservation agriculture, legume-based systems, horticultural and silvipastoral systems, integrated nutrient management, rainwater conservation and harvesting and organic matter addition.

Dr. Sahrawat discussed on the basic issues related to carbon sequestration in soils. He highlighted the role of C sequestration resulting win-2 situation both for environment quality and soil fertility. As of today, environment–related issues, especially global warming and climate change effects are indeed the main drivers of the research on C sequestration. But, he stressed on the need to make agriculture part of C trading for farmers to drive benefits. He told the fact that soils can act as sink or source of greenhouse gases based on their management. Moreover, biological turnover of organic C in soils was highlighted rather than merely the quantity accumulated.

Dr Janaki Alavalapati talked about the challenges and opportunities in agriculture and forest C markets. He clarified the concept of C markets. The factors for such markets were because of polluter pay principle, altruism-utility theory or strategy to expand business. He discussed Kyoto protocol, the legally binding treaty to reduce GHG's by 5.4% below 1990 levels by 2012. He clarified the concept of C credit, C markets (Regulatory and voluntary) and the mechanisms like emission trading, joint implementation and clean development mechanism. He stressed on the key rules for C sequestration i.e. additionality, permanence and leakage issues. He highlighted the need to fix asymmetries in policy making; need to look climate change policy from a development perspective and as carbon reflects a "luxury good" so institutional support is needed to support carbon markets.

Dr Tapas Bhattacharyya talked on soil C stocks - issues and priorities. He told about 3 reservoirs of C worldwide – ocean, atmosphere and terrestrial. He discussed about accelerated decomposition of SOC due to agriculture and need for restoration of tropical soil health through carbon (SOC) management. He shared that the the land use change resulted in the transfer of 1-2 Pg C/year from terrestrial ecosystem to the atmosphere of which 15-17 per cent carbon is contributed by decomposition of soil organic C (SOC). He shared the facts about carbon in Indian soils (Organic C = 23.4-27.1 Pg; inorganic C = 33.98 Pg). Detailed information was given on the C pools in different soil orders in India. The trainees learnt that the most prudent approach to estimate the role of soils to capture and store carbon should require information on the spatial distribution of soil type, soil carbon (SOC and SIC) and bulk density (BD). The trainees also learnt the calculations of estimating soil organic C which needs the estimate of %C and bulk density in any area at a marked depth of soil. He shared soil C maps of India, the utility of these maps for prioritizing areas for C sequestration in soils through a set of thematic maps on carbon stock. This tool (thematic maps on soil C stock) will help the planners in prioritizing C sequestration programs in different bioclimatic systems representing various ACZs and AESRs.

Dr. DK Pal discussed in detail about inorganic C sequestration – the factors leading to it and the consequences of it. He suggested that in dry climates calcification is one of the dominant pedogeneic processes that would retard the emission of CO_2 from soils. The unique role of soils as a potential substrate in mitigating the effects of atmospheric CO_2 has thus been realised.

On 14th, Dr Janaki talked about forest C sequestration and permanent displacement credit e.g. with wood for steel chair, ethanol for diesel etc. He admitted C markets a right concept, but asked for a need to look on C policy from a development perspective. He shared experiences of states in US where 7 to 40% fuel blending is targeted in a year. Good interactions were held with participants on the market issues. Certain questions were raised as if population or per capita energy concepts not be introduced in C agreements.

Dr Bhattacharya deliberated on soil C modeling. He shared details of different models viz. Roth C Model, Century Ecosystem Model, GEFSOC model and Info Crop Model. He also shared soil sampling protocol for estimating soil C stocks.

Dr DK Pal in post-lunch session talked on inorganic C ($CaCO_3$) in soil. He told that major soil types of India are becoming calcareous which reduces storage and release of water. In this context he also shared findings from historic watershed experiment in India where improvement management practices lowered $CaCO_3$ content as compared with the traditional practice.

C-Sequestration Research Proposals

All four groups presented in house the concepts of their proposals, each one of which had a good discussion and suggestions. The course coordinators, Dr Suhas P Wani and Dr K Ramesh Reddy critiqued and guided the teams now to incorporate the suggestions and integrate all into a combined proposal.

Post-course Evaluation: The session started with presentation of the combined project prepared by participants incorporating in it the learnings of the training to help improve livelihoods of farmers while simultaneously rendering ecosystem service through C sequestration. Ten participants scored > 75% and none of the participants scored < 50% indicating tremendous knowledge enrichment for the participants (Figure 3).

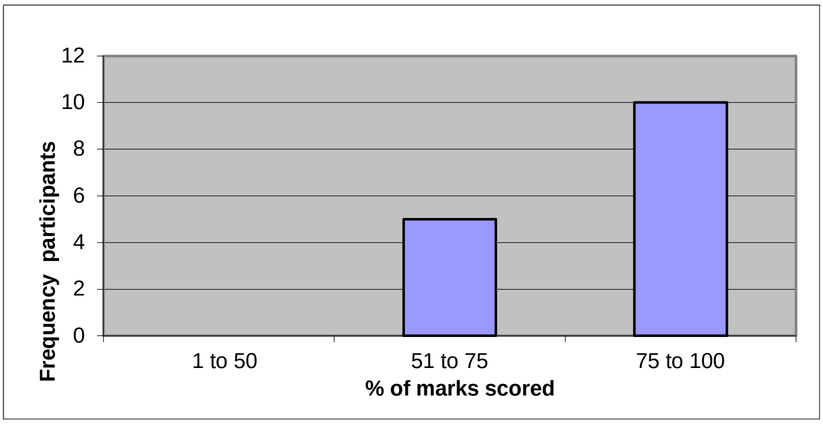

Figure 3. Frequency distribution of post-course evaluation of C-sequestration course trainees

Concluding Session

The concluding session was chaired by Hon'ble DG Dr William D Dar. In the session, Dr. Suhas P Wani shared the facts about the training. He told about pre-course evaluation performance of the participants and far significant performance in the post-course evaluation. Two representatives Dr Ramesh and Dr Vinod shared their experiences about the training and appreciated it all. Dr. William D Dar congratulated the organizers and trainees for the successful training. He showed happiness over the response from participants and that outcome of the training will benefit the smallholders of the semi-arid tropics. He urged all to anchor on the technologies learnt for mitigation and adaption w.r.t climate change. Certificates of participation were distributed by Hon'ble DG to all the participants (Figure 4). All the participants were provided with the lecture notes and copies of the presentations made by the faculty in the form of a CD. Copy of the CD is enclosed herewith. The training ended with vote of thanks by Dr Rosana Mula.

Figure 4. Participants receiving their certificates upon completion of the training course

Field Visits

The trainees visited the Adarsha Watershed at Kothapally. Mr Narayan Reddy, member of the watershed committee, shared experiences of the community with the implementation of the watershed. He told visitors that earlier they faced acute shortage of water and were taking only one crop. But with soil-crop-water interventions under watershed have improved their living far beyond their expectations. Now water table has tremendously increased and all are taking 2 crops in a year. People are also diversifying into market-led crop diversification and the community has now become self-reliant. From C sequestration point of view the organic matter turnover has increased due to more biomass produced. Moreover, farmers are utilizing their bunds and boundaries for more biomass generation through green manue *Gliricidia* plantation.

In the afternoon, participants visited the soil microbiology, and Charles Renard Analytical Laboratories and understood the operation of equipments. The participants also had a detailed discussion with Dr K Ramesh Reddy and Dr KL Sahrawat to clear doubts on topics related to C sequestration and Kothapally visit.

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C Fred Bentley Conference Hall (212)
ICRISAT, Patancheru, A.P.

Program

Day/Date	Time	Session	Facilitator
06 Feb Monday	0830-0900	Registration	LSU
	0900-0930	Welcome	Rosana Mula
		Special Remarks	Peter Craufurd
		Inaugural Message	Dave Hoisington, DDG
		Introduction of Participants and Faculty	
	0930-1000	Course Outline, Schedule	S P Wani
	1000-1030	Tea/Coffee and Group Photograph	
	1030-1200	Pre-course evaluation	Rosana Mula
	1200-1330	Lunch Break	
	1330-1500	C sequestration and poverty alleviation	S P Wani
	1500-1530	Tea/Coffee Break	
	1530-1630	Global carbon cycle and its major components	Ramesh Reddy
07 Feb Tuesday	0900-1000	Carbon cycling processes and organic matter decomposition	Ramesh Reddy
	1000-1030	Tea/Coffee Break	
	1030-1200	Organic matter accumulation, regulators of decomposition and organic matter characteristics	Ramesh Reddy
	1200-1330	Lunch Break	
	1330-1500	Methodologies and experimental techniques for studying C sequestration	Ramesh Reddy
	1500-1530	Tea/Coffee Break	

	1530-1630	C sequestration in agricultural ecosystems: Case studies	Ramesh Reddy
08 Feb Wednesday	0900-1000	C sequestration in natural ecosystems: Case studies	Ramesh Reddy
	1000-1030	Tea/Coffee Break	
	1030-1200	Environmental and ecological significance of C sequestration in soils	Ramesh Reddy
	1200-1330	Lunch Break	
	1330-1500	Visit to laboratories	
	1500-1530	Tea/Coffee Break	
	1530-1630	Visit to laboratories – Contd.	
9 Feb Thursday	0830-1300	Visit to Kothapally watershed	
	1300-1400	Lunch Break	
	1400-1630	Field visit at research station	
10 Feb Friday	0900-1000	C sequestration in rainfed agricultural systems: Case study from ICRISAT	S P Wani
	1000-1030	Tea/Coffee Break	
	1030-1200	Basic issues related to C sequestration in soils	KL Sahrawat
	1200-1330	Lunch Break	
	1330-1500	Practicals in Soil Chemistry laboratory	
	1500-1530	Tea/Coffee Break	
	1530-1630	General discussion on methodology and visit to Kothapally watershed	
11 Feb Saturday		Off Day	
12 Feb Sunday		Holiday	
13 Feb Monday	0900-1000	Carbon trading and markets	A Janaki
	1000-1030	Tea/Coffee Break	
	1030-1200	Soil carbon stocks: issues and priorities	T Bhattacharyya

	1200-1330	Lunch Break	
	1330-1630	Inorganic C sequestration: Factors and consequences	D K Pal
	1500-1530	Tea/Coffee Break	
	1530-1630	Carbon trading and policy	A Janaki
14 Feb Tuesday	0900-1000	Soil carbon modeling: Experience from long-term experiments in India	T Bhattacharyya
	1000-1030	Tea/Coffee Break	
	1030-1200	Practical exercise on soil sampling and analyses; and computation of C stocks	T Bhattacharyya
	1200-1330	Lunch Break	
	1330-1630	Role of inorganic C (CaCO3) in organic C sequestration and improving sustainability of Vertisols	D K Pal
	1500-1530	Tea/Coffee Break	
	1530-1630	General discussion on issues related to Carbon trading markets and policy	A Janaki
15 Feb Wednesday	0900-1630	Group presentation of proposal	
16 Feb Thursday	0900-1000	Proposal planning on C sequestration through networking based on facilities available: Discussion among participants	S P Wani and Ramesh Reddy
	1000-1030	Tea/Coffee Break	
	1030-1200	Post Course Evaluation	Rosana Mula
	1200-1330	Lunch Break	
	1330-1500	Discussion continued if needed	
	1500-1530	Tea/Coffee Break	
	1530-1630	Course Evaluation	Rosana Mula
17 Feb Friday	0900-1200	Concluding session including distribution of certificates	

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List of Attended Participants

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Photographs of the Training Program


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Science with a human face
Rosana P Mula
William D Dar
Suhas P Wani
G Dileepkumar

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William D Dar
Suhas P Wani

Appendix – I

PowerPoint Presentations
By the Participants

ASSESSMENT OF CARBON SEQUESTRATION AND SUSTENANCE OF SERICULTURE THROUGH AFFORESTATION WITH MULBERRY IN SUB-HIMALAYAN REGION

DURATION: 5 YEARS **BUDGET:** 60.00 LACS

PI: Dr. Y. Srinivasulu
Co-investigators:
Dr. M.S. Rathore, Dr. V. S. Gour & Dr. K. Ram

Potential impacts of climate change on the mountain ecosystems

- The mountain ecosystems not only influence the atmospheric circulation significantly, but also exhibit a great deal of variation in local climatic patterns
- Ecosystems are more susceptible to climate change, compared to others, due to extreme sensitivity of constituent elements.
- Due to climate change include shrinking of glaciers, glacial lake outburst floods

Potential impacts of climate change on the mountain ecosystems

- Shifts in precipitation patterns coupled with elevated temperature would have direct impact on crop productivity.
- There is a strong correlation between the climate change, failure of crops and Deforestation
- A depletion of soil moisture may cause productivity of major species to decline
- A holistic approach is required for achieving socio-economic development while minimizing the loss of Biodiversity, and ensuring the ecosystem services.

BACKGROUND

- Carbon dioxide is one of the greenhouse gases contributing to global warming and subject to the Kyoto Protocol.
- Carbon emissions from deforestation, the burning of fossil fuels, changes in land use, and other human activities are increasing, while the earth's ability to soak up, or "fix" the carbon, is decreasing because of ocean and forest changes.
- Afforestation is a way to help restore the balance.
- Planting trees, especially quick-growing native trees that will not be logged or burned, removes carbon from the cycle and sequesters, or "fixes" it within the wood itself.

BACKGROUND

- *Morus alba* is a fast-growing medium sized tree.
- *M. alba* thrives in climatic conditions ranging from temperate to sub-tropics.
- The plant grows on a variety of soils ranging from sandy loam to clayey loam of pH 6.0-7.5.
- Leaf is the sole food source of the silkworm (*Bombyx mori*, named after the mulberry genus *Morus*), the pupa/cocoon of which is used to make silk.

BACKGROUND

Benefits:

- Carbon sequestration and climate stabilization
- Erosion control: A useful species for soil-conservation.
- Reclamation: well grown on wastelands.
- Soil health: The species helps in maintaining soil fertility through litter fall.

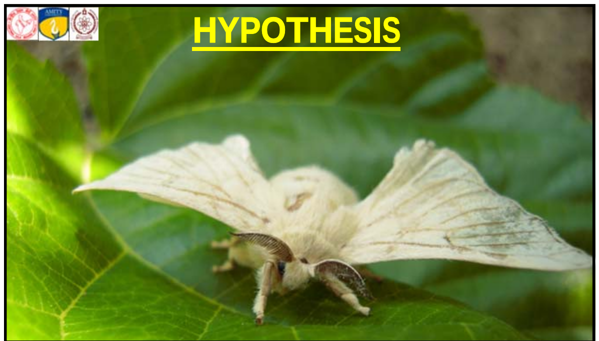
Substitution:

- Fodder: Cattle
- Fuel: Makes medium-quality fuel wood with a calorific value of 4370-4770 kcal/kg.

STRATEGY THROUGH MULBERRY RESERVES

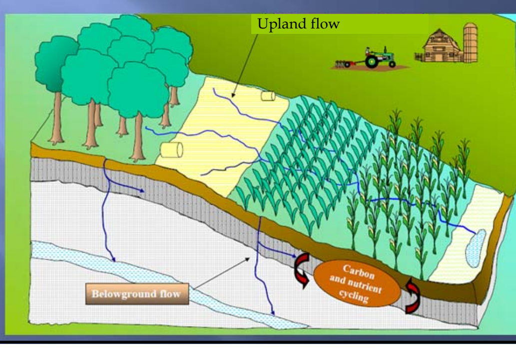
- Mulberry reserves could be developed on large scale in whole of the northern part of India, which would in long way help in sustaining sericulture in more competitive way without changing the environmental balance.
- It also helps in the maintenance of biological diversity by conservation of forest, agriculture ecosystem and sequestering atmospheric carbon.
- Mulberry reserves also may ensure longer term stability of C storage in fluctuating environments, apart from augmenting biomass production potential.

HYPOTHESIS



Afforestation with mulberry will improve soil and plant health to sustain sericulture in Kashmir

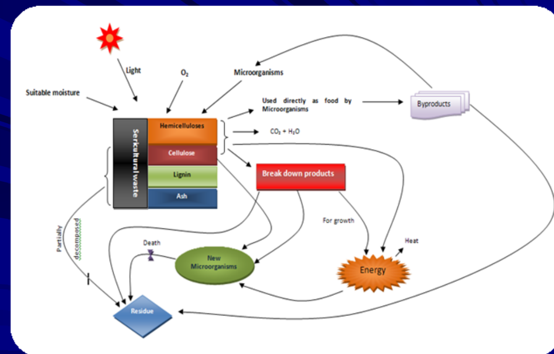
AFFORESTATION MODEL



OBJECTIVES

- To asses the impact of mulberry reserve on soil quality and carbon sequestration
- To elucidate the outcome of mulberry reserve on sustaining sericulture activities

DECOMPOSITION



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SIGNIFICANCE

- Monoculture is easy to maintain and quantify
- Mulberry is a hardy plant which can flourish in rain fed sub-himalayan regions
- Tree system has higher potential for long term C sequestration
- This type of system has additionalities, permanence and no chance of leakage
- Reduce soil erosion and run off
- Sustenance of sericulture and upliftment of socio-economic status of farmers

EXPERIMENT DETAILS

Area under experimentation: **0.625 acre**
Size of each plot: **5445 sq ft.**
Total number of plants: **375 plants**
Number of plants in each plot: **75 plants**
Spacing: **8'x 9'**
Number of treatments: **5**
Number of replicate: **5**

Treatment Details:
T1-Control (With no plants and inputs)
T2- Plants alone without inputs
T3-FYM 20 MT/ha/yr
T4-NPK (100:50:50 Kg/ha/yr)
T5-NPK (100:50:50 Kg/ha/yr) + FYM 20 MT/ha/yr

METHODOLOGY

Soil Samples will be collected from P4 basic seed farm, Manasbal, CSR&TI, Pampore & RSRS Miransahib, Jammu. The depth of sampling will be 0-30 cm & 30-60 cm from GPS tagged sites. Samples will be analyzed for Soil texture (Jackson, 1979), Water holding capacity (Larson and Pierce, 1991), pH and EC (Doran and Parkin, 1994).

The standard methods adopted for soil nutrient analysis are following:

1. Av. Nitrogen: (Subbiah and Asija, 1956)
2. Av. Potassium: (Hanway and Heidel, 1952)
3. Av. Phosphorus: (Olsen's *et al.,* 1954)
4. Av. Sulphur: (Chesnin and Yien, 1950)
5. Organic carbon: (Walkley and Black, 1934)
6. Bulk Density of soil (Klute, 1986).
7. Microbial biomass estimation by fumigation and extraction method (Jenkinson, 1988).
8. Soil respiration by (Anderson 1982).
9. SOC stock will be determined according to the following formula: [%OC] x [bulk density] x [depth of layer]; bulk density measured in g cm^{-3} and depth of layer in cm.
10. Micronutrients cations (Zn,Cu, Fe & Mn): (Lindsay and Norvell, 1978)

METHODOLOGY

The nutrient status of leaves of mulberry from the selected plantation will be analyzed twice (before and after application of inputs) in two seasons in a year. The standard methods adopted for biochemical analysis of plant material are:

1. Total Protein: (Bradford, 1976)
2. Total Carbohydrate: (Anthrone method by Hedge and Hofreiter, 1962)
3. Total Chlorophyll: (Arnon, 1949)
4. Total Nitrogen: using Kel Plus automatic digestion cum distillation unit.
5. Total leaf biomass.
6. Litter decomposition rate (litterbag method)

1. Sericulture experimentation will include F1 from SH6 x NB4D2.
2. The cocoon productivity (in kg) per hundred DFLs will be recorded.

WORK PLAN

Year	Activities
1st Year	Soil sampling and analysis (Physical, Chemical & Biological) Plantation of one year old *Goshoerami* saplings on one acre land with a spacing of 8' x 9 ' (605 saplings) Cultural operations as per experimental design. Soil sampling during autumn season. Annual report preparation and submission.
2nd Year	Survivability studies and gap filling activities Cultural operations as per experimental design. Soil sampling and analysis (Physical, Chemical & Biological) in spring and autumn seasons. Plant biochemical studies and biomass estimation. Annual report preparation and submission.
3rd Year	Cultural operations as per experimental design. Soil sampling and analysis (Physical, Chemical & Biological) in spring and autumn seasons. Plant biochemical studies and biomass estimation. Sericulture activity/productivity data will be recorded. Annual report preparation and submission

WORK PLAN

Year	Activities
4th Year	Cultural operations as per experimental design. Soil sampling and analysis (Physical, Chemical & Biological) in spring and autumn seasons. Plant biochemical studies and biomass estimation. Sericulture activity/productivity data will be recorded. Annual report preparation and submission.
5th Year	Cultural operations as per experimental design Soil sampling and analysis (Physical, Chemical & Biological) in spring and autumn seasons. Plant biochemical studies and biomass estimation. Sericulture activity/productivity data will be recorded. Pooling of data , interpretation , preparation of final report and submission.

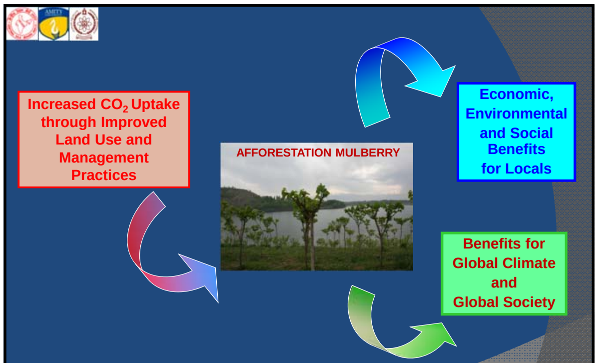
BUDGET PLAN

Item	(Rs. Lacs)					
	I yr	II yr	III yr	IV yr	IV yr	Total
Recurring						
Manpower*	7.488	7.488	7.488	7.488	7.488	37.44
Consumables (Chemical & Glasswares)	1.4	1.4	1.6	1.6	1.6	7.6
Contingencies (Stationary & farm implements)	0.8	0.6	0.4	0.4	0.4	2.6
Travel	0.4	0.4	0.2	0.2	0.16	1.36
Non-Recurring						
Equipments	11	-	-	-	-	11
Total	21.088	9.888	9.688	9.688	9.648	60

- *2 JRF and 4 FA

EXPECTED OUTCOMES

- Afforestation practices will have positive influence on soil health.
- Application of inputs will be recommended as per results obtained.
- Required quantity of healthy leaves will be available for sericulture practices in the region.
- The data obtained will be useful in carbon prediction modeling.



Adapted :UN Conventions on Climate Change, Biological Diversity, and Desertification

INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION

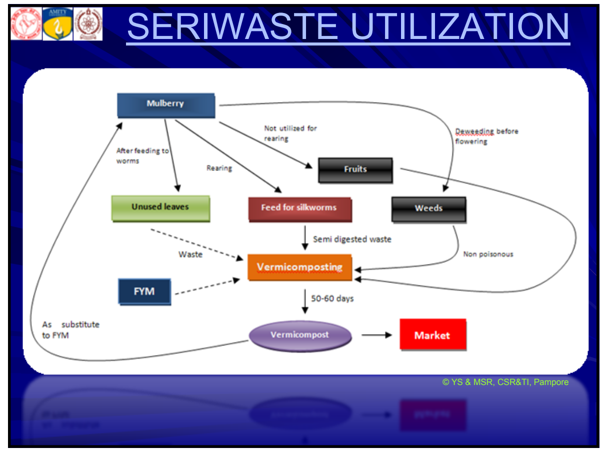
DEPARTMENT OF ATOMIC ENERGY

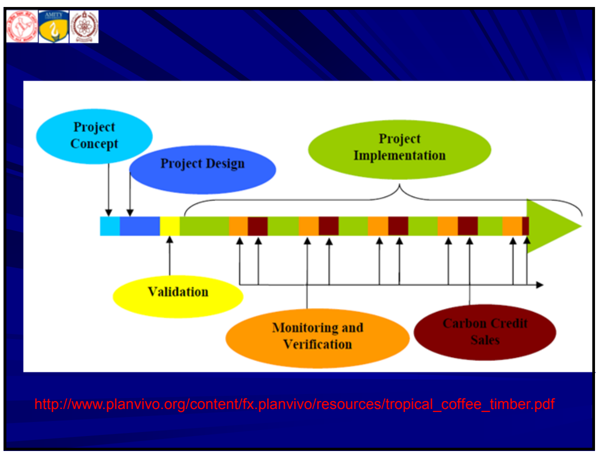
MINISTRY OF ENVIRONMENT AND FOREST

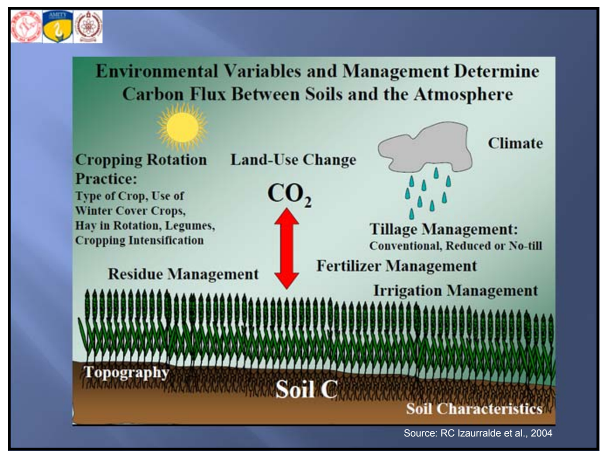
DEPARTMENT OF SCIENCE AND TECHNOLOGY

CENTRAL SILK BOARD


THANK YOU.....


SERIWASTE UTILIZATION
Mulberry
Not utilized for rearing
Deweeding before flowering
After feeding to worms
Rearing
Fruits
Unused leaves
Feed for silkworms
Weeds
Semi digested waste
Waste
Non poisonous
Vermicomposting
FYM
50-60 days
As substitute to FYM
Vermicompost
Market
© YS & MSR, CSR&TI, Pampore


Project Concept
Project Design
Project Implementation
Validation
Monitoring and Verification
Carbon Credit Sales
http://www.planvivo.org/content/fx.planvivo/resources/tropical_coffee_timber.pdf


Environmental Variables and Management Determine Carbon Flux Between Soils and the Atmosphere
Climate
Cropping Rotation Practice:
Type of Crop, Use of Winter Cover Crops, Hay in Rotation, Legumes, Cropping Intensification
Land-Use Change
CO2
Tillage Management:
Conventional, Reduced or No-till
Residue Management
Fertilizer Management
Irrigation Management
Topography
Soil C
Soil Characteristics
Source: RC Izaurralde et al., 2004

Improving farm livelihoods and Carbon Sequestration in rainfed land use Systems in Saurashtra and Konkan

Team: Group B

•A. D. Rane
•H. N. Meena
•Uttam Kumar
•Girish Chander

National Training on C sequestration and C trading, ICRISAT, 6-17 Feb, 2012

Background of the Project

- Groundnut, finger millet, cotton, paddy are important commercial crops in rain fed Gujarat and Maharashtra regions.
- Low crop productivity due to land degradation
- Competent uses of crops residues leaves little for recycling from soil fertility point of view
- In certain regions, shortage of soil moisture due to lack of improved water conservation technologies compel farmers to take only one crop in a year
- Large tracts of lands come under waste lands in possession of farmers without any competent uses, and which are in process of further degradation.

Hypothesis

The adoption of improved soil-crop-water management protocol in the rainfed Saurashtra and Konkan regions has the potential to improve productivity while simultaneously rendering ecosystem service though increased carbon sequestration and building sustainable production and social resilience

Objectives

- To improve livelihoods and resilience building through science led integrated resource management
- To increase C-sequestration in farm and waste lands through improved management practices from soil health point of view and generate additional incomes through C credits.
- To simulate the long term impact of different improved practices on C-Sequestration and productivity under different climate change scenarios.

Technical Programme-1

- **On-farm interventions:**
- Baseline characterization (level 1) of physical, chemical and biological properties of soil (Year 1).
- Diagnosis of soil related constraints and development and implementation of site specific nutrient management in on farms trial/ demo (Year 1, 2, 3, 4)
- Improved cultivars to increase cropping intensities in monocropped areas (Year 1, 2, 3, 4)
- Agroforestry components (Glyricidia, *Sesbania grandiflora*) and organic matter recycling (Year 1, 2, 3, 4)
- Intercropping (castor, Pigeonpea) (Year 1, 2, 3, 4)
- Land form management for soil and water conservation (Year 1, 2, 3, 4)

Technical Programme-2

- **Waste lands**
- Plantation with Pongamia and other suitable species with a purpose to rehabilitate wastelands through C sequestration, generate incomes and replace C in fossil fuel (Year 1, 2, 3, 4)

Technical Program-3

Observations

Crop
- Crop grain and straw yield under improved management practices
- Crop quality

C sequestration
- C-sequestration in agro-forestry components (Aboveground and belowground biomass)
- C sequestration is soil (4 yrs after implementation)
- Rate of CO_2 assimilation in leaves under different management practices

Soil and water
- Rainwater runoff and soil loss
- Groundwater
- Soil health

Socio-economic impact
- Incomes
- Nutrition
- Equity

Expected outputs

- Productivity improvement
- Improved farm income and livelihoods
- Increased C-sequestration (Farm/waste lands)
- Land reclamation
- C replacement in fossil fuel through biofuel
- Reduction in soil and water loss
- Increased water and other resource use efficiency
- Resilient building

Total budget proposed (lakhs)

Staffing;
- (i) RA/SO = 2XRs 30000X4 yrs = 28.8
- (ii) Field Assistants (NGO) = 6X Rs 10000 X 4 yrs = 28.8

Baseline characterization = 30.0 (ICRISAT)
On-farm intervention cost
- (i) Participatory trials/demos = 4.00
- (ii) Vermicomposting = 3.00
- (iii) Nursery/seedlings = 4.00
- (iv) Landform demos = 1.00
- (v) Cultivars = 1.00

Travel/Meetings = 10.0
Ttaining/Capacity building = 10.0
Contingency = 5.00
Institutional charges (25%) = 31.4
Total budget = 157 lakhs

- **Duration:** 4 years

- **Names of the collaborating institutions**
- (i) ICRISAT, Patancheru
- (ii) Directorate of Groundnut Research, Junagadh (ICAR), Gujarat
- (III) Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra

Thanks

Impact of rice based systems on carbon sequestration and mitigation of GHG emission

DURATION

5 years (2012-2017)

NAME OF THE INSTITUTE

Directorate of Rice Research (DRR), Hyderabad

NAME OF THE PI

Dr. M B B Prasad Babu

NAMES OF CO-PIs

1. Dr. M A Aziz Qureshi, Hyderabad
2. Dr. S Srinivasan, Tamil Nadu
3. Dr. M B Doddamani, Karnataka

COLLABORATING INSTITUTES

1. Directorate of Oilseeds Research, Hyderabad
2. Annamalai University, Tamil Nadu
3. University of Agricultural Sciences, Dharwad, Karnataka

INTRODUCTION

Total geographical area	: 328.7 m ha
Arable land	: 161.8 m ha
Irrigated area	: 57.0 m ha
Area under rice	: 43.0 m ha
RBCs	: 27.9 m ha

Area under major rice based cropping systems (RBCs) in India

Cropping system	Area ('000ha)	Cropping system	Area ('000ha)
Rice-wheat	9847.3	Rice-Gram	208.9
Rice-rice	**5894.0**	Rice- Blackgram	598.9
Rice-Fallow	**4419.9**	Rice-Greengram	597.5
Rice-Vegetable	1243.5	Rice-sugarcane	432.6
Rice-Ground nut	1022.9	Rice- Potato	462.4
Rice-Lathyrus	950.0	**Rice- Chickpea**	**304.0**
Rice-Mustard	480.7	Rice-Horsegram	245.9
Rice- Jute	120.1		

BACKGROUND

- Rice cultivation particularly under wetlands contributes to both carbon emission and sequestration.
- Out of nearly 2000 mt. of CO_2 eq. pa, rice cultivation accounts for 70 mt.
- Methane fluxes, vary with different soil types, and various agricultural practices such as choice of water management and cultivar, application of organic amendments, mineral fertilizers and SOC.

Contd..

BACKGROUND

- By inclusion of legumes in cereal based systems, the heavy demand of N can be partly met which will also ensure the improved physical and chemical properties of the soil (Kumar Rao *et al.* 1998).
- After harvest of rice, legume crops like chick pea could be grown successfully which mature on the residual moisture in the soil.
- In India, chickpea (*Cicer arietinum* L.) is an important winter grain legume crop grown on about 7 m ha.

Contd..

BACKGROUND

The soil organic carbon (SOC) content in Indian soils is in the range of 0.2 to 0.5% (2-5 g/kg soil) and works out to 21 and 150 billion tons up to 30 and 150 cm soil depth respectively, while total soil inorganic C pool (SIC) is about 196 billion tons (Pal *et al.*, 2000).

Contd..

BACKGROUND

- The quantity of residues from the principal grain crops in India is estimated at about 340 mt per year, of which rice residues alone constitute about 51%.
- Rice being a major crop in India, produces substantial quantities of crop residues, which can be returned to the soil to increase soil fertility and crop yields, while sequestering carbon.

BACKGROUND

- A novel approach to sequester carbon is the utilization of biomass for producing biochar which when returned to soil, produces a range of environmental benefits, such as enhanced soil carbon sequestration and soil fertility improvement (Lehmann 2007).
- About 309 m t of biochar could be produced annually in India, the application of which might offset about 50 per cent of carbon emission (292 teragram C yr^{-1}) from fossil fuel (Lal 2005).

BIOCHAR

- A solid carbon-rich, fine-grained, porous substance similar in its appearance to charcoal.
- When biomass is exposed to moderate temperatures, between about 400 and 500 C (low-temperature pyrolysis), under complete or partial exclusion of oxygen, biomass undergoes exothermic processes and releases a multitude of gases in addition to heat along with biochar.

BIOCHAR

- Both heat and gases can be captured to produce energy carriers such as electricity, hydrogen, or bio-oil, which can be used as a fuel for various purposes in the process of manufacturing biochar.
- In addition to energy, certain valuable co-products, including wood preservative, food flavouring, adhesives etc., can be obtained (Czernik and Bridgwater 2004).

Contd..

HYPOTHESES

- Rice cultivation contributes to both carbon emission and sequestration. Whether improved management can mitigate GHG emission?
- Biochar can enhance soil carbon sequestration and soil fertility improvement. Can diversified use of crop biomass lead to carbon sequestration?

OBJECTIVES

- To study the carbon sequestration potential of rice based systems in southern India.
- To study the utilization of crop biomass/ residues in improving soil health for sustainable productivity.
- To study the impact of improved management practices on the economic status of farming community of rice systems.
- To estimate the GHGs emitted from different rice based systems and to develop mitigation strategies.

Rice based systems to be studied

1. Rice-Rice (5.9 m ha)
2. Rice-Fallow (4.5 m ha)
3. Rice-Chickpea (0.3 m ha)

TECHINACAL PROGRAM

TREATMENTS

Kharif : Crop establishment techniques

Rabi : Tillage

Crop establishment techniques

- Irrigated/flooded rice
- Aerobic rice
- System of rice intensification (SRI)
- Direct seeded rice (DSR)

Tillage in *Rabi*

- Conventional tillage
- Conservation tillage (with residues at surface)

MILESTONES

- 1st year : Quantification of SOC in RBCs, Use of Biochar
- 2nd year : Quantification of SOC in RBCs
- 3rd year : Estimation of GHGs emitted
- 4th year : Estimation of GHGs emitted
- 5th year : Development of mitigation startegies for GHGs

EXPECTED OUTPUTS

- Quantification of the carbon sequestered in the soil in RBCs.
- Improved economic status of the rice farming community.
- Mitigation of the GHGs emitted from the rice systems.
- Better utilization of crop biomass/residues

BUDGET

Item	Cost (Rs. In Lakhs)
1. Contractual staff	25
2. Equipment	50
3. Contingencies	10
4. TA	5
5. Institutional Charges	9

Total : 99 L

Thank You

Sustainable management strategies for cassava to enhance productivity, soil quality and carbon sequestration in different agro climatic zones.

Dr. S. Sunitha, Dr. T. Rangaraj, Dr. V. Ramesh, Megan E. Fenton
Project Proposal
National Training on Carbon Sequestration and Carbon Trading
ICRISAT - NAIP
February 16th 2012

Background

- Cassava is the major tropical tuber crop and is widely adapted to different agro climatic zones.
- The crop is primarily grown by small and marginal farmers with poor management under rainfed conditions.
- The conventional practice of growing cassava with low inputs has resulted in depletion of soil organic matter, a reduction in productivity and an overall reduction in carbon sequestration.
- Inputs such as farm yard manure are not utilized and the options to improve soil carbon and productivity are limited.
- Mulching with soil test based nutrient management serves as a relatively low cost technology to improve soil organic matter, improve cassava productivity and therefore improve carbon sequestration.

Hypothesis

The use of leguminous mulches with soil test based nutrient management will result in increased productivity, soil organic matter, carbon sequestration and improved livelihoods for cassava farmers.

Objectives

1. To develop a suitable soil management system for cassava for enhanced productivity, soil quality and carbon sequestration in different agro-climatic zones
2. To study the effect of mulching practices on soil properties and organic carbon build up.
3. To determine an optimal nutrient management strategy for the cassava mulching system.
4. To work out the economics and input use efficiency of the different mulching and nutrient management systems.

Duration	Three Years
Name of the Institutions	Central Tuber Crops Research Institute (CTCRI)
Name of the Principal Investigators	Dr. S. Sunitha (CTCRI)
Name of the Co-Investigators	Dr. V. Ramesh (CTCRI) Dr. T. Rangaraj (TNAU)
Name of the Collaborating Institution	Tamil Nadu Agricultural University (TNAU)

Technical Program

- The experiment will be conducted in three different agro climatic zones; humid tropics, semi-arid and arid-tropics under uniform management.
- Locations

1. Central Tuber Crops Research Institute at Thiruvanathapuram, Kerala.
2. Eastern Ghats, Kadambur Hills, Tamil Nadu
3. Agricultural Research Station at Kovilpatti, Tamil Nadu Agricultural University.

Technical Program…

Experimental Design – Split Plot	
Main Plot Treatments – Mulches	
M_1	Coir pith compost at 10 tons per hectare at planting.
M_2	*Glyricidia* cuttings at 0.5 tons per hectare on dry weight basis at planting and after two months.
M_3	Cowpea/groundnut as live mulch.
M_4	No mulch
Sub Plot Treatments – Nutrient Management	
S_1	Standard recommended fertilizer dose
S_2	Soil test based nutrient management
S_3	Farmer practice
Replications – 2	Plot Size – 25 square meters

Observations

1. Initial pre-plant soil physical, chemical and biological properties. Such as
2. Analysis of the mulching materials for cellulose, lignin carbon and nutrient content.
3. The growth characteristics, biomass production and yield of cassava and living mulches.
4. Soil properties at annual intervals.
5. Changes in soil organic matter.
6. Carbon dioxide emissions at regular intervals.
7. Estimation of carbon stock
8. Economics of the different mulching and nutrient management strategies.

Soil Analysis

Physical Indicators:
- Aggregate Stability (%)
- Available Water Capacity (g g^{-1})
- Surface Hardness at 0-15 cm (M Pa)
- Subsurface Hardness at 15-45 cm (M Pa)
- Hydraulic Conductivity (mm^{-1} hr) *

Biological Indicators:
- Organic Matter (g kg^{-1})
- Active Carbon (mg kg^{-1})
- Potentially Mineralizable Nitrogen (μg N gdw soil- 1 week- 1)

Chemical Indicators
- pH
- Electrical Conductivity (dS m^{-1})
- Nutrient Analysis

Activities

Year One:
1. Pre-plant soil analysis
2. Raising cassava
3. Raising cover crop in the concerned treatments
4. Imposing treatments
5. Recording observations and post-harvest collection of soil samples

Year Two
1. Repetition of year one activities and analysis of soil samples
2. Working out the economics of different mulching and nutrient management systems

Year Three
1. Completion of soil studies
2. Compilation, analysis and interpretation of data
3. Preparation of reports

Expected Output

1. Information on the effectiveness of mulching materials in terms of soil carbon accumulation in different agro climatic zones.

2. Enhancement of the soil quality and productivity of poor and marginal cassava growing soils.

3. Increased productivity in cassava resulting in a management strategy that improves the livelihood of poor farmers and sustains the environment through sustainable soil management and carbon sequestration.

Total Proposed Budget

I. Non-returning expenses	Rupees (In lakhs)
TDR	8
Gas Chromatograph	10
Closed chambers for CO_2 measurement	15
C/N Analyzer	25
Minor equipment	5
II. Salaries and allowances	
Research fellows (3)	24
Supporting staff (3)	9
Traveling allowance	6
III. Recurring expenses	
Chemicals, fertilizers, inputs	6
Contracted wages	7
Misc expenses	6
Total	**122**

Thank You.

About ICRISAT

ICRISAT
Science with a human face

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT and its partners help empower these poor people to overcome poverty, hunger, malnutrition and a degraded environment through better and more resilient agriculture.

ICRISAT is headquartered in Hyderabad, Andhra Pradesh, India, with two regional hubs and four country offices in sub-Saharan Africa. It belongs to the Consortium of Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

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