INFORME DE VIAJE A LA INDIA

DE

INVESTIGADORES DEL ICTA Y PERSONAL DEL IICA

10-24 de octubre 2016

Integrantes de la Misión ICTA-IICA

ANTECEDENTES Y JUSTIFICACIÓN

El IICA ha estado involucrado en el Sistema de Intensificación del Arroz (SRI por sus siglas en inglés) desde el 2011 con parcelas de demostración en la República Dominicana y participando en la primera reunión regional sobre este tema organizada por las Universidades EARTH y Cornell en octubre de 2011.

En 2012 el Consejo Nacional de Investigaciones Agropecuarias y Forestales (CONIAF) de la República Dominicana aprobó al IICA, por primera vez en su historia, un proyecto de investigación sobre el SRI, el cual permitió hacer numerosas pruebas en parcelas en las principales zonas arroceras del país.

En enero de 2013, se organizó el V Seminario Internacional de Políticas Agropecuarias con la participación del Director General del IICA, el Dr. Víctor Villalobos, y el Dr. Norman Uphoff de la Universidad de Cornell.

En 2014, el programa FONTAGRO aprobó al IICA un proyecto de investigación sobre SRI para Colombia y República Dominicana, el cual se está ejecutando en la actualidad. Un proyecto similar, que fue originalmente formulado por el IICA, ha sido aprobado por FONTAGRO para Panamá, Costa Rica y Nicaragua.

En 2015 el Director General del IICA aprobó la realización de una misión del IICA a la India para aprender sobre las experiencias de los Sistemas de Intensificación de Cultivos (SCI por sus siglas en inglés), incluyendo el SRI.

Esta misión fue coordinada con el Dr. Norman Uphoff con las instituciones de la India que han sido responsables por la implementación y el desarrollo de los SCI en varios estados y un número creciente de cultivos.

LECCIONES APRENDIDAS

- Los Sistemas de Intensificación de Cultivos (SCI, por sus siglas en inglés), incluido el Sistema de Intensificación del Arroz (SRI, por sus siglas en inglés) están teniendo un muy importante impacto en las familias de agricultores pobres en varios estados de la India, aumentando los niveles de producción de los cultivos donde se han aplicado, la productividad y los ingresos. Las familias rurales ahora tienen suficiente comida todo el año e ingresos para mandar sus hijos a la escuela y para mejorar su nivel vida.

- Los principios del SRI se están aplicando y adaptando a otros cultivos como trigo, maíz, mijos, caña de azúcar, legumbres y vegetales con mucho éxito, y empezando a adaptar a la producción animal.

- La selección y el tratamiento de las semillas antes de la siembra, es un paso primordial para el mejoramiento del crecimiento de las plantas y su comportamiento.

- Debido a la tradición y a la abundancia de mano de obra, las prácticas han sido mayormente manuales, como relativa poca mecanización.

- El involucramiento de las Organizaciones No-Gubernamentales (ONGs) ha sido fundamental para el éxito y la expansión de SCI entre los productores más marginados y pobres. Los gobiernos a los tres niveles (nacional, estatal y distrital) y la academia (institutos de investigación) han apoyado igualmente.

- Las modalidades del SCI integra fuertemente la producción orgánica por motivos de reducción de los costos de producción (reducción o eliminación de la adquisición de insumos externos como fertilizantes y agro-químicos), por motivos de salud e inocuidad con ello logran una agricultura sostenible.

- Los componentes del SCI Y SRI aplicados logran de una forma sostenible la conservación de suelos y el uso y manejo eficiente del recurso agua.

- Los animales domésticos, especialmente los vacunos y los búfalos de agua, son parte esencial de los sistemas de producción, pues aprovechan los residuos de cosecha y los transforman en valiosos productos para la fertilización de los cultivos y para utilizarlos como combustible para cocinar, y proporcionan su fuerza para el transporte y para la preparación del suelo.

OBSERVACIONES

- Debido a la alta densidad de población, las áreas de cultivo son utilizadas en forma intensiva con dos o tres ciclos y varias especies. Sin embargo, las áreas de pastoreo no han recibido ninguna mejora y se siguen usando igual que desde, hace tal vez, milenios.

- Muchas áreas comunales y de pastoreo, están completamente deforestadas y solo quedan arbustos y herbáceas.

- La presencia de grandes cantidades de basura (de origen plástico) por todos lados están seguramente afectando la salud de los animales que pastorea libremente.

- La acumulación de agua, alrededor de los poblados y vías de comunicación, después de la época de lluvias, da lugar a la reproducción de numerosas plantas acuáticas, que al parecer no son utilizadas.
  La ausencia de servicios sanitarios en el área rural podría afectar no solo la salud de los habitantes sino también la inocuidad de los alimentos que produzcan.

SUGERENCIAS

- Considerar el utilizar los principios de la Agricultura de Conservación (cero labranza) para mejorar la fertilidad de los suelos y reducir el esfuerzo en la preparación de abonos.

- Considerar encerrar a los animales durante todo el tiempo o al menos durante la noche, en instalaciones o corrales, que permitan la recuperación total de los desechos (residuos de comida, heces y orina) para su procesamiento y uso como fertilizantes. Los bio-digestores constituyen una opción viable para solucionar muchos de los problemas comunitarios, ya que además de procesar de forma óptima los desechos animales y reemplazar muchos de los actuales preparados para la fertilización orgánica, podrían adicionalmente proporcionar biogás para cocinar y así reducir las necesidades de leña, el tiempo y el esfuerzo actuales para procesar el estiércol en forma sólida, principal fuente de combustible.

- Considerar establecer sistemas agroforestales con fines pecuarios en las zonas de pastoreo, ya sea para pastoreo directo (sistemas silvopastoriles) o para sistemas de corte y acarreo, con leguminosas forrajeras y otros forrajes de alta calidad como morera, moringa, tithonia, etc.

- Considerar capacitar a técnicos y productores líderes en nutrición y alimentación animal, para mejorar la salud, el crecimiento y el rendimiento de los animales domésticos.

- Al igual como se está empezando hacer con la *Azolla*, otras plantas acuáticas, como *Lemna*, podría cultivarse y utilizarse para la alimentación de peces y otros animales domésticos aprovechando la gran cantidad de cuerpos de agua existentes alrededor de los poblados.

- Considerar iniciar un programa de reducción de basura y de reciclaje, pues la gran acumulación de basura y de desechos, humanos incluidos, no van de acuerdo con los enormes esfuerzos que se están haciendo para mejorar los cultivos y los sistemas de producción.

- Se establecen los principios de la metodología SCI como una estrategia de adaptación y mitigación ante el cambio climático, por lo que es clave fortalecer capacidades de Referentes Agrícolas de Latinoamérica para que puedan diseminar y adaptar estos principios en los productores del hemisferio y les permita reducir su huella de carbono, enfrentar de una mejor forma el cambio climático y aseguren un mejor futuro en sus comunidades. Específicamente, se debe promover el manejo integrado de cultivos, las buenas prácticas agrícolas, el uso de bajas densidades de siembra y el uso más responsable y eficiente del agua por parte de los productores de ALC.

- Es importante el desarrollo de proyectos, talleres, foros que permitan compartir, promover y validar los principios del SCI en los sistemas agropecuarios latinoamericanos. De esta forma los productores contaran con estrategias sostenibles de adaptación y mitigación ante el cambio climático, además de que proporciona la posibilidad de incrementar los rendimientos con menor uso de insumos aspecto clave para la seguridad alimentaria de los aumentos de población proyectados. Por otro lado, es clave el desarrollo de parcelas demostrativas con productores latinoamericanos donde se facilita el aprendizaje, y el poder concientizar y mejorar las capacidades de los actores involucrados en la producción de cultivos en escenarios de CC.

INSTITUCIONES Y CONTACTOS

- Organizador, traductor y guía: Pratyaya Jagannath (pratyayj@gmail.com). Eco Tasar Silk PVT. LTD.

- PRAN (Preservation and Proliferation of Rural Resources and Nature), Road 1 (West), Shastri Nagar, Near Jail Press, Sikariya Mor, Gaya, Bihar State 823001, India. Email: pran@ngopran.org
  Director: Anil Kumar Verma (anilvermaprangaya@gmail.com)

Entrega de reconocimiento a Anil Serna, PRAN, Gaya, Bihar

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  Director: Debashish Sen (debu_manu@yahoo.co.in)

Entrega de reconocimiento a Debashish Sen, People´s Science Institute, Dehradun, Uttarakhand

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  Contact: Nityanand Dhal (Integrator) (nityanaddhal@pradan.net)

- INDIAN AGRICULTURAL RESEARCH INSTITUTE, Library Avenue, New Delhi. Division of Agricultural Economics
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  Division of Agronomy:
  Contact: Dr. Shiva Dhar (drsdmisra@gmail.com) Tel. +91 11 2584 2902

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VISITAS DE CAMPO:

Bihar State, Distrito Gaya.

Aldea Dhanachak, Bloque Brachatti

Reunión con Productoras Líderes de Aldeas (Village Resource Persons, VRP)

Temas: métodos de extensión

Cultivos: arroz, trigo, mijos (especialmente el mijo africano *Eleusine coracana*), vegetales y canola (colza)

Plantación de Arroz. Aldea Aldea Dhanachak. Bihar State

Mujeres Productoras. Aldea Dhanachak. Bihar State

Aldea Kesapi, Bloque Dobhi

Temas: producción orgánica, insumos (compostas, vermi-compostas, *Azolla* cultivation, varios preparados) y herramientas para cultivo (deshierbe) y siembra

Cultivo de Azolla. Aldea Kesapi

Preparados orgánicos. Aldea Kesapi

Aldea Jehlibigha, Bloque Atri

Reunión con VRP

Temas: producción orgánica, semillas locales, tratamiento de semillas, éxitos con el SRI y mejoras en rendimiento, ingresos y nivel de vida.

Figura hecha para recibir a los visitantes con colorantes, semillas de las especies cultivadas y muestras de los preparados de la agricultura orgánica

Aldea Salarpur, Bloque Tan Kuppa

Temas: producción de vegetales (chiles, berenjenas), mijo africano.

<u>Distrito Nalanda</u>

Aldea Mudhari, Bloque Harnaut

Temas: Tratamiento de semillas, siembra por contrato, insumos orgánicos, herramientas para corte de yemas de caña

Cultivos: arroz, maíz, trigo, ñame pata de elefante (*Amorphophallus paeoniifolius*), papa, coliflor, garbanzo

Distrito de Nalanda. Aldea Mudhari. Secado de Estiércol

Distrito de Nalanda. Aldea Mudhari. Campo de arroz

Distrito de Nalanda. Aldea Mudhari. Reunión de mujeres

Distrito de Nalanda. Aldea Mudhari. Productos orgánicos

Distrito de Nalanda. Aldea Mudhari. Intercambio con extensionistas

Aldea Sakraul, Bloque Sharif

Temas: cultivos de arroz y de mijo elefante

Aldea Darveshpura, Bloque Katri Sarai

Temas: conversación con el productor Sumant Kumar, con el record mundial de producción de arroz (22.4 ton/ha) en 2011 y sus colegas productores (con rendimientos de 17-19 ton/ha).

El productor de ese grupo Nitish Kumar, tiene el record de producción de papa de 79 ton/ha, utilizando los principios SRI.

Cultivos: arroz, trigo, melón Cantaloupe (muskmelon), papa, *Sesbania bispinosa*

Reunión en Aldea Aldea Darveshpura, Bloque Katri Sarai

Aldea Darveshpura, Bloque Katri Sarai

Himachal Pradesh

Aldea Thana Kashoga, Distrito Simaur

Temas: conversación con grupo de productores de la montaña, cultivo en terrazas, conservación de microcuencas para asegurar las fuentes de agua.

Cultivos: chile, jitomate, cúrcuma (*Curcuma longa*)

Aldea Thana Kashoga, Distrito Simaur

ACCIONES DE SEGUIMIENTO

- Explorar posibilidades de colaboración con las instituciones visitadas.
- Preparar una presentación sobre los SCI/SRI para el proyecto insignia de Agricultura Familiar, para el Mundo IICA y para el ICTA.
- Organizar un taller con autoridades e investigadores del ICTA para hacer la presentación del viaje y para discutir alternativas de adopción/adaptación y su incorporación en el programa CRIA.

PARTICIPANTES

ICTA:

Ing. Luis Márquez, Especialista en suelos (luamarquez@hotmail.com)

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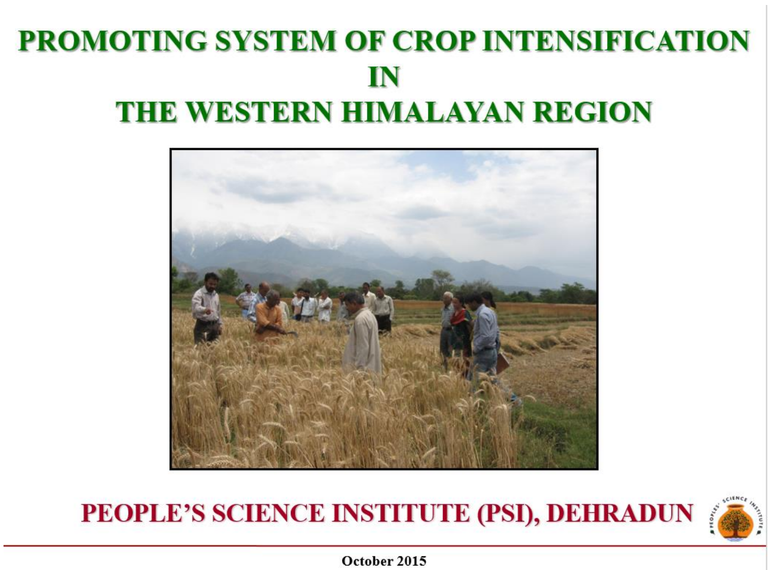
Productor:

Manuel Sánchez Montemayor (manuelsanchez43@hotmail.com)

PRESENTACIONES

Experiencias de Peoples´ Science Institute con:



SCI en varios cultivos

SWI Trigo con Mostaza

VIDEOS

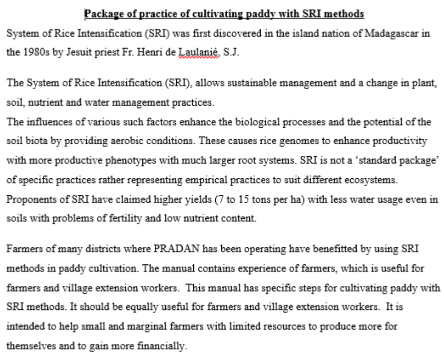
SRI Vietnam

Agricultura Orgánica India 1

Agricultura Orgánica India 2

MANUALES

Sistema de Intensificación del Arroz (SRI):



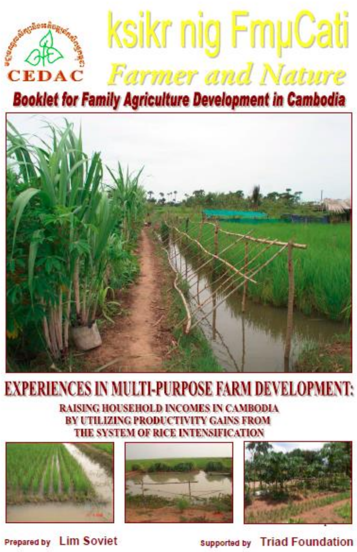
Package of practice of cultivating paddy with SRI methods

System of Rice Intensification (SRI) was first discovered in the island nation of Madagascar in the 1980s by Jesuit priest Fr. Henri de Laulanié, S.J.

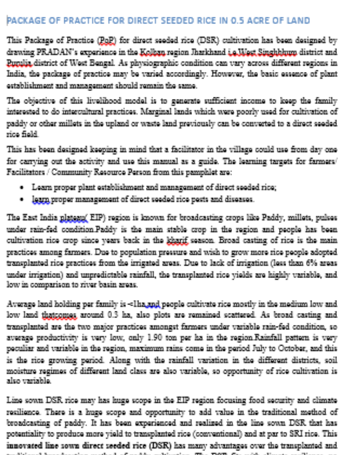
The System of Rice Intensification (SRI), allows sustainable management and a change in plant, soil, nutrient and water management practices.
The influences of various such factors enhance the biological processes and the potential of the soil biota by providing aerobic conditions. These causes rice genomes to enhance productivity with more productive phenotypes with much larger root systems. SRI is not a 'standard package' of specific practices rather representing empirical practices to suit different ecosystems. Proponents of SRI have claimed higher yields (7 to 15 tons per ha) with less water usage even in soils with problems of fertility and low nutrient content.

Farmers of many districts where PRADAN has been operating have benefitted by using SRI methods in paddy cultivation. The manual contains experience of farmers, which is useful for farmers and village extension workers. This manual has specific steps for cultivating paddy with SRI methods. It should be equally useful for farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves and to gain more financially.

Manual Corto



SRI en Agricultura Familiar



PACKAGE OF PRACTICE FOR DIRECT SEEDED RICE IN 0.5 ACRE OF LAND

This Package of Practice (PoP) for direct seeded rice (DSR) cultivation has been designed by drawing PRADAN's experience in the Kolhan region Jharkhand i.e.West Singhbhum district and Purulia district of West Bengal. As physiographic condition can vary across different regions in India, the package of practice may be varied accordingly. However, the basic essence of plant establishment and management should remain the same.

The objective of this livelihood model is to generate sufficient income to keep the family interested to do intercultural practices. Marginal lands which were poorly used for cultivation of paddy or other millets in the upland or waste land previously can be converted to a direct seeded rice field.

This has been designed keeping in mind that a facilitator in the village could use from day one for carrying out the activity and use this manual as a guide. The learning targets for farmers/ Facilitators / Community Resource Person from this pamphlet are:

- Learn proper plant establishment and management of direct seeded rice;
- learn proper management of direct seeded rice pests and diseases.

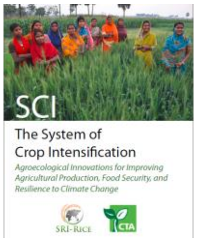
The East India plateau(EIP) region is known for broadcasting crops like Paddy, millets, pulses under rain-fed condition.Paddy is the main stable crop in the region and people has been cultivation rice crop since years back in the kharif season. Broad casting of rice is the main practices among farmers. Due to population pressure and wish to grow more rice people adopted transplanted rice practices from the irrigated areas. Due to lack of irrigation (less than 6% areas under irrigation) and unpredictable rainfall, the transplanted rice yields are highly variable, and low in comparison to river basin areas.

Average land holding per family is -<1ha and people cultivate rice mostly in the medium low and low land thatcomes around 0.3 ha, also plots are remained scattered. As broad casting and transplanted are the two major practices amongst farmers under variable rain-fed condition, so average productivity is very low, only 1.90 ton per ha in the region.Rainfall pattern is very peculiar and variable in the region, maximum rains come in the period July to October, and this is the rice growing period. Along with the rainfall variation in the different districts, soil moisture regimes of different land class are also variable, so opportunity of rice cultivation is also variable.

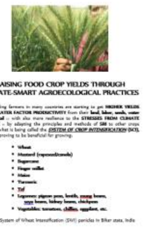
Line sown DSR rice may has huge scope in the EIP region focusing food security and climate resilience. There is a huge scope and opportunity to add value in the traditional method of broadcasting of paddy. It has been experienced and realised in the line sown DSR that has potentiality to produce more yield to transplanted rice (conventional) and at par to SRI rice. This **innovated line sown direct seeded rice (DSR)** has many advantages over the transplanted and traditional broadcasting method of paddy cultivation. The DSR fits with climate resilience, no

Siembra Directa

Sistemas de Intensificación de Cultivos (SCI):



Monografía



Folleto

Mostaza

Cúrcuma

Trigo

Mijo Africano

FICHAS TECNICAS

PRADAN

Col/Coliflor

Cabras

Peces-Patos

Mango

Guandul

Aves

Tomates/Chile/Berenjena

Calabazas

FOTOGRAFIAS ADICIONALES DEL VIAJE

Bihar State, Distrito Gaya.

Aldea Dhanachak, Bloque Brachatti

Aldea Kesapi, Bloque Dobhi

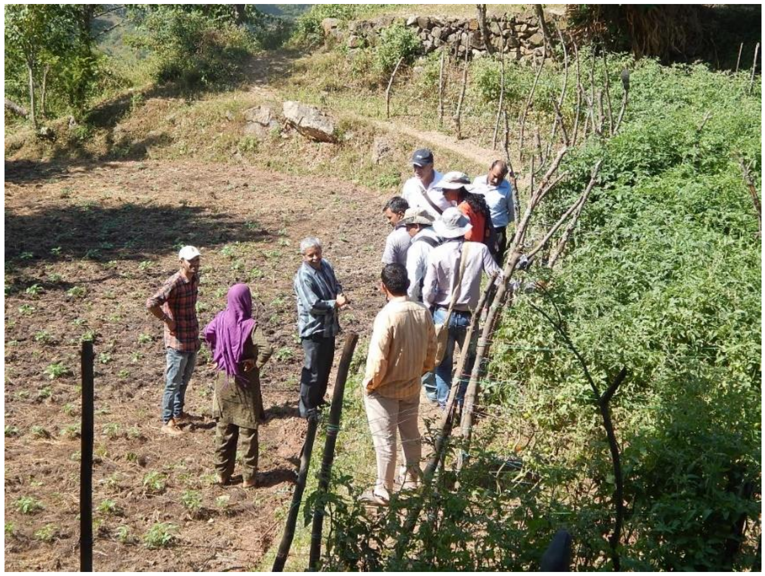
Aldea Jehlibigha, Bloque Atri

Distrito Nalanda

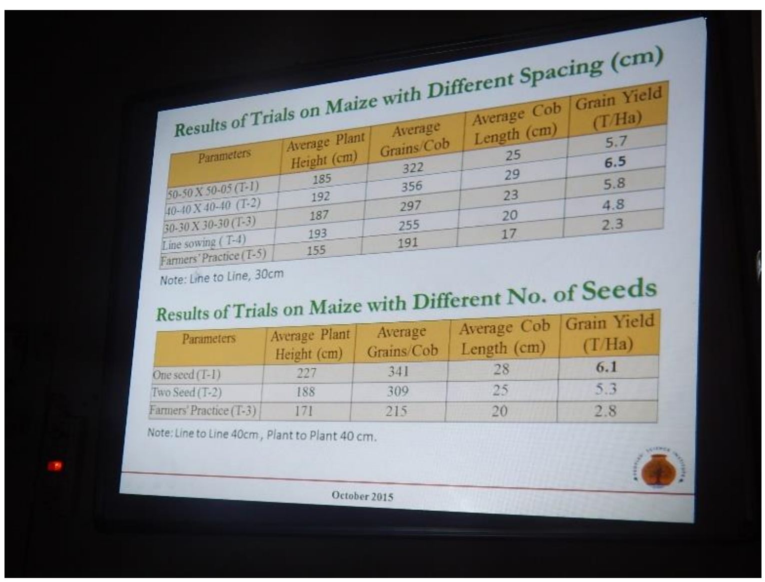
Aldea Mudhari, Bloque Harnaut

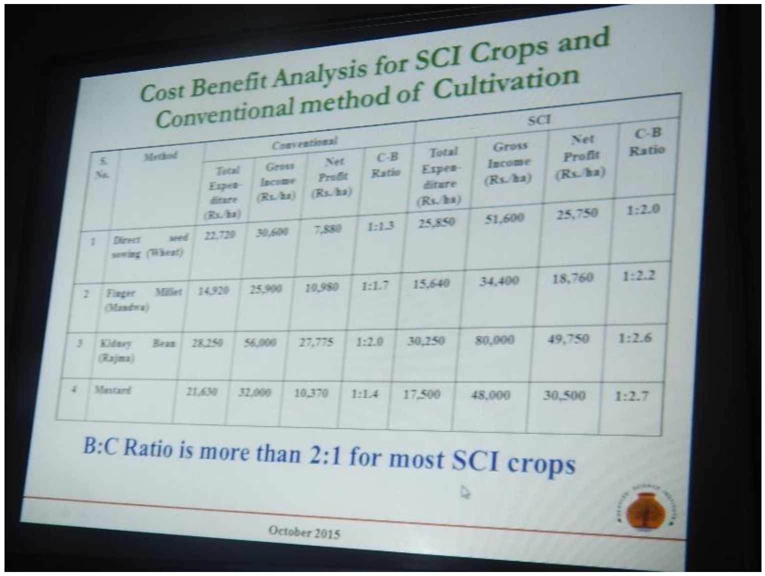
Himachal Pradesh

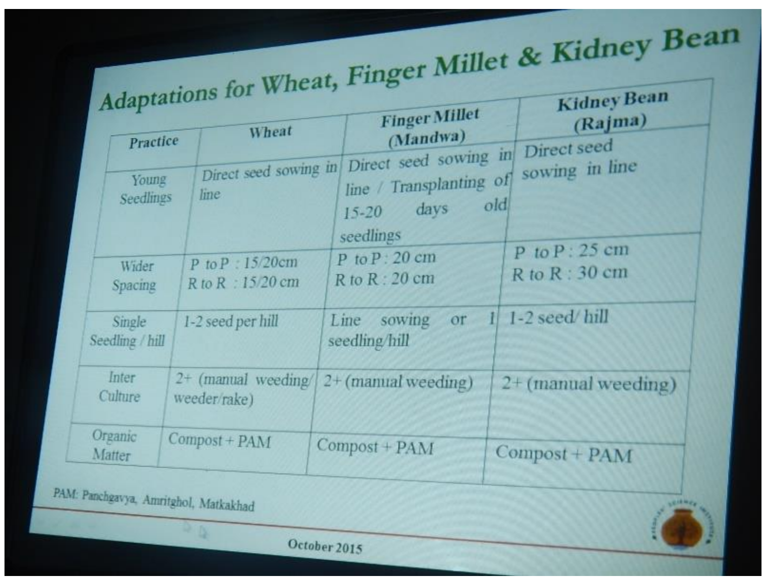
Aldea Thana Kashoga, Distrito Simaur

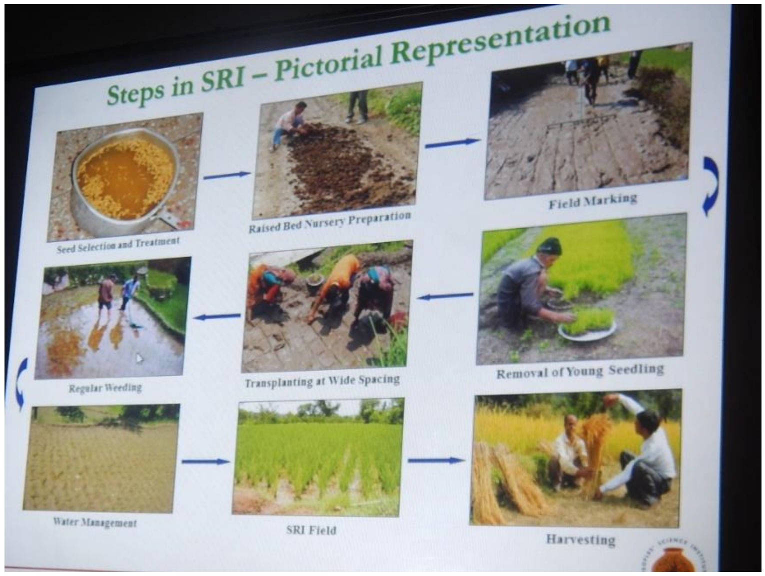


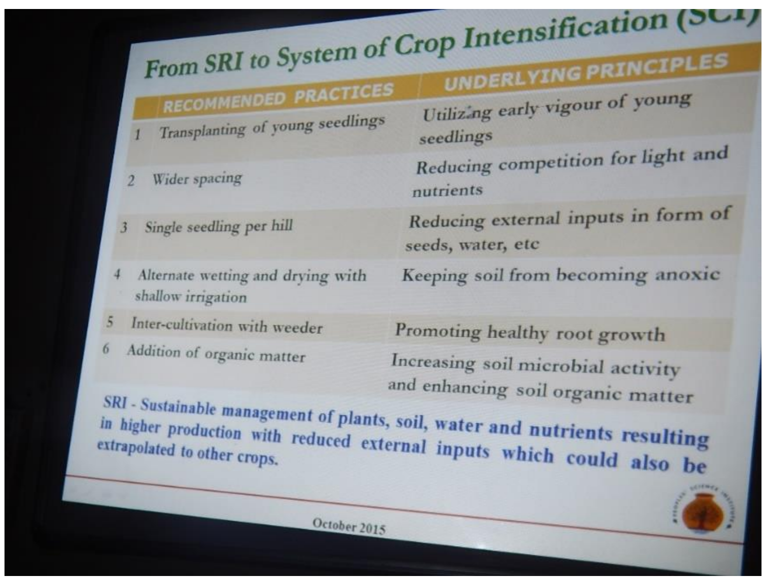
PEOPLE´S SCIENCE INSTITUTE, Dehradun

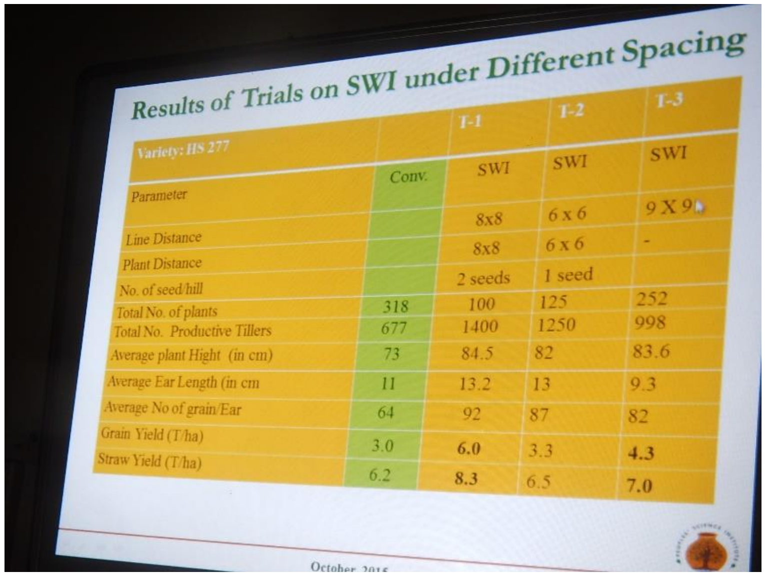



Cost Benefit Analysis for SCI Crops and Conventional method of Cultivation
S. No. | Method | Conventional: Total Expenditure (Rs./ha) | Gross Income (Rs./ha) | Net Profit (Rs./ha) | C-B Ratio | SCI: Total Expenditure (Rs./ha) | Gross Income (Rs./ha) | Net Profit (Rs./ha) | C-B Ratio
1 | Direct seed sowing (Wheat) | 22,720 | 30,600 | 7,880 | 1:1.3 | 25,850 | 51,600 | 25,750 | 1:2.0
2 | Finger Millet (Mandwa) | 14,920 | 25,900 | 10,980 | 1:1.7 | 15,640 | 34,400 | 18,760 | 1:2.2
3 | Kidney Bean (Rajma) | 28,250 | 56,000 | 27,775 | 1:2.0 | 30,250 | 80,000 | 49,750 | 1:2.6
4 | Mustard | 21,630 | 32,000 | 10,370 | 1:1.4 | 17,500 | 48,000 | 30,500 | 1:2.7
B:C Ratio is more than 2:1 for most SCI crops
October 2015


Adaptations for Wheat, Finger Millet & Kidney Bean
Practice | Wheat | Finger Millet (Mandwa) | Kidney Bean (Rajma)
Young Seedlings | Direct seed sowing in line | Direct seed sowing in line / Transplanting of 15-20 days old seedlings | Direct seed sowing in line
Wider Spacing | P to P : 15/20cm R to R : 15/20 cm | P to P : 20 cm R to R : 20 cm | P to P : 25 cm R to R : 30 cm
Single Seedling / hill | 1-2 seed per hill | Line sowing or 1 seedling/hill | 1-2 seed/ hill
Inter Culture | 2+ (manual weeding/ weeder/rake) | 2+ (manual weeding) | 2+ (manual weeding)
Organic Matter | Compost + PAM | Compost + PAM | Compost + PAM
PAM: Panchgavya, Amritghol, Matkakhad
October 2015

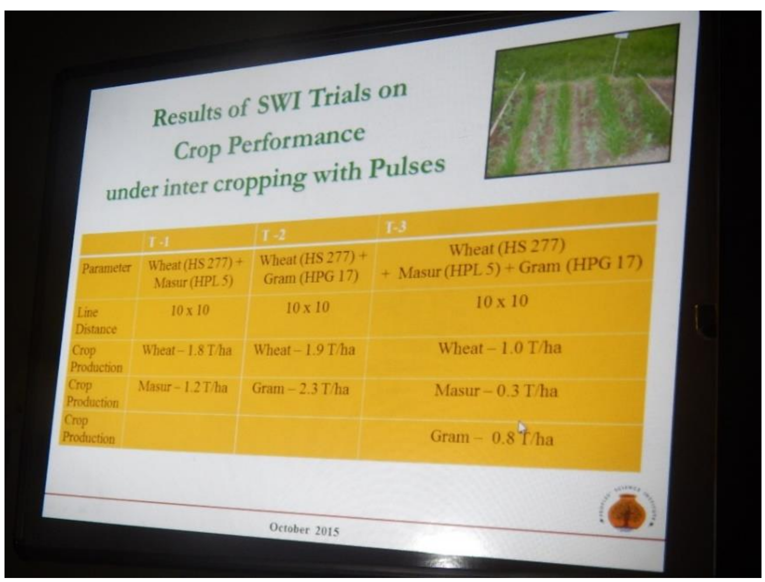

Steps in SRI – Pictorial Representation
Seed Selection and Treatment
Raised Bed Nursery Preparation
Field Marking
Removal of Young Seedling
Transplanting at Wide Spacing
Regular Weeding
Water Management
SRI Field
Harvesting


From SRI to System of Crop Intensification (SCI)
RECOMMENDED PRACTICES
UNDERLYING PRINCIPLES
1 Transplanting of young seedlings
Utilizing early vigour of young seedlings
2 Wider spacing
Reducing competition for light and nutrients
3 Single seedling per hill
Reducing external inputs in form of seeds, water, etc
4 Alternate wetting and drying with shallow irrigation
Keeping soil from becoming anoxic
5 Inter-cultivation with weeder
Promoting healthy root growth
6 Addition of organic matter
Increasing soil microbial activity and enhancing soil organic matter
SRI - Sustainable management of plants, soil, water and nutrients resulting in higher production with reduced external inputs which could also be extrapolated to other crops.
October 2015



Results of Trials on SWI under Different Spacing

Variety: HS 277		T-1	T-2	T-3
Parameter	Conv.	SWI	SWI	SWI
Line Distance		8x8	6 x 6	9 X 9
Plant Distance		8x8	6 x 6	-
No. of seed/hill		2 seeds	1 seed	
Total No. of plants	318	100	125	252
Total No. Productive Tillers	677	1400	1250	998
Average plant Hight (in cm)	73	84.5	82	83.6
Average Ear Length (in cm	11	13.2	13	9.3
Average No of grain/Ear	64	92	87	82
Grain Yield (T/ha)	3.0	**6.0**	3.3	**4.3**
Straw Yield (T/ha)	6.2	**8.3**	6.5	**7.0**

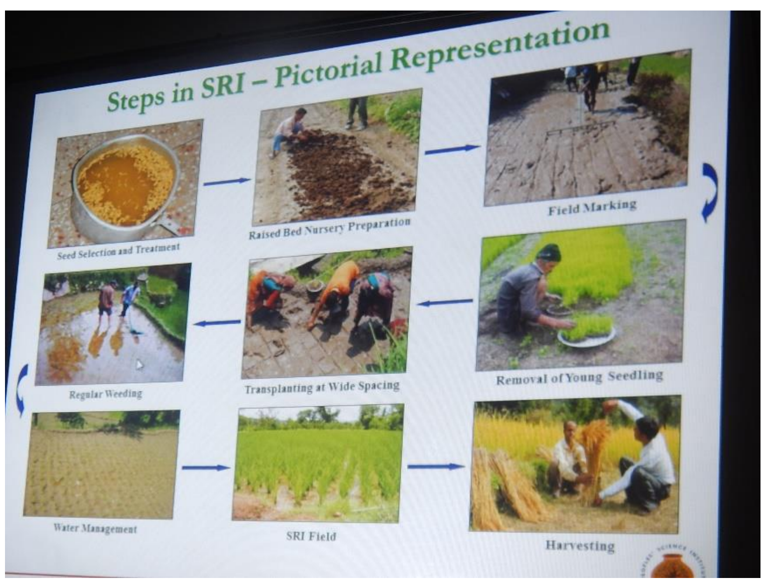


Results of SWI Trials on
Crop Performance
under inter cropping with Pulses

Parameter	T-1 Wheat (HS 277) + Masur (HPL 5)	T-2 Wheat (HS 277) + Gram (HPG 17)	T-3 Wheat (HS 277) + Masur (HPL 5) + Gram (HPG 17)
Line Distance	10 x 10	10 x 10	10 x 10
Crop Production	Wheat – 1.8 T/ha	Wheat – 1.9 T/ha	Wheat – 1.0 T/ha
Crop Production	Masur – 1.2 T/ha	Gram – 2.3 T/ha	Masur – 0.3 T/ha
Crop Production			Gram – 0.8 T/ha

October 2015


Promoting Strategy
Selection of Basins and Partner Organizations (POs)
Selection of villages and farmers
Capacity building of master trainers and village level resource persons
Training of farmers
Information dissemination through media
Field Support (including formation of Farmers' Groups)
Monitoring
Exposure Trips
Data Gathering & Dist. Workshops during Harvesting
State Workshops
Research
Networking
Advocacy
October 2015

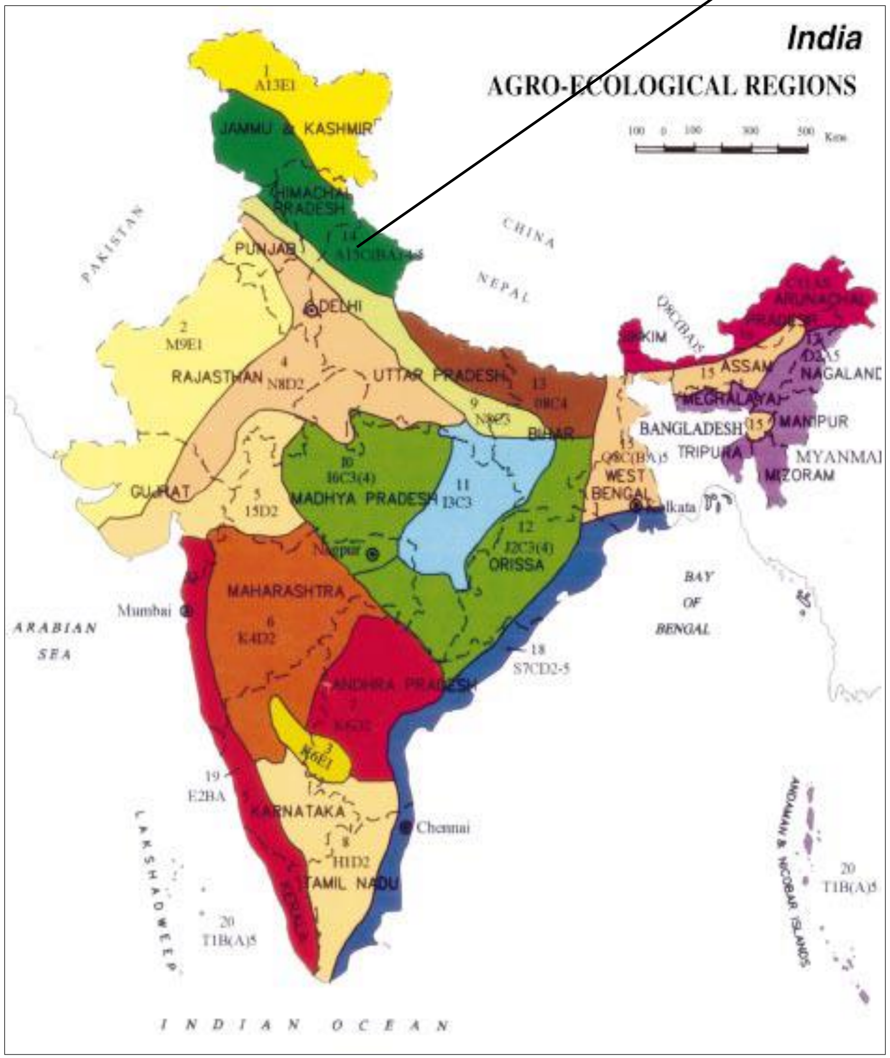

Steps in SRI – Pictorial Representation
Seed Selection and Treatment
Raised Bed Nursery Preparation
Field Marking
Removal of Young Seedling
Transplanting at Wide Spacing
Regular Weeding
Water Management
SRI Field
Harvesting

PROMOTING SYSTEM OF CROP INTENSIFICATION
IN
THE WESTERN HIMALAYAN REGION

PEOPLE'S SCIENCE INSTITUTE (PSI), DEHRADUN

October 2015

Farming in The Western Himalayan Region



- Highland Mixed Farming System along with agro-forestry & animal husbandry
- Diverse Cropping – Millets and Pulses (Un-irrigated), Wheat and Mustard (Irrigated)
- Isolated, fragmented and small landholdings (average – 0.4 ha/hh)
- Predominantly women farmers, use of family and shared labour
- Mostly utilization of local varieties, organic matter and hand tools
- Subsistence oriented agriculture with average rice-wheat yields < 2 T/ha

Farming System in Transition: Increased Mono-cropping, Decreased Crop Rotation, Decreased Draft Animals and Increased Off-Farm Activities

Rice Farming in Western Himalayas : Main Features

- Predominant kharif irrigated and un-irrigated crop
- Grown simultaneously with mixed crops in unirrigated fields
- Diverse methods (*Sathi*, *Bijwad* and *Saindha*) utilizing hand tools
- Multiple long duration (120-165 days) varieties, mostly local
- Limited availability of draft power forces hiring/sharing of bullocks
- Rituals associated with transplanting and harvesting of rice (*Din Bar*)
- Women's collectives (*Padiyals*) undertaking transplanting

Maximize Utilization of Diversity, Minimize Uncertainty, Rationalize Labour

Steps in SRI – Pictorial Representation

Seed Selection and Treatment

Raised Bed Nursery Preparation

Field Marking

Regular Weeding

Transplanting at Wide Spacing

Removal of Young Seedling

Water Management

SRI Field

Harvesting

Promoting System of Crop Intensification (SCI)

Goal - To enable farmers of Himachal Pradesh and Uttarakhand from the Western Himalayan Region (and now even Bundelkhand Region) to enhance food and livelihood security through promotion of SCI

Objectives -

- Undertake capacity building of farmers to adopt the SRI principles and practices for paddy, wheat and other cops.
- Build the capacities of local voluntary organizations by creating a talent pool of master trainers for promoting SCI.
- Help formulate state agricultural policy for promoting the extension of SCI.

Promoting Strategy

Selection of Basins and Partner Organizations (POs)

↓

Selection of villages and farmers

↓

Capacity building of master trainers and village level resource persons

↓

Training of farmers

↓

Information dissemination through media

↓

Field Support (including formation of Farmers' Groups)

↓

Monitoring

↓

Exposure Trips

↓

Data Gathering & Dist. Workshops during Harvesting

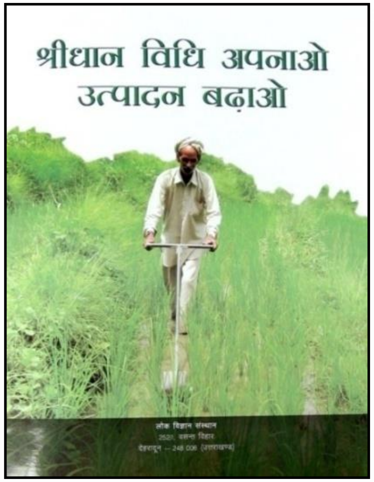
↓

State Workshops

- **Research**
- **Networking**
- **Advocacy**

Communication Materials & Information Dissemination

- **Advertisements spots in Doordarshan**
- **User-friendly manual on SRI (in Hindi) for farmer**
- **Poster sets on SRI (in Hindi) for MTs and VLRPs**
- **Film on SRI (in Hindi)**



Results of SRI Trials in Himachal Pradesh & Uttarakhand (2006 - 08)

Particulars	2006		2007		2008	
	Conventional	SRI	Conventional	SRI	Conventional	SRI
No. of Farmers (Villages)	40 (25)		591 (133)		12,214 (496)	
Area (ha)	-	0.95	-	15.00		252.98
Average Grain Yield (Q/ha)	31.5	52.5	28.5	54	39.5	60.5
Per Cent Increase in Grain Yield	-	67	-	89	-	53
Average Straw Yield (Q/ha)	58	72.5	55	73.5	110.5	145
Per cent Increase in Straw Yield	-	25	-	34	-	31

The average percent increase in grain yield was about 70 per cent

SRI: Comparing Normal and Drought Years

S. No.	Particulars	Normal Year (2006-2008)		Drought Year (2009)	
		Conventional	SRI	Conventional	SRI
1	Average no. of effective tillers/ Plant	7	21	5	18
2	Average Plant Height (cm)	99	122	88	102
3	Average Panicle Length (cm)	18	24	19	25
4	Average No. of Grains/Panicle	93	177	90	174
5	Grain Yield (Q/ha)	**36**	**55**	**25**	**48**
6	Straw Yield (Q/ha)	**111**	**145**	**51**	**85**

The grain yields of conventional crop decreased by 31% as compared to reduction of only 13% in SRI crop.

In the drought year while non-SRI yields stood close to 25 quintals per ha, the SRI yields were about 48 quintals per ha (average increase of 92 %).

SRI- Farmers' Perceived Benefits & Constraints

A. BENEFITS

- Less seed requirement
- Less use of chemical fertilizers
- Less disease occurrence
- Early maturity
- High grain yields
- High grain quality
- Increased biomass
- Improves soil fertility

B. CONSTRAINTS

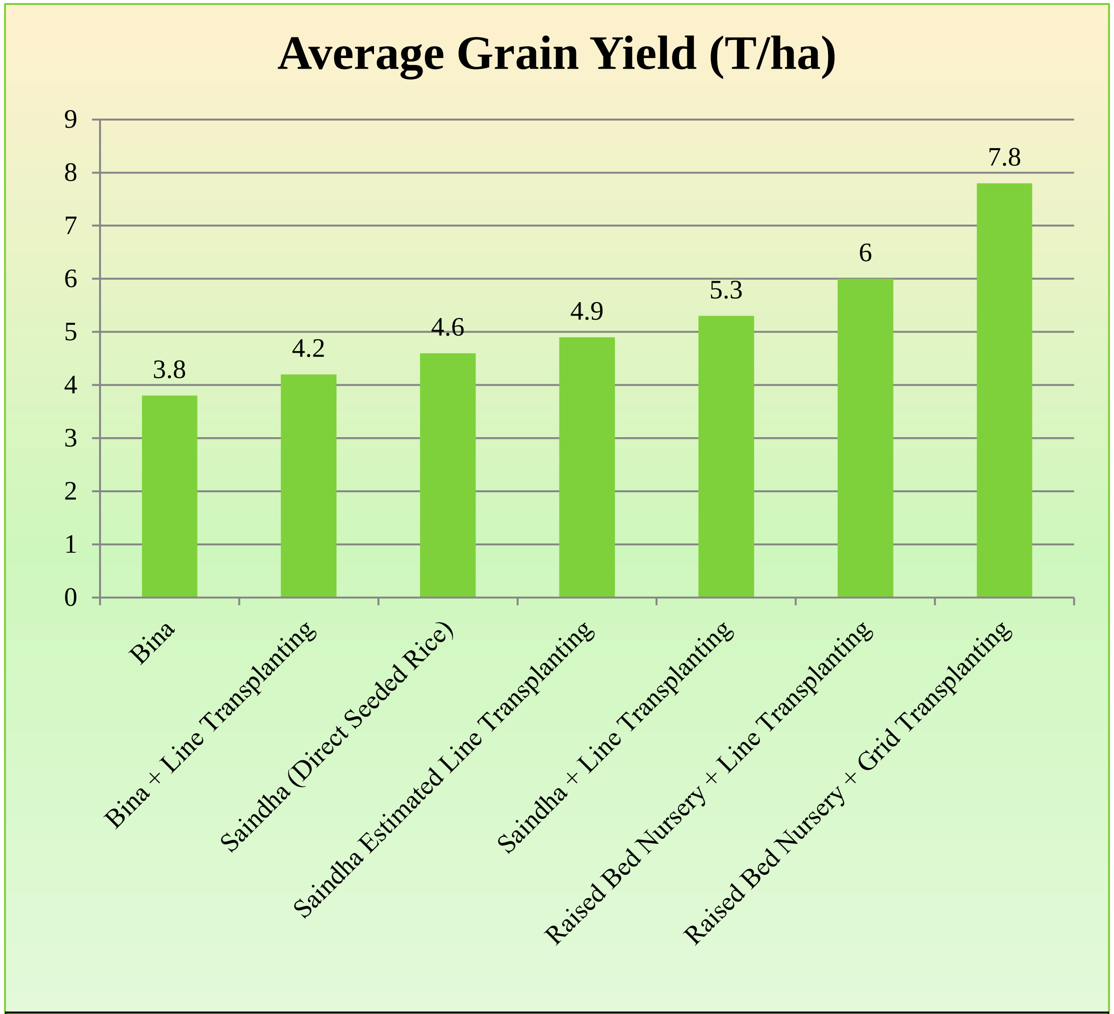
- Difficulty in changing mindset
- Time bound operations
- Labour intensive in initial years
- Unavailability of irrigation and rainfall aberrations
- Limited availability of quality equipment
- Inadequate compost material
- More effort required in operating weeder for small terraces & clayey soil
- Lack of timely quality training & field support

SRI cannot be promoted as a set of rigid practices -ADAPTATIONS

Modified SRI Practices

SRI Concept	Recommended SRI Practices	Farmers' Modified SRI Practices
Young Seedlings	8-12 days' old seedlings	12-25 days' old seedlings
1 Seedling/Hill	1 seedling/Hill	1 - 4 seedlings/ Hill
Wider Spacing	Row to Row: 25 cms Plant to Plant: 25 cms	Row to Row: 20 - 25 cms Plant to Plant: 15 - 25 cms
Alternate Wetting and Drying	Alternate Wetting and Drying	Flooded Condition (5-10 cms of water)
Inter-cultivation with weeder	Use of Mandva weeder at 10, 20 and 30 days	Use of Mandva weeder as per convenience (not more than two times) + hand weeding
Use of organic types of fertilizers	Use of liquid organic manures i.e. *Panchgabya*, *Amritghol*, *Matkakhad* prior to weeding	Use of *Panchgabya* as per convenience

Introduction of SRI Results in Diverse Practices



Source: Crop Cutting of 205 rice fields, Kharif 2011

Modified management practices led to an incremental yield of 5-70 %

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From SRI to System of Crop Intensification (SCI)

	RECOMMENDED PRACTICES	UNDERLYING PRINCIPLES
1	Transplanting of young seedlings	Utilizing early vigour of young seedlings
2	Wider spacing	Reducing competition for light and nutrients
3	Single seedling per hill	Reducing external inputs in form of seeds, water, etc
4	Alternate wetting and drying with shallow irrigation	Keeping soil from becoming anoxic
5	Inter-cultivation with weeder	Promoting healthy root growth
6	Addition of organic matter	Increasing soil microbial activity and enhancing soil organic matter

SRI - Sustainable management of plants, soil, water and nutrients resulting in higher production with reduced external inputs which could also be extrapolated to other crops.

Initial Crops for SCI Trials (2006-08)

Wheat

Finger Millet

Kidney Bean

Adaptations for Wheat, Finger Millet & Kidney Bean

Practice	Wheat	Finger Millet (Mandwa)	Kidney Bean (Rajma)
Young Seedlings	Direct seed sowing in line	Direct seed sowing in line / Transplanting of 15-20 days old seedlings	Direct seed sowing in line
Wider Spacing	P to P : 15/20cm R to R : 15/20 cm	P to P : 20 cm R to R : 20 cm	P to P : 25 cm R to R : 30 cm
Single Seedling / hill	1-2 seed per hill	Line sowing or 1 seedling/hill	1-2 seed/ hill
Inter Culture	2+ (manual weeding/ weeder/rake)	2+ (manual weeding)	2+ (manual weeding)
Organic Matter	Compost + PAM	Compost + PAM	Compost + PAM

PAM: Panchgavya, Amritghol, Matkakhad

Results of Trials on Initial Crops (2006-08)

	2006			2007			2008		
Crop	No. of Farmers (Area in Ha)	Conv. Grain Yield (Q/ha)	SCI Grain Yield (Q/ha) % Incr.	No. of Farmers (Area in Ha)	Conv. Grain Yield (Q/ha)	SCI Grain Yield (Q/ha) % Incr.	No. of Farmers (Area in Ha)	Conv. Grain Yield (Q/ha)	SCI Grain Yield (Q/ha) % Incr.
Wheat (I)	Research Farm (5.0 Ha)	16	22 (38%)	30 (0.224 Ha)	23.5	42.5 (81%)	557 (14.5 ha)	24.4	48 (97%)
Wheat (UI)	-	-	-	19 (0.086 Ha)	15.5	25 (61%)	491 (6.7 Ha)	17.7	32.1 (81%)
Mandwa	-	-	-	5 (0.40 Ha)	18	24 (33%)	43 (0.80 Ha)	15	24 (60%)
Rajma	-	-	-	5 (0.40 Ha)	14	20 (43%)	113 (2.26 Ha)	18	30 (67%)

Average percent increase in grain yield was more than 60 per cent

Trials on Additional Kharif Crops (2009 & 2010)

Maize

Black Gram

Soyabean

Adaptations for Maize, Black Gram & Soyabean

Practice	Conventional	SCI Maize	SCI Black Gram	SCI Soyabean
Young Seedling	Direct seed Sowing	Direct seed sowing in line	Direct seed sowing in line	Direct seed sowing in line
Spacing	Broadcasting	P to P : 30 cm R to R : 30 cm	P to P: 25 cm R to R: 30cm	P to P : 30 cm R to R : 30 cm
Single Seedling/ hill	-	1-2 seed/hill	1-2 seed/ hill	1-2 seed/hill
Inter-Culture	1+ (manual weeding)	3+ (manual weeding)	2+ (manual weeding)	2+ (manual weeding)
Organic matter	Compost	Compost, PAM	Compost, PAM	Compost, PAM

Results of Trials on Kharif Crops (2009-10)

Particulars	Finger Millet		Maize		Black Gram		Soyabean		Kidney Bean	
	Conv.	SCI	Conv.	SCI	Conv.	SCI	Conv.	SCI	Conv.	SCI
Avg. no. of ears/plant or cobs/plant or pods/plant	3	5	2	3	46	79	35	56	36	55
Average Plant Height (cm)	69	87	142	177	42	56	47	66	160	210
Average no. of grains /ear or corns/cob or grains/pod	310	493	230	380	4	5	3	4	5	7
Grain Yield (T/ha)	1.2	2.2	2.0	3.5	0.85	1.4	2.2	3.3	1.3	1.9
% Inc. in Grain Yield	-	**83**	-	**75**	-	**65**	-	**50**	-	**46**

The average percent increase in grain yield was more than 45 per cent

Trials on Additional Rabi Crops (2009 & 2010)

Mustard

Peas

Gram

Adaptations for Mustard, Peas and Gram

Practice	Conventional	SCI Mustard	SCI Peas	SCI Gram
Young Seedling	Direct seed Sowing	Direct seed sowing in line	Direct seed sowing in line	Direct seed sowing in line
Spacing	Broadcasting	R to R : 15/20 cm	P to P: 20 cm R to R: 30 cm	P to P : 15-20 cm R to R : 30-45 cm
Single Seedling/ hill	-	1-2 seed/hill	1-2 seed/ hill	1-2 seed/hill
Inter-Culture	1+ (manual weeding)	2+ (manual weeding)	2+ (manual weeding)	2+ (manual weeding)
Organic matter	Compost	Compost, PAM	Compost, PAM	Compost, PAM

Results of Trials on Rabi Crops (2009-10)

Particulars	Wheat		Mustard		Peas		Gram	
	Conv.	**SCI**	**Conv.**	**SCI**	**Conv.**	**SCI**	**Conv.**	**SCI**
Avg. no. of tillers/hill or siliquae/pods per plant	2	10	105	150	53	61	33	40
Average Plant Height (cm)	83	105	150	275	19	27	9	14
Average no. of grains /panicle or seed/siliquae or grains /pod	39	60	10	15	3	5	1	2
Grain Yield (T/ha)	2.8	5.1	1.4	2.0	21.3	30.2	0.9	1.3
% Inc. in Grain Yield		**82**		**42**	-	**42**	-	**44**

Average percent increase in grain yield was more than 40 per cent

Results of Trials on SWI under Different Spacing

Variety: HS 277		T-1	T-2	T-3
Parameter	Conv.	SWI	SWI	SWI
Line Distance		8x8	6 x 6	9 X 9
Plant Distance		8x8	6 x 6	-
No. of seed/hill		2 seeds	1 seed	
Total No. of plants	318	100	125	252
Total No. Productive Tillers	677	1400	1250	998
Average plant Hight (in cm)	73	84.5	82	83.6
Average Ear Length (in cm	11	13.2	13	9.3
Average No of grain/Ear	64	92	87	82
Grain Yield (T/ha)	3.0	**6.0**	3.3	**4.3**
Straw Yield (T/ha)	6.2	**8.3**	6.5	**7.0**

Results of SWI Trials on Crop Performance under inter cropping with Pulses

	T -1	T -2	T-3
Parameter	Wheat (HS 277) + Masur (HPL 5)	Wheat (HS 277) + Gram (HPG 17)	Wheat (HS 277) + Masur (HPL 5) + Gram (HPG 17)
Line Distance	10 x 10	10 x 10	10 x 10
Crop Production	Wheat – 1.8 T/ha	Wheat – 1.9 T/ha	Wheat – 1.0 T/ha
Crop Production	Masur – 1.2 T/ha	Gram – 2.3 T/ha	Masur – 0.3 T/ha
Crop Production			Gram – 0.8 T/ha

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Results of Trials on Maize with Different Spacing (cm)

Parameters	Average Plant Height (cm)	Average Grains/Cob	Average Cob Length (cm)	Grain Yield (T/Ha)
50-50 X 50-05 (T-1)	185	322	25	5.7
40-40 X 40-40 (T-2)	192	356	29	**6.5**
30-30 X 30-30 (T-3)	187	297	23	5.8
Line sowing (T-4)	193	255	20	4.8
Farmers' Practice (T-5)	155	191	17	2.3

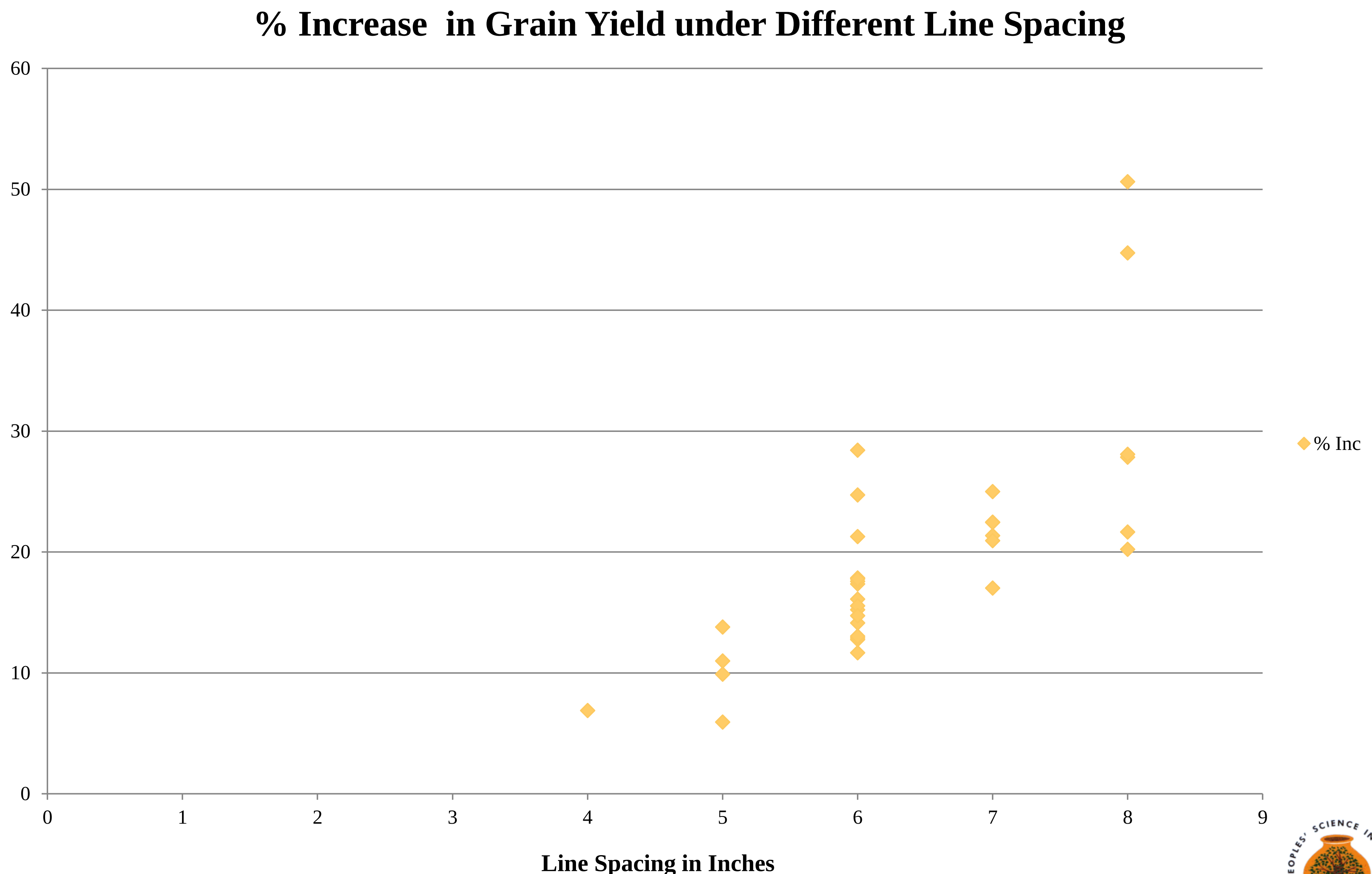
Note: Line to Line, 30cm

Results of Trials on Maize with Different No. of Seeds

Parameters	Average Plant Height (cm)	Average Grains/Cob	Average Cob Length (cm)	Grain Yield (T/Ha)
One seed (T-1)	227	341	28	**6.1**
Two Seed (T-2)	188	309	25	5.3
Farmers' Practice (T-3)	171	215	20	2.8

Note: Line to Line 40cm , Plant to Plant 40 cm.

Direct Seeded Rice (Kharif 2015)



Cost Benefit Analysis for SCI Crops and Conventional method of Cultivation

S. No.	Method	Conventional				SCI			
		Total Expen-diture (Rs./ha)	Gross Income (Rs./ha)	Net Profit (Rs./ha)	C-B Ratio	Total Expen-diture (Rs./ha)	Gross Income (Rs./ha)	Net Profit (Rs./ha)	C-B Ratio
1	Direct seed sowing (Wheat)	22,720	30,600	7,880	1:1.3	25,850	51,600	25,750	1:2.0
2	Finger Millet (Mandwa)	14,920	25,900	10,980	1:1.7	15,640	34,400	18,760	1:2.2
3	Kidney Bean (Rajma)	28,250	56,000	27,775	1:2.0	30,250	80,000	49,750	1:2.6
4	Mustard	21,630	32,000	10,370	1:1.4	17,500	48,000	30,500	1:2.7

B:C Ratio is more than 2:1 for most SCI crops

SRI Changing Rural Landscape

- Conventional methods as well as SRI undergo changes
- Application of SRI practices on other crops like wheat
- Emergence of new task groups – MTs/VLRPs
- Higher Participation of children and men folk in rice cultivation
- Reduced work load for women for nursery operations
- Cultural rules and routines undergoing changes
- Specific agro-ecological context influence transitions

Critical Areas for Upscaling SCI

- Improvements in package of practice (water, nutrient, and labour management, cost effective equipment, etc.).
- Capacity building strategy (village level resource persons and regular quality training).
- Capacity building of government extension personnel (CAOs, ADOs and persons at Nyay Panchayat level).
- Research (other crops, disease resistant and tillering varieties, equipments, etc.).

- Networking amongst stakeholders (farmers, CSOs, government, research institutions, agriculture universities, media, etc.).
- Policy Framework (incentives, assured irrigation, outlets for equipment, market, etc.).

Provide flexibility for adapting different principles under SCI

Upscaling Approach

Av. Family Size : 5-6 members/household

Av. Landholding: 0.4 ha/household (UKD); 0.1ha irrigated (5 nalis)

	Daily Per Capita Req. (gm/p/d)	**Total Annual HH Req. (T)**	**Average SCI Production (T/ha/season)**	**Target Area Coverage (Ha/ HH)**
Cereals	420	0.85-1.00	3.0 = 120 kg/nali/yr	0.14 = 7 nalis
Pulses	40	0.08-0.09	1.5 = 60 kg/nali/yr	0.03 = 1.5 nalis

POTENTIAL TO ADDRESS THE FOOD SECURITY AND LIVELIHOOD NEEDS OF SMALL AND MARGINAL FARMERS

Adoption of SCI in 3.25 lakh ha (45% of NSA) in UKD and in 1.31 lakh ha (23% of NSA) in HP can lead to states' foodgrain security

PSI's Future Strategy

- Enhance household level food security by increasing land under SCI by each farmer
- Expand SCI as livelihoods promotion activity through committed VOs
- Expand SCI to rainfed areas through developing location specific optional package of practices
- Capacity building of MTs, VLRPs and farmers on varietal selection, seed treatment and crop protection
- Formation and capacity building of farmers groups

Develop strategies for making SRI demand driven

Thank You

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Crop Establishment - Deviations

Recommended SRI Practices	Farmers' Modified SRI Practices	Reasons for Deviations
8-12 days' old seedlings	9-26 days' old seedlings	• Difficult to handle young seedlings • Young seedlings prone to insect damage • Young seedlings prone to water rot • Unavailability of water, bullocks & other agricultural operations cause delay
1 seedling/Hill	1 - 4 seedlings/ Hill	• Risk coping strategy against mortality • Number of seedlings increased according to age
Row to Row : 25 cms Plant to Plant : 25 cms	R-R: 20 - 30 cms P-P: 12.5 - 25 cms	• Cross Marking is difficult • Transplanting within grid is difficult

Crop Management – Deviations

Recommended SRI Practices	Farmers' Modified SRI Practices	Reasons for Deviations
Alternate Wetting and Drying	Flooded Condition (5-10 cm of water)	• Poor drainage and heavy rains • Scattered landholdings • Flooding controls insect damage • Flooding curbs weed growth
Use of Mandva weeder at 10, 20 and 30 days	Use of weeder as per convenience (not more than 2 times) + hand weeding	• Delayed due to other agricultural operations • Third weeding leads to cutting of tillers • Weeder operation difficult in sandy soil
Use of 3 types of liquid organic manures	Use of only *Panchgabya* 1-3 times at10-20 days interval	• Preparation of *Panchgabya* is time taking and requires costly ingredients • *Panchgabya* flows away

Farmers' Decision Making Process

- Whether to adopt SRI or not ?
- How many and which fields to be brought under SRI ?
- What practices to adopt or reject ?

MATERIAL FACTORS

- **Soil – Type, Biota….**
- **Water - Supply, Temp…..**
- **Variety**
- **Micro-Climate**
- **Plot- Size, Shape & Access**
- **Manure/Fertilizer**
- **Tools**
- **Present Cropping Practice**

SOCIAL FACTORS

- **Labour**
- **Bullock Ownership**
- **Group Affinity**
- **Social Status**
- **Economic Status**
- **Relationship with MT/VLRP**
- **Culture**
- **Policy**

Practices are contextual, resulting from negotiations & compromises

Field Support Activities

Seed Treatment

Mulching

Marking

Transplanting

Field Support Activities

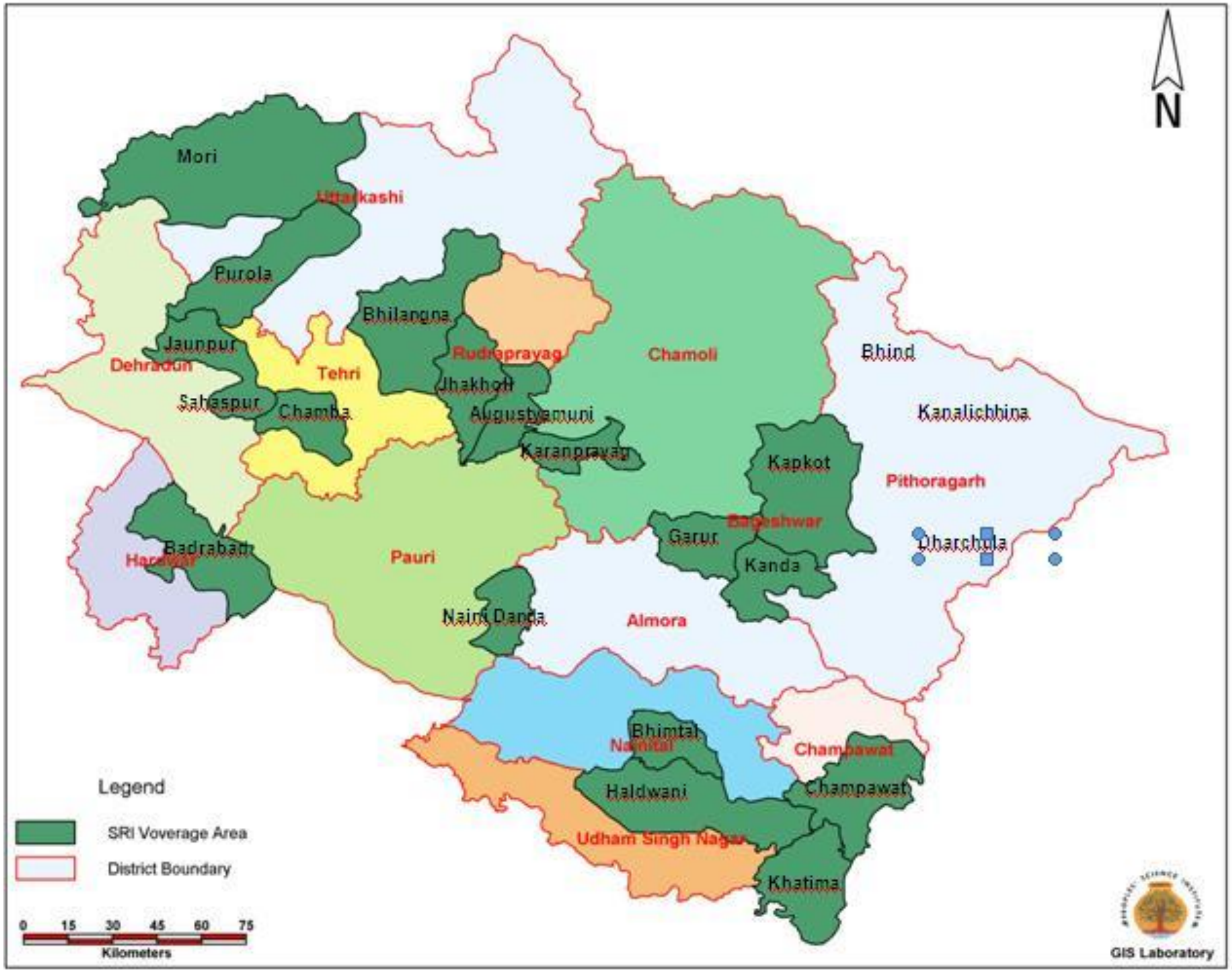
Standing Crop

Farmers' Interactions

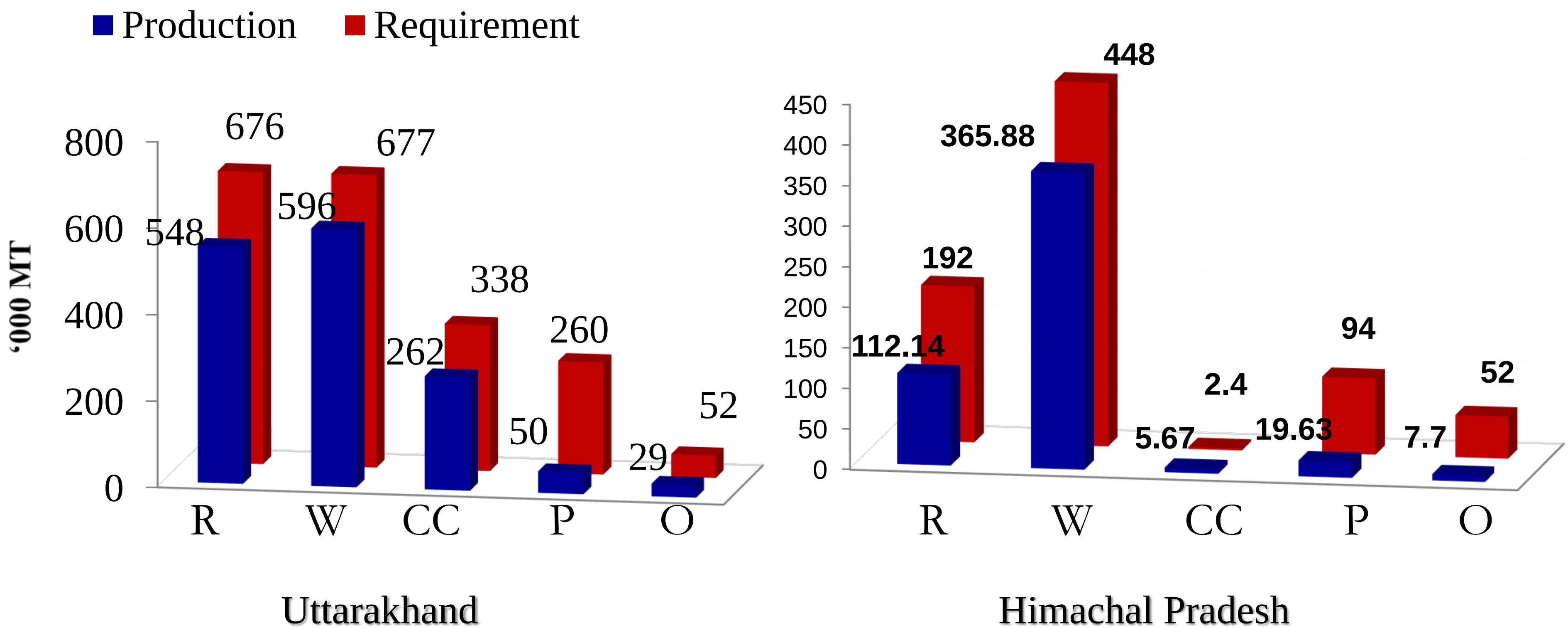
Monitoring

Crop Performance

SRI Coverage Area



Uttarakhand and Himachal Pradesh: Food Deficit States

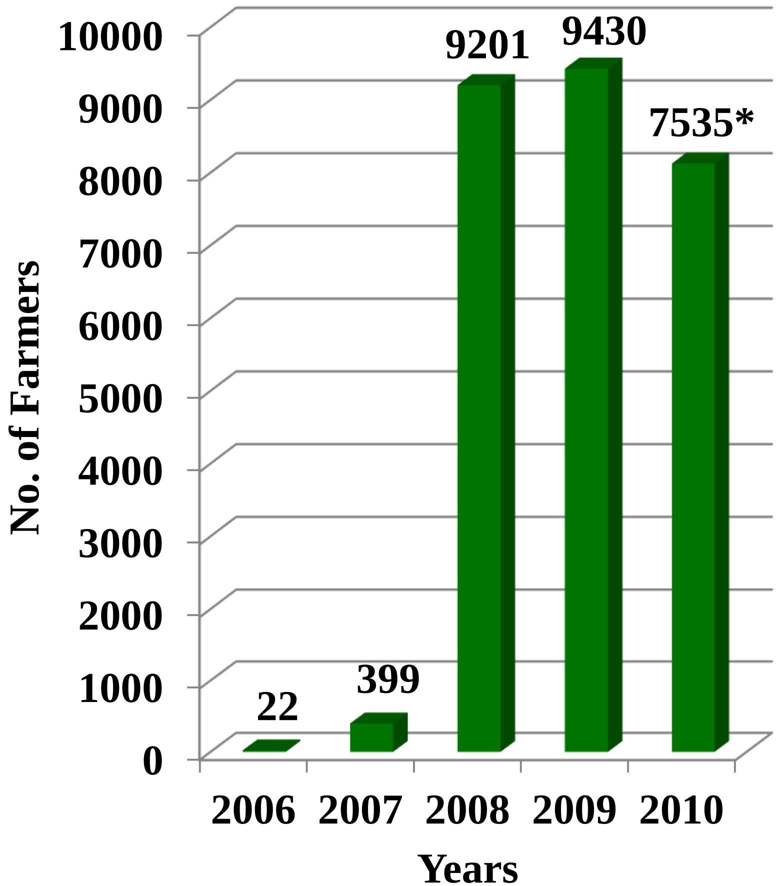


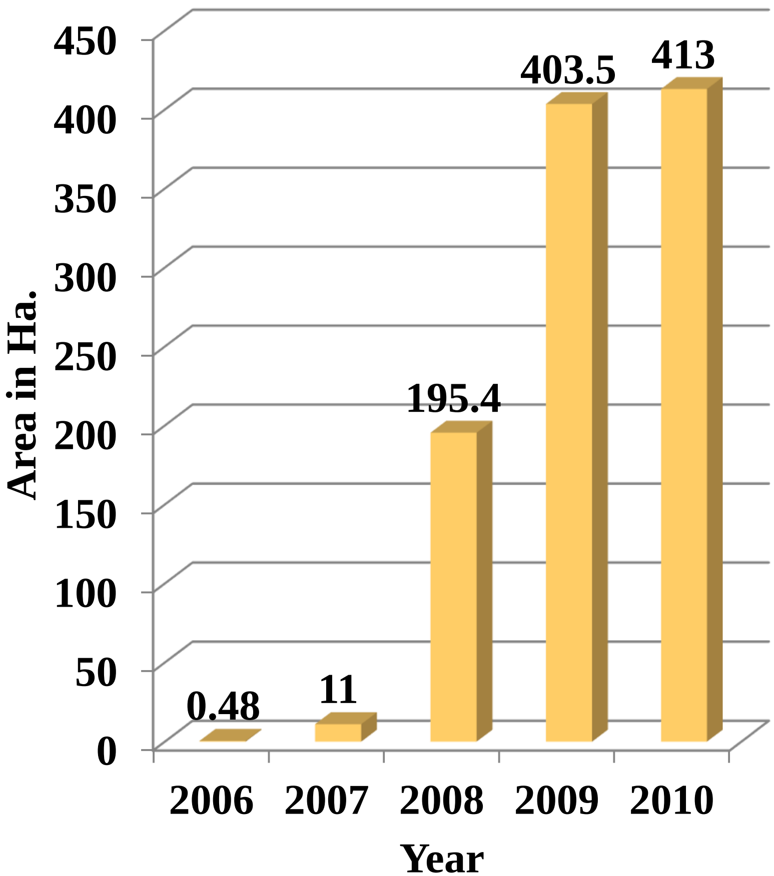
R- Rice W-Wheat CC- Coarse Cereals P- Pulses O- Oilseed

Source: Uttarakhand at a Glance, 2008

Source: Statistical Outline of H.P., 2008

SRI Farmers and Area Coverage in Uttarakhand (2006 to 2010)



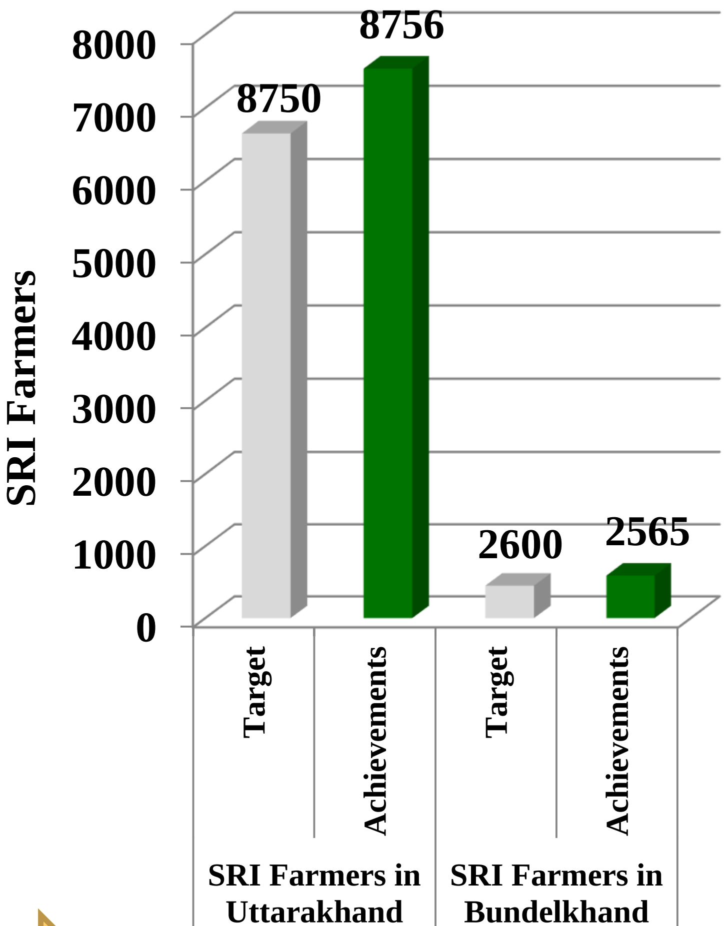


Others POs added 9621 farmers
Total No. of Farmers : 17,156

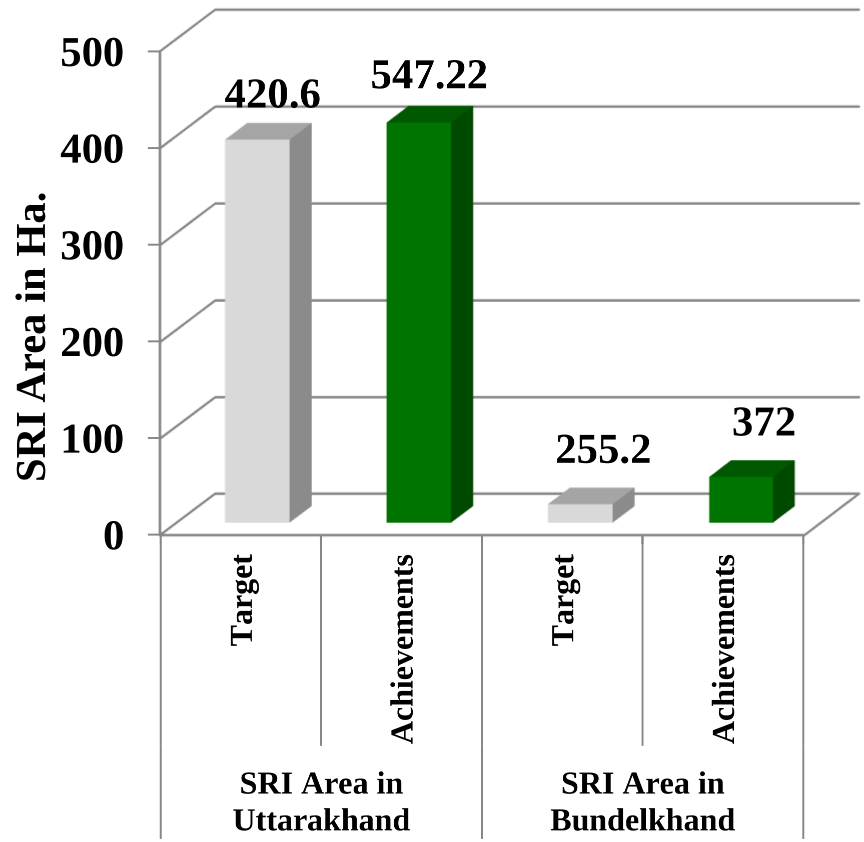
Others POs covered 544.9 Ha.
Total Coverage : 958 Ha (2.8 Nalis/HH)

SRI Target and Achievement : Kharif 2011

No. of SRI Farmers in UKD & BKD



Area Coverage in UKD & BKD



Coverage : UKD- 0.062 ha per farmer (3.1 nali/ farmer)

BKD-0.14 ha per farmer

SRI Crop Performance - Kharif 2011 (UKD)

Particulars	Conventional	SRI
No. of Effective Tillers/ hill	256	407
Average Plant Height (cm)	104	120
Average Panicle Length (cm)	19	25
Average no. of grains /Panicle	113	191
Grain Yield (Q/ha)	24	59
Straw Yield (Q/ha)	99	144
% Inc. in Grain Yield	-	**73**
% Inc. in Straw Yield	-	**45**

SRI Crop Performance - Kharif 2011 (BKD)

Particulars	Conventional	SRI
Total no. of tillers / hill	10	25
No. of Effective Tillers/ hill	9	23
Average Plant Height (cm)	96	86
Average Panicle Length (cm)	21	26
Average no. of grains /Panicle	117	206
Grain Yield (Q/ha)	47	75
Straw Yield (Q/ha)	133	173
% Inc. in Grain Yield	-	**60**
% Inc. in Straw Yield	-	**30**

Updated Status of Rabi 2011-12

S.No.	Name of Districts	Name of POs	No. of villages	Total Achieved framers (SWI)
1	Tehri Garhwal	JVS	5	125
2	Tehri Garhwal	CVS	3	0
3	Rudraprayag	PNVS	8	410
4	Uttarkashi	HENSAR	13	189
5	Uttarkshi	SRADHA	5	190
7	Bageshwer	HT	10	375
8	Bageshwer	KSS	11	754
9	Almora	BSLKS	5	50
10	Almora	LA	5	50
11	Almora	BVVM	5	75
12	Nainital	PGVS	5	0
13	Nainital	VIMARSH	9	87
	Uttarakhand		**84**	**2305**
14	Chitrakoot	GPVS	8	300
15	Panna	KSS	32	350
16	Damoh	GVS	14	600
	Bundelkhand		54	1250
Total		**15**	**138**	**3556**

Coverage under SCI Rabi Crops (2009 & 2010)

		2009		2010	
S. No.	Name of crops	Total Farmers	Area (in Ha)	Total Farmers	Area (in Ha)
1.	Wheat	4151	84.03	8237	364.79
2.	Mustard	68	1.74	227	10.34
3.	Peas	215	3.92	325	10.86
4.	Lentil (Masur)	31	1.88	232	9.05
5.	Gram	48	2.68	188	8.82
6.	Others (Onion, Garlic, etc.)	82	1.46	84	2.15
Total		**4595**	**95.71**	**9293**	**406.01**

Coverage under SCI Kharif Crops (2009 & 2010)

		2009		2010	
S. No.	**Name of crops**	**Total Farmers**	**Area (in Ha)**	**Total Farmers**	**Area (in Ha)**
1.	Maize	183	10.34	582	63.61
2.	Kidney bean (*Rajma*)	679	14.01	598	11.36
3.	Finger Millet (*Mandwa*)	340	8.04	747	15.66
4.	Black gram (*Urad*)	314	2.00	121	3.28
5.	Soyabean	77	2.47	298	7.32
6.	Others (Tomato, French bean , etc.)	111	5.12	109	6.60
Total		**1,704**	**41.98**	**2,455**	**107.83**

Problems/ Constraints

- Drop out by one PO
- Unavailability of funds
- Lack of farmers friendly equ.
- Crop damage by wild animals
- Inadequate irrigation facilities
- Higher cost of organic manures
- Less focus on seed selection
- Less focus on rain fed areas
- Less focus on other crops
- Delay in the process of formation of farmers groups

PEOPLES' SCIENCE INSTITUTE

Issues for Discussion

- Household food security
- Irrigated land vs rain fed area
- Area specific Package of Practices
- Principles, flexibility and non negotiables
- Analysis of adoption and dis adoption
- Labor saving vs labor intensive
- Farmers friendly equipments
- Farmers groups and federation
- Involvement / Support from Agriculture department
- Convergence
- Media and mass communication

Future Strategy

- To ensure the household food security by increasing the per farmer land under SRI
- Expand SRI to new potential areas
- Develop package of practices for rain fed areas
- Expand SRI to rain fed areas
- Capacity of MTs, VLRPs and farmers on seed selection and crop protection
- Up scaling of other crops
- Capacity building of farmers groups
- Develop strategies for making SRI demand driven

SCI – A Boon for Mountain Farmers

- 88% of farmers are small and marginal farmers with less than 0.4 ha (1 acre) per family.
- Rice and wheat are the staple food of the populace.
- Higher stalk volume means more fodder for the cattle.
- More farmyard manure and possibly increased milk yields.

POTENTIAL TO ADDRESS THE FOOD SECURITY AND LIVELIHOOD NEEDS OF SMALL AND MARGINAL FARMERS

PSI's Upscaling Strategy for SRI (2011-12)

Goal – To ensure effective promotion of SCI cultivation of paddy, wheat and other grains in Uttarakhand and Bundelkhand by expanding the area under cultivation by repeat farmers and reaching out to new farmers in 12 districts (8 mountain districts in Ukd and 4 in Bkd).

Objectives:

- **Train 18,175 farmers** : Ukd (14,140) and Bkd (4035)
- **Expand the area coverage:** from 513 ha to about 1070 ha
- **Build the capacities:** of V Os in Ukd and Bkd and create a talent pool
- **Motivate all stakeholders:** PSI, POs' MTs, VLRPs, farmers
- **To form farmer groups:** to collectively focus on the gamut of problems and influence the state agricultural policy for wide scale extension of SCI.

Training of Master Trainers and Village Level Resource Persons (Kharif 2011)

Classroom Sessions

Practical Exercises

- Eight 2-days' training workshops conducted (UKD- 6, BKD-2)
- 54 Master Trainers (UKD-41, BKD-13)
- 161 VLRPs (UKD-124, BKD -37)

Capacity Building of Farmers (Kharif 2011)

- **240 Orientation Workshops**
  (UKD- 177, BKD-63) focusing on

- **12,766 farmers trained (Target 11,350)**
  UKD : 9739 (Target 7700)
  BKD : 3027 (Target 2600)

Details of achieved farmers and area for Kharif season 2011

S.No.	Name of Districts	Name of POs	No. of Farmers		Area (Ha.)	
			Target	Achieved	Target	Achieved
1	TehriGarhwal	JVS	503	553	20.21	15.14
2		CVS	200	250	9	9.24
3	Rudraprayag	PNVS	2220	2257	125.4	210.54
4	Uttarkashi	HISAR*	225	235	8.25	4.7
5		SRADHA	500	470	17.5	15.8
6	Pauri	BVSS	580	500	30.6	56.5
7		HIRA	250	284	5	4.3
8	Bageshwar	HT	600	660	34.8	30
		PLVS	100	45	2	1.23
9		KSS	1500	1524	72.75	93.84
10		Hitaisy	100	--	--	--
11	Pithoragarh	SWATI	1000	950	57.6	54.7
12	Almora	BSLKS	300	306	13.45	19
13		BVVM	100	90	2	1.8
15		Laxmi A	100	102	2	2.3
16	Nainital	VIMARSH	100	35	2	0.4
17		PGVS	472	495	18.04	28.43
	UTTARAKHAND		**8850**	**8756**	**420.6**	**547.22**
18	Chitrakoot	GPVS	400	325	41.92	32
19	Banda	AS	200	120	23.44	10
20	Panna	KSS	1000	820	93.6	80
21	Damoh	GVS	1000	1300	96.24	250
	BUNDELKHAND		**2600**	**2565**	**255.2**	**372**
	Total		**11450**	**11321**	**675.8**	**919.92**

Extension & Policy Advocacy (Kharif 2011)

Exposure Visits

- Exposure visits of farmers from neighboring villages organized before the harvesting of the paddy crop.

Experience-sharing Workshops

- Eight district-level experience-sharing workshops organized at the time of harvesting of the paddy crop to popularize and extend the SRI method in the state.

Programme Monitoring

- PSI's resource staff regularly visits programme areas for monitoring and guidance.
- A state level programme advisory committee (PAC) of experienced persons constituted, including experts, govt. officials, scientists.
- PAC reviews the programme through field visits and holds meetings with the programme staff.
- Agriculture Department and KVK officials invited to crop cutting events.

- the process of getting farmers to try SRI techniques on a variety of crops (is/was there a reluctance at first? how has awareness spread?)
- how exactly has SRI has been adapted from rice to apply to wheat, and other different (non-grass) crops such as tomatoes (ie. how much new knowledge and technical variation is necessary for each type of crop?)
- to what extent is this a farmer-driven process, or a taught system?
- where is the experimentation/innovation happening, and why? (Specific regions in India and elsewhere?) Who is supporting it (NGOs, local/national government policy support?)
- to what extent have the larger, international development organisations taken notice? Do you think they could play a role?

On Farm Research on SCI

- Trials on SWI crop performance under direct seed sowing with different spacing
- Trials on other crops like mustard, gram, peas, lentil etc.
- SWI trials on crop performance under inter cropping with pulses crops
- Trials on newly designed seed drill

WSRP

SWI-Intercropping, 2013

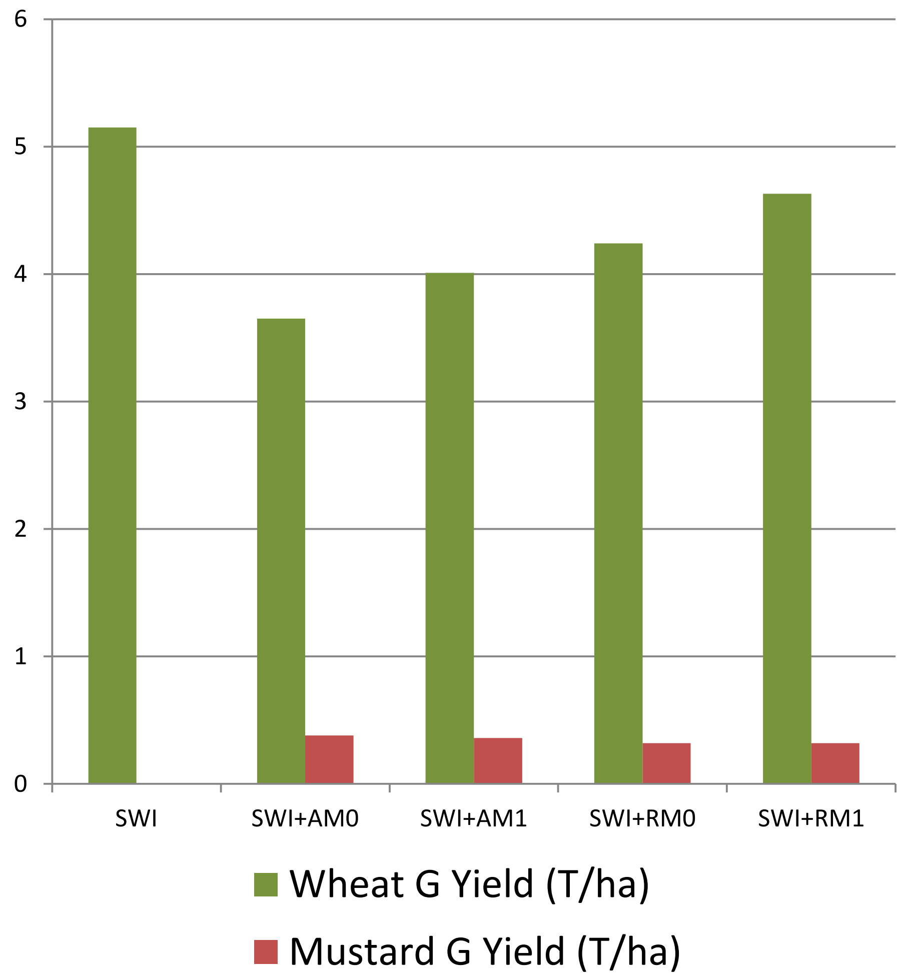
Objective: To study the effect of intercropping in SWI on wheat and mustard yields and economics

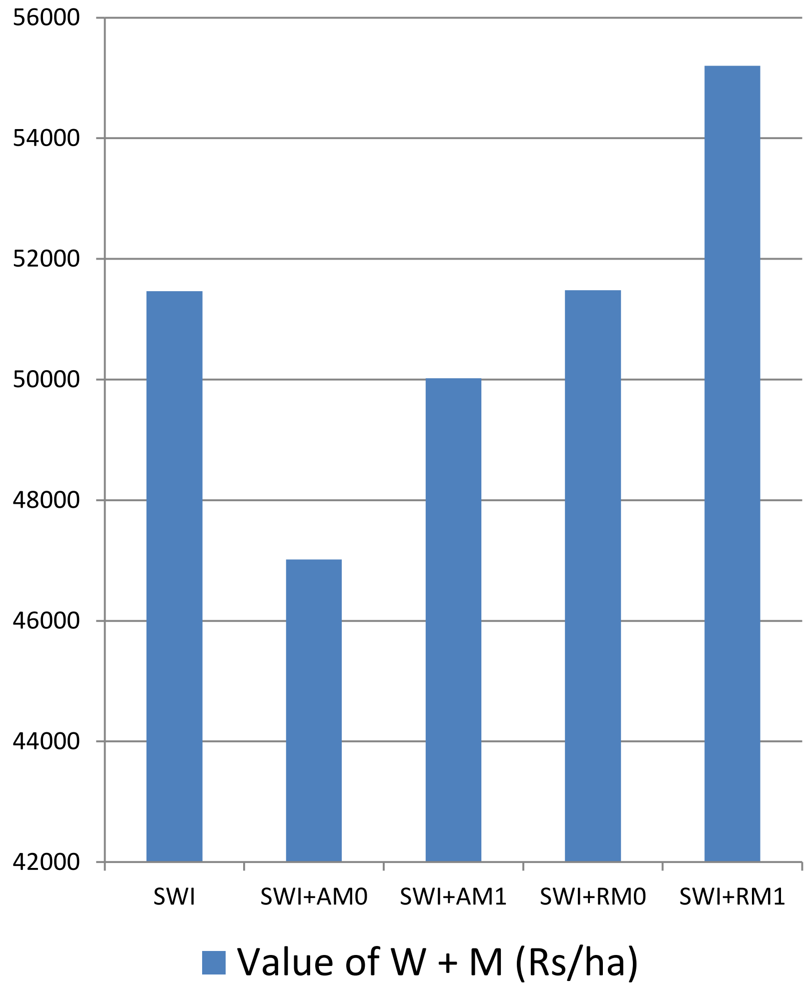
SWI (8” x 8”)	SWI + AM0 (Additional Mustard sown along with wheat)	SWI+ AM1 (Additional Mustard sown after establishment of wheat)
	SWI + RM0 (3rd Wheat Row replaced by Mustard sown along with wheat)	SWI + RM1 (3rd Wheat Row replaced by Mustard sown after establishment of wheat)

Wheat and Mustard Yields

Treatment (28 Farmers)	Wheat G Yield (T/ha)	Mustard G Yield (T/ha)	Value of W + M (Rs/ha)
Pure SWI	**5.15**	0	51464
SWI+AM0	3.65	**0.38**	47014
SWI+AM1	4.01	0.36	50021
SWI+RM0	4.24	0.32	51479
SWI+RM1	**4.63**	0.32	**55200**

Wheat and Mustard Yields





SRI, 2014

2013: Studied the effect of interaction of seedling age and planting density on rice yields

The earlier experiments showed

- Young seedlings if transplanted late give lower yields
- Low planting density works out well with young seedlings

Objective (2014):

If transplanting gets delayed for some reason or other, what configuration can give better yields with older seedlings raised in Raised Bed Nurseries (SRI)

Experiment

Interaction of

- Age of Seedling
- Planting Density (Seedling Spacing and Number)

SC-	Random Spacing
SO-	Wider Spacing (12”)
S1-	Ideal Spacing (10”)
S2-	Closer Spacing (8”)

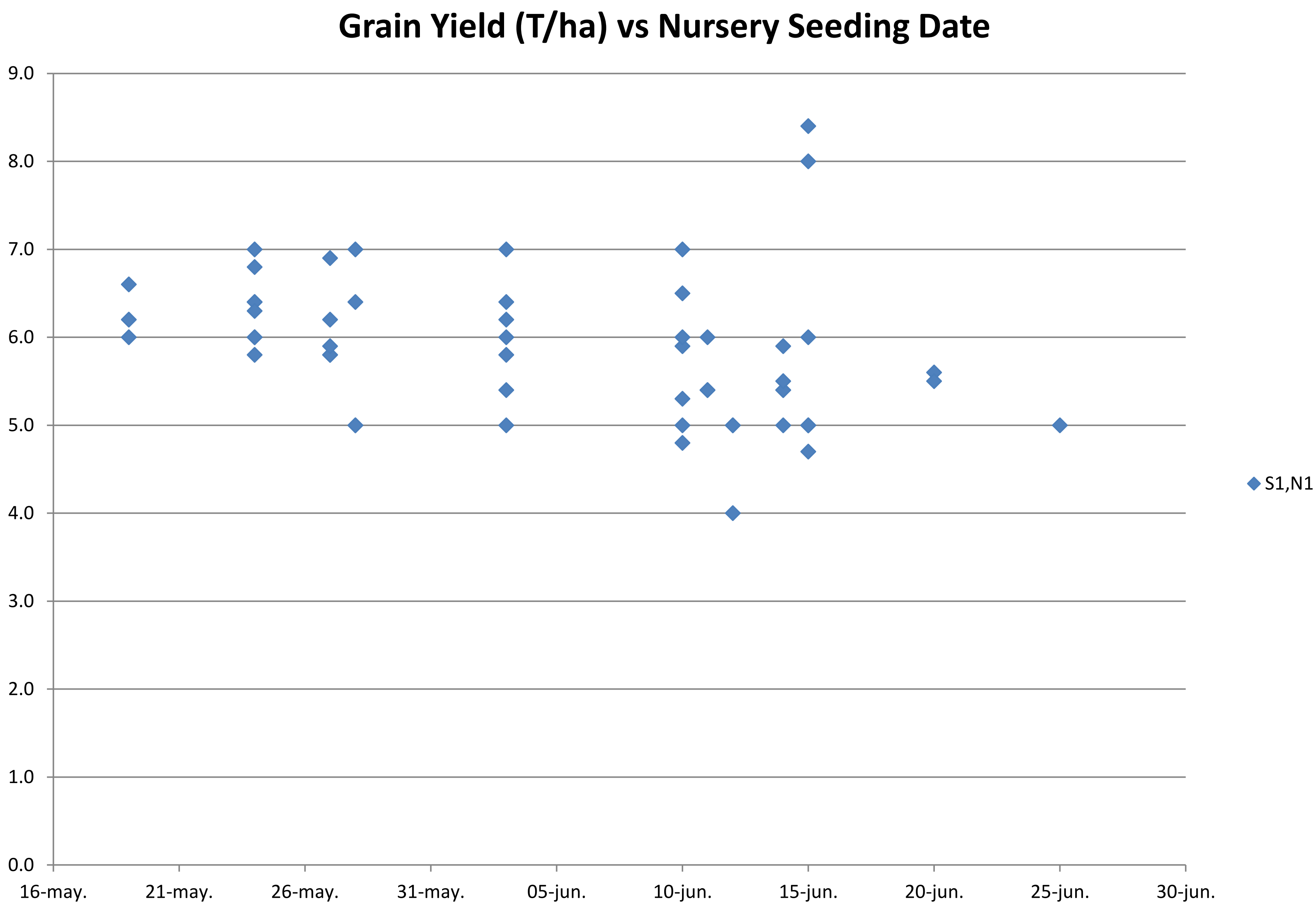
NC-	5-6 Seedlings/Hill
N1-	1 Seedlings/Hill
N2-	3 Seedlings/Hill

- Raise enough RBNs according to the normal transplanting time in the village
- Select two groups of farmers in the village doing ready to do (a) early transplanting (with 10 to 15 days’ old seedlings) and (b) late transplanting (with 25 to 40 days’ old seedling) from the same RBNs
- A farmer undertakes transplanting in all the 7 sub plots at the same time with same seedling age (using seedlings from the same RBN)

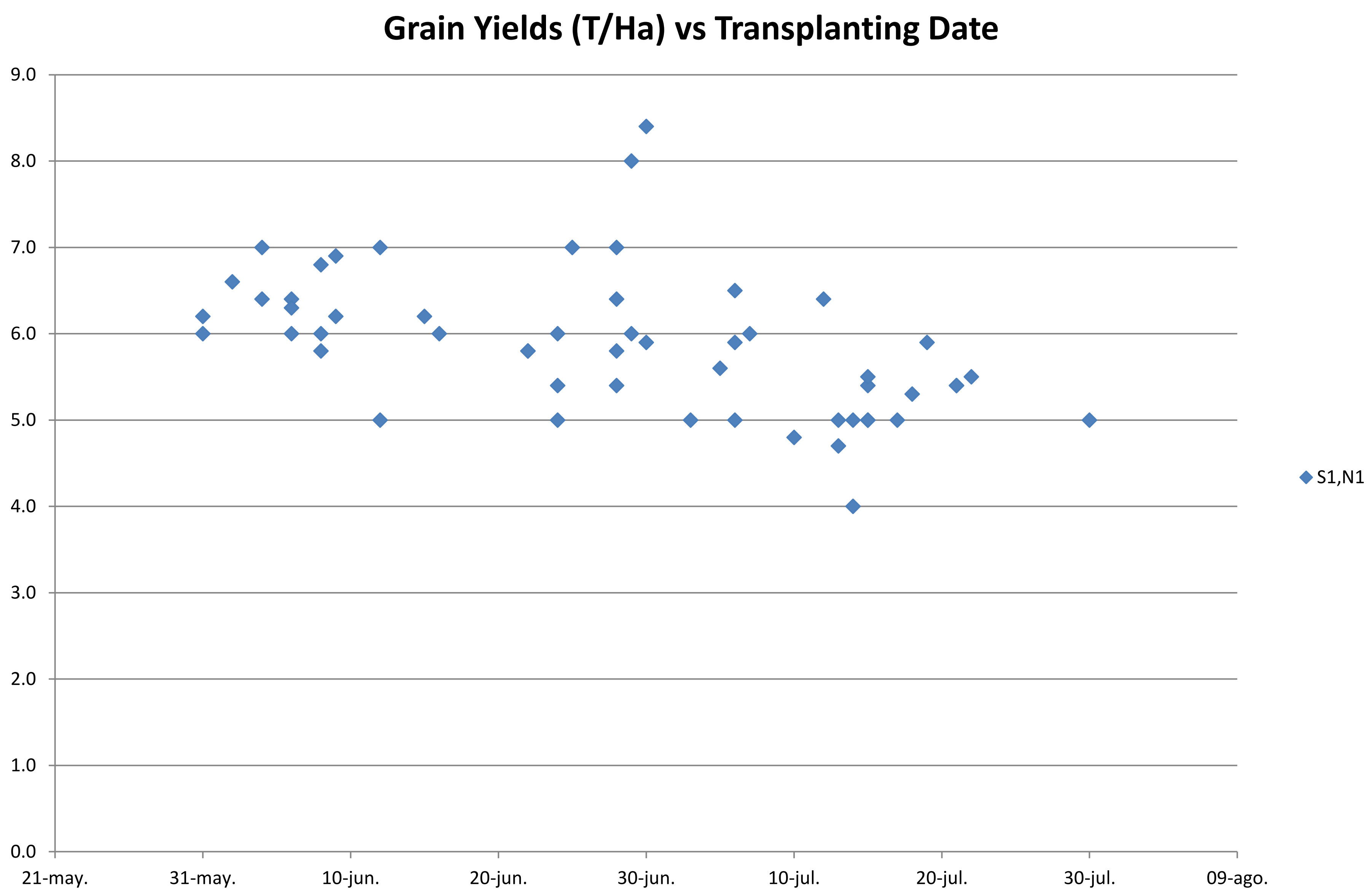
Experimental Layout

Conventional Method SC, NC	12 inch (1 seedling/Hill) SO, N1	10 inch (1 seedling/Hill) S1, N1	8 inch (1 seedling/Hill) S2, N1
	12 inch (3 seedlings/Hill) SO, N2	10 inch (3 seedlings/Hill) S1, N2	8 inch (3 seedlings/Hill) S2, N2

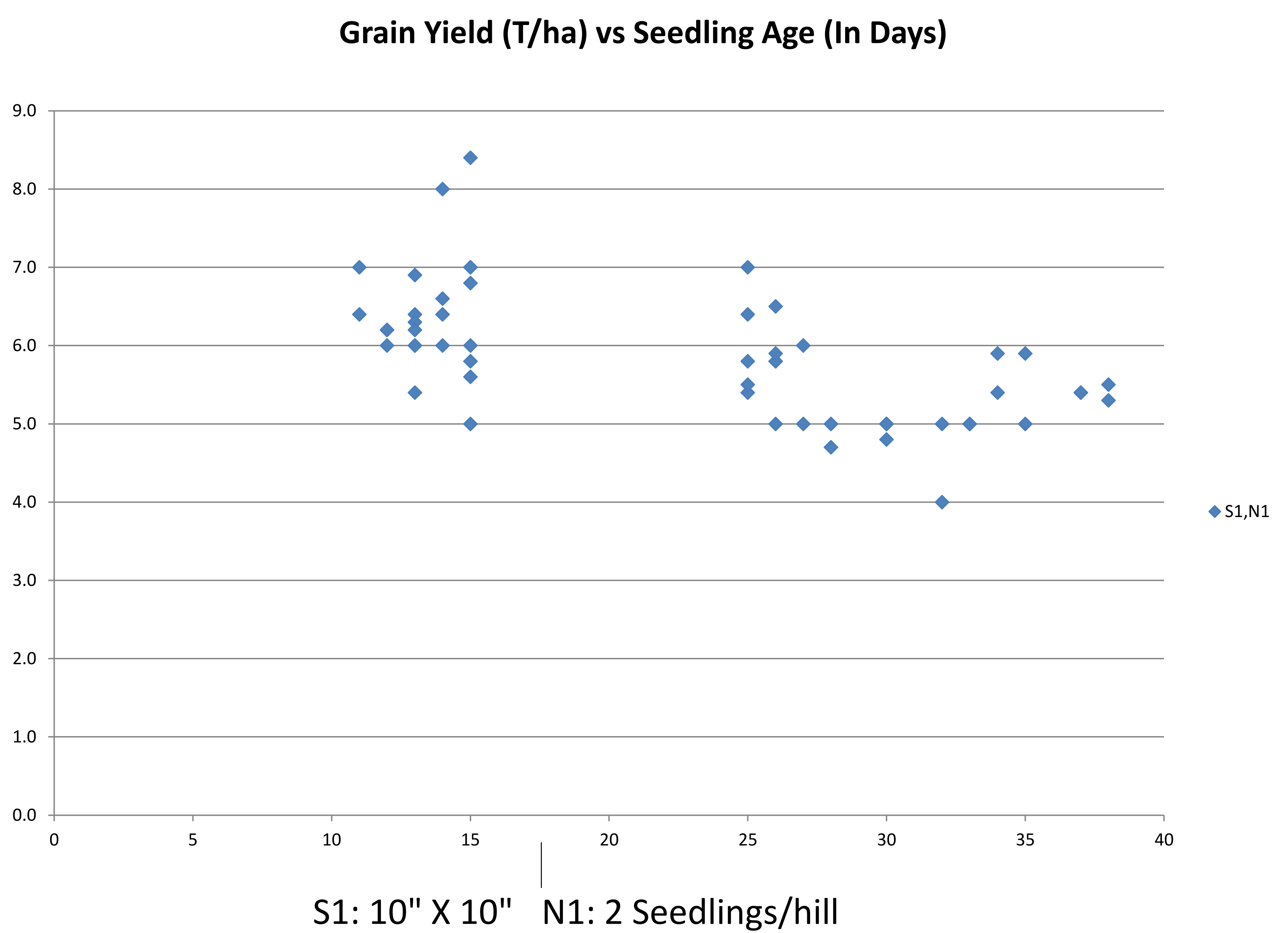
Alternatives: Spacing of 10” (SO), 8” (S1) and 6” (S2)
No. of Seedlings – 2 (N1) and 4 per hill (N2)



S1: 10" X 10" N1: 2 Seedlings/hill

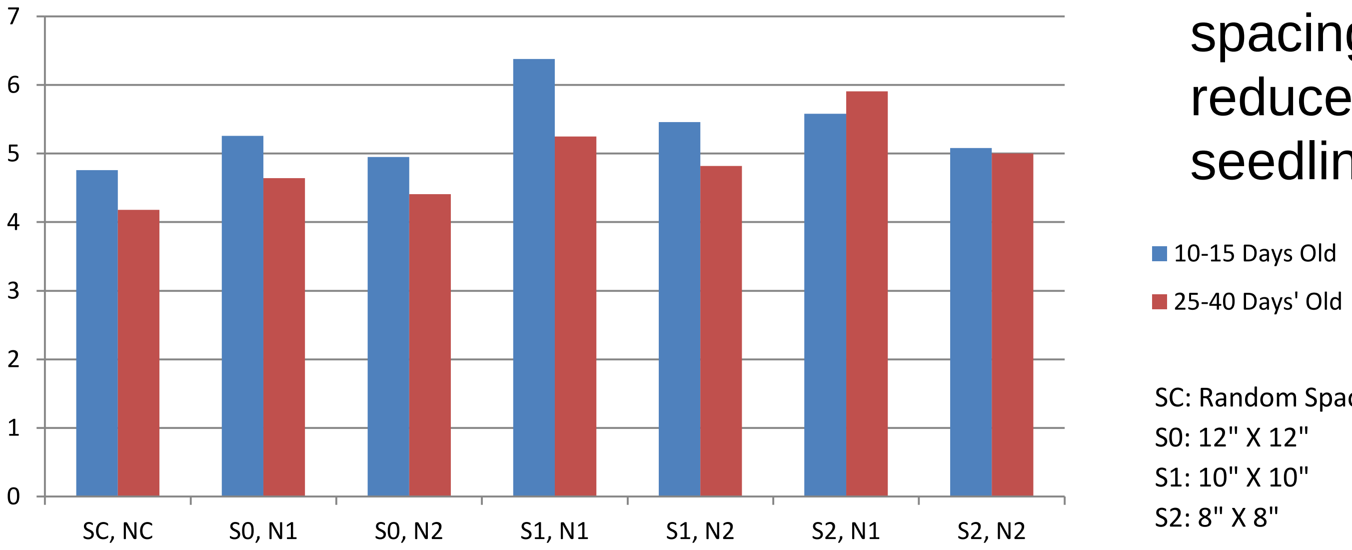


S1: 10" X 10"   N1: 2 Seedlings/hill


Grain Yield (T/ha) vs Seedling Age (In Days)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
35
40
S1,N1
S1: 10" X 10"
N1: 2 Seedlings/hill

Grain Yields (T/ha)

Treatment	10-15 Days Old	25-40 Days' Old
	25 Farmers	30 Farmers
SC, NC	4.8	4.2
S0, N1	5.3	4.6
S0, N2	5.0	4.4
S1, N1	**6.4**	5.3
S1, N2	5.5	4.8
S2, N1	5.6	**5.9**
S2, N2	5.1	5.0



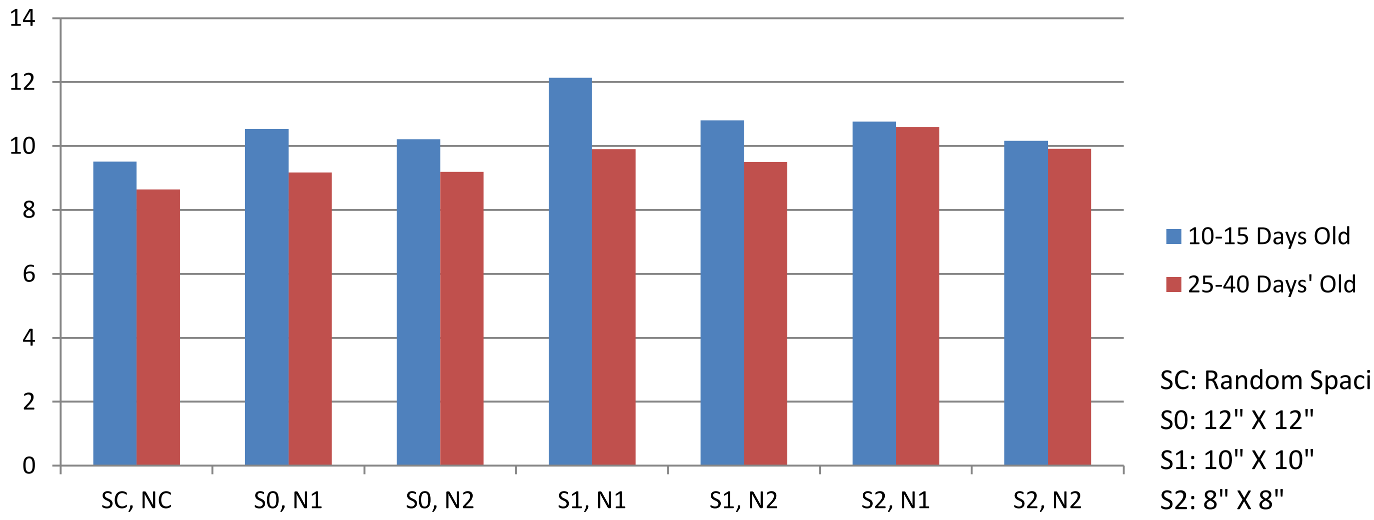
- Younger seedlings give higher yields with 10" plant spacing with 2 seedlings/hill
- Increase in seedling age (late transplanting) results in reduction of grain yields
- For older seedlings spacing should then be reduced to 8" with 2 seedlings/hill

SC: Random Spacing
S0: 12" X 12"
S1: 10" X 10"
S2: 8" X 8"

NC: 5-6 Seedlings/Hill
N1: 2 Seedlings/hill
N2: 4 Seedlings/Hill

Straw Yields (T/ha)

Treatment	10-15 Days Old	25-40 Days' Old
	25 Farmers	30 Farmers
SC, NC	9.5	8.6
S0, N1	10.5	9.2
S0, N2	10.2	9.2
S1, N1	**12.1**	9.9
S1, N2	10.8	9.5
S2, N1	10.8	**10.6**
S2, N2	10.2	9.9



SC: Random Spacing
S0: 12" X 12"
S1: 10" X 10"
S2: 8" X 8"

NC: 5-6 Seedlings/Hill
N1: 2 Seedlings/hill
N2: 4 Seedlings/Hill

Recommendations

- Take farmers’ opinion about intercropping data
- In SWI intercropping, mustard (replacement method)should be sown after establishment of wheat
- Under SRI, nursery should be preferably established earlier
- In case of late transplanting, spacing should be reduced to 8” not increasing seedlings/hill

Package of practice of cultivating paddy with SRI methods

System of Rice Intensification (SRI) was first discovered in the island nation of Madagascar in the 1980s by Jesuit priest Fr. Henri de Laulanié, S.J.

The System of Rice Intensification (SRI), allows sustainable management and a change in plant, soil, nutrient and water management practices.

The influences of various such factors enhance the biological processes and the potential of the soil biota by providing aerobic conditions. These causes rice genomes to enhance productivity with more productive phenotypes with much larger root systems. SRI is not a ‘standard package’ of specific practices rather representing empirical practices to suit different ecosystems. Proponents of SRI have claimed higher yields (7 to 15 tons per ha) with less water usage even in soils with problems of fertility and low nutrient content.

Farmers of many districts where PRADAN has been operating have benefitted by using SRI methods in paddy cultivation. The manual contains experience of farmers, which is useful for farmers and village extension workers. This manual has specific steps for cultivating paddy with SRI methods. It should be equally useful for farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves and to gain more financially.

Necessary information about SRI

- Plant the young seedling at the age of 7 to 12 days (2 leaves stage).
- Plant each seedling at a distance of 25 centimeters (10 inches) on a square pattern.
- Only two kg of seeds is required for an acre of land for plantation.
- There is a need of weeding the field at least for twice so that the organic manure is incorporated in to the soil.
- It produces 40 to 80 tillers per seedling.
- Yield is two to four times more than the conventional methods i.e 25 to 30 quintals per acre (6.75 to 7.5 tons per hectare).

Millions of farmers have adapted the SRI methods for food security and superior productivity

Why should we take up SRI methods?

- A poor farmer can only achieve yields of 7 to 9 quintals per acre which has a serious repercussion on the food security.
- From an acre of land 25 to 30 quintals of yield can be achieved, which is a major thrust towards food security of the household.
- Water requirement is less (about 3 million liters less per hectare compared to the conventional methods of paddy cultivation)
- SRI methods can be applied for any season of cultivation.
- This can be done on any piece of land where water can be managed with a proper drainage system.

Farmers who have adopted SRI methods have shown that food security can be achieved with an acre of land for a small family.

Priming of seeds

Seed selection

There is no specific preference for any particular variety of seed, but it is better to use newer seeds, while getting rid of older ones.

Seeding rate : 2 kg per acre

- Add salt in fresh water until a good quality egg can float in that water.
- Remove the egg and put the seeds in that brine water solution.
- Remove the seeds floating on the surface as those are useless.
- Drain the brine water and wash the seeds with fresh water
- Mix *Bavistin* (5 grams)/ cow urine with the seeds and put them inside a moist gunny bag in the shed for 24 hours for sprouting of the seeds.

Priming of seed helps in growth of the plant and provides strength.

Drawings with English caption

Nursery preparation

- For cultivation of paddy in one acre of land; prepare four seedbeds (each with 25 feet X 4 feet = 100 square feet area).
- Make sure that there is a distance of 1.5 feet between each seedbed to ensure proper water control.
- Use about 2 to 3 headloads of compost/ cowdung per seedbed for nutrition.
- Divide the treated the seeds in to four parts and use each part per seedbed.
- The soil should be **moist** when putting in the sprouted seeds, and the sprouted seeds should be at a **depth of one-half inch**, keeping a spacing of about 2 X 2 inches between the sprouted seeds.
- Each morning and in the evening, spray or sprinkle **water** on the nursery for gentle irrigation.

Field preparation

- The land preparation does not require special steps, though the soil should be well worked as it would be to get the best results from any method for growing rice.
- Make sure that there are adequate drainage canals either through the center of the field or along the edges (of 1.5 feet width) of the field to ensure proper water.
- About 60 to 80 kg of compost / cow dung is used for an acre of land.
- Use 25 kg **di-ammonium phosphate** (DAP) and 25 kg of **potash** (MOP), 30 kg of Urea along with *Jeevamrita*, Azolla, Vermicompost on the field.

Photo

Photo

Transporting the seedlings to the field from seedbeds

- The seedbed should be prepared as closely as possible to the field that will be planted, so as to minimize transport time between seedlings removal from the seedbed and their transplanting in the field.
- Seedlings should be lifted out of the seedbed gently, rather than being pulled up. It is important that the seed sac remain attached to the infant root. A single seedling (with two leaves of 7 to 12 days age) should be gently removed from the cutting with the thumb and forefinger.
- The young seedlings are transported in a flat utensil for minimum stress to the young plant.

The growth of the plant depends on healthier roots.

Planting the seedlings in the field

- The field should be well puddled before transplantation.
- Seedlings should always be transplanted from the nursery into the field within half an hour, and preferably within 30 minutes. The roots should never be allowed to dry out. They should also not be handled roughly or slammed or hit with

the palm of the hand.

- To plant in a uniform square pattern, with regular spacing, one method is to use lines (strings or ropes) tied between sticks on the edge of the field, spaced 10 to 12 inches apart The lines should be marked (or knotted) at similar intervals to match the width of the rows so that there will be uniform spacing that facilitates weeding. Or one can use a specially constructed simple "rake" that has teeth spaced the desired distance apart.
- The plant should be put in the soil lightly avoiding any shock to the plant.

Weeding and water management

- After transplanting mechanical weeding must be done in the field at an interval of every 15 days. This should be done until the growth of plants' canopy makes it difficult to pass the weeder between them. Mechanical weeding makes it difficult for the weeds to grow.
- Mechanical weeding helps in aeration of the soil and helps the roots to grow and enhances moisture and nutrient uptake from the soil. This also turns the weeds as soil organic matter by assimilating in the soil biota.

- The weeding should be done on both sides of the plant.
- In flood affected regions, when the field is inundated, apply 4 kg of Zinc Sulphate along with sand for an acre of land.
- The addition of water should occur on or about a week after transplanting, and then the first weeding (using the rotary hoe) should be done after soil is sufficiently moist, within the first 10 days. If there is intermittent rain, sufficient to keep the soil moist, no water additions are needed. The best time to add water is before the periodic weedings.

- During the growth phase, roughly the first three months, water should be applied only to the fields for weeding purposes, being left to dry out even to the point of surface cracking. This will contribute to soil aeration. This drying should be done at least 3 or 4 times before the phase of flowering and panicle initiation.

- Aeration is required for healthy root systems.

Organic manure



- By application of green and organic manure with the SRI methods of paddy cultivation, required nutrition can be provided to the crop and the health of the soil well maintained.
- By application of different types of manure (Vermicompost, Compost, Jeevamrita and Pot Soultion) helpful microorganisms thrive in the field.
- The productivity of the field increases with use of green manure.

Yield

- Every plant produces 40 to 80 tillers.
- About 25 to 50 tillers produces good panicles
- Each panicle contains about 150 to 240 seeds.
- The yield with SRI methods of paddy cultivation is about 25 to 30 quintals per acre (6.75 to 7.5 tons per hectare).

Pest and Disease management

Gandhi bug
Symptoms

- With the attack of this bug during the milking stage, the seeds become hollow.
- Spots come up and the seeds look dirty.
- The seeds get blackened.

Chemical management

- When the number of bugs per plant reaches to (15-20), apply chemical pesticide.
- 100 ml of Lambda-cyhalothrin should be applied per acre of land.
- 50 liters of water should be mixed with 100 ml of Lambda-cyhalothrin (2 ml per one litre) before spraying.

Stem borer
Symptoms

- Presence of brown coloured egg mass near leaf tip.
- Caterpillar bore into central shoot of paddy seedling and tiller
- Causes drying of the central shoot known as "dead heart"
- Grown up plant whole panicle becomes dried "white ear".
- Eggs bare or covered with hairs, laid in masses
- Neonate larvae suspend themselves from leaves by silken threads and blown to other plants to feed
- Mature larvae bore into the sheath and tiller of the plant presence of frass or fecal matter

Management

- The pest increases its activity at the end of the rainy season.
- 100 ml of Lambda-cyhalothrin should be applied per acre of land.
- 50 liters of water should be mixed with 100 ml of Lambda-cyhalothrin (2 ml per one litre) before spraying.

Bacterial infection on the leaves

Symptoms

- Plant’s condition deteriorates by leaves turning yellow or by drying up.
- High temperature, excess moisture, rain and stagnation of water lead to bacterial infection.

Management

- This infection can happen at any stage and is very difficult to contain.
- Seed can be treated with Bleaching powder (100 gram in a litre of water) and Zinc Sulphate (2%), which can decrease the bacterial infestation. Copper Compound, Antibiotics and other chemical treatment has not proven effective against it. Streptocyclin / Agrimycin.(6 grams in a 100 litres of water) can be sprayed at periodic intervals

Blast and Sheath blight

Sheath blight of rice

Symptoms

<u>Blast</u>

On the leaves the symptoms first appear as small, bluish flecks, about 1-3 mm in diameter. In older leaves, they may remain circular but on young leaves, they enlarge up to several centimeters long and 1 cm broad. The lesions bear a grey or dark brown margin with a pale green or dull greyish green water soaked central portion which later turn grey or straw coloured. Similar spots are formed on the leaf sheath.

<u>Sheath blight</u>

Lesions are formed on the sheath and culm at the water level. The spots on the leaf sheath are first ellipsoid or ovoid, about 10 mm long and greenish grey in colour. The spots enlarge and may reach 2-3 cm in length and become irregular in outline. The centre of the spots becomes white with brown or purplish margins depending on the host variety. Outer leaves may fall off, plant look yellow and may ultimately wilt. In favourable weather conditions, infection may spread up to the culm, killing the entire leaves. On the surface of the lesions and sometimes on the inner surface of the sheath and on the culm, brownish silky wefts of mycelium are present.

Management

- It is wiser transplant little late than with the start of the rainy season.
- Unnecessary application of chemical fertilizers should be avoided which aids in the growth of the bacteria.
- During the field preparation, application of Nitrogen should be minimum.
- 200 ml of fungicide such as Tricyclozole (Blast-off, Beam), Hexaconazole (conquer), Propiconazole (TILT) should be mixed with a 200 litres of water to be sprayed in an acre of land for control of this disease.

ksikr nig FmµCati

Farmer and Nature

Booklet for Family Agriculture Development in Cambodia

EXPERIENCES IN MULTI-PURPOSE FARM DEVELOPMENT:

RAISING HOUSEHOLD INCOMES IN CAMBODIA BY UTILIZING PRODUCTIVITY GAINS FROM THE SYSTEM OF RICE INTENSIFICATION

Prepared by **Lim Soviet**

Supported by **Triad Foundation**

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Published for **3000 copies**
Printed by **Entry Meas Printing House**

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Especially, I thank Dr.Yang Saing Koma, CEDAC president, for making an opportunity for me to be involved with this work as well as for providing useful advice to improve and compile this manual.

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This document still has some weaknesses in terms of pictures and its content. Therefore, CEDAC would appreciate any comments or impressions that you may wish to contribute to further improvement of this booklet. Thank you for your time in reading this document.

Lim Soviet

PREFACE

Through its field work and experience with Cambodian farmers over the last 10 years, CEDAC know that farmers' ability for sustain and improve food supply and income generation is still a big problem at present. Small-sized rice fields, low productivity, and growing only rice are serious constraints on reducing poverty in rural areas of Cambodia.

Over the past 10 years, CEDAC has been conducting studies and working cooperatively with farmers in order to find suitable ways to deal with these problems. CEDAC has published, in sequence, technical documents on Home Gardening, the System of Rice Intensification (SRI), and other subjects. Through the application and combination of innovations, farmers have been able to deal with their families' food and nutrition supply. Nevertheless, farmers are still facing some shortages of protein food (fish and meat), of firewood, and of organic matter for improving soil quality, because of the low productivity of their agricultural land, especially their rice fields.

Responding to these needs, a document on **Experiences in Multi-Purpose Farm Development** has been prepared to contribute to increased productivity of rice fields and farming systems as a whole, thereby increasing opportunities for income generation for farmers and their families. Multi-Purpose Farm (MPF) development is a concrete example of integrated farming systems that combine rice production with fruit trees, multi-purpose trees, perennial crops, vegetables and seasonal crops, animals, and fish. This document has been compiled from the experiences of farmers who have been collaborating with CEDAC, especially around the challenge and opportunity of ***successful MPF development***.

This document on ***Experiences of Multi-Purpose Farm Development*** will be disseminated and used for supporting farmers to become successful in MPF development, as many as possible in Cambodia through the development projects of CEDAC and partner NGOs. We hope that this document will help farmers to increase their agricultural productivity for improving family food supply, enhancing nutrition and health, and generating additional family income.

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I. INTRODUCTION

Cultivation on homestead land and rice fields plus the collection of natural resources (e.g., fishing and non-timber forest products) and non-farm activities that earn additional family income are the main sources of food supply and income for rural farmers and their families in Cambodia.

Cultivation is the predominant source of food supply and income generation, so **agriculture** is the main occupation for rural households. They focus much of efforts on their homesteads and their rice fields, seeking to achieve a degree of ***self-reliance*** and to ensure livelihood ***sustainability*** consistent with their living situations and existing resources. However, their area of land for cultivation is usually very small, which sets serious constraints on their well-being and satisfaction.

About 75% of Cambodian people are rice-based farmers. Many farmers are not able to produce sufficient rice to meet the consumption needs of their families, making other activities necessary for subsistence. When farmers grow only rice and grow it only once a year (in the rainy season), there is low household income and much insecurity. Those who increase their use of and dependence upon chemical fertilizers often see their soil quality decrease over time, having lower rice yields rather than more; and in any case, their costs of production become increasingly difficult to meet. Moreover, as population size grow, there is shrinkage in the size of household land holdings, making it more and more difficult for farmers to produce enough food to meet the needs of their families.

To improve this situation, CEDAC has been supporting 'ecological agricultural techniques' that enable farmers to increase and sustain more intensive productivity from their limited land resources. In particular, CEDAC has introduced methods such as the System of Rice Intensification (SRI) starting in 2000 and Multi-Purpose Farming (MPF) since 2001. MPF converts the layout and use of specific rice fields into an ***integrated farming system*** through the ***diversification*** of agricultural items and productivities. MPF includes many kinds of production such as rice, crops, vegetables, fruit trees, multi-purpose trees, animals, fish, firewood, fodder, medicinal plants, etc., going from monoculture to a dynamic, well-managed polyculture.

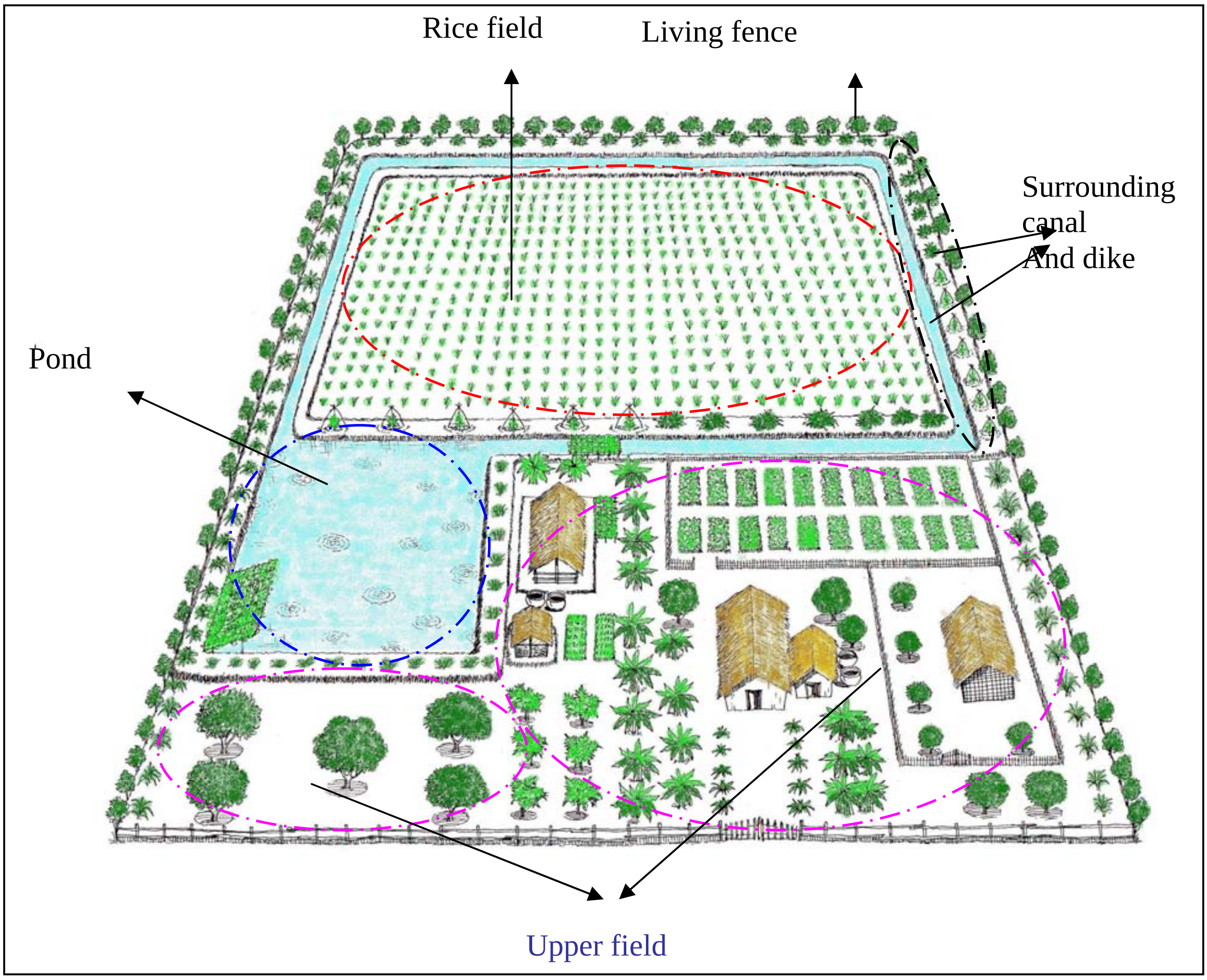
A growing number of farming families have decided to convert their rice fields into MPF, diversifying production beyond the familiar rice cultivation. Due to a lack of effective resources and knowledge, some farmers have failed in their MPF designs and efforts, which is unfortunate, while others were not completely successful, also unfortunate. To date, only a small number of farming families have been successful in developing MPF in Cambodia. However, those who have succeeded in this transition, have been very successful indeed. Learning from their experience and example can benefit many other households that are willing to intensify their farming system management in order to gain greater productivity and security.

This document on farmers' experiences in developing MPF has been initiated, studied and compiled by CEDAC. It was produced through interaction with 15 farmers in different provinces who have effectively converted their small rice farms to MPF. Of these, 5 have been the ***most successful*** MPF farmers, and they have participated in preparing case studies that form the main basis for this document.

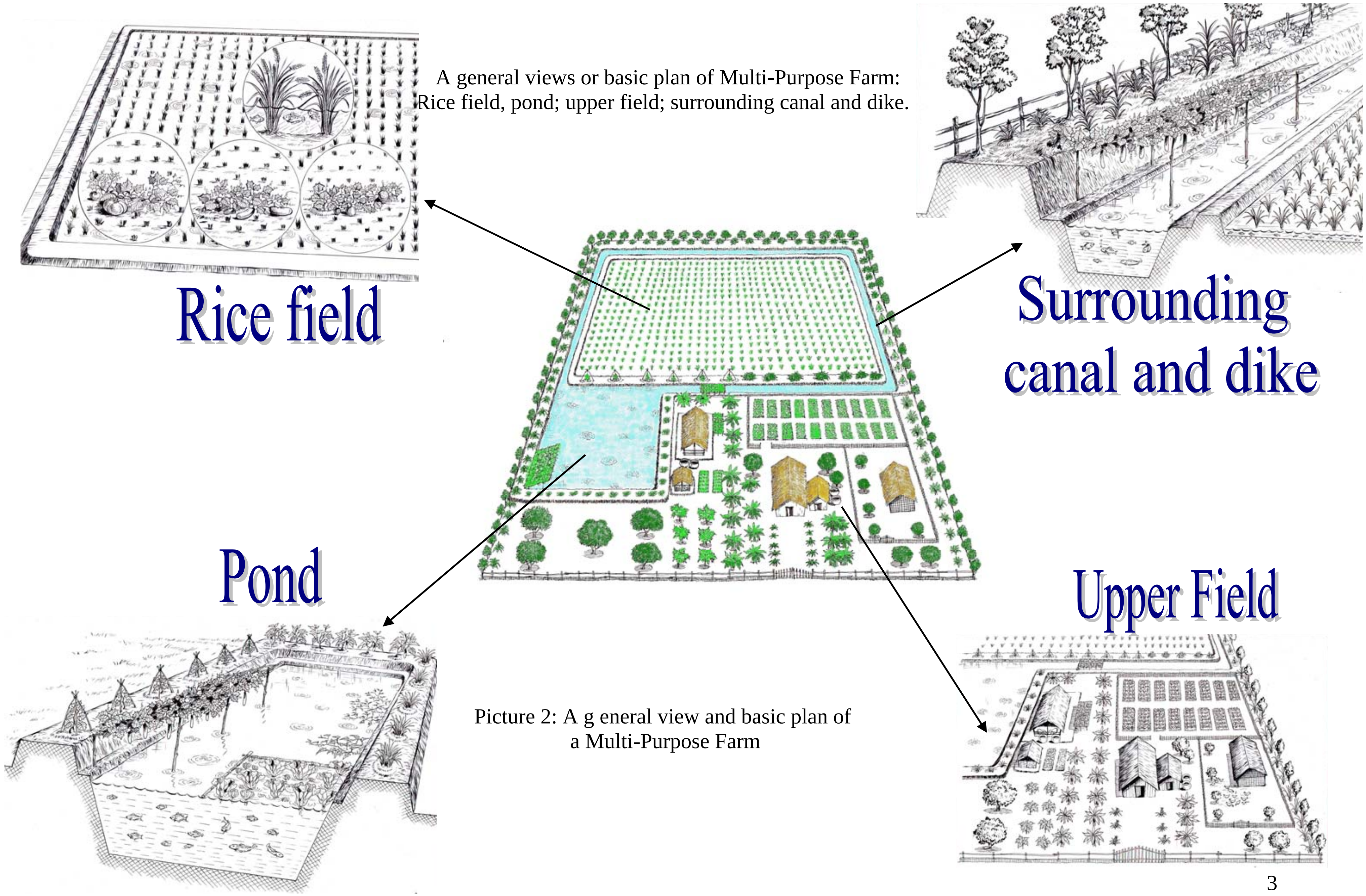
II. GENERAL ASPECTS OF A MULTI-PURPOSE FARM

2.1. What is a Multi-Purpose Farm?

A Multi-Purpose Farm (MPF) is the concrete practice of an integrated farming system which includes rice production, fruit trees, multi-purpose trees, perennial crops, vegetables and seasonal crops, appropriate animals, and fish. This system is designed to convert certain rice-field are to enhance agricultural productivity of the whole area. MPF is a system for improving and ensuring the sustainability of farmers' livelihood, especially for small-holding rice farmers (with fields from 0.2 to 0.6 ha) who cannot otherwise produce enough food to support their families.

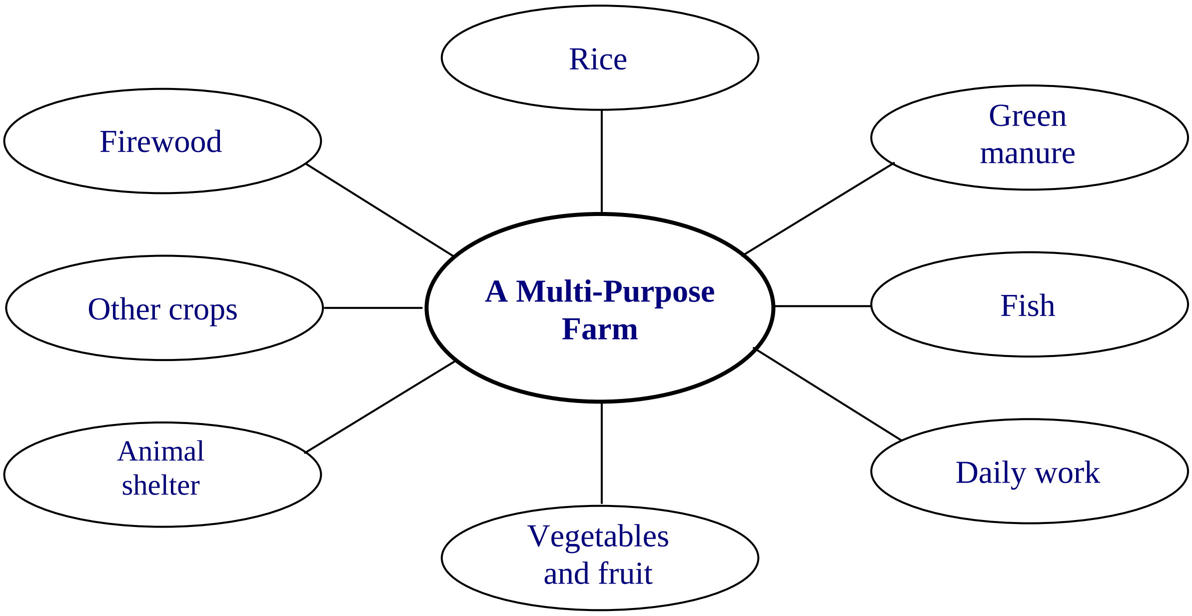


Picture 1: General view of a Multi-Purpose Farm



Picture 2: A g eneral view and basic plan of
a Multi-Purpose Farm

A Multi-Purpose Farm (MPF) produces a large number of products for farming families. It provides a higher rice yield with SRI as well as yielding vegetables, fruit and other crops, fish, firewood, fodder and green manure and giving animals food and shelter (from natural enemies). It becomes site providing year-round profitable work opportunities for farmers.



Picture 3: Products received from Multi-Purpose Farm

2.2. Principles and techniques of Multi-Purpose Farm development

2.2.1. Rice field management

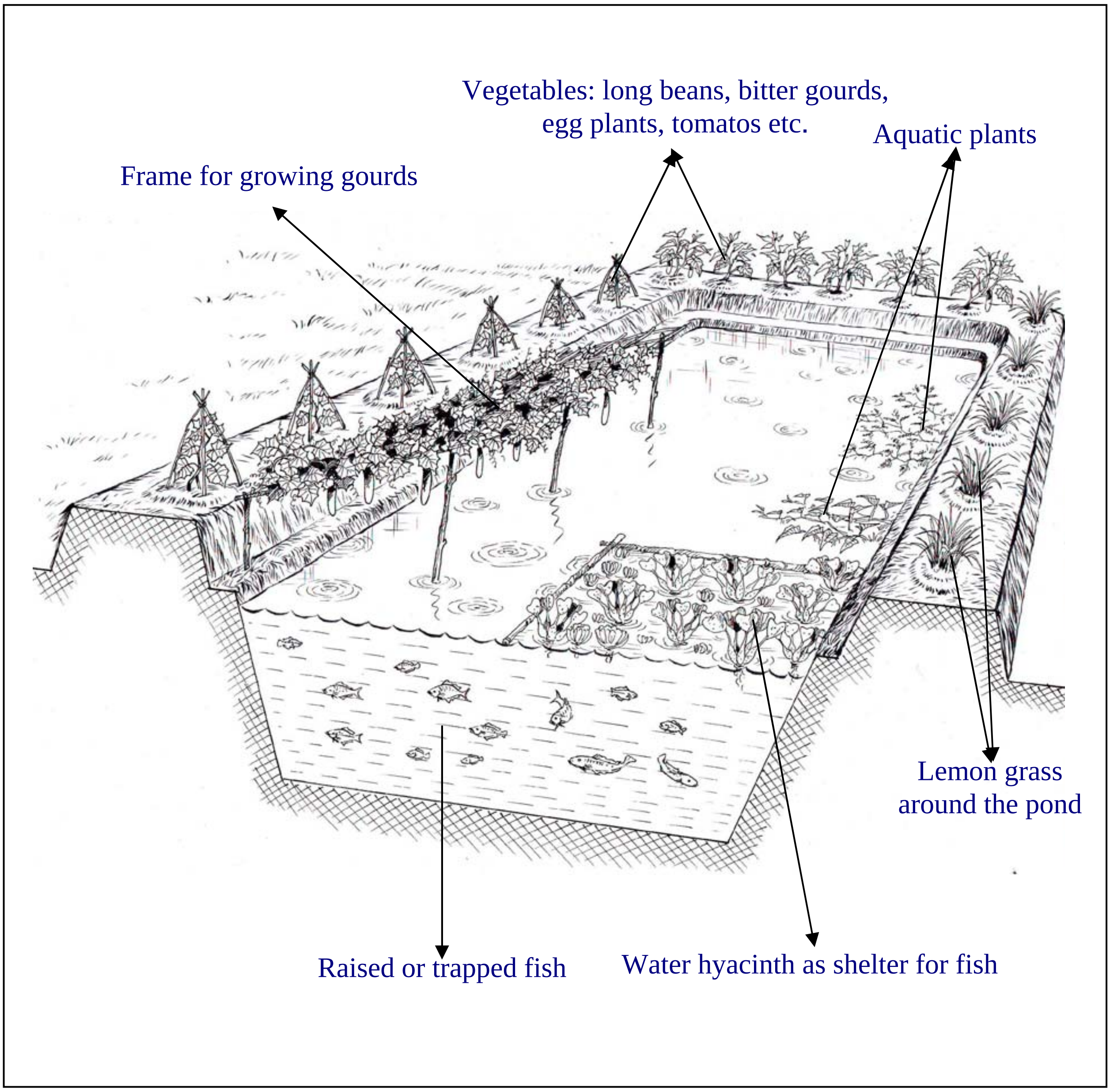
Rice fields in MPF remain about 50% to 60% for the area in MPF. With SRI methods, 0.5 ha of rice field should produce enough rice for a family year-round. The proportion in rice fields can remain larger than 50-60% if the MPF area is small, of course, but with good use of SRI methods, which enhance soil fertility over time, the size of the rice field can be even smaller than 0.5 ha (see Table 2).

Rice fields play a crucial role in producing sufficient rice for farmers' families. Rice fields in MPF can be smaller than before because they can producing yields 2-3 times higher than before, once soil quality has been improved and water is well managed. For MPF, SRI should be well applied in the remaining rice area, with fish production added as a core activity, along with growing other crops such as watermelons, cucumbers, pumpkins, etc. for supplementary vegetable production along field borders and growing other plants such as mung beans or other legumes as green manure.

Picture 4: Rice field in Multi-Purpose Farm

2.2.2. Pond preparation

On average, the size of the pond in MPF is 10 m x 15 m or bigger, with depth of 2 to 3 m. In a MPF there should be at least one pond, but possibly more. The number and layout will depend on farmers' space and design. The pond plays an important role in storing water for a variety of purposes, including growing crops, saving rice during short drought periods, and assisting farmers to grow many kinds of plants as vegetables, including aquatic ones.



Picture 5: Preparation of pond in Multi-Purpose Farm

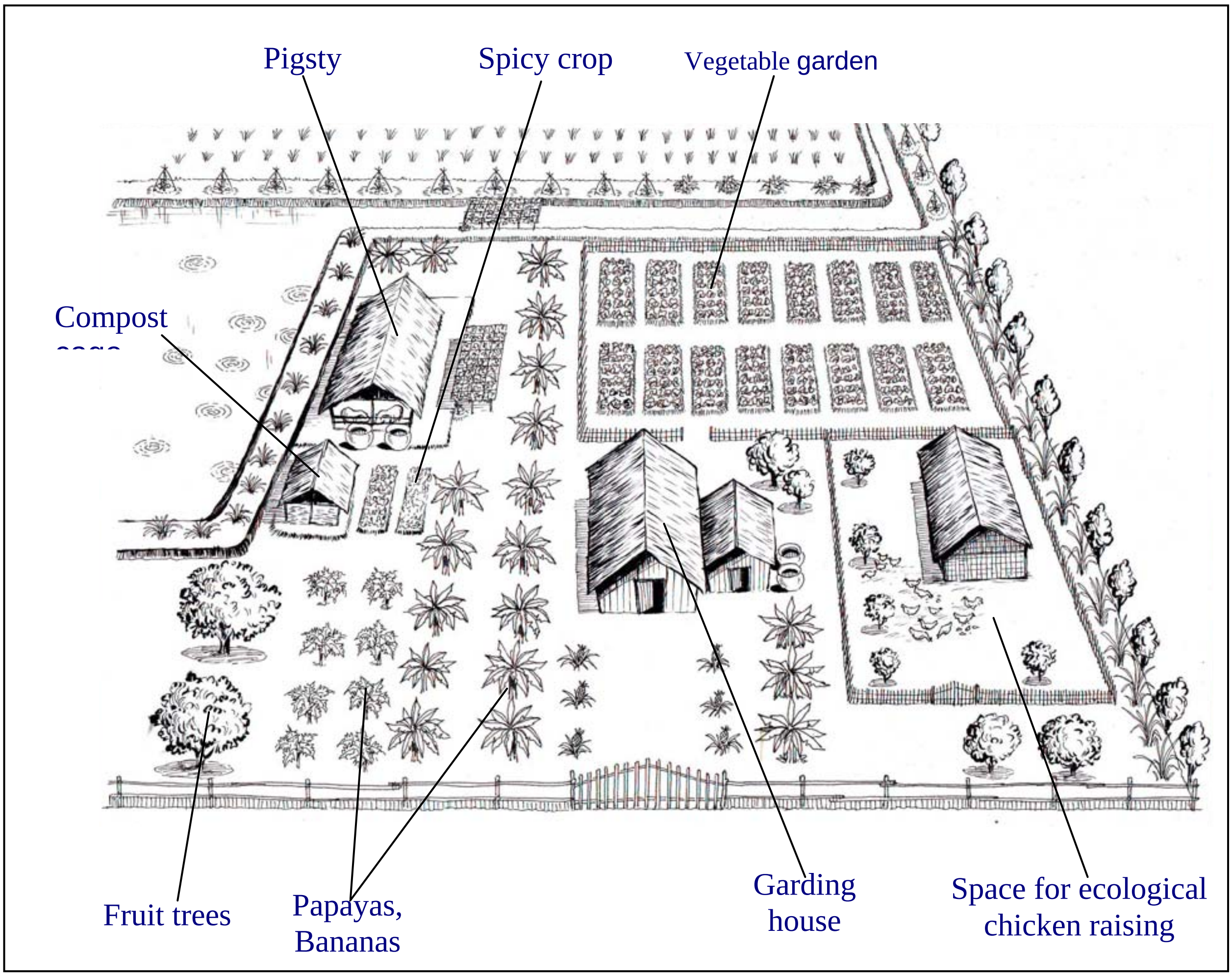
The digging of ponds should be carefully carried out to prevent the water from becoming filled with sediment and to keep the soil from eroding in the first year. The wall of the pond should have a proper slope with a surrounding dike that is built 0.5 m from the pond side (leaving 0.5 m interval for grass or growing *Sesbania rostrata*). Once there are grasses or other plants growing on the bunds around the pond, the soil will be stabilized. There needs also to be a few holes in the dike to enable fish to move in or out of the pond. These should be prepared and connected to the canal.

Farmers need to have a clear plan for the preparation and construction of ponds. Construction should be commenced late in the dry season, around February-March. This timing is important to complete the digging before the rainy season comes. If farmers are late in completing their digging, the functioning of their pond will be delayed for one year.

Picture 6: Ponds in farmers' Multi-Purpose Farm

2.2.3. Upper field preparation

The upper field should be laid out adjacent to the pond, using the soil excavated from digging the pond as this will provide more soil depth for growing other crops. This area is planned for integrated production of crops and animals, so farmers well plant fruit trees, perennial plants, vegetables, and spices there, as well as use it for raising pigs, chickens, ducks, etc. These upper fields are commonly places where farm-owners will construct a guard house or watch house to protect their plants and animals and to facilitate their intensified management in a comfortable manner.



Picture 7: Upper field preparation in a Multi-Purpose Farm

Some farmers are most interested in growing annual/seasonal crops on the upper fields of their MPF. This enables their MPF to produce some income all year-round, especially in the dry season (despite water shortage – because there is reserve water in the pond). Farmers should think carefully to include all or some fruit trees, perennial plants, annual/seasonal crops and spices to achieve year-round production of their MPF. Market opportunities as well as agronomic factors will influence these decisions.

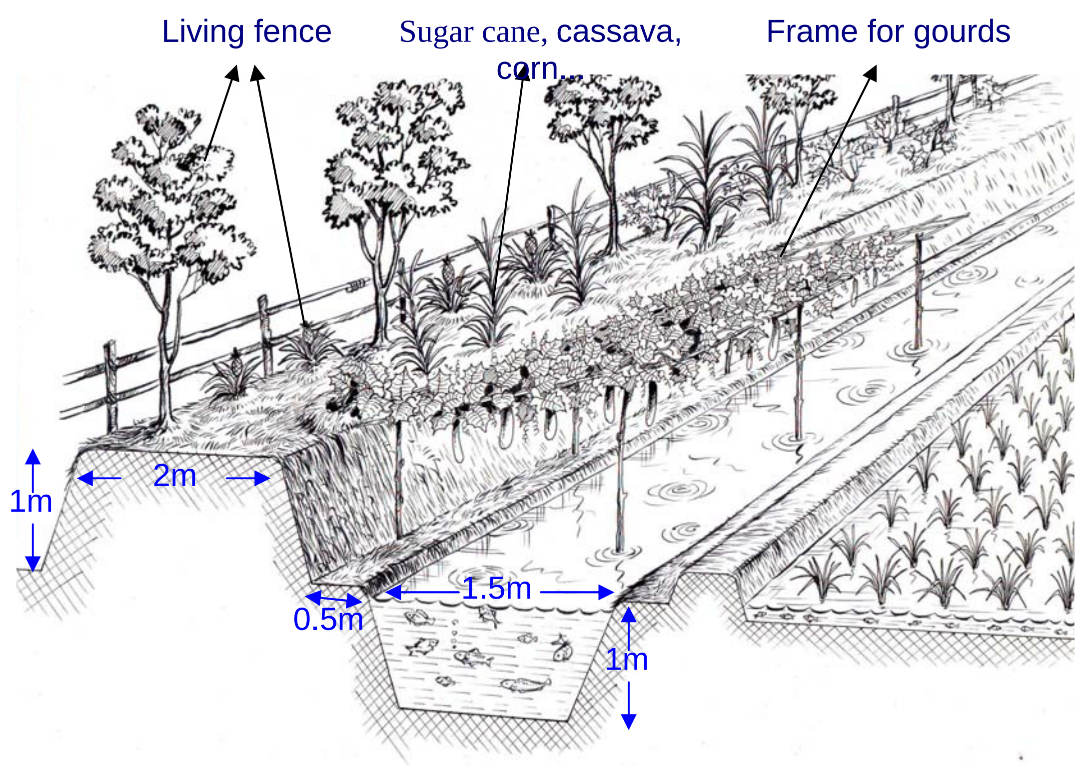
Picture 8: Mixed cropping of papayas and chilies on upper field Multi-Purpose Farm

Picture 9: Mixed cropping on an upper field Multi-Purpose Farm

2.2.4. Surrounding canal and dike preparation

Surrounding canal: An appropriate size for this is 1.5 m width, with sloped walls, and 1 m depth. If farmers do not have enough capital (money or labor), they can start with a canal on just one side of their MPF and this canal can made bigger and deeper rather than have a surrounding canal that is smaller and shallower.

Surrounding dike: This should be built by using the soil from digging a canal. The dike around the MPF should be 1 to 1.5 m height and 2 to 3 m in width with appropriate sloped walls and grassed-over surface. This dike will protect fish and nutrients from going out of the farm, and will also prevent minor flooding. Farmers can plant multi-purpose trees as a living fence and can grow a variety of crops on the inner side of the dike.



Picture 10: The design of surrounding canal and dike in a Multi-Purpose Farm

The digging of a canal should be well-done in the same way as the pond in order to protect the soil from erosion in the first year. Farmers must be careful in building the surrounding dike to minimize conflict with neighboring rice fields. This all sounds like a lot of work, but the economic benefits, evaluated below (section 2.5), justify the investment of time and effort. This transformation is intended to be one which requires minimum capital resources so that it will be accessible to resource-limited farm households.

Picture 11: Canal and dike in farmer's Multi-Purpose Farm.

2.3. Progress of Multi-Purpose Farm under the support of CEDAC

CEDAC has introduced and disseminated SRI methods since 1999, and this system started to be adapted and applied by farmers in 2000. SRI is a combination of good techniques and practices for assisting rice to grow well and produce higher yields according to the rice plants' natural potential. The application of SRI requires farmers to prepare the proper conditions for rice plants' effective growing and tillering to achieve high yields, soil improvement, and water management and saving. In this booklet, we are focusing on MPF rather than SRI, taking SRI as a given. Information on SRI can be obtained from CEDAC or from the web (http://ciifad.cornell.edu/sri/).

Early on, with the support of CEDAC's knowledge and techniques, some farmers started converting and developing their rice fields into what we now understand as a System of Intensification and Diversification (SID). This they achieved through the digging of canals, building higher surrounding dikes, making 'living fences' by planting multi-purpose trees, digging small ponds to increase water sources, and by growing additional crops on the dike, in upper fields and in rice fields as an intercrop, etc.

This system has been improved sequentially into Multi-Purpose Farming. Farmers have well-designed plans on their farm. In MPF, farmers retain around 50% of their land area for their rice field, and other spaces are transformed by higher and larger surrounding dikes with deeper and larger canals around rice fields, or by dividing the farm into two or three parts, with ponds for storing water and aquaculture production and upper fields for mixed varieties of crops and fruit trees as well as animal raising. The upper field is made more productive by using the soil taken from the digging of the pond.

CEDAC has introduced and disseminated MPF innovations to farmers since 2001. From year to year, the number of farmers who have begun developing MPF has been increasing. Almost 400 families are currently developing MPF systems as seen in Table 1.

Table 1: Progress of Multi-Purpose Farm with the support of CEDAC

Province	**2002**	**2003**	**2004**	**2005**	**2006**
Takeo	35	37	37	40	45
Prey Veng	158	162	182	200	215
Kampong Cham	23	23	36	36	40
Kampong Speu	0	10	36	40	49
Kampong Thom	1	1	1	1	12
Svay Rieng	0	0	32	35	36
Total	**217**	**233**	**324**	**352**	**397**

2.4. Farmers' experiences in designing Multi-Purpose Farm

Based on the successful experience of 5 farmers in the development and design of MPF, we are assuming that the average land size (rice field) for developing MPF is 66.64 ares (0.66 hectare, or 1.65 acre). This area is divided into three main parts:

- The rice field is 42.8 ares (0.43 hectare),
- Area for water sources including pond and canal is 8.78 ares (0.09 hectare), and
- Area for some combination of mixed crops and animal raising, including the upper field and surrounding dike is 15.06 ares (0.15 ha).

Note: As seen from Table 5 below, this calculation, with breakdown in Table 2, is based on an average for 5 farmers' experience. One of these five has a land area about four times larger than the other four, so the average total area for most of the successful MFP farmers is actually 43.8 ares, less than half of a hectare. This strategy can thus be utilized by households with very small landholdings.

Table 2: Average land size to be developed and designed Multi-Purpose Farm

	Total space	Rice field	Pond and canals	Upland area and dike surfaces
Average size (ares)	66.64	42.8	8.78	15.06
Percentage (%)	100%	57.24%	15.12%	27.64%

Note: 1are=0.01ha

2.5. Investment and income of Multi-Purpose Farm development

Normally, the development of rice fields into a Multi-Purpose Farm requires farmers to make some investment at the first stage when they have some money and/or labor time to invest, specifically for making/digging ponds and canals, building higher and bigger surrounding dikes, and preparing upper fields for mixed cropping and animal raising, and especially the making of fences around the farm. With higher-value production which can be more easily stolen than rice from a paddy field, it is necessary to secure crops, animals and fish.

The scale of the inverstment budget can be higher or lower depending on the ability of farmers and whether they are investing mainly money or teir own labor. According to farmers' experiences, the average amount of money invested for developing a MPF is around 1,200,000 riels (about 300 USD).

Through that first investment, farmers must pay attention to harvesting or getting a return from their MPF as soon and as much as possible. They should have enough ability to increase their crop growing and animal or/and fish raising. Skilled farmers can harvest and get a return large enough to settle the investment usually by the second or third year of MPF development. This is actually a very good return on investment.

Table 3: Investment and income of Multi-Purpose Farm development

	Average annual income without MPF	Average annual income with MPF	Total average of investment for MPF development
In Riel	763 600	2 395 000	1 219 800
In US dollar	190.9	598.75	304.95

Note: 1USD=4000riels

2.6. Farmers' received benefits

The productivity of MPF is many times more than the economic benefits reported in Table 3 if we compare its productivity with the same-sized rice field because MPF does more than simply increasing rice output. It produces also many kinds of products such as fish, meat, vegetables, fruit, firewood, and fodder. The economic benefits reported in Table 4 below cover only income from market sales, almost 10 times more than before. They do not include home-consumption from the increased and diversified farm production, which improves household members' diet with more meat, fish, fruits and vegetables, thereby enhancing their health and vitality.

Moreover, MPF provides other benefits such as improving soil quality, eliminating the use of chemical fertilizers, protecting against soil erosion through the diversification of crops, and making greener landscapes. It also helps in conserving bio-diversity such as increasing shelter for beneficial animals (e.g., natural enemies that play an important role in protecting crops from pests). .

Through our study with the 5 best MPF farmers, we can campare the productivity of the average benefits of rice field area with and without MPF as follows:

Table 4: Income from selling products before and after Multi-Purpose Farm

		Before MPF	**After MPF**
Land size (ares)		66.6	66.6
Selling rice	In riels	100 000	206 900
	In USD	**25.00**	**51.72**
Selling vegetables	In riels	0	836 500
	In USD	**0**	**209.12**
Selling fish	In riels	30 000	192 200
	In USD	**7.50**	**48.05**
Selling animals	In riels	0	101 000
	In USD	**0**	**25.25**
Other: Hosting exchange visits etc.	In riels	30 000	238 600
	In USD	**7.50**	**59.65**
Total	***In riels***	***160 000***	***1 575 200***
	In USD	**40**	**393.8**

III. FARMERS' EXPERIENCES OF SUCCESSFUL MULTI-PURPOSE FARM DEVELOPMENT

The results presented above are reported from the experiences of the 5 best farmers who have succeeded in MPF development in cooperation with CEDAC staff.

Table 5: List of farmers who succeeded in Multi-Purpose Farm development

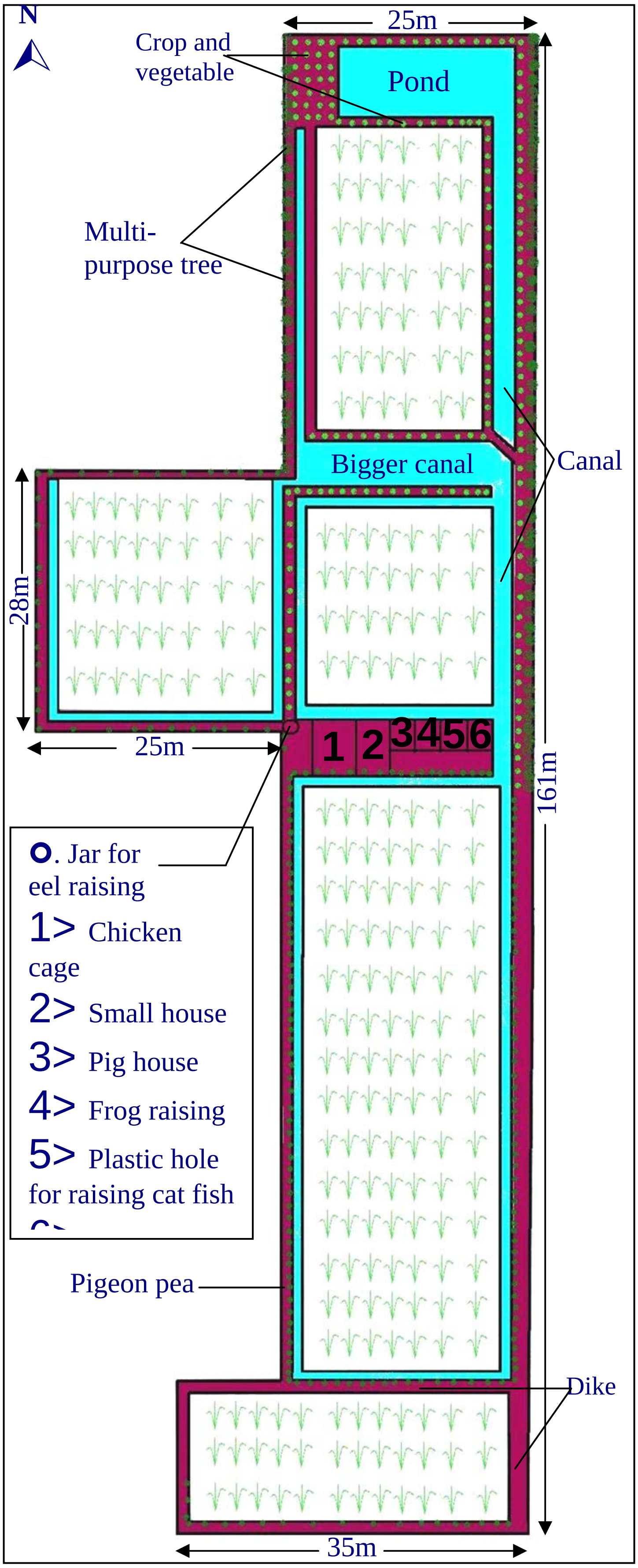
Nº	Name	Sex	Village	Commune	District	Province	Size of MPF (are)	Year started
01	Roas Mao	M	Chormpul	Popel	Tramkak	Takeo	48.3	2003
02	Um Sun	M	Ang Raing	Boeng Tranh Cheung	Samrong	Takeo	23.5	2004
03	Prak Chres	M	Tasuon	Trapaing Thom Cheung	Tramkak	Takeo	44.5	2002
04	Mao Pheng	M	Hob	Kork Kchork	Kampong Trabek	Prey Veng	55.0	2003
05	Teab Leng	M	Samnoy	Senareach Oudom	Prah Sdach	Prey Veng	162.0	2005

3.1. Land use experiences of farmers

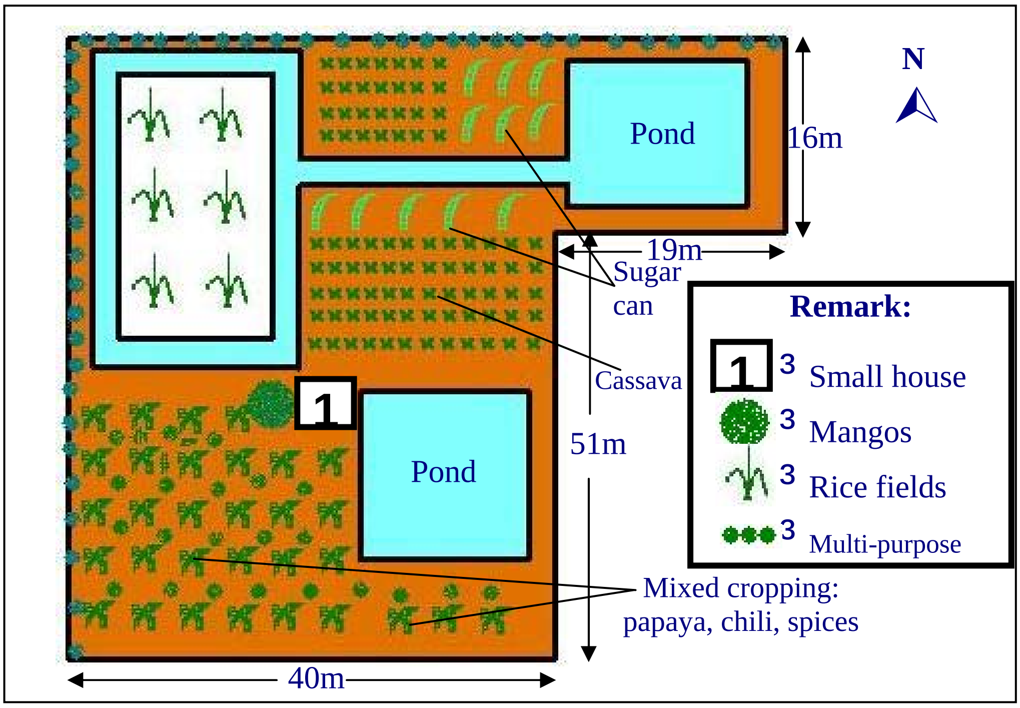
The design of MPF plans is quite varied. It depends particularly on the desire and creativeness of farmers themselves. Some farmers have retained bigger areas for their rice production, while other farmers have retained smaller areas for their rice fields by using other spaces to make ponds, canals, dikes and upper fields. The following are the different designs of MPF from the 5 best MPF farmers:

Table 6: Land uses of farmers in Multi-Purpose Farm development

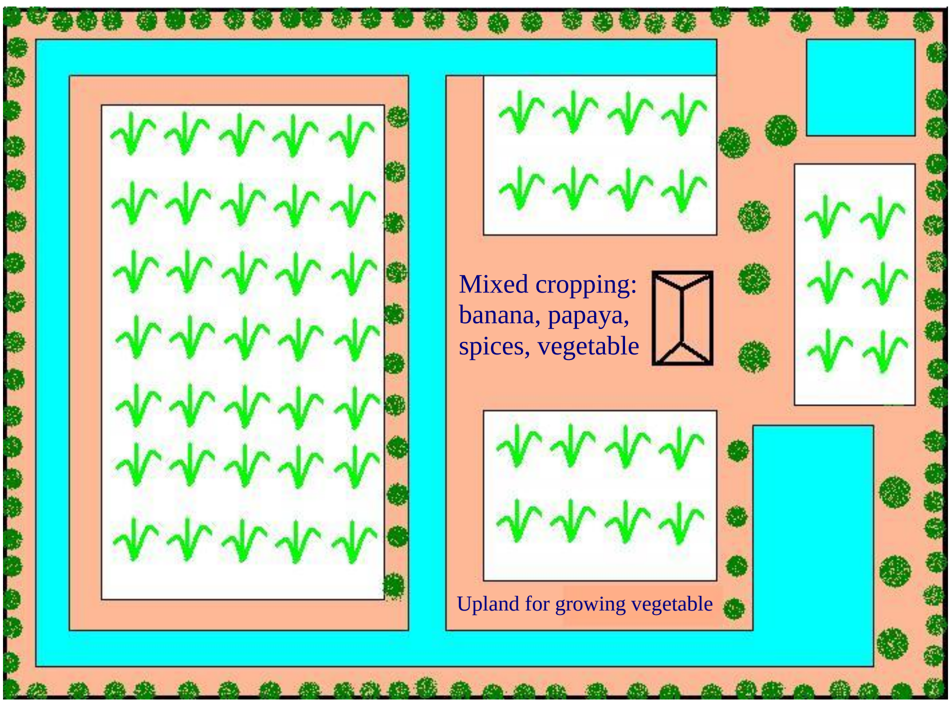
Farmers' Name	Total space		Rice field		Space for pond and canal		Space for upland and dike	
	Ares	%	Ares	%	Ares	%	Ares	%
Roas Mao	48.3	100	32.0	66.3	7.4	15.3	8.9	18.4
Um Sun	23.4	100	3.7	15.8	5.8	24.8	13.9	59.4
Prak Chres	44.5	100	28.0	62.9	7.5	16.9	9.0	20.2
Mao Pheng	55.0	100	40.3	73.3	3.6	6.5	11.1	20.2
Teab Leng	162.0	100	110.0	67.9	19.6	12.1	32.4	20.0



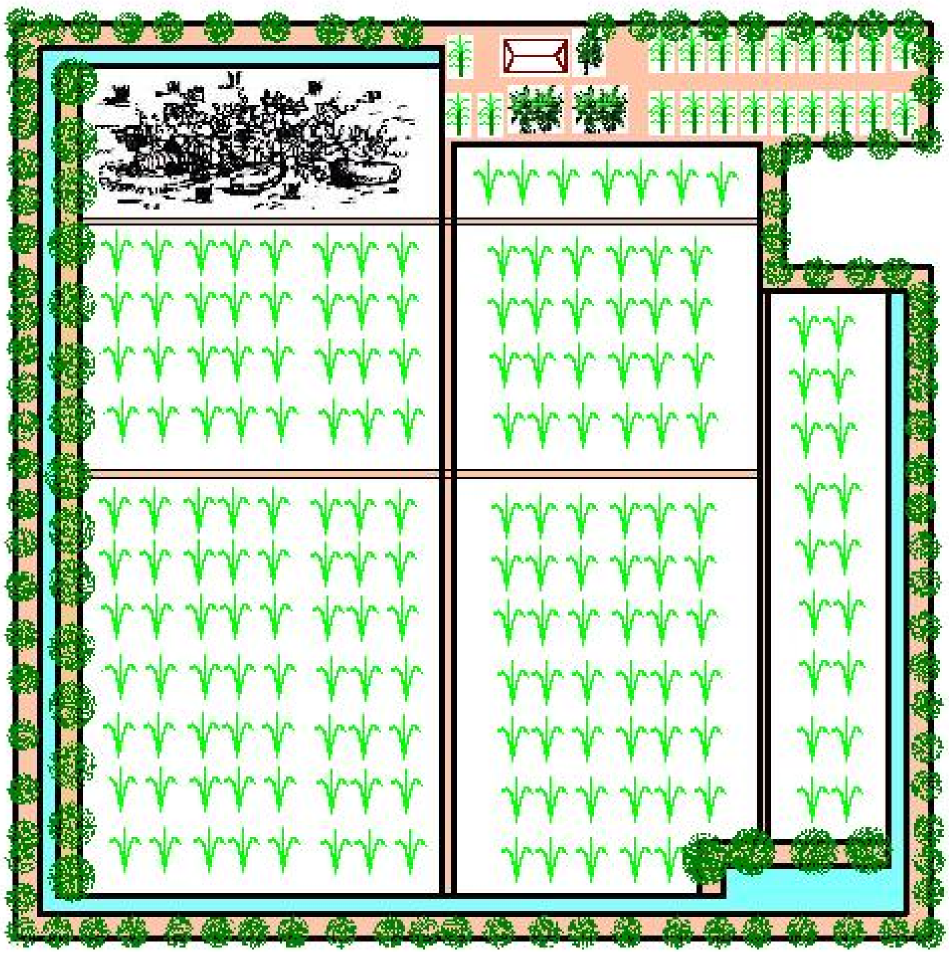
Picture 12: Land uses of developed Multi-Purpose Farm of Mr.Roas Mao



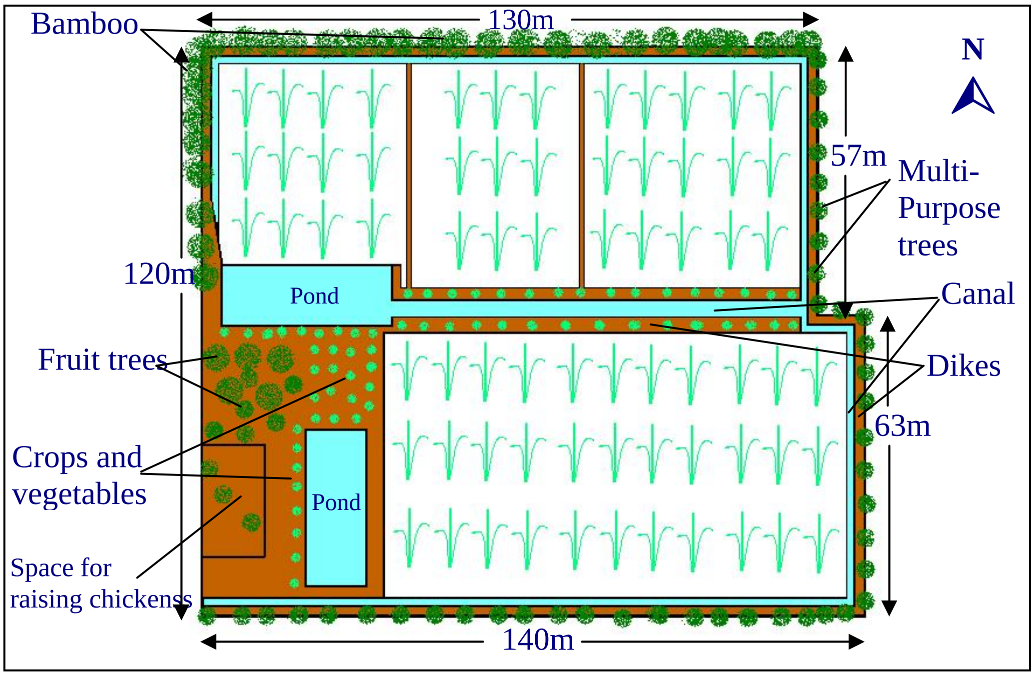
Picture 13: Land usage of developed Multi-Purpose Farm of Mr. Um Sun



Picture 14: Land uses of developed Multi-Purpose Farm of Mr. Prak Chres



Picture 15: Land usage of developed Multi-Purpose Farm of Mr. Mao Pheng



Picture 16: Land usages of developed Multi-Purpose Farm of Mr. Teab Leng

3.2. Farmers' experiences in designing each plot of Multi-Purpose Farm

From a specific rice field, farmers could convert/develop into many plots in order to increase the abilities for growing other crops/plants, raising fish and animals. The main objective is to intensify the productivity of each plot as much as possible. We can learn from the experiences of some farmers in designing and preparing each plot of MPF. They are as follows.

Table 7: Farmers' experiences in designing each plot of Multi-Purpose Farm

Farmer	Rice field	Pond	Upper Field	Canal and dike
Roas Mao	- Applies SRI methods effectively - Grows watermelons and green gourds before and after rice - Uses only organic fertilizer, with no use of agrochemicals	- Grows lemon grass around the pond and also aqua-plants - Made frame over the pond for growing gourds - Raises fish in pond - Has proper pond slope	- Has two uppper field plots; one for growing vegetables and the other for raising animals - Built small house for guarding the farm - No large fruit trees due to the small space available	- Larger and deeper canal connected to the pond - Made frame over the canal for growing gourds - Made hole for fish to go into andout of the rice field - Larger and higher dike with fence, planting pigeon peas as well as many other crops such as sugar cane and cassava, etc.
Um Sun	- Retains smaller rice field than others - Has canal around rice field to do rice-growing and fish raising - Applies SRI methods effectively to produce higher yields	- Made two ponds for raising fish - Prepared proper slope for the pond and planted lemon grass around the pond	- Has three upper field plots with wider spaces - Planted mixed papayas, chillies and spices that can earn income for long time - Planted other crops such as sugar cane and cassava, etc.	- Has surrounding dike but one side is still low - Planted multi-purpose trees, but these are not yet large - Has canal around the rice field connected to the pond
Prak Chres	- Applies SRI methods effectively - Constructed canal around rice field for good water management	- Has two large ponds - Did good preparation to prevent soil erosion - Made fish-trapping ponds	- Made wider space for upland production - Planted many mango trees - Grows a lot of vegetables and crops for all year-round production	- Built larger and deeper canal around the rice field and in the center of the farm - Prepared a fish trapping system - Has larger and higher surrounding dike with a living fence
Mao Pheng	- Applies SRI methods effectively - Grows dry-season rice and green gourds on rice fields - No chemicals used	-Has a small pond which can trap fish	- Has large enough upper field for growing many kinds of vegetables and crops	- Built a larger and higher dike around the farm with a living fence, and a canal around the whole farm
Teab Leng	- Retained larger rice field - Grows short-	- Has two big ponds for storing water for all year round	- Has wider upper field land for planting many fruit	- Built larger and higher dike around the farm with a living

	duration rice and cucumbers on rice fields in early rainy season before rainy-season rice - Applies SRI methods effectively	- Raises fish and grows aqua-plants - Grows lemon grass around the pond with well-designed preparation	trees, mixed crops and vegetables - Prepared a double fence for ecological chicken raising	fence - Has larger and deeper canal around the farm

3.3. Investment and income of Multi-Purpose Farm development

According to the different designs of MPF for each farmer, the amount of investment and income is also different from one to another. We can see that more space that farmers convert into water sources and upper fields, including a commitment to grow a variety of crops, the higher income they can earn compared to others. Mr. Um Sun has retained a very small rice field, but he could earn the highest income from his MPF compared to the other 4 farmers.

Table 8: Investment and income of Multi-Purpose Farm development

Farmer		Income before MPF (average/year)	Income after MPF (average/year)	Investment
Roas Mao	In riels	286,000	2,943,300	450,000
	In USD	**71.50**	**735.80**	**112.50**
Um Sun	In riels	770,000	3,309,000	1,635,000
	In USD	**192.50**	**827.30**	**408.80**
Prak Chres	In riels	1,896,000	2,601,000	1,800,000
	In USD	**474.00**	**650.30**	**450.00**
Mao Pheng	In riels	320,000	1,816,800	146,000
	In USD	**80.00**	**454.20**	**36.50**
Teab Leng	In riels	546,000	1,305,000	2,068,400
	In USD	**136.50**	**326.30**	**517.10**

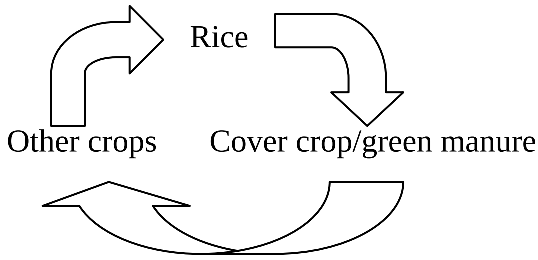
3.4. Experiences of fish raising and trapping in a Multi-Purpose Farms

With a pond and surrounding canals as part of their MPF, farmers are able to maintain an effective system of rice-fish culture that includes both *cultivated fish and natural fish*. Rice-fish culture is a system that can help farmers to make higher yields of both rice and fish. The fish are allowed to go and find feed in the rice field, and they eat worms, insects and grass seeds which are pests for rice. The fish also helps in improving oxygenation to the soil and deposit faeces that enrich the soil. In addition, when there is abandance of food sources for the fish, this helps the fish to grow very well.

This rice-fish system in MPF involves having a canal around rice field connected to the pond which is the main fish habitat. The fish can move freely into and out of the rice field through the canal. Farmers have often built a larger and higher dike around their farms in order to protect the fish in their farms. From fish raising, farmers can earn money up to 192,200 riels (about 48 USD), wherease previously, they would have gotten only 30,000 riels (7.5 US dollars) from this source. This calculation does not count the amount of home-consumption of fish with MPF which can be significant for family health.

3.5. Experiences of designing cropping system in Multi-Purpose Farms

The cropping system with MPF should be well-designed in terms of its basic plots, which include rice fields, upper-field land, and surrounding dikes. Farmers must apply crop rotation system on their rice fields in order to maintain soil fertility and to ensure high yields of rice for the next year. This usually means alternating rice in the main wet summer season with some vegetables or legumes grown in the dryer winter season. Ideally, there is also a green manure or cover crop inserted between the rice and other crops, as shown in the following diagram.



On upper field lands, farmers can grow many kinds of crops/plants with good selection in designing their cropping plan. Large fruit trees should be planted on the western side of the farm to avoid the impact of their shade on other crops when they become large.

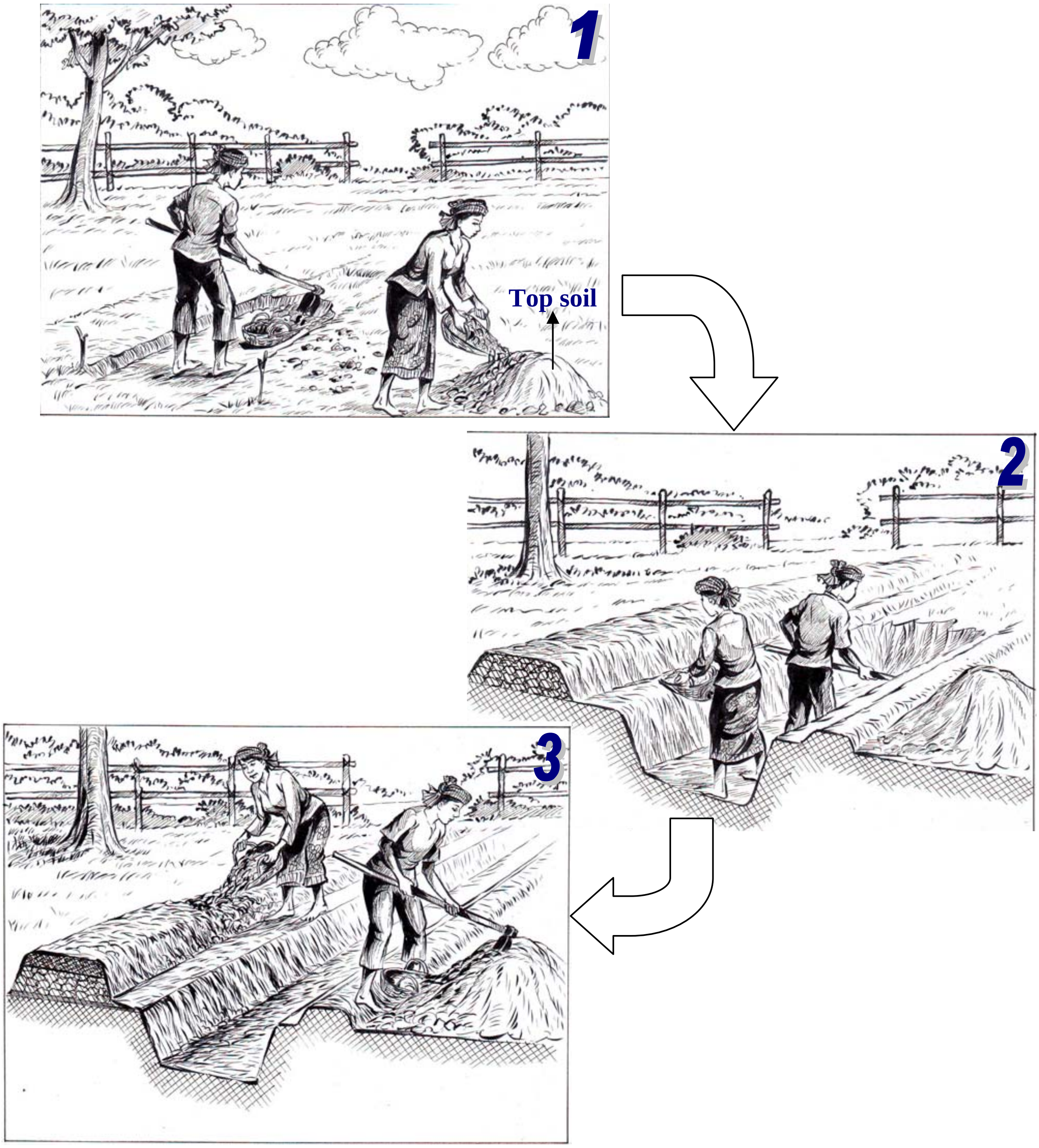
On the surrounding dike, farmers could plant multi-purpose trees (coppicable/pollardable) as a living fence. Good species include *Cassia siamea Papilionaceae*, *Sesbania grandiflora Papilionaceae* and *Leucaena leucacephala Leguminosae*. On the inner side of the dike, farmers can grow other crops such as cassava, sugar cane and corn.

The following are some kinds of crops/plants that are commonly being grown on upper field lands of MPF:

- Fruit trees: mangoes, jack fruit, coconuts...
- Perennial plants: papayas, bananas, pineapple, chillies...
- Vegetables: fruity, leafy and root vegetables.
- Spices: lemon grass, basil, mint, garlic and turmeric...

3.6. Experiences of soil quality management in Multi-Purpose Farms

Some farmers did not pay attention to managing soil quality at the outset, especially when they dug their ponds and canals. They put topsoil at the bottom of their dikes or upper fields land and then used clay soil (from deeper land) to build their dikes or upper fields. It is very difficult to grow any crops in the first year unless farmers have ensured the quality of their soil first. Therefore, farmers should be careful to manage their soil quality, especially on upper field land and dikes where they produce many crops. This involves thought and care in their initial land forming and on-going enrichment of their crop soil with organic matter.



Picture 17: A method to manage soil quality

V. SYNTHESIS OF GOOD EXPERIENCES

Briefly, developing a good MPF requires farmers to concretely apply many techniques and to carefully and purposefully practice their agriculture. The main ideas and techniques of MPF development are as follows:

- Initially, take small steps to convert part of the rice field into ponds, canals, upper field land, dikes and living fences, investing money, labor, time and materials as necessary to create a **more productive farming operation**.

- Plan the location and scale of each element of MPF, according to market opportunities, soil capabilities, and time and logistical considerations. This means that farmers should draw a map of what they want to achieved, thinking through the reasons for each decision, so they have a clear design and plan for their MPF development for **best use of all available resources**.

- Diversification of crops, animals and aquaculture production is the main process of MPF development. This should be well planned and implemented by farmers in order to increase the **productivity** of their MPF, especially making optimum use of available family labor.

- Management systems of MPF should be carefully organized by farmers in order to ensure the **sustainability** of their production such as soil quality management, water management, diversification of elements, living fences, and timing, harvesting, possibly processing, and sales of MPF products.

- Farmers should effectively apply **ecological agricultural techniques** such as the System of Rice Intensificaftion (SRI), Ecological Chicken Raising (ECR), Fish Raising and Trapping, and Ecological Crop Growing, as well as other techniques such as frog raising, eel raising, earthworm raising, and fish raising in plastic containers, etc.

- For the **diversification** of crops, farmers should include perennial and semi-perennial trees/plants along with annual and seasonal crops. This is to ensure the production throughout the year because some perennial plants will produce products during the dry season when farmers face difficulties in growing annual and seasonal crops.

V. CONCLUSION

Briefly, we can assume that farmers will try to develop an effective MPF to diversify their production and increase the productivity of their small rice fields if these are about 0.65ha, although a number of the most successful MPF farmers have started with an area only two-thirds this size. Determined investment with clear planning can enable farmers' families to escape from their chronic food shortages, creating regular work and year-round income.

It has been gratifying to see that with MFP, it may become possible for farmers to pay their children a decent income for work on their household MPF enterprise. This gives them a reasonable alternative to migration to urban areas. This has been the experience of Roas Mao, showing how MFP is an on-going evolving process to improve the quality and security of rural Cambodian households.

Facing and resolving difficulties in the beginning of their MPF development can serve to improve farmers' family livelihoods subsequently.

PACKAGE OF PRACTICE FOR DIRECT SEEDED RICE IN 0.5 ACRE OF LAND

This Package of Practice (PoP) for direct seeded rice (DSR) cultivation has been designed by drawing PRADAN's experience in the Kolhan region Jharkhand i.e.West Singhbhum district and Purulia district of West Bengal. As physiographic condition can vary across different regions in India, the package of practice may be varied accordingly. However, the basic essence of plant establishment and management should remain the same.

The objective of this livelihood model is to generate sufficient income to keep the family interested to do intercultural practices. Marginal lands which were poorly used for cultivation of paddy or other millets in the upland or waste land previously can be converted to a direct seeded rice field.

This has been designed keeping in mind that a facilitator in the village could use from day one for carrying out the activity and use this manual as a guide. The learning targets for farmers/ Facilitators / Community Resource Person from this pamphlet are:

- Learn proper plant establishment and management of direct seeded rice;
- learn proper management of direct seeded rice pests and diseases.

The East India plateau(EIP) region is known for broadcasting crops like Paddy, millets, pulses under rain-fed condition.Paddy is the main stable crop in the region and people has been cultivation rice crop since years back in the kharif season. Broad casting of rice is the main practices among farmers. Due to population pressure and wish to grow more rice people adopted transplanted rice practices from the irrigated areas. Due to lack of irrigation (less than 6% areas under irrigation) and unpredictable rainfall, the transplanted rice yields are highly variable, and low in comparison to river basin areas.

Average land holding per family is <1ha,and people cultivate rice mostly in the medium low and low land thatcomes around 0.3 ha, also plots are remained scattered. As broad casting and transplanted are the two major practices amongst farmers under variable rain-fed condition, so average productivity is very low, only 1.90 ton per ha in the region.Rainfall pattern is very peculiar and variable in the region, maximum rains come in the period July to October, and this is the rice growing period. Along with the rainfall variation in the different districts, soil moisture regimes of different land class are also variable, so opportunity of rice cultivation is also variable.

Line sown DSR rice may has huge scope in the EIP region focusing food security and climate resilience. There is a huge scope and opportunity to add value in the traditional method of broadcasting of paddy. It has been experienced and realized in the line sown DSR that has potentiality to produce more yield to transplanted rice (conventional) and at par to SRI rice. This **innovated line sown direct seeded rice (DSR)** has many advantages over the transplanted and traditional broadcasting method of paddy cultivation. The DSR fits with climate resilience, no dependency on enough rains for puddling, no pass nursery phase, least soil disturbance, minimal chances of getting soil crack under dry spells, scope of using small tools, less labor and reduced women drudgery etc.

Why to promote line sown DSR?

Transplanted rice is inherently risky due to climate variability during the nursery-transplanting period; traditional directed seeded rice is highly labor intensive, produce low yield.

Line sown DSR can allow a rice crop to be established in seasons when transplanted rice often fails or yields poorly due to late sowing. Additional advantages may include:

- Reduced labor requirement (no nursery phase, no puddling or no transplanting), Drudgery for women in agriculture can be reduced – no transplantation, no manual weeding.
- Farmers need not depend on onset of monsoon, as sowing can be completed in dry soil after receiving pre-monsoon shower,
- Effective and efficient weed management using mechanical weeder facilitated by line sowing,
- Earlier sowing, earlier harvest, creating opportunities for early sowing of a Rabi crop accessing soil residual moisture with partial irrigation if requires.
- Less quantity of seeds is require as compare to broadcasted paddy (reduced by 50%),

As there are many scope of value addition and innovation in the traditional DSR cultivation, advantages over transplanted rice. The above mentioned reasons are contextual, relevant to the current agriculture scenario to promote **line sown DSR.**

Crop period: Mid June to end of October

Land Requirement:

Dry rice cultivation is followed in uplands where there is less possibility for water stagnation. Uplands are characterized by aerobic soil in which attempt is made to impound water. Upland rice is grown on both leveled and sloppy fields those are not bunded and are prepared well for dry seeding. The rice crop solely depends upon rainfall for its water requirement.

Upland rice is called differently in many parts of India as Aus in West Bengal, Aus or Ahu in Assam, Beali in Odisha, Bhadai. This system of DSR can be followed in the areas generally having medium rainfed (shallow low-land) and low-lands, semi dry system of cultivation is followed.

Use of Tools and small equipment: In the value added DSR cultivation technology, there are three small but important tools are being utilized.

1. ***Litho marker***- this tool is used for row marking and used after final field preparation and leveling for sowing seeds in line.
2. **Wheel hoe**: this is a three blade hoe fitted with a wheel and shaft, and use for weeding and loosening of soil after 15-25 days of sowing at dry soil condition with young tender weeds available in the field. During this operation period, thinning of seedling also be ensured maintain proper seed to seed spacing.
3. **Cono weeder**: This tool is used after 30-40 days of sowing having 1”-2” of standing water in the paddy field.

Wooden marker **Iron marker**

Land Preparation:

The land preparation does not require special steps, though the soil should be well worked as it would be to get the best results from any method for growing rice. The land is ploughed sufficiently during summer to get the good tilth and sowing of rice is usually done in immediately after one or two pre-monsoon showers, generally during the month of May. Plough the field 3 times; 2 of these ploughings should be done within an interval of 8-10 days in between during the nursery preparation. **Apply four bags of Ghana Jiwamrita over the field before the last ploughing to preserve soil organic matter.** After ploughing the field, make it level using a wooden leveler. For transplanting, mark lines on the field in a square grid pattern, at a distance of 10 inches (25 cms) apart, one direction being perpendicular to the gradient; wooden markers or iron marker can be used for marking these lines. When transplanting, the plants should be spaced at a distance of 10 x 10 inches. Furrows and ridges can be made on the field’s surface with a cycle wheel or hoe.

Seed requirement:

Seed rate depends upon the duration and test weight of variety. Soil tilth, moisture content and system of cultivation also determine the seed rate requirement. Optimum seed rate should be adopted for the direct seeded crop so that crop stand is neither too thick nor too thin. In general, a seed rate of 16 kg ha^{-1} is required for line sown DSR. The seed should be stored in advance and should be ready to be sown after the pre monsoon showers in the field.

Priming of seeds:

Add salt in fresh water until a good quality egg can float in that water. Remove the egg and put the seeds in that brine water solution. Remove the seeds floating on the surface as those are useless. Drain the brine water and wash the seeds with fresh water. Mix *Bavistin* (5 grams)/ cow urine with the seeds and put them inside a moist gunny bag in the shed for 24 hours for sprouting of the seeds. Priming of seed helps in growth of the plant and provides strength.

Planting the seed per hill:

To obtain uniform and better germination, it is necessary that the seeds should be placed at optimum depth. A study on the germination of the seeds sown at varying depths revealed that the seeds sown at 5 cm depth took about 4 to 6 days for their plumules emergence on the surface of the soil. While the seeds lying exposed on the surface as well as those below 5 cm depth required 6 to 10 days for emergence. The seeds lying at a depth below 10 cm from the soil surface germinated but their plumules didn't come out of the soil and died. Therefore, seeding depth of rice should not be more than 5 cm and preferably it must be 3-5 cm. The seeds should be put at the hill as per the square grid pattern and covered with the soil immediately after putting one to two seeds per hill.

Marking the hills

Planting the seeds

Care of the field after plantation:

After fifteen days

Extra plants should be plucked by hand by measuring with four fingers (approximately 6 inches) and all the initial weeds should be removed on the fifteenth day of plantation. For weeding the field; conoweeder should be used if the field is moist and wheel hoe incase of an inundated one. Apply 100 litres of Jeevamrita should be applied in the field after the weeding.

After 30-35 days

Weeding should be done with conoweeder (if there is no standing water) and wheel hoe (if the field has water in it). After weeding apply 100 litres of Jeevamrita.

After 40-45 days

Weeding should be done with conoweeder (if there is no standing water) and wheel hoe (if the field has water in it). After weeding apply 100 litres of Jeevamrita.

After milking starts in the seeds, sour butter milk (one litre in 15 litres of water) should be applied on the field.

For management of stem borer, Gandhi bug or any other infestation apply Pot Solution (100 ml in 5 litres of water), and Neemastra (100 ml in 5 litres of water).

Preparation of different organic manure and pesticides

Jeevamrita

Ingredients (for 1 acre)
Water - 200-250 litres
Cow dung - 10-15 kgs
Cow Urine - 3-4 litres
Jaggery - 1-2 kgs
Soil under a tree or un-disturbed location form the same land - 2-3 handfuls

Mix all of them and keep them in a shade for 3-4 days. Stir the mixture once a day. Apply the mixture when the ground is wet for the plants. This seems to work wonders for the plants due to increased microbial activity by 3rd and 4th day. This is an excellent culture for enabling the exponential increase of beneficial microbes. The microbes are added thru 2-3 handful of local soil. Though it can be used even after 6-7 days, it is quite a challenge getting near the mixture due to overpowering stench, hence advisable to use this within 3-4 days of preparation.

Neem Solution (for sucking pests & mealy bug)

Add 100 liters of water to a large container along with 5 liters of cow urine. Add also 5 kg of cow dung to this. Crush 5 kg of neem leaves, making a pulp from them, and add this into the pot. Stir the solution and let it stabilize for 24 hours. Stir this solution twice a day by any stick. Filter the liquid through a cloth and spray the filtered liquid (100 ml added to 5 liters of water) for controlling the above pests.

Pot Solution

Sl.No	Items	Amount
1.	Cow dung (deshi cow)	1kg
2.	Cow urine	2 liters
3.	Neem (*Azadiracta indica*)	1 kg
4.	Akanda (*Calotropis zygantia*)	1 kg
5.	Karanja (*Pongamea pinnata*)	1 kg
6.	Jaggary/ molasses	50 gm
7.	Plus a handful of termite soil	-

SCI

The System of Crop Intensification

Agroecological Innovations for Improving Agricultural Production, Food Security, and Resilience to Climate Change

SRI-RICE

CTA

The **SRI International Network and Resources Center** (SRI-Rice) was established at Cornell University in 2010 to meet the growing demand for knowledge, advice, and technical support for the System of Rice Intensification (SRI), a climate-smart, resource-conserving, yield-increasing methodology whose benefits have been demonstrated in over 50 countries. SRI-Rice currently operates under the auspices of International Programs of Cornell's College of Agriculture and Life Sciences. The Center seeks to advance and share knowledge about SRI practices and principles, now being extended to many crops beyond rice under the rubric of System of Crop Intensification (SCI). SRI-Rice supports networking and cooperation among interested organizations and individuals around the globe. For more information on SRI-Rice and SRI, visit ***www.sririce.org***

The **Technical Centre for Agricultural and Rural Cooperation** (CTA) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). Its mission is to advance food and nutritional security, increase prosperity and encourage sound natural resource management in ACP countries. It provides access to information and knowledge, facilitates policy dialogue and strengthens the capacity of agricultural and rural development institutions and communities. CTA operates under the framework of the Cotonou Agreement and is funded by the EU. For more information on CTA, visit ***www.cta.int***

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Cover: Women of Chandrapura village in the Khageria district, Bihar, India, in one of their fields of wheat grown with SCI methods, widely referred to as SWI, the System of Wheat Intensification.

Back cover: Comparison of SWI panicles on the right and conventionally-grown wheat panicles on the left from 2009/2010 trials in the Timbuktu region of Mali.

Publication design: Devon Jenkins

Available online at: ***sri.ciifad.cornell.edu/aboutsri/othercrops/SCImonograph_SRIRice2014.pdf***, and at ***http://publications.cta.int***

The System of Crop Intensification: Agroecological Innovations for Improving Agricultural Production, Food Security, and Resilience to Climate Change

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FOREWORD

This publication reports on current 'work in progress' to raise agricultural productivity in eco-friendly ways in a number of countries around the world. We think that farmers, communities and institutions in the African, Caribbean and Pacific regions would like to know about this and to benefit from it to the extent that they can.

Hundreds of thousands of households in Asia and Africa are finding that they can increase the productivity of their available resources for producing a wide variety of crops -- in the process, making these crops more resilient to the multiple stresses of climate change -- just by making changes in the ways that their plants, soil, water and nutrients are managed, as shown in this publication co-published by CTA and SRI-Rice.

The contributors to this report are listed below in alphabetical order because while most of the writing for this monograph was done by Uphoff on their behalf, it was the material, data, pictures and feedback provided by the co-authors that made this publication possible. And most importantly, it was their work with farmers in their respective countries that has helped to create what is becoming widely known now as the System of Crop Intensification (SCI), reported on in this small volume.

This booklet is not presenting a new 'technology' -- to be transferred and adopted -- but a set of ideas and experiences that we hope will encourage many people to 'think outside the boxes' of their current practices and to capitalize upon certain biological processes and potentials that exist both within their present crops and within the soil systems in which these crops grow.

We hope that as more knowledge about SCI opportunities is gained through people's experimentation and experience that this will be communicated and widely shared. Both CTA and SRI-Rice welcome feedback and will try to disseminate information on further experience with SCI, both good and bad, to enable households in the ACP and beyond to have more secure and prosperous lives.

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Contents

1. The Need for Sustainable Intensification of Agriculture

__Figure 1:__ Biswaroop Thakur, Bihar state coordinator for the NGO ASA, during a field visit to Chandrapura village in Khagaria district, Bihar, India. The wheat field using SCI principles on the left matured earlier than the traditionally-managed field on the right, with panicles already emerged, while the traditional crop is still in its vegetative stage.

Without clear agreement yet on what the term means, there is growing consensus that to meet our global food-security requirements throughout this 21st century, agricultural sectors around the world will need to pursue appropriate strategies for **sustainable intensification** of agricultural production (Royal Society 2009; Montpellier Panel 2013). The terminology used can vary: **sustainable agricultural intensification** (IFAD/UNEP 2013; World Bank 2006), **low-input intensification** (European Parliament 2009), **sustainable crop production intensification** (FAO 2011). But the intended redirection of thinking and practice is broadly shared.

A common denominator for these recommendations for sustainable intensification is their divergence from the kind of agricultural strategy that has prevailed over the past 50 years. Technologies for what is known as 'modern agriculture,' particularly those associated with the Green Revolution, have enabled farmers who have access to sufficient land, water, machinery and purchased inputs to cultivate ever-larger areas and produce more food and fiber.

Following the precepts of the Green Revolution, farmers have raised their production by planting (a) **improved varieties**, benefited by (b) **more water** and (c) **increased inputs** of agrochemicals, fossil-fuel energy, and capital investment. By investing more inputs to obtain greater output, they have improved upon the previously more 'extensive' strategies of production that were characterized by both low inputs per unit area and correspondingly low outputs.

This contemporary strategy for intensification that depends primarily on making genetic improvements and increasing external inputs is, however, **not the only kind of intensification that warrants consideration** -- especially given growing concerns about the **sustainability** of current agricultural practices (IAASTD 2009) and about their impacts on **climate change**. A Worldwatch Institute report in 2009 found that the land use sector was responsible for more than 30% of all greenhouse gas emissions, while another study found that the industrialized food production system as a whole is responsible for 44 to 57% of all global greenhouse gas emissions (Grain 2011).

An alternative strategy for intensification that can be broadly characterized as **agroecological** seeks to make the most productive use possible of available natural resources, including the myriad species and genetic biodiversity found in nature, and of the fields of many millions of smallholder farmers, especially women. Particularly land and water resources are becoming less abundant relative to the human populations that depend on them, with their quantity often diminishing and their quality frequently degrading. The increasing scarcity of our natural resources relative to the needs of our growing populations places an ever-greater premium upon improving the management of the soil systems, water, and biotic resources still available.

The agroecological innovations reported here can be grouped under the broad heading of **System of Crop Intensification** (SCI).[1] This approach seeks not just to get more output from a given amount of inputs, a long-standing and universal goal, but aims to achieve ***higher output with less use of or less expenditure on land, labor, capital, and water*** – all by making modifications in crop management practices.

SCI practices enable farmers to mobilize biological processes and potentials that are present and available within crop plants and within the soil systems that support them (Uphoff et al. 2006). Such agroecological innovations represent a departure from the current paradigm for 'modern agriculture.'

We do not expect that these new approaches can or will simply replace all current practices. Agricultural development does not work that way. Rather, the aim is to give farmers **more options** for meeting their own needs and those of consumers, while at the same time protecting and conserving environmental resources and services.

Farmers in quite a range of countries -- India, Nepal, Pakistan, Cambodia, Ethiopia, Mali and Cuba – have started managing the growing environments for their respective crops to bring them closer to

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1 There are also other acronyms and names given for this domain for the advancement of agricultural knowledge and practice, usually including the name of the focal crop, such as System of Wheat Intensification (SWI) or System of Tef Intensification (STI). For a summary account of SCI and the material in this monograph, see Abraham et al. (2014).

an optimum, producing more food with a lighter 'footprint' on the environment. What we report here is from farmers' fields, not experiment stations, since as yet there has been limited interest in SCI from agricultural science researchers.

Two NGOs in India -- PRADAN and the People's Science Institute -- and an Ethiopian NGO -- the Institute for Sustainable Development (ISD) -- have been particularly active in applying SCI ideas across a number of crops, with results reported here. The largest-scale introduction and adaptation of SCI has been in Bihar state of India, where its rural livelihoods program JEEVIKA, supported by the state government and by World Bank IDA assistance, has enabled several hundred thousand poor households to benefit from these new approaches (Behera et al. 2013).

The contributors to this monograph are reporting as initiators or supporters of the changes being introduced, not as researchers studying them, although all have done and continue to do publishable research. By communicating observed outcomes achieved under real-world circumstances as accurately as possible, it is hoped that this information will stimulate the interest of others to undertake more systematic studies and to help establish scientific explanations for promoting the greater utilization of SCI adaptations under 21st century conditions.

No firm or final conclusions are proposed as this is a fast-moving, fast-growing domain of knowledge. The agricultural experiences reported here have become known mostly within the last five years, as part of efforts to improve food security for communities, many of them impoverished or distressed. The main concern is to assist resource-limited households that must deal with the severe and growing challenges found in degraded environments, which are now being exacerbated by the climate change that adds to their burdens and insecurity.

__Figure 2:__ Children in Gaya district of Bihar state of India admiring and playing with a simple mechanical weeder used for controlling weeds and aerating the soil when producing mustard (rapeseed or canola) with SCI methods.

The results of SCI practice -- ***producing more food outputs with fewer inputs*** -- will appear counter-intuitive to many readers, maybe even to most. But this reorientation of agriculture is what 'sustainable intensification' will require as our populations get larger and as the resources on which they depend become relatively, and in some places even absolutely, more limiting.

`2. Agroecological Management

Agroecological crop management represents a different form of 'intensification' from what is usually understood by that term, e.g., Reichardt et al. (1998). Agroecological management is exemplified by the **System of Rice Intensification** (SRI) developed in Madagascar (Stoop et al. 2002; Uphoff 2012a) as well as by ***conservation agriculture***, ***integrated pest management***, ***agroforestry***, and other combinations of practices that modify the management of crops, soil, water and nutrients. These changes achieve, among other things, enhanced soil microbial abundance and activity in the crops' rhizosphere (root zone), and even within the crops' phyllosphere (canopy) (Uphoff et al. 2013).

__Figure 3:__ A mustard field in Gaya district of Bihar state of India grown from seedlings transplanted at a young age into widely spaced pits filled with loosened soil and organic matter. This field will yield triple the usual grain harvest. Standing in front of the field are Dr. O.P. Rupela, former senior microbiologist with ICRISAT in Hyderabad, India, and a young village boy who was passing by.

Such strategies can reduce, and sometimes eliminate, the need for use of the agrochemical inputs that have been a mainstay of 20th century agriculture, particularly since the Second World War. These alternative strategies can benefit from, although they do not require, improvements or modifications in crops' genetic endowments. The alternative management methods employed elicit improved **phenotypes** from most if not all existing **genotypes**, whether these are 'improved' or 'unimproved' varieties (Altieri 1995; Gliessman 2007; Uphoff 2002).

Agroecological management mostly intensifies knowledge and skills (mental inputs) rather than seeds, equipment or chemicals (material inputs). More labor input is required in some situations, but not in others, so these strategies are not necessarily more labor-intensive. Some degree of mechanization can often be introduced, utilizing capital and external energy inputs (pages 52-57); but if so, these resources are relied upon less than in 'modern agriculture.' Dependence on agrochemicals to enhance soil nutrient supply and to protect crops from pests can be reduced or replaced by capitalizing on biological resources and dynamics that make soil systems more sustainably fertile, and that can enhance crops' inherent resistance to pests and diseases (Chaboussou 2004).

Agroecology focuses on supporting the interactions, dependencies and interdependencies among myriad organisms and especially among diverse species. By making modifications in crop management practices, we are learning, we can enhance the symbiotic relationships between plants and the communities of microorganisms that constitute the plants' microbiomes (Anas et al. 2011).[2]

Recently we have been learning that ecological interactions and interdependences exist not only ***among*** organisms and species, but also ***within*** organisms as research shows how microorganisms inhabit crop plants as symbiotic endophytes. These, when living in the tissues and cells of crops' leaves and stalks as well as in their roots and even in seeds, can beneficially affect these plants' expression of their genetic potentials (Chi et al. 2005, 2010; Rodriguez et al. 2009; Uphoff et al. 2013).

Although agroecological management may appear 'old-fashioned' to some people, scientific advances in the fields of microbiology, microbial ecology, and epigenetics in the decades ahead should make it the most modern agriculture.

Crops with larger, more effective root systems in association with more abundant and diverse life in the soil are more resilient when subjected to drought, storm damage and other climatic hazards. Buffering of such effects has been seen frequently with SRI management for rice (Uphoff 2012a). Similar effects are reported also for other crops with agroecological management, making them also less vulnerable to climate stresses including extreme weather.

Much remains to be learned about how and why agroecological management can have beneficial effects on crops' productivity and resilience, but this monograph shows that there are many advantageous relationships waiting to be explained. It is now known that certain management practices, assembled inductively to improve the performance of rice crops, can have desirable impacts on many other crops as well.

These effects will take on greater significance in a future that is affected by **climate change**. We are finding that crops grown with attention to nurturing larger, more effective root systems and more abundant, diverse soil biota show greater resilience when subjected to climate stresses and have more resistance to drought, storm damage, and other hazards.

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2 The functions and protection that beneficial microorganisms perform for crops are parallel to those that our respective human microbiomes contribute to the growth and health of members of our human species (Arnold 2013)

3. Applications of Agroecological Strategies to other Crops

The System of Rice Intensification (SRI) was developed in the 1980s to improve the circumstances of poor, rice-growing households in Madagascar (Laulanié 1993). Over the past decade, the SRI principles that were assembled to raise irrigated rice production have been extended first to rainfed rice, and then to improving yields of a variety of other crops (Uphoff 2012b).

This broader application, referred to as the System of Crop Intensification (SCI), extrapolates practices derived from the core principles of SRI, with appropriate modifications, to other cereals, legumes and vegetables (Araya et al. 2013; Behera et al. 2013; WOTR 2013). It is even broadened to include other kinds of agricultural production, as reported on in section 7.

Some practitioners in India who want to keep the SRI acronym intact refer to SCI and SRI together as the System of ***Root*** Intensification. This is an apt characterization, directing attention to what goes on below-ground. But its focus on roots is incomplete since much of the impact of SRI practices should be attributed to the massive, invisible multitudes of symbiotic microorganisms that inhabit soils and also plants.

The bacteria and fungi that live in, on and around plants (and animals) provide the substrate for vast and intricate soil-plant 'food webs' that range from miniscule microbes up to larger, vis-

Figure 4: *Harouna Ibrahim, Africare technician working in the Timbuktu region of Mali who has motivated and guided farmer innovation with SWI, showing difference between wheat plants of the same variety that were grown with different management practices. SWI methods, seen on the right, promote root growth and soil organisms that contribute to more tillering, larger panicles, and more grain than with conventional practices, seen on the left.*

ible creatures. These networks are composed of organisms that feed upon each other and that improve the environments of other complementary species. The soil biota channel large flows of energy (Ball 2006) that support and sustain the production of all of our crops and livestock (Coleman et al. 2004; Lowenfels and Lewis 2006; Thies and Grossman 2006).

The methodology recommended for SRI or SCI practice can be summarized under four simple ***principles*** that interact in synergistic ways:

- Establish healthy plants both early and carefully, taking care to conserve and nurture their inherent potential for root growth and associated shoot growth;
- Reduce plant populations significantly, giving each plant more room to grow both above and below ground;
- Enrich the soil with decomposed organic matter, as much as possible, also keeping the soil well-aerated to support the better growth of roots and of beneficial soil biota.
- Apply water in ways that favor plant-root and soil-microbial growth, avoiding hypoxic soil conditions that adversely affect both roots and aerobic soil organisms.

These principles translate into concrete **practices** that have proved productive for increasing yields of irrigated rice, as confirmed in large-scale factorial trials (Uphoff and Randriamiharisoa 2002). The methods which are to be adapted to local conditions such as crop, soil type and climate include:

- Planting young seedlings carefully and singly, with optimally wide spacing in a square grid or diamond pattern for better exposure to sun and air.
- Providing the crop with sufficient water to support the growth of plant roots and beneficial soil organisms, but not so much as to suffocate or inhibit them.
- Adding as much organic matter to soil systems as possible to improve soil structure and functioning, enhancing the soil's ability to support healthy plant growth.
- Breaking up the soil's surface in the process of controlling weeds, actively aerating the soil and stimulating root and microbial growth, also incorporating weeds into the soil as green manure.

The cumulative result of these practices is to induce the growth of more productive and healthier plants – phenotypes -- from any given crop variety -- genotype.

Once farmers in parts of Cambodia, Philippines, India and Myanmar who had no access to irrigation facilities saw the results of SRI practices and understood its principles, they started extending and adapting these to their rice production in ***upland areas*** that had no irrigation.[3]

This was a first step beyond the use of SRI principles for irrigated rice. Subsequently, various farmers and NGOs in these and other countries began adapting SRI principles and practices to other crops beyond rice.

There has been little scientific evaluation of SCI so far, but systematic studies should begin soon. The data that follow represent a first step toward quantitative assessment, having been gathered for purposes of comparison, for farmers to know the effects of their change in practices. Often the data have been assessed through on-site visits by one or more of the contributing authors, usually with members of the local agricultural development community.

We can assure readers that the same methods were used when calculating yields from both SCI and conventional fields. This means that the **relative** yields reported, i.e., the ratios and percentages, are reasonably reliable even if there might be questions raised about the **absolute** numbers. The purpose of measurement was, as noted above, to make comparisons for farmers' sake, not to be setting any records.

Figures 5 and 6: *Applications of SCI ideas to vegetable production in Bihar state of India: at top, profuse branching of eggplant (brinjal) plants under SCI management; at bottom, SCI tomatoes ready for market.*

That there can be increases in production without requiring greater inputs is what counts most for farming households. The standard of comparison is farmers' current practices, recognizing that what some would consider as 'best management practices' recommended by agricultural scientists have substantially higher out-of-pocket costs of production, and are beyond the means of most food-insecure farmers.

While the information on SCI given in section 4 which follows contains some limitations of precision and coverage, the impacts being observed and reported are both large and consistent. Assessments of statistical significance are more relevant when one is considering small differences that may just be measurement artifacts or chance occurrences. Such tests are less relevant for the kind of large divergences reported here.

3 Myanmar farmers' experience with rainfed SRI is documented in Kabir and Uphoff (2007).

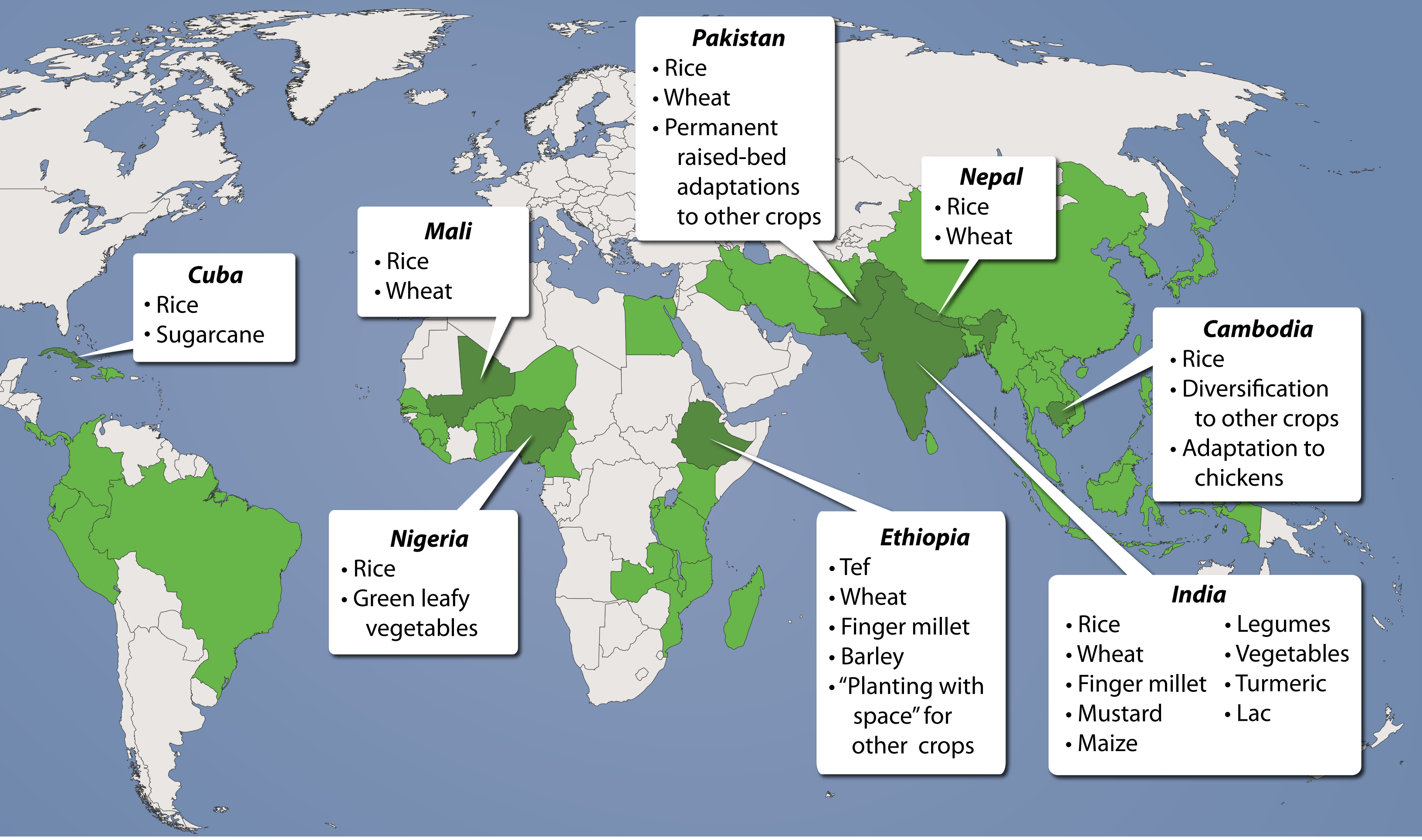

Figure 7: *Spread of SRI and SCI ideas and practices: in the light green colored countries, SRI methods have been seen to produce better phenotypes from available rice genotypes; in the dark green colored countries, in addition to this, there has been experimentation with and confirmation of SCI principles and techniques; lists for each country show which crops have to-date been shown to improve yields with SCI methods.*

The photographic evidence shown in accompanying figures reinforces the proposition that something of agricultural significance is occurring. Data from the crop-by-crop reviews that follow and from other crop performance evaluations are summarized in Annexes I and II at the end of this monograph (pages 60-63).

4. Crop Adaptations and Results from Farmers' Fields

Figure 8: A finger millet plant grown with SCI methods in Jharkhand state of India, with more tillers and larger root system, being shown by farmer and PRADAN field staff.

a. Finger millet (*Eleusine coracana*)

Finger millet is the staple food for millions of poor households in India, Sri Lanka, Nepal and parts of Eastern Africa. Its high nutritional content has made it a food traditionally fed to pregnant and lactating women and often used as a weaning food for babies.

India: Farmers in Haveri district in the southern state of Karnataka over several decades developed their own set of novel practices for growing finger millet that are remarkably close to SRI management (Green Foundation 2006).

Conventional crop management starts with broadcasting finger millet seeds on a tilled field and gives yields between 1.25 to 2 tons/ha. With good irrigation and fertilizer applications, conventional finger millet yields in Haveri district can reach 3.75 tons.

With a methodology that they call *Guli Vidhana*, farmers in Haveri, after ploughing their fields, make a square 'grid' of shallow furrows on the surface of their fields using a simple ox-drawn plow. The grooves in the soil are made in parallel and perpendicular directions with wide spacing, 45x45 cm.

Figures 9 and 10: *On left, demonstration of the korudu implement that Indian farmers in the Haveri district of Karnataka state use for bending over young finger millet plants to promote the growth of roots and tillers; right, farmers demonstrating the yedekunte implement that is used to cut weeds' roots below the soil's surface between the rows. This has the additional benefit of breaking up and aerating the top layer of soil around plants' roots.*

At each intersection of the grid, two 12-day-old seedlings are transplanted, putting a handful of compost or manure around the roots to give the young plants a good environment in which to begin growing.

While the plants are still young, between 15 and 45 days after transplanting, farmers pull a light board across the field in several directions. Bending the young plants over in different directions promotes more growth of roots and tillers from the meristematic tissue in the plants' crowns, which are at or just below the soil surface level (Figure 9).

Concurrently, farmers loosen the soil between the plants several times with another ox-drawn implement that cuts the roots of any weeds growing between the millet plants about 3-5 cm below the soil surface (Figure 10). This active soil aeration along with organic matter supplementation enables the millet plants to have 40-80 tillers and give yields of 3.75 to 5 tons/ha, even up to 6.25 tons.[4]

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4 NGOs working with farmers in Karnataka have further evolved this system as seen at: **http://www.slideshare.net/SRI.CORNELL/1163-experience-of-system-of-crop-intensification-sci-in-finger-millet#btnNext**

In the eastern state of Jharkand, Indian farmers after being introduced to SRI for growing rice by the Indian NGO PRADAN (Professional Assistance for Development Action) began experimenting with SRI methods for their rainfed finger millet crop in 2005, referring to this as the **System of Finger Millet Intensification** (SFMI).

With traditional broadcast practices, usual yields in the area are around 1 ton/ha. By starting their crop with young transplanted seedlings (not broadcasted seeds), with wide spacing and modified water and nutrient management, SFMI yields rose to 3 tons/ha or more. While the intensified management increases farmers' costs by about 25%, the higher yields reduce their costs of production by 60%, from Rs. 34.00 per kg to Rs. 13.50 per kg, making SFMI very profitable. These data and information on SFMI methods are presented in a manual prepared by PRADAN (2012a).

In northern India, the People's Science Institute (PSI) undertook trials of another version of SFMI in 2008. In the Himalayan state of Uttarakhand, 43 farmers tried out these methods on a small area, just 0.8 ha. Their results showed a 60% increase in grain output, moving up from an average yield of 1.5 tons/ha to 2.4 tons/ha. By 2012, more than 1,000 farmers were using locally-adapted SFMI methods, spacing their plants 20x20 cm apart and establishing them either by direct-seeding or by transplanting young seedlings 15-20 days old. Such modified practices induce the kind of more productive plant phenotypes seen in figures 8 (page 11), 11 (below), 12-14 (following page), and 15-16 (page 15).

Figure 11: *Field day for farmers, technicians and officials to observe SCI finger millet being grown in Tigray province of Ethiopia.*

Ethiopia: Similar finger millet crop responses to SCI management have been observed in Tigray province. The first farmer to transplant finger millet seedlings there was an elderly woman who obtained a yield equivalent to 7.8 tons/ha in 2003, compared to usual finger millet yields of 1.4 tons/ha with broadcasting, or 2.8 tons/ha with generous use of compost (Araya et al. 2013).

This was considered quite fantastic, evoking curiosity and interest among farmers there and elsewhere in Ethiopia. This management strategy has come to be called 'planting with space,' and farmers are now applying its concepts and principles to many other crops as reported in section 5 below.

Figure 12: *Comparison of finger millet plants grown with different management practices. On left is a plant of an improved variety (A404) grown with farmers' SFMI practices; in center, is a plant of the same improved variety grown with farmers' conventional broadcasting; on right is a local (unimproved) variety grown also with farmers' usual methods.*

Figure 13: *Contrasting panicles of finger millet; SFMI plant is on left, and conventionally grown plant is on right.*

Figure 14: *Comparison of the root systems of SFMI plant on left and conventionally-grown finger millet plant on right.*

Transplanting methods have become standard practice among farmers in the Axum area of Tigray province. Finger millet yields now average 3.5 to 4 tons/ha, similar to the SFMI yields in Bihar, and higher than those reported from northern India. Some Tigrayan farmers have even obtained yields of >6 tons/ha when the rainy season is long enough, i.e., when it continues from July into mid-September. Farmers implementing SCI are all making and using compost which they apply to the soil when they transplant their seedlings.

***Figures 15 and 16:** Evident differences in the phenotypic expression of finger millet's growth potential: on left, a farmer's son holds a single plant of broadcast finger millet; on right, a single plant grown with SCI transplanting and management, both in Kewnit village, Ethiopia.*

b. Wheat
(*Triticum spp.*)

Once farmers and researchers in India, Mali and Nepal began seeing the effects of SRI practices on rice, there was a fairly quick extension of the ideas and methods to wheat.

India: What is now called the **System of Wheat Intensification** (SWI) was first tested in northern India in 2006 by farmers working with the People's Science Institute (PSI). First-year trials near Dehradun, using several varieties, showed average increases of 18-67% in grain yield and 9-27% higher straw yields (very important for subsistence farmers as fodder) compared with the yields that farmers there usually obtained with these varieties using conventional broadcast methods for crop establishment.

Impressed with these results, PSI began promoting SWI in the states of Uttarakhand and Himachal Pradesh (Prasad 2008). Starting with 50 farmers in 2007, the number of smallholders using SWI methods expanded to more than 12,000 by the 2011-12 winter season. Average increases in grain yields from irrigated SWI reached 80-100% over usual farmers' practice, while in unirrigated rainfed fields, SWI methods increased yield by 60-80%. Despite the need for higher labor investments in sowing and weeding operations, farmers have found the ratio of benefit-to-cost with SWI to be very favorable due to the higher yields of both grain and straw.

Encouraged by good farmer response and results in these two states, PSI has been promoting SWI within a wider region of northern India since 2010 including some districts in Uttar Pradesh and Madhya Pradesh states. Households there suffer from low food productivity, having little irrigated area and frequent rainfall failures. Starting with 590 farmers in this larger area in 2010, the number of SWI farmers rose to 1,015 the next year. More details on PSI experience with SWI in northern India are given in Chopra and Sen (2013).

The most dramatic results and the most rapid growth in use of SWI have been in the state of Bihar where landholdings are very small, with an average of only 0.3 ha. At the initiative of the NGO PRADAN, 278 farmers in the Gaya and Nalanda districts, mostly women, tried out the new methods in 2008-09. Their yields averaged 3.6 tons/ha compared with 1.6 tons/ha using usual practices, which attracted farmer interest.

The next year, 15,808 farmers used SWI methods and with somewhat better weather, yields averaged 4.6 tons/ha. This led the state government's Bihar Rural Livelihood Promotion Society (BRLPS, or

JEEVIKA) to support efforts by many NGOs and the state's extension service to spread SWI use, utilizing IDA funding from the World Bank. Two years later, in 2012, the area under SWI management had expanded to 183,063 hectares, and average SWI yields were 5.1 tons/ha, according to Bihar Department of Agriculture calculations.

Intensified management for SWI does require more labor and more organic matter inputs; so farmers' costs of SWI production per hectare in Bihar are about 60% higher than with conventional practices. Still, with yields that are more than doubled, the net income per hectare soars by 150%, from Rs. 17,460 to Rs. 43,952, as farmers' costs of production per kg of wheat produced decline by 28%. The experience of Bihar farmers working with SWI methods has been summarized in a manual prepared by PRADAN (2012b).

The Aga Khan Rural Support Programme in India (AKRSP-I) has also been introducing SWI in Bihar state, with different but still favorable results. Its SWI yield increases have been 32%, with farmers averaging 3.48 tons/ha instead of 2.63 tons/ha. However, with this less-intensive version of SWI, costs of production decline by 26% per hectare, so the cost of producing wheat is only Rs. 8.17 per kg under SWI compared to Rs. 11.05 with standard practices. Standard cultivation practices for wheat have produced little net income for farmers, just Rs. 1,802 per ha, whereas with SWI practices, farmers' net income from their production of wheat is Rs. 18,265 per ha, according to an AKRSP evaluation (Raol 2012).

Mali: The international NGO Africare began introducing SRI methods for irrigated rice into the Timbuktu region in 2007. During an evaluation of SRI results the next year, with 60 farmers who had grown irrigated rice on side-by-side comparison plots evaluating SRI and conventional methods (Styger 2008-09; Styger et al. 2011), the idea was born to apply the same principles to wheat, their winter crop.

Three farmers from three villages volunteered to do SWI trials, using the same methods as SRI; but simple imitation of SRI was not very successful; mortality of transplanted seedlings was 9 to 22% in the cold winter climate, and the 25x25 cm spacing was too wide for plants to utilize all the arable area. Transplanted SWI produced 29% less grain than the control plots (1.4 tons/ha vs. 1.97 tons/ha).

Direct-seeded SWI, on the other hand, showed a 13% yield increase, producing 2.22 tons/ha. Farmers were pleased with their 94% reduction in seed requirements with SWI (10 kg/ha versus 170 kg/ha), and with a 40% reduction in labor and 30% lower irrigation water requirement (Styger and Ibrahim 2009). Thus, farmer interest in this innovation was aroused.

In the next season, 2009/2010, Africare undertook systematic SWI trials comparing different spacing and seeding techniques (Styger

Figure 17: *Comparison of SWI panicles on left and conventionally-grown wheat panicles on right, from 2009/10 trials in Timbuktu region of Mali.*

2010). While a spacing of 15x15 cm gave the highest yield (5.4 tons/ha), all of the treatments using single plants per hill gave yields above 4 tons/ha, with spacing ranging from 10x10cm to 20x20cm, as did row-planting with 20 cm distance between rows (Figure 17). These yields were all higher than the 2.22 tons/ha obtained from the broadcast control plots where farmers' usual methods were used (Styger, Ibrahim and Diaty, unpublished).

In a third season, SWI trials continued among farmers, even though Africare had no funding to support their testing; the experience of 21 farmers was monitored. Their average SWI yields were 5.45 tons/ha, compared to 1.96 tons/ha from conventional practice (Styger and Ibrahim, unpublished).

The next year, when there was drought and irrigation water was limited, Africare was able to monitor 142 farmers using SWI methods in 13 villages. Despite the adverse weather conditions, SWI yields averaged 3.2 tons/ha compared to 0.94 tons/ha from conventionally-grown plots (Styger and Ibrahim, unpublished).

Farmers indicated that their applying SWI on a larger scale was constrained by lack of good implements for direct-seeding; difficulties in soil preparation and manure transportation; and shortages of timely irrigation water. These factors limit the area of land that can be planted with SWI methods at present. Remedying these constraints could greatly enhance wheat production in Mali in the future.

Nepal: A majority of Nepalese farmers are smallholders having landholdings below 0.5 ha, and their wheat yields usually average about 1.2 tons/ha.

For the last half decade, farmers have faced severe scarcity of fertilizers for their main wheat cropping season, and rainfall in the winter season has been erratic. These factors, plus very low seed replacement rates in the hill and mountain areas, have contributed to the very low productivity of wheat in Nepal.

Figure 18: *Comparison of wheat panicles from farmer field school trials in mid-Nepal.*

Under an EU-funded Food Facility Program implemented in the Far Western Region by FAO and local NGOs, SWI concepts and practices were introduced to smallholding farmers in 2009, using direct-seeding (DS) rather than transplanting because DS performed better under local conditions. It was found that "sowing with proper plant density allows for sufficient aeration, moisture, sunlight and nutrient availability leading to proper root system development from the early stage of crop growth" (Khadka and Raut 2012). Such management led to more productive phenotypes of wheat.

Comparison trials in 2010-11 at 16 locations in 3 districts (Dadeldhura, Baitadi and Kailali) showed that SWI methods with seed-priming and line-sowing, using a recommended improved variety (WK-1204), and reducing the seed rate by >80%, gave smallholder farmers 91% more yield than from their local practices with this same variety (6.5 versus 3.4 tons/ha). The average number of grains per panicle was 75 vs. 44, and grain weight (grams per 1000 grains) was 29% higher with SWI (Figure 18). Although farmers' expenditures/ha were 58% higher with this more intensive crop management (Rs. 5,010 versus Rs. 3,170), farmers' net income more than doubled, rising from Rs. 4,830/ha to Rs. 9,830/ha.

In 2011-12, farmer field school experiments conducted in Sindhuli district with similarly modified SWI practices also showed better yield and economic returns. Pre-germinated seed of Bhirkuti variety sown at 20x20 cm spacing gave 54% more yield than the available 'best practices' used under similar conditions of irrigation and fertilization: 6.5 tons/ha from SWI, compared to 3.7 tons/ha with conventional broadcasting, and 5 tons/ha with row sowing (Adhikari 2012).

With SWI methods, farmers' seed requirements are reduced by >80% (20 kg/ha compared with 120 kg for usual practice). This means that the limited supply of improved seed available can be used on four times more cultivated area. Also, fertilizer is less necessary if biofertilizer can be produced or procured locally. By using improved seed with SWI crop management techniques, it has been calculated that an average household with six members in the Far West, a region known for its extreme poverty, can achieve an additional 6 months of food security each year (Khadka and Raut 2012).

Ethiopia: Experience with SWI methods has been similar in this country as well, as seen in Figures 19 and 20. We discuss Ethiopian experience with several versions of SWI (and other crops) in section 5 below on 'Planting with Space.'

That SRI methods which could enhance the productivity of rice plants would have similar effects on finger millet and wheat was not so surprising as they belong to the same large family of grasses known as Gramineae (or Poaceae) in which rice is placed. However, learning that concepts and adapted methods from SRI cultivation could be successful also for a crop as ostensibly different as sugarcane, discussed next, was unexpected. Botanically speaking, sugarcane is also a member of the Gramineae family, and its productivity is similarly enhanced by more profuse tillering and root growth.

Figures 19 and 20: *Comparison of wheat panicles from the same variety in Gembichu Woreda, Ethiopia: on left are plants grown with usual farmer methods of cultivation (39 grains per panicle on average); and on right, SWI crop management (56 grains).*

C. Sugarcane
(*Saccarum officinarum*)

India: Sugar is the world's largest crop according to FAO crop production statistics. Shortly after they began using SRI methods, some rice farmers in Andhra Pradesh state of India began adapting these ideas and practices also to their sugarcane production, as early as 2004. Some farmers were able to get much higher yields while cutting their planting materials by 80-90%, reducing their water applications, and applying fewer purchased inputs of fertilizer and chemical protectants, as with SRI-grown rice.

By 2009, there had been enough testing, demonstration and evolution of these initial practices that a joint Dialogue Project on Food, Water and Environment between the World Wide Fund for Nature (WWF) and the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad, launched a 'sustainable sugarcane initiative' publishing a detailed manual on SSI (ICRISAT/WWF 2009).

Subsequently in 2010, the director of this project, Dr. Biksham Gujja, together with other SRI and SSI colleagues, established a company called ***AgSri*** based in Hyderabad (***http://www.agsri.com/index.html***). This pro-bono enterprise is disseminating knowledge and practice of SRI, SSI and other ecologically-friendly innovations among farmers in India and beyond.

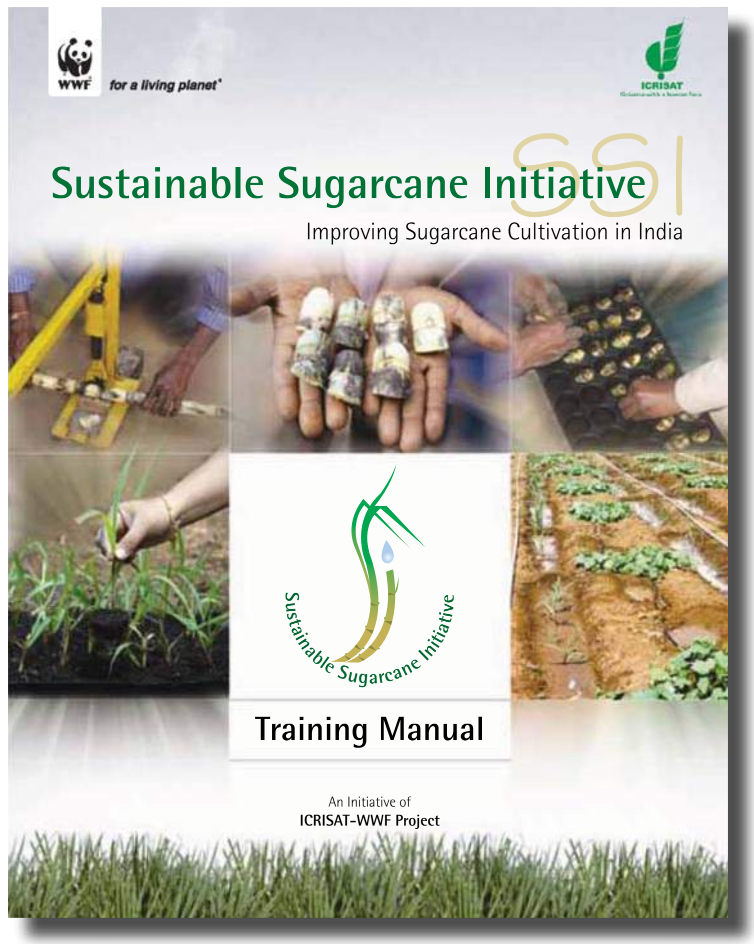

Figure 21: *The cover of a 2009 SSI training manual, published by WWF and ICRISAT.*

Large-scale field testing of SSI methods has been undertaken in all the major sugarcane-producing states of India. Currently it is estimated that at least 10,000 Indian farmers are practicing SSI, although this is still small compared to the large total numbers cultivating 5 million hectares of sugarcane. AgSri and the National Bank for Agriculture and Rural Development (NABARD) have jointly published a revised SSI manual (AgSri/NABARD 2012).

Figure 22: *Sugarcane being grown with SSI management in India.*

The Tamil Nadu state government has agreed to extend financial and technical support to farmers wanting to utilize SSI methods as it did previously in the case of SRI. The Tamil Nadu Agricultural University, having launched an SSI promotion campaign, reports that the new methods are raising average cane yields up to 225 tons per hectare, from present yields of 100 tons. This is achieved by reducing the seed rate by >90%, planting 12,500 single bud chips per acre instead of 75,000 double-budded chips as is usually done now (Anon. 2013b; Anon. 2013c).

AgSri has begun establishing high-quality nurseries to supply vigorous young seedlings to farmers. While there are still some challenges to be dealt with for meeting farmers' demand for seedlings in a timely way, good initial results have encouraged the private sector, sugar mills and agriculture development agencies to begin cooperating to scale up SSI in India and capitalize on the ability of these methods to yield phenotypes that boost both productivity and profitability in this sector (Figure 22).

Elsewhere: The first trials of SSI in Cuba using AgSri manuals posted on the web gave good results with yield estimated at 150 tons/ha (Figures 22 and 23, following page). Ministry of Sugar officials have set up a task force to establish and evaluate SSI trials/demonstrations in all provinces of the country. Farmers in Nicaragua and Tanzania are now also establishing SSI field trials.

Since sugarcane as a crop consumes about as much water as rice, requiring 1500-3000 liters of water per kg of sugar ultimately produced, management methods that can reduce water requirements similar to SRI's reductions for rice will have substantial economic and environmental benefits.

Figures 23 and 24: *First SSI trials at the CPA Camilo Cienfuegos sugar cooperative in Bahia Honda, Cuba, at 10.5 months; yield from the test plot was estimated at 150 tons/ha.*

d. Tef
(*Eragrostis tef*)

Ethiopia: Tef, the preferred cereal crop in this large food-deficit country, is grown from tiny seeds (2500 per gram) that are traditionally broadcast on repeatedly ploughed soil. Despite investment of much labor, mostly by women and children, tef yields are usually low, about 1 ton/ha.

Adaptation of SRI methods to tef cultivation was started in 2008-09 under the direction of Dr. Tareke Berhe, at the time with the Sasakawa-Global 2000 program, and now director of the Tef Value Chain Program under the government's Agricultural Transformation Agency (ATA).

By transplanting young, 20-day-old tef seedlings at 20x20 cm spacing with application of organic and inorganic soil nutrients, yields reached 3 to 5 tons/ha. Further, on plots with small soil amendments of micronutrients such as Zn, S, Mn and Mg, these improved yields were almost doubled again, responding well to the practices that Tareke christened as STI, the System of Tef Intensification.

In 2010-11, in collaboration with the Institute for Sustainable Development (ISD) which obtained some funding from Oxfam America for SCI evaluation and demonstration, Tareke conducted further controlled STI trials at two major centers for agricultural research in Ethiopia. Good results there gained acceptance for the new practices from other tef scientists and government decision-makers, and ATA began more systematic evaluations and demonstrations (Berhe et al. 2013).

In 2011-12, over 1,400 farmers who tried STI methods averaged 2.7 tons/ha. Then in 2012-13, there were 7,000 farmers using STI methods in expanded trials with transplanted seedlings, while another 160,000 farmers applied less-intensified STI methods, doing direct-seeding in rows instead of transplanting. This kind of 'STI-lite' was able to raise tef yields on a large scale by 70%, from 1.2 tons/ha to 2.1 tons/ha (ATA 2013). With such results, the government is scaling up the area under STI management to 1.6 million ha in 2013-14.

The direct-seeded method follows SRI principles including wider spacing (20 cm) between rows and enhancement of soil organic matter with compost, supplemented with some urea and DAP. 'STI-lite' practices which improve the balance of air and moisture in the soil require less labor for sowing and weeding than the full STI management.

More intensive management that starts with transplanting young tef seedlings and puts more emphasis on organic soil fertilization gives farmers better results, but the choice of methods is left to farmers, whose labor is a key factor (Figure 25).

Like other crops, the tef genome is highly responsive to management practices that do not crowd the plants together and also improve soil conditions. When individual tef plants are given ample space, their leaves are longer and wider; their darker green color indicates that the plants' photosynthetic efficiency, usually low, is enhanced by their altered growing conditions. Tef plants given wider spacing exhibit much larger and longer root systems. These in turn support larger, taller canopies that resist lodging, a major constraint with conventionally-grown tef.

For countless generations, this crop has been grown by broadcasting seed with high plant densities. STI, in contrast, reduces plant density by 90%, using 9-15 million seeds/ha instead of 90-150 million/ha. It is seen that by transplanting and making other changes in field management, tef grain and straw yields can be tripled or more (Figure 26).

Figures 25 and 26: *Top, comparison of a transplanted STI plant on left, and a broadcasted tef plant on right, both same variety; bottom, STI tef crop ready for harvest at Debre Zeit Research Station in Ethiopia.*

e. Mustard
(*Brassica nigra*)

India: Many farmers in Bihar state have begun adapting SRI methods for growing mustard -- also called ***rapeseed*** or ***canola***. Although its seeds are just 1-2 mm in diameter, when mustard is grown with more favorable management practices, the resulting plants and yields can be very impressive (see Figure 3 on page 5).

In 2009-10, 7 women farmers in Gaya district who cooperated with PRADAN and the government's Agricultural Technology Management Agency (ATMA) started adapting SRI practices to their mustard crop (SMI). Usual grain yields using broadcasting methods were 1 ton/ha; but with alternative management, their yield was tripled, to 3 tons/ha. The following year, 283 women farmers using SMI methods averaged 3.25 tons/ha. Then in 2011-12, 1,636 farmers, mostly women, got average mustard yields of 3.5 tons/ha.

Indeed, those who used all of the practices recommended for SMI averaged 4 tons/ha, while one farmer with best management reached 4.92 tons/ha as measured by government technicians. PRADAN calculated that with SMI, farmers' costs of production were reduced by about half, from Rs. 50 per kg of mustard oil seed to just Rs. 25 per kg. The SMI methods developed by farmers in Bihar are detailed in a manual produced by PRADAN based on experience there (PRADAN 2012c).

In the mountain states of Himachal Pradesh and Uttarakhand, mustard is the second most important winter crop after wheat. Accordingly, the People's Science Institute (PSI) in Dehradun ventured into applying SRI principles to mustard cropping in 2009 with the help of 68 farmers on 1.74 ha. The methods used were less intensive than those developed in Bihar: no transplanting with wide inter-plant distances; just direct-sowing in lines, 1 or 2 seeds per hill, with 15 x 20 cm spacing. Organic methods of soil fertilization are used, but only hand weeding is done, without any effort at soil aeration. Even with these less ambitious modifications of conventional practice, farmers had a 42% increase in grain yield, raising average yield from 1.4 tons/ha to 2 tons/ha. In 2010, the number of farmers increased to 227 farmers (10.34 ha), mostly doing line sowing.

A World Bank evaluation in Bihar state of India has reported an average increase in oilseed production of 50% using SCI methods, with the profitability of oilseed almost doubled, being raised by 93% (Behera et al. 2013).

f. Maize
(*Zea mays*)

India: Growing maize with SRI concepts and methods is still in its early stages. In northern India, PSI has begun working with smallholders in Uttarakhand and Himachal Pradesh states to improve their maize production with adapted SRI practices, which produce more robust phenotypes with maize as they do with rice. No transplanting is involved, and no irrigation. Farmers plant 1-2 seeds per hill with a square spacing of 30x30 cm, having added compost and other organic matter to the soil; and then they do three soil-aerating weedings. Some varieties they have found to perform best at wider spacing of 30x50 cm.

The number of farmers practicing SCI with maize in Uttarakhand went from 183 in 2009 to 582 in 2010, their area cultivated expanding from 10.34 ha to 63.61 ha in this time. The average SCI yield was 3.5 tons/ha, which was 75% more than farmers were getting with their conventional management, 2 tons/ha.

PSI has conducted on-farm trials of maize cropping in Uttarakhand to assess different spacings and plant densities. As seen from Table 1, the best results have been obtained from hills spaced 40 x 40 cm, each with just 1-2 seeds. Their yield was 6.5 tons/ha compared to 2.3 tons/ha from control plots using the usual practices. In another set of trials, where plant number was evaluated, 1 seed/hill gave an average yield of 6.1 tons/ha, compared with 5.3 tons/ha from 2-seed hills, and 2.8 tons/ha from farmers' practice (Table 1).

In Himachal Pradesh, SCI maize cultivation has also been promoted under a program supported by the Sir Ratan Tata Trust of Mumbai. The number of SCI maize farmers in two districts there, Kangra and Hamirpur, and the area cultivated under this program in 2011-12 are given in Table 2 (following page). These areas are much drier and have poorer soils compared to most areas in Uttarakhand. Nevertheless, the recorded gains in maize crop productivity through SCI methods have been 17% to 38%. Farmers' incomes were enhanced by even more because SCI reduced farmers' seed requirements.

Maize SCI in northern India has thus shown definite yield improvements from modifying management of farmers' land and seed resources. Improving soil organic matter is a critical factor given that poor households' soils are so often deficient in this material for improving the life in the soil.

Table 1: Maize yields with different plant spacings and numbers of seeds per hill, Uttarakhand, India, 2010

Plant geometry and spacing	Ave. plant height (cm)	Ave. no. of grains/cob	Ave. cob length (cm)	Grain yield (t/ha)
Square: 50 x 50 cm	185	322	25	5.7
Square: 40 x 40 cm	192	356	29	6.5
Square: 30 x 30 cm	187	297	23	5.8
Line sowing: 30 cm	193	255	20	4.8
Farmers' practice	155	191	17	2.3
No. of seeds/hill (hill spacing: 40cm row to row, and 40cm plant to plant):				
One seed	227	341	28	6.1
Two seeds	188	309	25	5.3
Farmers' practice	171	215	20	2.8

Table 2: SCI maize cultivation and yields in two districts of Himachal Pradesh, India, 2011-12

	2011		2012	
	Kangra	Hamirpur	Kangra	Hamirpur
SCI maize farmers (no.)	104	50	169	125
Area under SCI maize (ha)	4	1.1	15.12	17.86
Conventional yield (tons/ha)	-	-	2.09	0.96
SCI maize yield (tons/ha)	-	-	2.89	1.12
Yield increase (%)			38%	17%

Because maize is such an important food crop for so many millions of food-insecure households throughout Africa, Asia and Latin America, enabling them to get greater production from their limited land resources -- with their present varieties or with improved ones -- should be a priority for agricultural innovation and evaluations. This crop has already given indications that SCI adaptations can evoke genotypic potential under the wide range of ecological conditions where it is grown.

Some of the first efforts by farmers and NGOs to adapt SRI ideas and methods beyond rice were to other cereals, then to various legumes, and also to vegetables. These efforts began in a number of Indian states from 2006 onward at the initiative of PSI, PRADAN, AME, the Green Foundation, and other NGOs. In this same period, Ethiopian farmers in Tigray province working with the Institute for Sustainable Development (ISD) began experimenting with a similar range of crops. Since the most evident aspect of the new management practices was their wider spacing between plants, in Ethiopia the principles and practices have become known and communicated under the rubric of 'planting with space' discussed in section 5.

g. Legumes

India: In Figure 27 we see a farmer holding a prolific **pigeon pea** plant (*Cajanus cajan*) -- also called red gram -- grown with adapted SRI practices in Karnataka state in southern India. The Agriculture-Man-Environment Foundation (AMEF) based in Bangalore, which started promoting SRI for rice some years ago, reports that with these practices, pigeon pea yields are increased by 70%, from a usual yield of 875 kg/ha to 1.5 tons/ha (AMEF 2011).

A recent report from Karnataka describes how farmers with such methods are now getting even tripled yields from pigeon pea, as small transplanted red gram plants can grow up to have as many as 2,000 pods compared to the usual 50-100 pods per plant. Reducing the population of plants per m^2 thus has very beneficial effects on crop productivity. Although more labor is required for SCI crop management with pigeon pea, farmer incomes are reported to be greatly improved (Anon. 2013a).

Use of young seedling and wide spacing is being promoted for red gram by Department of Agriculture staff in Tamil Nadu state with a doubling of yield and with a crop cycle shortened from 160 days to 130 days, as seen in Fig. 28 (Ganesan 2013).

In central India's Madhya Pradesh state, the Aga Khan Rural Support Programme (India) began piloting, with mostly-tribal communities, the application of SCI principles to **soya beans** (*Glysine max*) in 2013. The main adaptation for this crop is wide spacing of seeds, 2 per hill at 45x45 cm distances, plus soil-aerating weeding and organic fertilization. Analysis of initial harvest results showed the yield with adapted SCI methods to be as much as 86% higher.

The phenotypical improvements in the soya plants that supported such yield increase were having: 4.2 times more branches per plant, 3.7 times more pods per plant, as many as 4.3 times more seeds per plant and 4% higher weight (grams per 100 seeds). Average dry matter per plant was 2.75 times greater. From calculations of the cost of production and revenue per acre, the increase in benefit-cost ratio with these alternative methods compared with farmers' traditional practice was 75-100% greater (AKRSP-I 2013).

The Aga Khan Rural Support Programme has worked in western India, in Dangs district of Gujarat state, with SCI **chick pea** (*Cicer arietinum*), also known as garbanzo beans or as *chana* in several Indian languages. The first and most evident change from conventional practice is to

Figures 27 and 28: *Top, visible effect of SCI practices on pigeon pea plants; bottom, red gram seedling nursery in Tiruchi, Tamil Nadu, where government technicians are now promoting SCI red gram as an intercrop with groundnut, facilitated by the one-month reduction in crop cycle for the red gram (Ganesan 2013).*

Figures 29 and 30: Top, chick-peas growing in Dangs district, Gujarat state of India – note differences seen in the size of the grains – conventionally-grown grains on the left, SCI grains on the right; bottom, an Ethiopian farmer in Gimbichu district holding up two lentil plants to show the increases possible in number of stems and number of pods per stem using SRI 'planting with space' methods. The plant on left was grown with conventional practices, the plant on the right with SCI practices.

establish single plants at wide (50x50 cm) spacing, followed by 3-4 periodic weedings with a soil-aerating implement. Other new practices are regular use of a traditional organic pesticide known as *amrut pani* at 15-20 day intervals, and timely nipping (removal) of budding leaves to keep the plant from becoming too bushy. This directs the plant's nutrient supply to a limited number of branches so that these become more productive than if many branches are competing for nutrients.

Farmers observe the following effects with these changes in their practice:

- Much-reduced number of unfilled pods;
- Increase in the number of pods and number of grains per pod;
- Larger grains; and,
- Lesser attack of insect pests

Farmers report that the leaves of these better chick pea plants have a more acidic taste, which appears to discourage insect attacks. They have also observed the importance of soil health, enhanced by organic matter applications and good drainage so that the soil is aerobic. With increased soil organic matter in the soil, water is better retained so that the soil does not dry out so quickly and readily.

The programme recommends and provides farmers with an improved-variety of chick pea seed, so some of the productivity increase observed is attributable to genetic upgrading of the crop, but the expression of the variety's potential is enhanced by the management practices. Also, attention is paid to providing the plants with some micronutrient supplementation, potassium (potash) being a key element supporting pod formation.

The management changes make an evident make an evident different in crop performance, which farmers appreciate. This work is just getting started, but it indicates how different practices can enhance crop productivity. The extra labor invested in intensified management, to raise yields and improve plant health and resilience is well rewarded (Bhatt 2014).

In eastern India, the Bihar Rural Livelihoods Support Program has reported a tripling of yields from **mung bean** or green gram (*Vigna radiata*) when using SCI methods. Usual yields are about 625 kg/ha, whereas with SCI management, the average is 1.875 tons/ha on farmers' fields.

In northern India, PSI reports that with adaptation of SRI practices to the cultivation of various legumes, small farmers in Uttarakhand and Himachal Pradesh states are getting:

- 65% increase for **lentils** or black gram (*Vigna mungo*) – yields are being raised from 850 kg/ha to 1.4 tons/ha;
- 50% increase for **soya bean** (*Glysine max*) – yields go up from 2.2 tons/ha to 3.3 tons/ha;
- 67% increase for **kidney beans** (*Phaseolus vulgaris*) – yields rise from 1.8 tons/ha to 3.0 tons/ha; and
- 42% increase for **peas** (*Pisum sativum*) – yields go up from 2.13 tons/ha to 3.02 tons/ha.

No transplanting is involved with these legume crops, just sowing only 1-2 seeds per hill at much wider spacing than in conventional practice. The spacing varies by crop with the distances ranging from 15 to 30 cm between plants (hills), and 30 to 45 cm between rows. Two or more weedings are done, aerating the soil to enhance root growth and leaving the weeds on the soil surface as a mulch.

Soil fertility is enhanced with organic inputs, applying compost made from vegetative biomass and with some farmyard manure where available, augmented by a trio of indigenous organic fertilizers known locally as PAM (*panchagavya*, *amritghol* and *matkakhad*).

The first is a mixture of five products from cattle -- ghee (clarified butter), milk, curd (yoghurt), dung, and urine -- which is seen to improve plant vigor and health, possibly by stimulating the growth of beneficial soil organisms. Also, crop seeds are treated with cow urine before being planted, to make them more resistant to soil-borne pests and disease. These methods for promoting the crops' growth and giving them protection are actually rather old instead of new, having their origins in teachings and texts from the Vedic era (1200-500 BC).

These intensive production strategies for legumes as well as for vegetables require little or no cash expenditure. Poor, resource-limited households are necessarily seeking to get the maximum yield from the very small areas of land that are available to them. The resulting SCI crops they find to be more robust, more resistant to pest and disease damage, and less affected by adverse climatic conditions.

A World Bank evaluation of SCI in Bihar reported average yield increases for pulses of 56%, and profitability increases of 67% (Behera et al. 2013).

A further element of intensification has been the *intercropping* of legumes such as lentil with SWI wheat, replacing some rows of wheat with pulses. The soil benefits from nitrogen fixation done in the legumes' roots, while households can attain greater income and/or have a more diversified diet.

h. Vegetables

India: Similar SCI experimentation has been done in different states with a variety of vegetables and with similar results. In Uttarakhand, farmers working with PSI have had some good results with **tomatoes** and **French beans**, and also the oilseed crop **sesame**.

The most extensive support for farmer applications of SCI methods to vegetable crops has occurred under the aegis of the Bihar Rural Livelihoods Promotion Society (BRLPS). This agency, known as JEEVIKA, works as an arm of the Bihar state government with financial support from the World Bank's IDA. NGOs such as PRADAN lead the field operations undertaken by local NGOs that interface with women's self-help groups which need to and want to raise their households' production of vegetables (Figures 5 and 6, page 9).

Women farmers in Bihar have experimented with transplanting young vegetable seedlings widely. They place the roots of the seedlings carefully into pits that have been dug deeper than the length of the roots and are then filled with loose soil and organic soil amendments, particularly vermicompost. Water is used very precisely and carefully. While this system is indeed labor-intensive, it greatly increases yields and hence the benefits to households, especially the very poorest ones that have access to only a little land and water. These farmers need to use their limited resources with maximum productivity, making little or no cash expenditure.

BRLPS has concluded from farmer experiences with these more agroecologically-based management methods: "It is found that in SRI, SWI & SCI, the disease & pest infestations are less, use of agro chemicals are lesser, [crops] requires less water, can sustain water-stressed condition; with more application of organic matter, yields in terms of grain, fodder & firewood are higher." (BRLPS 2011; see Table 3 on following page).

These vegetable systems of crop management are each a little different from one another, in order to fit to the respective plant characteristics and needs. But all have gotten their impetus from hearing about or seeing the results of farmers working with the System of Rice Intensification (Dash and Pal 2011). A World Bank evaluation of project impact in Bihar state reported an average vegetable yield increase of 20% with SCI methods on an area basis, with profitability increased by 47% (Behera et al. 2013).

Table 3: Differences in vegetable yields between SCI and conventional practices, Bihar, 2010-11

Crop	Unit	No. of small-holders	Conventional practices	SCI practices	Increase
Chilies	kg/plant	69	1.5-2.0	4.5-5.0	170%
Tomatoes	kg/plant	168	3.0-4.0	12.0-14.0	270%
Eggplant	kg/plant	42	5.0-6.0	10.0-12.0	100%

Source: BRLPS (2011)

With upland crops, there is no reduction in the flooding of fields through SRI-type irrigation management because water supply comes from rainfall. There is little opportunity for any direct application of water during the dry season unless steps have been taken to create some supplementary supply of water. Farmers are encouraged to invest labor and possibly some cash in simple kinds of water harvesting, such as catchment ponds, thereby creating in-field capacity for water collection and storage (Box 2, page 51).

An important part of the strategy is to loosen the topsoil through weeding, thereby enabling both water and air to enter the soil, both promoting root growth and the abundance of aerobic soil organisms.

In the same village in Bihar state of India where a new world-record yield for paddy rice was set in 2011 using SRI methods (Diwakar et al. 2012), a farmer also set a new world record for potato yield that year, 72.9 tons/ha, surpassing the previous record of 45 tons/ha set in the Netherlands (Patna Daily 2012). The potatoes weighed 1 kg each (Figure 33, following page), The farmer got ideas for his innovative potato growing from his neighbors who were practicing SRI (see Box 1 on page 35).

Recently, SCI methods have been extended to improving the production of **elephant foot yam**, an important root crop in Bihar and other parts of South and Southeast Asia. Farmers' yields are usually in the range of 20 to 30 tons/ha. Following recommended practices from the state agricultural university, including inorganic fertilizer applications, this level can be pushed up to 50 to 60 tons/ha. In 2012, two farmers who adapted SCI practices to elephant foot yam were rewarded with an average yield of 102.3 tons/ha.

Huge yams, much like huge potatoes, have the liability of being less marketable than more convenient, smaller-sized tubers. But to meet some households' current needs as well as the greater general food needs in the future, these options could become important for future food security. They show what potential there is for greater output.

Figures 31 and 32: *Top, vegetable seed sowing in a farmer-participatory SCI trial with green leafy vegetables in Ibadan, Nigeria; bottom,* Corchorus olitorus *(jute mallow) with SCI management at Ajibode, Ibadan, Nigeria.*

Nigeria: Green leafy vegetables are often overlooked in considerations of how to improve vegetable production, even though these are very important parts of people's diets in much of Africa and many parts of Asia, and particularly in the Caribbean and Pacific Islands. The leaves and shoots of Celosia argentea, a member of the amaranth family, as well as the leaves of a mallow plant, Corchorus olitorus, whose fibers are used as jute, are eaten in Nigeria and other parts of the forest zone of West Africa. Poor soil fertility is known to limit the yields of these crops, but SCI experience is showing that production is constrained also by planting these crops too densely.

A research team led by Dr. Olugbenga AdeOluwa in the Department of Agronomy at the University of Ibadan, after becoming acquainted with the ideas and principles of SRI and SCI, began experimenting with SCI methods for Celosia and Corchorus. These leafy vegetables are consumed for their high content of protein and dietary fiber, as well as for high levels of vitamins and minerals, particularly iron, calcium and magnesium.

The experimental variables evaluated in initial trials on farmers' fields and with active farmer participation were seeding rate (26 kg/ha as a high rate and 13 kg/ha as a low rate) and fertilization of the soil (with or without poultry manure extract). Celosia yields usually range between 16 and 28 tons/ha. Using the lower seed rate, with wider spacing between plants, gave by far the best fresh-weight harvest, 54.7 tons/ha, almost the highest yield ever recorded.

Corchorus yields are generally not as high as with Celosia, but the same positive response was observed when plant population was reduced with organic soil amendments and active soil aeration provided, breaking up the soil with a weeder. Poultry manure extract was seen to increase both the fresh weight and dry weight of the plants. With this extract and the low seed rate, the marketable fresh leaf harvested was 12.24 tons/ha. This was 40% higher than the 8.82 tons/ha achieved with the high seed rate. The revenue resulting from the high seed rate was calculated to be $5,880 per hectare, compared to $8,160 with the low seed rate. Reduction in seed rate was thus definitely advantageous for households following SCI principles (AdeOluwa et al. 2013).

BOX 1: RECORD YIELD FOR POTATO PRODUCTION

One farmer in Darveshpura village, Nitish Kumar, with the same name as Bihar's Former Chief Minister, produced a world-record potato yield in 2012 of almost 73 tons/ha, surpassing a previous record yield of 45 tons/ha reported from the Netherlands (IANS 2012).

After learning of this success, Anil Verma visited the farmer to discuss his potato production methods. Kumar's practices featured:

- Extracting the 'eyes' from the seed potatoes, treating them with a chemical solution, and sprouting them before planting;
- Wider spacing between plants than usually provided;
- Good pulverisation of the soil, so that the roots could grow easily;
- Use of both organic and inorganic fertilisers--vermicompost, poultry compost, and NPK; and
- Intercultivating between rows and plants two times, to loosen the surface soil.

These practices contributed to having a well-aerated, organically-rich environment around the roots, with room for both roots and canopies to grow.

The soil we should note was relatively rich in silicon, an element often neglected. Although not considered as a nutrient, it is essential for plant growth. Like other farmers in the village, Kumar acknowledged having been influenced by the new knowledge coming into his village from SRI training, and his practices represented an adaptation of agroecological principles.

Figure 33: *Former Chief Minister Nitish Kumar of Bihar State, India, holding 1-kilogram potatoes grown in Darveshpura village, Nalanda district of his state.*

5. Planting with Space

Figure 34: Wide spacing of rice plants in a grid pattern -- a hall-mark of SCI methods -- is clearly visible in this picture of an Indian farmer weeding her SRI rice field with a mechanical weeder.

As noted already, the Institute for Sustainable Development (ISD) in Ethiopia works with farmers who are dependent on rainfed production, having small parcels of land ranging between less than a quarter of a hectare and half a hectare. Most live and farm in drought-prone areas of northern Tigray and South Wollo provinces, although some are in better-endowed areas nearer to Addis Ababa.

Following from the farmer experimentation that started in 2003, when finger millet was first established by transplanting seedlings as discussed on pages 13-15, ISD has had little difficulty in getting support from farmers and local extension staff to adapt SRI/SCI ideas to other crops. Ethiopian farmers have found this strategy, referred to as 'planting with space,' easy to comprehend because it builds on some of their traditional experience in growing vegetables (Araya and Edwards 2011; Araya et al. 2013).

Crops whose yields have been substantially improved by such practices have included both **cereals** (tef, durum wheat, barley, maize, and sorghum) and **legumes** (faba bean and lentils – see Figure 30 on page 30).

Optimally-wider spacing between plants proves able to raise crop productivity so long as the soil is well-supplied with organic matter, enabling both rainwater and air to enter the soil more easily through pore spaces. Also, soil moisture is retained in the humus component of soil systems managed this way.

Crop establishment and fertilization: For a number of crops, Ethiopian farmers are now either transplanting young seedlings or sowing seeds directly in rows, with wide spacing between the rows and between the plants in each row.

Farmers make and use compost, which is now being promoted as part of the government's extension package for all crop-growing areas, either to be used alone or with small amounts of chemical fertilizer.

Starting in 2012, through the Agricultural Transformation Agency (ATA), all smallholder farmers are being strongly encouraged to change from their traditional broadcasting system for sowing, to planting seeds or seedlings in rows.

__Figure 35:__ Farmer Abbadi in Ethiopia demonstrating the use of a European-style weeder/digger that can control weeds and break up the topsoil between plants when they are being grown by 'planting with space' methods.

Weed control: Weeds are managed by digging up the topsoil with a fork or some other implement that also aerates the soil. ISD has introduced hoes that slice through the roots of weeds and break up the surface crust (Figure 35). However, reliable local manufacturers of such hoes have not yet been established. Farmers are finding their traditional pronged forks adequate for the task, although not the most efficient tool.

The weeds uprooted by this process are collected by farmers, mostly to provide animal forage because grazing is highly restricted during the growing season. Some weedy species such as amaranth and wild-type brassicas are gathered to be cooked up as greens for the family to eat.

Intercropping strategies: Particularly farmers who have access to local urban markets are starting to use the space between their smaller cereal plants (such as finger millet and tef) to transplant and grow selected vegetables that either mature before the main crop reaches flowering stage, e.g., head cabbage, or that can continue to grow after the cereal crop has been harvested, such as chilies and tomatoes. All farmers follow the ideas of using young seedlings with wide spacing, increasing organic fertilization, and promoting soil aeration.

The yields and economic returns from these innovations in intercropping have not been systematically documented. But farmers find that they can get more income from their inter-planted chilies and tomatoes than they earn from their cereal crop because these vegetables are ready for market before the vegetables of other farmers are ready. The latter are planting their irrigated crops only after the rainfed growing season has ended. Such intercropping can be quite profitable, as well as beneficial for the soil.

Experience with specific crops: This varies across different crops but the general pattern of beneficial phenotypic responses of crops to 'planting with space' as a version of SCI is quite consistent.

- ***Tef***: Farmers who have cooperated with ISD on this crop (reported on in section 4d) quickly adapted to sowing tef seeds in rows 20 cm apart. They mix the seed, which is very small (2500 per gram), with either sand or compost in the ratio of 1 to 3 so that they can better manage sowing the seeds spaced farther apart in the 'STI-lite' management system described earlier. By the 2012 growing season, over 90 farmers in the Axum area had adopted this method for their tef cultivation.

  Near Addis Ababa, a model farmer producing high quantities of compost from bioslurry has designed a tool for tef row planting based on a funnel that has an opening the exact size to let out one seed at a time. This farmer can harvest around 4.5 tons of tef seed per hectare and can sell it at a premium price, 12% higher than the usual farm gate price, because of its evident quality. He has completely discontinued the use of chemical fertilizer, thereby reducing his costs of production.

- ***Durum wheat***: In 2009, there were initial promising results from applying SCI concepts to this crop in demonstration plots in two provinces. In Tigray, seven farmers obtained an average yield of 5.45 tons/ha, with one of them achieving the equivalent of 10 tons/ha. But SWI has not become an established practice in this area because wheat is not as important a crop in Tigray as are tef and finger millet. So farmers have preferred to invest their labor in these crops rather than in wheat.

  In Gembichu, on the other hand, where growing durum wheat is popular, 21 farmers and 5 farmer training centers have experimented with SWI on 4-m^2 plots. Their yields have ranged from 1.25 tons/ha (the national average) to 8.5 tons/ha, a huge increase, with most of the farmers (17) getting over 2.5 tons/ha, which was double their normal yield.

  On SWI plots, Gembichu farmers have counted up to 35 tillers on a plant, with each spike having between 50 and 60 seeds. Plants in broadcast-sown fields normally produce a maximum of 5 tillers per plant and between 35 and 40 seeds per spike (see Figures 19 and 20 on page 20).

Lack of funding has prevented ISD from continuing its work on wheat with Gembichu farmers. But another local NGO, Ecological Organic Seed Action (EOSA), is now working with them. It reports that farmers are making and using high quantities of compost, around 8-10 tons/ha, and have taken up row planting as a standard practice after seeing these positive initial results.

- ***Lentil***: Gembichu farmers have also experimented with SCI management for this legume, their next most important commercial crop after durum wheat. In a normal rainy season, an improved variety of lentil yields about 1.8 tons/ha. The 2009 rainy season was not a good one for lentil or other crops, as the rains started late and stopped early. Even so, 7 farmers who experimented with wider spacing and row planting got an average yield of 1.27 tons/ha in that year despite the drought, with the best farmer obtaining 2.12 tons/ha. All the farmers using the new methods observed that their lentil plants had increased numbers of branches per plant and set more pods from the bottom up to the top of each branch (Figure 31, page 31).

- ***Barley***: Barley being deeper-rooted than wheat is generally more drought-resistant. The first SCI yield recorded for barley was from Gembichu district in the very dry 2009 season, when a farmer who used SCI methods for this crop got an unprecedented yield of 13.2 tons/ha, much higher than achieved for wheat, which gave a yield as high as 8.5 tons/ha with SCI management in the same area.

  Barley is the most important crop in the drier parts of eastern Tigray where it too is being developed through 'planting with space' ideas, responding very well to this alternative management. One problem encountered was that the first barley plot established with transplanted seedlings had its yield decimated by birds because the SCI plants matured earlier than the other crops. However, it was seen that the barley plants had developed up to 20 tillers per plant, and what was left of the ears showed them to have well-developed plump grains. It is no wonder that the birds feasted on them!

  Another farmer's field of barley with direct-seeding in rows 20 cm apart produced a yield of 2.3 tons/ha, compared to one neighbor's broadcast field of only 300 kg/ha and 700 kg/ha from the field of another neighbor. A second farmer in Mai Abyi who transplanted his barley seedlings with wide spacing got a yield of 5 tons/ha, showing the potential of this methodology.

All the data reported here are from 2010, when ISD had funding from Oxfam America and was able to promote SCI with the NGO REST (Relief Society of Tigray). Unfortunately, ISD has not been able to monitor SCI impacts with barley since then.

- ***Other crops***: In the Aksum area of Tigray and in South Wollo where SCI is becoming standard practice, farmers are making their own recommendations for SCI adaptation, particularly on spacing and on direct-seeding vs. transplanting.

  For larger-seeded crops such as maize, sorghum and faba bean, they prefer direct seeding, because the larger seeds are easy to handle precisely, and they observe that the roots of these plants quickly penetrate into the soil and can get easily damaged during transplanting. For these crops, spacing of up to 75 cm between rows and 45 cm between plants in the row is recommended by the farmers.

  Direct seeding is preferred also for wheat and barley crops because their seedlings are considered to have 'soft,' easily damaged leaves compared to those of finger millet and even tef, which are more suitable for transplanting. Farmers generally establish these crops with spacing of about 20 cm between rows and 15 cm between plants in each row. This greatly reduces plant populations.

ISD now has yield data for most of these crops from 2009 to 2012. Overall, the application of SCI management in Ethiopia is resulting in both grain and straw yields doubling. And as described earlier for tef, the government's Agricultural Transformation Agency (ATA) is now strongly promoting that farmers change from broadcasting to row planting for all their field crops. Although the ATA is promoting the use of chemical fertilizer, ISD has found that most farmers are increasingly making and using compost. This enables them to greatly reduce the amount of chemical fertilizer that they need, or even to give up using fertilizer altogether.

6. Wider Applications and Adaptations of SCI

That SRI principles and methods developed for raising the productivity of irrigated rice cultivation could be extended to wheat, finger millet, sugarcane, maize, and even tef, may not be especially surprising since these plants, like rice, are all classified botanically as grasses. These members of the *Gramineae* (or *Poaceae*) family are all characterized as **monocotyledons** (monocots) because they have just one embryonic leaf in their seeds, rather than having two. The tillers and stalks of monocots grow upward from a ground-level crown, from which the plant roots concurrently grow downward.

That mustard, legumes and various vegetables would also respond so well to SRI management practices was unexpected because they are **dicotyledons** (dicots). Such plants start with two embryonic leaves in their seed and grow differently from monocots. They have stems and leaves that branch off from a primary above-ground stem, while a primary (tap) root grows downward with secondary and tertiary roots branching off from it, similar to the observable above-ground branching. Monocots, in contrast, put out a welter of adventitious roots, all having a similar structure.

That SRI management practices can benefit both of these groups of crops, promoting the growth of legumes and vegetables as well as a great variety of cereal plants, makes SCI innovations all the more interesting scientifically. It presents an opportunity for scientists to conduct detailed experiments in order to derive agreeable explanations. In practical rather than just theoretical terms, one would like to know to what extent these proposed modifications for SCI crop management can broadly improve 21st century agriculture across a wide range of crops.

***Figure 36:** Ethiopian farmer Nigussie and his family transplanting finger millet seedlings between their rows of head cabbage adapting SCI practices to intercropping for higher income and better nutrition.*

7. Further Extensions of Agroecological Management

Figure 37: *Mrs. Im Sarim of Pak Bang Oeun village in Cambodia holding up a rice plant pulled up at random in the middle of her paddy field. Before she started using SRI methods, her usual paddy yields from this field were 2 to 3 tons/ha. With SRI management, she harvested 333 kg from her 500 m2 field, a yield equivalent to 6.72 tons/ha. A crop-cutting in the best part of her field that year gave 1.1 kg from 1 m2, representing a yield of 11 tons/ha. Encouraged by these results, she and her neighbors began experimenting with SRI ideas for other aspects of their agricultural production, notably chicken raising, as discussed in c. below.*

As SRI ideas and impacts have become more widely known among farmers, we have seen some novel extensions of SRI principles and practices to very different kinds of crops than rice (or wheat, finger millet, sugarcane, etc.). Here we report on three quite unexpected extrapolations from SRI experience to a rhizome crop, an entomological (insect) product, and even to chicken rearing. The Cambodian farmer shown above reported on 'chicken SRI' to Koma and Uphoff in 2005 when they visited her village together. This sparked the realization that SRI principles could be extended well beyond rice.

a. Turmeric intensification

Where this process of innovation will end, nobody knows. But growing numbers of farmers are gaining confidence in their ability to get 'more from less,' providing more adequately for their families' food security while enhancing the quality of their soil resources and buffering their crops against the temperature and precipitation stresses of climate change. One initiative has come from the Thumbal SRI Farmers Association in Salem district of Tamil Nadu state in India. Its members have adapted SRI ideas to the production of a rhizome crop, turmeric (*Curcuma longa*).

Farmers have designated this methodology as the System of Turmeric Intensification (STI). They start by reducing their planting material by more than 80%, using much smaller rhizome portions to start their seedlings. When the seedlings are large enough to transplant, these are replanted at 30x40 cm spacing instead of the usual 30x30 cm distance.

Organic means of fertilization are applied to the soil: green manure plus vermicompost and soil inoculations of beneficial microbes such as *Trichoderma* and *Pseudomonas*. A microbe 'cocktail' patented as Effective Microorganisms (EM) is also used. The water requirements for growing turmeric are reduced by two-thirds with STI.

Figures 38 and 39: *Top, president of the Thambal SRI Farmers' Association in Salem district, Tamil Nadu, India, P. Baskaran, showing the mixing of organic inputs with coco-peat for filling the cups in which turmeric seedlings are grown for use in STI turmeric production; bottom, STI turmeric seedlings being planted in a field in wide spacing, supported by drip irrigation, in Thambal village, Tamil Nadu.*

With this management, crop yields are increased by 25%. While this is not as much as with some other SCI production, farmers' costs of production are lowered by 21%. The net result is that their income from turmeric crop can be practically doubled. An instructional manual and a cost-benefit analysis for this innovation have been developed by the president of the Thambal SRI Farmers Association (Baskaran 2012).

Farmers in Cambodia have reportedly applied SRI ideas also to their production of ginger, another rhizome crop; but we have no detailed information on this.

b. Lac intensification

Outside of producing areas in Asia and Mexico, few people know much about the source of the natural raw material known as lac, which is used for making lacquer, varnish and shellac paints and for lacquer carvings and jewelry (RCDC 2010). This is an entomological product from lac insects, which are members of the large family of scale insects *Coccoidea*. Their mouthparts pierce through the bark of trees or shrubs to feed on the sap, and they secrete a resin, which can be collected by scraping it off the bark (Abraham 2012). Once purified, this resin can be used in various products. In the traditional system of lac harvesting, the resin is collected only once during each growth cycle of the lac insect, which dies soon after it has laid its eggs.

One of the main current sources of demand for lac is to make an organic spray that can be used to thinly coat the surfaces of fruit like apples and pears, keeping them from becoming dehydrated during their shipping, storing and display in stores. At present, world demand exceeds supply, so the price is rather favorable; the farmgate price paid to peasant resin collectors is currently about $10 per kg.

Collection of lac, very labor-intensive, is done by only the poorest of the poor who have low opportunity cost for their labor. Fortunately, lac can be produced on land areas that are too poor for agricultural production, since the trees and shrubs needed to rear and harvest resin from the bark-piercing insects can grow almost anywhere, even in very dry regions.

Jharkhand state of India is the world's leading source of lac, as poor farmers and landless households there can collect lac resin from trees and shrubs scattered over that state's extensive wasteland areas. These areas are common property and not privately owned and controlled.

In Jharkhand, peasant farmers and household members working with the NGO PRADAN, most of them ethnic tribals, have begun extrapolating what they had learned from using SRI methods for their rice production to this important supplementary activity for increasing family incomes.

Since lac is produced by insects, in a process that is fundamentally different from the planting and transplanting of rice seedlings, it took considerable imagination to figure out how SRI ideas and practices could enhance their lac production. Jharkhand farmers have adapted three of the SRI concepts to raise their lac productivity (Abraham 2012).

__Figures 40 and 41:__ On top, a farmer showing resin excretions of lac insects with the locally-devised System of Lac Intensification in Khunti district, Jharkhand state, India; on bottom, mature lac ready for harvest on a kusum tree.

1. ***Reduced populations***: Farmers have found that they can get as good, or even better, production of resin by reducing their bark inoculation rate by 80%, compared to the rate that they have used traditionally. Like rice farmers, lac cultivators had come to believe that by increasing the number of larvae per square meter of bark they could increase output, but concentrating many insects on a given area of bark compromises their health and their productivity.

   Tribal farmers have learned they can raise their yield of resin by reducing the number of insect larvae that they transfer to new bark areas. Coincidentally, this reduction is about as great as is recommended with SRI for reducing the number of transplanted rice seedlings per m^2. This reduction enables lac collectors to greatly expand their scale of production because under SLI management they have 4 times more inoculation material available to apply to the bark areas.

2. ***Earlier transplanting***: Normally, when lac insects are cultivated, farmers remove the bark that the insects inhabit when their larvae first begin to hatch and come out onto the bark. This bark is then grafted onto a new area of tree or shrub stem. Prompted by their SRI experience, however, farmers now know that they can boost their production by 'early transplanting' of the inhabited bark, doing this about 10 days before the larvae begin to emerge.

With 'early transplanting,' there is little or no loss of larvae during the transfer process while the eggs are still unhatched in the bark. Once larvae begin to emerge, some are lost during their movement to a new habitat.

Most important, early transfer usually permits farmers to make a second collection (scraping) of resin during the growth cycle. These two effects considerably enhance farmers' incomes.

3. ***Wider spacing***: Traditionally, lac farmers inoculated the bark of trees, until they found that inoculating the bark of shrubs instead of trees gives them better productivity per hour of labor. Shrubs can be planted much closer together than trees that grow naturally in the wild, and shrubs' multiple shoots give farmers more bark surface area that can be inoculated. This enabled collectors to reduce the time spent walking from tree to tree to monitor the condition of the lac insects and to collect the resin.

   But farmers have now realized from their SRI experience that they have been planting their shrubs too closely together, thinking that more plants would give them more bark area to exploit. With wider spacing between shrubs, as between rice plants with SRI, they find that the shrubs produce more branches on a per-square-meter basis. This enables them to 'farm' the lac insects more intensively. More widely-spaced shrubs are healthier and can better support their (parasitic) populations of insects, presumably because larger and deeper root systems enable them to produce more sap to support the insects.

   Collecting lac secretions, seen in Figures 40 and 41, requires no capital investment, just labor and skill. There is no need for land ownership as the insects' production is quick and moveable. However, having some security of land tenure could encourage better husbandry of the shrubs that support the insect populations.

Lac production is well suited for poor households living in environments with poor soil and even little rain. If the demand for 'organic' products worldwide continues to increase, there are good economic prospects for this commodity, which synthetic alternatives have not succeeded in displacing thus far. Labor productivity and returns from traditional lac production methods were always very low. SLI concepts are now making both the land and the labor involved more productive.

C. Chicken intensification

Possibly extending SRI ideas to poultry is even more unexpected than using them to improve entomological production. In Cambodia, farmers in Pak Bang Oeun village in Takeo province were among the first to begin working with CEDAC, the Center for Study and Development of Cambodian Agriculture, to introduce SRI methods with rice.

When Koma and Uphoff, respectively the directors of CEDAC and CIIFAD, visited this village in March 2005, farmers there who were using SRI methods, including Mrs. Im Sarim (Figure 37, page 42), explained how they had begun to use SRI ideas to increase their chicken production!

The farmers said that they now understand the value of making compost for their paddy fields. Households each have a compost pile near their homes to decompose food waste, kitchen scraps, plant residues, etc. Someone got the idea of putting bamboo fences around these piles and putting their free-ranging chickens inside the fences. There they can feed on insects and grubs in the decomposing organic matter, but they also then deposit their manure in the compost, which is a win-win situation for both chickens and farmers.

Most important, during hot summer months when free-ranging chickens suffer from heat stress and lack of water, getting sick and some even dying, households can easily keep their chickens well watered and healthy by giving them water within the enclosure.

Farmers told Koma and Uphoff that with this intensive system of management they do not lose any chickens to dogs or any to wild animals or to thieves. "With fewer chickens that are well-managed, we can produce more meat and more eggs. This gives us more from less, just like SRI," one farmer explained.

Chicks are kept with their mother for up to 2 weeks before separation, and water supply is changed daily, while the ground within the enclosure is regularly cleaned. Local herbs are used as medicines to prevent or cure diseases, and the chicken manure is used to grow more fodder for feeding the chickens. These are low-cost solutions to different challenges in traditional chicken rearing.

This example shows how SRI insights are contributing to a way of thinking about agriculture that rediscovers the potency of better management practices using farmers' own, locally-available genetic and other resources, so as to enable plants and also animals to give fuller expression to their genetic potentials for various products, even including meat and eggs.

Some of the specific practices evolved by Cambodian farmers have been to fence in the chicken pens, in which the compost pile is maintained and built up, by growing trees and shrubs as live fencing. This creates a more natural and healthier living environment for chicken rearing.

Achieving greater productivity from individual crops or commodities is important for farming households. But we need to keep in mind that families depend for their well-being on their ***whole farming systems***, not just on any one component of these systems.

8. Applications of Agroecological Thinking and Practice

Figure 42: View of the farm of Roas Mao in Takeo Province of Cambodia whose farming system has been diversified and intensified on the basis of SRI productivity gains. The net annual household cash income from his farm (0.48 ha) has been raised from $72 to $735, with an investment of just $112, as detailed in Lim (2007). Two of his five children now work on the farm with incomes more than they would earn from working in Phnom Penh if they migrated there.

a. Diversification of smallholder farming systems

In Cambodia, farmers working with the NGO CEDAC have very small landholdings, on average about 0.66 ha. With CEDAC encouragement, farmers have started capitalizing on productivity gains that SRI management can bring to their rice fields by reorganizing, diversifying and intensifying their rice-based farming systems. Once SRI enables them to double or triple their previous paddy yields, farmers can take 30-50% of their paddy land out of rice production and reassign it to other uses. They are now able to meet or exceed their households' staple food needs by using SRI methods on their remaining rice area (Lim 2007).

The first step for such diversification is constructing a ***farm pond***, about 10x15 m in area and 2-3 m deep. This can capture water during the rainy season and store it into the dry season. Fish, eels, frogs and other plants and animals are raised in the pond and canals, which provide water and liquid manure that can make the rest of the farmed area more productive (see Indian example on page 51).

A great variety of crops and livestock are grown on the remaining area: tomatoes, eggplants, watermelons, cucumbers, pumpkins;

mung beans and other legumes; bananas, papayas and other fruit trees; sugarcane, cassava and maize in upland areas; as well as chickens, pigs and/or rabbits.

Ponds and canals in the rice fields serve a number of functions. During the early monsoon, they help farmers to drain excess water from their rice fields, so that young seedlings will not suffer from too-high water levels. During any short dry periods within the monsoon, water from the pond can be used to irrigate the young rice plants so that they can withstand the stress of insufficient water.

Frogs and fishes living in the ponds and canals help control insects during the growing season. During the late monsoon, when the rice starts to flower with shallow flooding of the paddy, the frogs and fish move from the ponds into the rice fields, where there is plenty of food for them. During the grain-filling phase, fields are kept covered with just a few centimeters of water to ensure sufficient water supply for producing full grains. Once the crop is ripe, the fields are drained for easier harvesting of the rice; at this time, fish and frogs can also be harvested, augmenting household income and food supply.

Details on cropping, land use and investments made from the experience of five innovative but representative farmers are given in Lim (2007). These farmers' household incomes were tripled on average, with households' cash income rising from an equivalent of $200 per annum to $600. The average capital investment required for this improvement was only about $300, so it could be made incrementally over several years, with no need for credit or loans.

Apart from these monetary gains, Cambodian households appreciate the diversification and enrichment of their diets which this redesigning of their farming systems makes possible. They feel, and are, much more secure when they have multiple sources of income that bring in at least some cash income every week of the year.

Household food security no longer depends just on their seasonal rice harvests with one or two peaks of income during the year. This kind of intensification can create paid employment opportunities in rural areas that make migration to urban areas less necessary. Households can remain intact, not fragmented by economic necessity.

Farmers following agroecological management in Cambodia further report improvements in their soil and water quality, with less build-up of synthetic chemicals. Such diversification based on farming system intensification will not meet the needs of all rural households, e.g., it requires at least some access to irrigation or sufficient rainfall to fill the farm ponds. But the productivity of rather small cultivated areas can be greatly enhanced by this kind of intensified agroecological management.

BOX 2: PRODUCTIVE REDEPLOYMENT OF RESOURCES IN INDIA

A similar agroecological strategy has been developed by PRADAN working in upland areas of eastern India. Working with farmers, this NGO has developed a low-cost water-harvesting technology called 'the 5% model' that complements the innovations in crop management (SRI and SCI) that it is introducing in the region (UNEP 2012).

PRADAN encourages farmers to take 5% of their rainfed paddy land out of production in order to dig a catchment pond that can trap and store some of the water that runs over their fields during monsoon rains.

This enables farmers to provide supplementary irrigation when their crops come under water stress for lack of rainfall or low soil moisture later in the season. It also increases percolation into the soil that augments water availability downstream. The loss of cropped area is more than compensated for by the higher yields achieved.

An investment of Rs. 80,000 (1,775 USD) per hectare can increase food security for as many as 7 households by 20-30%, and can raise family incomes by 10-25%, depending on the crop mix. Farmers working with PRADAN staff, as seen for a number of crops reported on in this monograph, have been quite innovative in extrapolating their SRI experience to improving productivity of other crops.

b. Mechanization in larger-scale farming systems

Most applications of SCI ideas and methods have focused on raising the productivity of smallholder agriculture, as reported above. Accordingly, it has been mistakenly assumed by some that agroecological innovations are of limited relevance in the contemporary world with its spread of large-scale, mechanized production. Presently, much of the food supply that reaches markets for feeding urban populations and non-agricultural households comes from large and medium-scale commercial operations.

However, agroecological principles and practices being biologically based are relatively scale-neutral and can be adapted to larger-scale production, as has been shown in the Punjab province of Pakistan (Sharif 2011). There, the relatively high cost and limited availability of agricultural labor has created barriers for the adoption of any methods that seem to require much labor. Mechanization of production practices has become dominant in much of the agricultural sector in Pakistan.

Sharif, a farmer and businessman whose career had been focused on agricultural mechanization (he was the first farmer in Pakistan to laser-level his fields as a water-saving measure), became interested in SRI methods for improving rice production in his area because of its lower requirement for water. Water is the starkest constraint on farming in Punjab.

At the same time, Sharif was interested in adopting conservation agriculture (CA) because he saw the damage that was being done to his region's soil systems from continuing tillage, heavy applications of chemical fertilizer, over-irrigation of fields, and lack of ground cover that could protect the soil from erosion and from superheating by the intense sunlight. All of these stresses are complicated by the salinization of Punjab soils.

To reverse the deterioration of these soils and their declining crop yields, Sharif took steps to halt: 1) repeated plowing; 2) excessive use of water; and 3) leaving the soils bare during the summer months. These practices result in loss of organic matter from the soil, lowering its capacity for water-absorption and water-retention as well as its retention of plant nutrients that can become available over the life cycle of the crop.

Accordingly, machinery was developed as explained in Sharif (2011) that could quickly and cheaply construct permanent raised beds on laser-leveled fields, also applying small but precise amounts of fertilizer and compost (Figure 44, following page). Quick and efficient crop establishment was done by a second machine which punched holes in the raised beds at regular intervals and then filled them with water from a tank on the machine, after laborers riding on the machine had dropped 10-day-old seedlings into them (Figure 45, following page).

Figure 43: *Irrigation done by syphon tubes in furrows between permanent raised beds, saving both water and energy.*

Once the plants were growing, a third machine weeded the raised beds periodically, breaking up the soil between the precision-placed plants and thereby aerating their root zones while eliminating weeds (Figure 46, following page). The field was flooded only once, after the transplanting was completed, to 1 inch above the top of the beds. Thereafter, only furrow irrigation was done intermittently with siphons that eliminated the energy costs of pumping (Figure 43).

Sharif's initial SRI trial field was 8 hectares (20 acres), hardly a typical experiment-station plot. Its paddy yield was 12.8 tons/ha, about three times the average yield in the region. This was achieved with 70% less labor requirement than usual for paddy production, and the water use was also cut by 70%.

Because Sharif understood the principles of conservation agriculture, he introduced crop rotations along with no-till practice and ground cover, alternating many other crops in the winter season with irrigated rice in the summer season. Rice was followed by wheat, maize or cotton, or by a vegetable crop such as potato, tomato, carrots, onion, garlic or mung bean (*Vigna radiata*). The structure and fertility of the raised-bed soils is maintained with wide spacing between plants and with enhanced soil organic matter and aeration. Sharif adapted SRI ideas to all of these other crops.

Despite its productivity and profitability, the introduction of fully mechanized SRI (MSRI) production of rice has not caught on in the area, however, because of the need for specialized machines that are quite expensive for most rice or wheat growers. Even so, the principles and practices associated with MSRI are being understood and adapted for rice and other crops using manual operations once raised beds have been established.

The real test of a new crop production process is its rapid adoption by all types and sizes of farmers. From the demonstration effects of MSRI, about 80% of the farmers who grow maize, cotton, sunflower

Figure 44: *Machine making permanent raised beds on laser-leveled field, also applying fertilizer and banding compost precisely in Punjab Province of Pakistan.*

Figure 45: *Machine carrying laborers who drop 10-day-old seedlings into holes punched by the machine as it moves along the beds.*

Figure 46: *Weeder moving along raised beds, aerating the soil while uprooting weeds.*

and vegetables in the area around Sharif's farming operations have begun moving to raised-bed cultivation following SRI fundamentals.

The concepts and practices of SCI can be adapted to the production of almost any crop, according to Sharif's experience. The basic principles for such crop management are, in simple language:

- Keep the soil healthy:
    - Avoid plowing as much as possible as this destroys soil structure, degrades organic matter, and sacrifices nitrogen and other nutrients.
    - Avoid inundation of fields and grow crops on raised beds since standing water affects the soil adversely and suppresses most life in the soil
    - Make provision for a proper drainage system if necessary to keep the soil well-drained.
    - Keep the soil covered by cover crops, as much as possible, to provide it with a living mulch.

- Use enough water to keep the soil moist but also well-aerated, neither saturated nor flooded, meeting the needs of plant roots and soil organisms without any excess.

- Give more space to plants for their growth above and below ground, so that they can better harvest the sun's energy and take up the soil's nutrients.

- Leave crop plant residues on the soil so that it is protected, water is conserved, weed competition is minimized, and the biomass can become decomposed back into plant nutrients.

- Grow a variety and succession of crops, including legumes, as this minimizes plant diseases and enhances the soil's health and fertility.

With these principles, farmers can save up to 70% on their costs of purchased inputs and can expect yield increases of at least 40% compared to adjoining farmers who use conventional methods.

Appropriate management practices (timing, spacing, etc.) are developed for each crop and for yearly crop rotations according to experience and conditions. Here are some examples:

> ***Potatoes***: Yields of the best farmers in the surrounding area are 100 bags of 120 kilograms each (12 tons/ha). The SCI potato harvest in February 2013 yielded 150 bags, 50% more. With raised beds, one more row of plants can be added in the space between the two rows on a bed. Planting cover plants on the beds protects the potato plants from cold and frost in the winter season, extending their period for growth and giving larger tubers.

Carrots: Conventional farmers sow this crop by broadcasting seed on the field, and then they make ridges with a tractor to be able to irrigate along the furrows that this makes. However, making furrows this way concentrates seeds on the top of the ridge, so the plants become crowded together, lowering crop yield. Moreover, the carrots are not uniform in size and shape; only 20% qualify as 'A' grade for best market price.

In mechanized SCI production, carrot seeds are drilled on beds 42 inches wide (1.05 m), in 5 rows that are 9 inches apart (22.5 cm). One week after germination, hand-thinning is done to give the plants near-uniform spacing. Yields are increased thereby by 400%, with over 80% of these carrots classified as 'A' grade, justifying the supplemental labor.

Wheat: When an organic wheat crop was planted on raised beds, a 40% higher yield was obtained than was produced by adjacent farmers growing their wheat on flat fields. Average yield of the best farmers in the area is now about 2.5 tons/ha, while Sharif's average is around 5 tons.

Trials are underway to introduce intercropping on raised beds, e.g., rapeseed with wheat. Harvesting this presents problems for large farmers until a dual-crop harvester can be developed; however, small farmers can manage such combinations as they harvest manually.

Cotton: For the last two years, following a multi-cropping strategy, two rows of cotton are planted 30 inches (75 cm) apart, on a 42-inch (1.05 m) bed top leaving 6 inches on each side, with one row of cucurbits, melons or watermelon planted down the middle. The cotton plants provide shade to the cucurbits which yield much better than with sole-cropping, while the cotton yields the same if not more than when this crop is grown alone.

Figure 47: *This cotton crop at a Department of Agriculture research station in Punjab, Pakistan, is at flowering stage, with no fertilizer or pesticide having been used.*

There are strong financial interests in Pakistan as elsewhere promoting input-intensive modes of production and favoring new seed varieties that demand more and more purchased inputs. Now there are counter-currents, however, favoring environmental health and boosting smallholder farmer incomes currently constrained by high input costs. The On-Farm Water Management Department of the Provincial Department of Agriculture now has an SCI cotton demonstration in the 2013-14 season (Figure 47).

Sharif (2011) characterizes SCI development in Pakistan as **'paradoxical agriculture'** because it enables farmers, from large to small scales of production, to achieve more output with reduced inputs.

Where agricultural fields have been managed for years with heavy agrochemical inputs, the transition to essentially organically-managed cultivation takes some time, usually at least three crop seasons to renew chemical-dependent soil with organic amendments that make it ready for natural sustainability, giving good yields with minimum purchased inputs.

This strategy is being adopted or adapted for many crops, as a gradual process, making gradual reduction in inorganic fertilization. External nutrient amendments are applied only to meet soil deficiencies during the transition process. This work must remain both experimental and empirical.

9. Conclusions

__Figure 48:__ A wheat field in India, grown using SCI principles, and exhibiting abundant panicles.

This is an interim report on SCI as it is an evolving phenomenon, a work in progress (ILEIA 2013). Most of the information available has not yet been published in journals, although some of the data reported are from controlled, even replicated trials, and most of the data and reports that we cite are available on-line for others' examination.

The data summarized in the tables in Annexes I and II show considerable variability; but overall, the impacts of SCI management are usually ***more than a doubling of yield***. Crop-wise, the yield increases range from 60% for sugarcane to 180% for wheat.

In economic terms, ***the costs of production per hectare*** with intensification, according to data in Annex II, ***go up on average by about 50% per hectare***. However, given the increases in yield, on average ***the costs per unit of crop produced decline by about 40%*** across the crops for which detailed cost and return data are available. This makes for more than a doubling of farmer income per hectare.

While the data presented here are not complete or standardized enough for strong scientific conclusions, the patterns of improvement in yield and profitability are dramatic and consistent enough to have attracted the attention of large numbers of farmers and also of policy makers, particularly in Bihar state of India and Ethiopia.

The results enumerated in this monograph are quite consistent with those reported from a recent evaluation of SCI in Bihar done for the World Bank (Behera et al. 2013). The study reported that as of June 2012, 348,759 farmers were using SCI methods on over 50,000 ha in Bihar with yield increases that it summarized as:

- 86% for rice
- 72% for wheat
- 56% for pulses
- 50% for oilseeds, and
- 20% for vegetables

The respective average increases in profitability for these different crop categories were calculated and reported as:

- 250% for rice
- 86% for wheat
- 67% for pulses
- 93% for oilseeds, and
- 47% for vegetables

The information in this monograph has been assembled to bring these opportunities to the attention of a wider audience that is concerned with improving agricultural production and food security -- and for those who want also to conserve environmental resources and help farmers cope with increasing climatic stresses now and in the future.

Finding explanations for the evident improvements in soil/plant interaction and farmer performance presents both challenges and opportunities to the scientific community. These experiences and observations provide unanticipated and needed opportunities to the development community, and offer even greater opportunities and security to farming communities around the world.

Annex 1 Summary of Yield Effects of SCI Management with Different Crops

Crop	Country	Location	No. of farmers	Conventional yields (t/ha)	Average yields (t/ha)	SCI increase (%)	Highest SCI yield (t/ha)	Comments
Finger Millet	India	Karnataka State	Whole villages	1.2-2.5	3.75-5.0	100-200	6.25	Farmer-developed method known as *Guli Vidhana* in Haveri district
		Uttarkhand State	43	1.5	2.4	60	–	2008 trials under People's Science Institute program
	Ethiopia	Tigray Region	Whole villages	1.4 broadcasted	3.5-4.0 transplanted	150-180	7.8	Now farmers' standard practice in very dry areas, stressing compost and wider spacing
	Range and Average			**1.2-2.5**	**2.4-5.0**	**125**	**–**	**–**
Wheat	India	Uttarakhand State	151 irrigated	2.77	5.04	82	–	Evaluations done by People's Science Institute in 2008-09 season
			317 unirrigated	1.74	3.32	91	–	
		Bihar State	2008-09: 278	1.6	3.6	125	–	Initial on-farm trials done in Gaya District by NGO; Bihar State govt. started supporting SWI in 2010; in 2011-12, SWI methods were used on 183,063 ha with average yield of 5.1 t/ha
			2009-10: 15,808	1.8	4.6	150	–	
	Mali	Timbuktu Region	2010-11: 21	1.96	5.45	178	–	On-farm trials in response to initiatives of Africare
			2011-12: 142	0.94	3.2	240	–	Drought year; results were from 13 villages
	Nepal	Kailali District	2010-11: 16 locations in 3 districts	3.4 broadcasted	6.5 line sowing + conoweeder + seed treatment	90	–	Farmer field school trials at; both broadcasting and SWI with improved variety
		Sindhuli District	2011-12: 12 FFS	3.7 broadcasted	6.5 transplanted	74	–	FFS trials, with improved variety; line sowing gave an intermediate yield of 5.0 t/ha
	Range and average			**0.94-3.7**	**3.2-6.5**	**130**	**–**	**–**

Crop	Country	Location	No. of farmers	Conventional yields (t/ha)	Average yields (t/ha)	SCI increase (%)	Highest SCI yield (t/ha)	Comments
Tef	Ethiopia	Various districts	4 years of trials	± 1.0 broadcasted	3.0-5.0 transplanted; 2.1 direct-seeded	200-400	6.2	Use by farmers in 2012 expanded under a government program to 7,000 transplanting and 160,000 with direct seeding in rows
Mustard	India	Gaya District, Bihar	2009-10: 7	±1.0 broadcasted	3.0 transplanted	200	–	Trials were initiated with 7 farmers, and within 2 years expanded to >1,600 farmers
			2010-11: 283	±1.0 broadcasted	3.25 transplanted	**225**	–	–
			2011-12: 1,636	±1.0 broadcasted	3.5 transplanted	250	4.92	4.0 t/ha yields achieved by farmers who used all SCI methods as recommended
		Himachal Pradesh State	2010: 27	1.4 broadcasted	2.0 line planting	42	–	Initiative of People's Science Institute; direct seeding, not transplanting
	Range and average			**1.0-1.4**	**2.0-3.5**	**180**	–	–
Maize	India	Himachal Pradesh State	2010: 582	2.0 farmer practice	3.5 adapted SCI	75	--	Results from farmers' on-farm trials; direct seeding, wider spacing
			Farmer participatory research	2.3 farmer practice	6.5 40x40 cm space	181	--	Spacing trials: 40x40 cm spacing of hills had highest yield
				2.8 farmer practice	6.1 1 seed/hill	118	–	Seeds/hill trials: in these trials the yield from 2 seeds/hill was 5.3 t/ha
	Range and average			**2.0-2.8**	**3.5-6.5**	**108**	**–**	**–**
Sugarcane	India	Zaheerabad, Andhra Pradesh State	30SSI and 15 conventional	115	138	20	170	Trials conducted by AgSri during 2010-11
		Latur District, Maharashtra State	33 both SSI & convetional	70	95	35	173	Trials conducted by AgSri during 2011-12 under severe drought conditions
		Tamil Nadu State	Summary of TNAU evaluations	40	90	125	Seedbud rate cut by >90%	Anon., 2013c
	Range and average			**40-115**	**90-138**	**60**	**–**	With less water and lower costs

Crop	Country	Location	No. of farmers	Conventional yields (t/ha)	Average yields (t/ha)	SCI increase (%)	Highest SCI yield (t/ha)	Comments
Legumes	India	**Pigeon pea** Karnataka	On-farm trials	0.8-0.9	1.5	76	–	Results reported by Agriculture-Man-Environment Foundation, Bangalore
		Mung bean Bihar	On-farm trials	0.625	1.875	200	–	Results from Bihar Rural Livelihood Prom. Society, Patna
		Lentils Uttarakhand	On-farm trials	0.85	1.4	65	–	Results from People's Science Institute (PSI), Dehradun
		Soya bean Uttarakhand	On-farm trials	2.2	3.3	50	–	Results reported from PSI, Dehradun
		Kidney beans Uttarakhand	On-farm trials	1.8	3.0	67	–	Results reported from PSI, Dehradun
		Peas Uttarakhand	On-farm trials	2.13	3.02	42	–	Results reported from PSI, Dehradun
	Range and average			**0.8-2.2**	**1.5-3.02**	**83**	**–**	**–**
Barley	Ethiopia	Gembichu Woreda (District)	2010	2.3 broadcasted	5.0 transplanted	117	13.2	Drought-resistance, a big issue here, is enhanced with SCI practices

Annex 2 Summary of Economic Effects of SCI Management with Different Crops

Crop	Country	State/Province	Cost of production/ha	Cost of production/kg	Farmer net income/ha	COMMENTS
Finger Millet	India	Jharkhand State	+25%	-60%		Farmer methods showed loss of Rs 5,628/acre, while SFMI had net return of Rs 8,110/acre
Wheat	India	Bihar State	+60%	-28%	+150%	Net income/ha increased from Rs 17,460 to 43,952 reported by PRADAN
	India	Bihar State	-2%	-35%	+913%*	Yield increased 32%, from Rs 2,625 to 3,475 kg/ha, net revenue/ha went from Rs 1,802 to 18,265; return per man-day rose by 123%, reported by AKRSP
	India	Himachal Pradesh State	+58%		+494	Average profit per hectare for unirrigated SWI was Rs 4,813; for irrigated SWI it was Rs 28,603
	Mali	Timbuktu Region	Labor inputs for direct-sown SWI were reduced by 35-40%; returns to labor (kg of wheat produced/day) were increased by 74%			
	Nepal	Far Western Region	+58%	--	104%	Net income/ha increased from Rs 4,830 to 9,830
Mustard	India	Bihar State	+100%	-50%	'Made crop profitable'	Traditional methods showed a loss of Rs 4,346/acre, while SMI had net returns of Rs 23,487; gross revenue per acre increased from Rs 15,900 to Rs 64,100 as costs per acre declined from Rs 20,246 to Rs 40,613

* This percentage was not included in calculating average increase in farmer net income/ha reported in text.

r. References

Abraham, B. (2012). ***A value-chain analysis of the lac sub-sector and strategies to improve incomes of lac growers with suggestions for program expansion in the poverty context of Jharkhand state in India***. MPS project paper, Cornell University, Ithaca, NY.

Abraham, B., H. Arayu, T. Berhe, S. Edwards, B. Gujja, R.B. Khadka, Y.S. Koma, D. Sen, A. Sharif, E. Styger, N. Uphoff and A. Verma (2014). The system of crop intensification: reports from the field on improving agricultural production, food security, and resilience to climate change for multiple crops. ***Agriculture & Food Security***, 3:4. ***http://www.agricultureandfoodsecurity.com/content/3/1/4***

AdeOluwa, O.O., O. R. Gbadamosi, T.D. Adediran, and A. O. Ogundeji (2013). ***System with crop intensification for improving yield of Celosia (*****Celosia argentea*****) and Chorchorus (*****Corchorus olitorus*****)***. Unpublished research report, Department of Agronomy, University of Ibadan, Ibadan.

Adhikari, D. (2012). ***A Sharing on System of Wheat Intensification (SWI) in Sindhuli, Nepal***. Powerpoint presentation of the District Agricultural Development Office, Sindhuli, Nepal. ***http://www.slideshare.net/SRI.CORNELL/12107-swi-sindhuli-nepal***

AKRSP-I (2013). Impact Assessment of Soyabean Intensification Pilot Project in Madhya Pradesh. Report for Aga Khan Rural Support Project-India, Khandwa, Madhya Pradesh, India.

AgSri/NABARD (2012). ***SSI: Sustainable Sugarcane Initiative -- Producing 'More with Less'.*** AgSri and National Bank for Agriculture and Rural Development, Hyderabad. ***http://www.agsri.com/images/documents/ssi/ssi_manual_2012.pdf***

Altieri, M.A. (1995). ***Agroecology: The Science of Sustainable Agriculture***. Westview Press, Boulder CO.

AMEF (2009). ***System of Crop Intensification: AMEF Experience in Red Gram***. Agriculture-Man-Environment Foundation, Bangalore. ***http://sri.ciifad.cornell.edu/aboutsri/othercrops/otherSCI/InKarnSCIRedGram_AME2011.pdf***

Anas, I., O.P. Rupela, T.M. Thiyagarajan and N. Uphoff (2011). A review of studies on SRI effects on beneficial organisms in rice soil rhizospheres. ***Paddy and Water Environment***, 9: 53-64.

Anon. (2013a). Special red gram planting method from Bidar catching on. ***The Hindu***, May 31. ***http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/special-red-gram-planting-method-from-bidar-catching-on/article4768056.ece***

Anon. (2013b). SSI sweetens the deal for sugarcane growers: Farmers can achieve a yield of 80 tonnes an acre against the normal average of 40 to 45 tonnes. ***The Hindu***, August 23. ***http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/ssi-sweetens-the-deal-for-sugarcane-growers/article5051407.ece***

Anon. (2013c). TN agri varsity launches sustainable sugarcane initiative. ***The Hindu***, June 8. ***http://www.thehindubusinessline.com/news/states/tn-agri-varsity-launches-sustainable-sugarcane-initiative/%20article4794901.ece***

Araya, H. and S. Edwards (2011) ***Planting with Space***. Institute for Sustainable Development, Addis Ababa. ***www.isd.org.et/Publications/planting%20with%20space.pdf***

Araya H., S. Edwards, A. Asmelash, H. Legasse, G.H. Zibelo, T. Assefa, E. Mohammed and S. Misgina (2013). SCI: Planting with space. ***Farming Matters***, 29: 34-37.

Arnold, C. (2013). The other you. ***New Scientist***, 12 January, 31-34.

ATA (2013). ***Results of 2012 New Tef Technology Demonstration Trials***. Agricultural Transformation Agency, Ethiopian Institute for Agricultural Research, and Ministry of Agriculture, Federal Democratic Republic of Ethiopia, Addis Ababa, July.

Baskaran, P. (2012). STI – ***The System of Turmeric Intensification: An Innovative Method for Cultivation of Turmeric (Cucurma longa)***. Thambal SRI Farmers Association, Thambal, Salem District, Tamil Nadu, India, published by SRI-Rice, CIIFAD, Ithaca, NY. http://sri.ciifad.cornell.edu/aboutsri/othercrops/otherSCI/InTN_STI_Baskaran092712.pdf

Ball, A. (2006). Energy inputs in soil systems. In: ***Biological Approaches to Sustainable Soil Systems***, eds. N. Uphoff et al., 79-89. CRC Press, Boca Raton, FL.

Behera, D., A.K. Chaudhury, V.K. Vutukutu, A. Gupta, S. Machiraju and P. Shah (2013). ***Enhancing Agricultural Livelihoods through Community Institutions in Bihar, India***. South Asia Livelihoods Learning Note, Series 3, Note 1. The World Bank, New Delhi, and JEEVIKA, Patna. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/04/02/000333037_20130402105225/Rendered/PDF/763380NWP0P0900030Note10Box0374379B.pdf

Berhe, T., Z. Gebretsadik, S. Edwards and H. Araya (2013). Boosting tef productivity using improved agronomic practices and appropriate fertilizer. In: ***Achievements and Prospects of Tef Improvement***, eds. H. Assefa, S. Chanyalew and Z. Tadele, 133-140. Ethiopian Institute of Agricultural Research, Addis Ababa, and Institute of Plant Sciences, Bern, Switzerland.

Bhatt, Y. (2014) System of crop intensification (SCI) experience with chick pea (chana) crop. Aga Khan Rural Support Program-India, Gujarat http://garsher.wordpress.com/2014/03/10/system-of-crop-intensification-experience-with-chick-pea-crop/

BRLPS (2011). ***System of Crop Intensification (SCI)***. Background paper for National Symposium on System of Crop Intensification, March 2, organized by the Bihar Rural Livelihood Promotion Society, Patna. www.brlp.in/admin/Files/Concept%20Note%20on%20National%20Colloquium%20on%20SCI.pdf

Chaboussou, F. (2004). ***Healthy Crops: A New Agricultural Revolution***. John Anderson, Charnley, UK.

Coleman, D.C., D.A. Crowley and P.F. Hendrix (2004). ***Fundamentals of Soil Ecology***. Elsevier, Amsterdam.

Chi, F., S.H. Shen, H.P. Cheng, Y.X. Jing, Y.G. Yanni and F.B. Dazzo (2005). Ascending migration of endophytic rhizobia, from roots to leaves, inside rice plants and assessment of benefits to rice growth physiology. ***Journal of Applied and Environmental Microbiology***, 71: 7271-7278.

Chi, F., P.F. Yan, F. Han, X.Y. Shen and S.H. Shen (2010). Proteomic analysis of rice seedlings infected by Sinorhizobium meliloti 1021. ***Proteomics***, 10: 1861-1874.

Chopra, R. and D. Sen (2013). Golden wheat becomes more golden: Extending SRI to wheat. ***LEISA-India***, 15:1, 30-32. Agriculture-Man-Environment Foundation, Bangalore, India.

Dash, T.K. and A. Pal (2011). ***Growing Crops with SRI Principles***. SRI Secretariat and Sir Dorabji Tata Trust, Bhubaneswar. http://sdtt-sri.org/wp-content/themes/SDTT-SRI/Document/output.pdf

Diwakar, M.C., A. Kumar, A. Verma and N. Uphoff (2012). Report on the world-record SRI yields in kharif season 2011 in Nalanda District, Bihar State, India. ***Agriculture Today***, New Delhi, 15, 54-56.

European Parliament (2009). ***Agricultural Technologies for Developing Countries***. Report of project for the EU's Science and Technology Options Assessment project (IP/A/STOA/FWC/2005-28/SC42). European Parliament, Brussels.

FAO (2011). ***Save and Grow: A Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production***. UN Food and Agriculture Organization, Rome.

Ganesan, S. (2013). Red gram seedlings may double yield in Tiruchi. ***The Hindu***, Aug. 24. http://www.thehindu.com/news/cities/Tiruchirapalli/red-gram-seedlings-may-double-yield-in-tiruchi/article5055268.ece

Gliessman, S.R. (2007). ***Agroecology: The Ecology of Sustainable Food Systems***. CRC Press, Boca Raton, FL.

GRAIN (2011). Food and climate change: The forgotten link. ***Against the Grain***, 28 September . GRAIN, Barcelona, Spain.

Green Foundation (2006). ***Guli Vidhana: A Farmer Innovation for Bumper Crop***. The Green Foundation, Bangalore. http://sri.ciifad.cornell.edu/aboutsri/othercrops/fingermillet/InKar_Ragi_GreenFoundationPoster.pdf

IAASTD (2009). ***Agriculture at a Crossroads: Synthesis Report of the International Assessment of Agricultural Knowledge, Science and Technology for Development***. Island Press, Washington, DC.

IANS (2012). Bihar potato farmer sets new world record. Indo-Asian News Service, February 18. http://www.ndtv.com/article/india/bihar-potato-farmer-sets-new-world-record-332290?v

ICRISAT/WWF (2009). ***Sustainable Sugarcane Initiative: Improving Sugarcane Cultivation in India – A Training Manual***. Dialogue Project on Food, Water and Environment. International Crop Research Institute for Semi-Arid Tropics& World Wide Fund for Nature, Hyderabad. http://www.indiawaterportal.org/sites/indiawaterportal.org/files/SSI%20Training%20Manual_WWF_ICRISAT_2009.pdf

IFAD/UNEP (2013). ***Smallholders, Food Security and the Environment***. International Fund for Agricultural Development, Rome, and U.N. Environmental Program, Nairobi.

ILEIA (2013). SRI: Much More than More Rice. Special issue of ***Farming Matters***, 29:1. Center for Learning on Sustainable Agriculture, Wageningen.

Kabir, H. and N. Uphoff (2007). Results of disseminating the System of Rice Intensification with farmer field school methods in Northern Myanmar. ***Experimental Agriculture***, 43: 463-475.

Khadka, R.B. and P. Raut (2012). ***System of Wheat Intensification (SWI): A new concept on low-input technology for increasing wheat yield in marginal land***. Paper for the European Union Food Facility Project, Kathmandu.

Laulanié, H. (1993). Le système de riziculture intensive malgache. ***Tropicultura***, 11: 110-114; an English synopsis is republished in ***Tropicultura*** (2011), 29: 183-187.

Lim, S. (2007). ***Experiences in Multi-Purpose Farm Development: Raising Household Incomes in Cambodia by Utilizing Productivity Gains from the System of Rice Intensification***. Cambodian Center for Study and Development of Agriculture (CEDAC), Phnom Penh. http://sri.ciifad.cornell.edu/countries/cambodia/cambSidMPREng.pdf

Lowenfels, J. and W. Lewis (2006). ***Teaming with Microbes: A Gardener's Guide to the Soil Food Web***. Timber Press, Portland, OR.

Montpellier Panel (2013). ***Sustainable Intensification: A New Paradigm for African Intensification***. Imperial College, London.

Patna Daily (2012). World record in potato production for Bihar farmer. ***Patna Daily***, March 14. http://www.patnadaily.com/index.php/news/7060-world-record-in-potato-production-for-bihar-farmer.html

Prabu, M.J. (2010). Bicycle-inspired plougher and weeder gains popularity. ***The Hindu***, April 29. http://www.hindu.com/seta/2010/04/29/stories/2010042950601500.htm

PRADAN (2012a). ***Cultivating Finger Millet with SRI Principles: A Training Manual***. PRADAN, Ranchi, Jharkhand, and Sir Dorabji Tata Trust, Mumbai; published in English by SRI-Rice, CIIFAD, Ithaca, NY. http://sri.ciifad.cornell.edu/aboutsri/othercrops/fingermillet/In_SFMI_Pradan.pdf

PRADAN (2012b). ***Cultivating Wheat with SRI Principles: A Training Manual***. PRADAN, Gaya, Bihar, published in English by SRI-Rice, CIIFAD, Ithaca, NY. http://sri.ciifad.cornell.edu/aboutsri/othercrops/wheat/In_SWI_Pradan.pdf

PRADAN (2012c). ***Cultivating Rapeseed/Mustard with SRI Principles: A Training Manual***. PRADAN, Gaya, Bihar, published in English by SRI-Rice, CIIFAD, Ithaca, NY. http://sri.ciifad.cornell.edu/aboutsri/othercrops/otherSCI/In_SMImustard_Pradan.pdf

Prasad, A. (2008). Going against the grain: The system of rice intensification is now being adapted to wheat – with similar good results. ***Outlook Business***, October 18, 54-55, New Delhi.

Raol, R.K. (2012). ***SWI Experience in Bihar***. Aga Khan Rural Support Programme-India, New Delhi.

RCDC (2010). Report of the State-Level Workshop Workshop on Promotion of Lac-based Livelihood. Regional Centre for Development Cooperation, Bhubaneswar. http://www.rcdcindia.org/PbDocument/579f50051389341-6299-4799-a9a7-cb82ae3af8bfReport%20of%20the%20State%20level%20Workshop%20on%20Promotion%20of%20Lac%20based%20Livelihood.pdf

Reichardt, W., A. Dobermann and T. George (1998). Intensification of rice production systems: Opportunities and limits. In: ***Rice in the Global Food System***, eds. N.G. Dowling, S.M. Greenfield and K.S. Fischer, 127-144. International Rice Research Institute, Los Baños, Philippines.

Rodriguez, R.J., D.C. Freeman, E.D. McArthur, Y.O. Kim and R.S. Redman (2009). Symbiotic regulation of plant growth, development and reproduction. ***Journal of Communicative and Integrative Biology***, 2-3: 1-3.

Royal Society (2009). ***Reaping the Benefits: Science and the Sustainable intensification of Global Agriculture***. The Royal Society, London.

Sharif, A. (2011). Technical adaptations for mechanized SRI production to achieve water saving and increased profitability in Punjab, Pakistan. ***Paddy and Water Environment***, 9: 111-119. https://docs.google.com/file/d/0BxKIfua619dacTdOYnRYb0ItdXc/edit?usp=sharing

Stoop, W.A., N. Uphoff and A. Kassam (2002). A review of agricultural research issues raised by the System of Rice Intensification (SRI) from Madagascar: Opportunities for improving farming systems for resource-poor farmers. ***Agricultural Systems***, 71: 249-274.

Styger, E. (2008-09). 60 farmers evaluate the System of Rice Intensification in Timbuktu 2008/09. http://www.erikastyger.com/SRI_Timbuktu_Blog/SRI_Timbuktu_Blog.html

Styger, E. (2010). ***Scaling up SRI in Goundam and Dire Circles of Timbuktu, 2009/2010***. Africare Mali, Bamako. http://sri.ciifad.cornell.edu/countries/mali/MaliTimbuktu_2009_2010.pdf

Styger, E. and H. Ibrahim (2009). ***The System of Wheat Intensification: First time testing by farmers in Goundam and Dire, Timbuktu, Mali, 2009***. Africare Mali, Bamako. http://ciifad.cornell.edu/sri/countries/mali/MaliSWIrpt071309.pdf

Styger, E., G. Aboubacrine, M.A. Attaher and N. Uphoff (2011). The system of rice intensification as a sustainable agricultural innovation: Introducing, adapting and scaling up SRI in the Timbuktu region of Mali. ***International Journal of Agricultural Sustainability***, 9: 67-75.

Thies, J.E. and J.M. Grossman (2006). The soil habitat and soil ecology. In: ***Biological Approaches to Sustainable Soil Systems***, eds. N. Uphoff et al., 59-78. CRC Press, Boca Raton, FL.

UNEP (2012). ***Avoiding Future Famines: Strengthening the Ecological Foundations of Food Security through Sustainable Food Systems – A UNEP Synthesis Report***. U.N. Environmental Programme, Nairobi, Kenya. ***http://www.unep.org/publications/ebooks/avoidingfamines/portals/19/UNEP_Food_Security_Report.pdf***

Uphoff, N., ed. (2002). ***Agroecological Innovations: Increasing Food Production with Participatory Development***. Earthscan, London.

Uphoff, N. (2011). Agroecological opportunities to help 'climate-proof' agriculture while raising productivity in the 21st century. In: ***Sustainable Soil Productivity in Response to Global Climate Change: Science, Policy and Ethics***, eds. T.S. Sauer, J.M. Norman and M.K. Sivakumar, 87-102. Wiley-Blackwell, Hoboken, NJ.

Uphoff, N. (2012a). Supporting food security in the 21st century through resource-conserving increases in agricultural production. ***Agriculture and Food Security***, 1:18. ***http://www.agricultureandfoodsecurity.com/content/1/1/18***

Uphoff, N. (2012b). ***Raising Smallholder Food Crop Yields with Climate-Smart Agroecological Practices***. Booklet prepared for World Bank Institute seminar, Oct. 10. ***http://sri.ciifad.cornell.edu/aboutsri/othercrops/Other_Crops_Brochure_Uphoff101012.pdf***

Uphoff, N. and R. Randriamiharisoa (2002). Possibilities for reducing water use in irrigated rice production through the Madagascar System of Rice Intensification (SRI). In: ***Water-Wise Rice Production***, eds. B.A. Bouman et al., 71-87. International Rice Research Institute, Los Baños, Philippines.

Uphoff, N., A. Ball, E.C.M. Fernandes, H. Herren, O. Husson, M. Laing, C.A. Palm, J. Pretty, P.A. Sanchez, N. Sanginga and J.E. Thies, eds. (2006). ***Biological Approaches to Sustainable Soil Systems***. CRC Press, Boca Raton, FL.

Uphoff, N., F. Chi, F.B. Dazzo and R.J. Rodriguez (2013). Soil fertility as a contingent rather than inherent characteristic: Considering the contributions of crop-symbiotic soil biota. In: ***Principles of Sustainable Soil Management in Agroecosystems***, eds. R. Lal and B. Stewart, 141-166. Taylor & Francis, Boca Raton FL.

World Bank (2006). ***Agricultural Investment Sourcebook***, Module 4: Investments in Sustainable Agricultural Intensification. The World Bank, Washington DC.

WOTR (2013). ***SCI: System of Crop Intensification – A Step towards Climate-Resistant Agriculture***. Watershed Organisation Trust, Pune, Maharashtra, India.

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CTA

RAISING FOOD CROP YIELDS THROUGH CLIMATE-SMART AGROECOLOGICAL PRACTICES

Smallholding farmers in many countries are starting to get **HIGHER YIELDS** with **GREATER FACTOR PRODUCTIVITY** from their **land, labor, seeds, water** and **capital** -- with also more resilience to the **STRESSES FROM CLIMATE CHANGE** – by adapting the principles and methods of **SRI** to other crops through what is being called the ***SYSTEM OF CROP INTENSIFICATION*** **(SCI)**, which is proving to be beneficial for growing:

- **Wheat**
- **Mustard (rapeseed/canola)**
- **Sugarcane**
- **Finger millet**
- **Maize**
- **Turmeric**
- **Tef**
- **Legumes: pigeon peas, lentils, mung beans, soya beans, kidney beans, chickpeas**
- **Vegetables: tomatoes, chillies, eggplant, etc.**

Above: System of Wheat Intensification (SWI) panicles in Bihar state, India

THE SYSTEM OF CROP INTENSIFICATION

Starting from Madagascar, the **System of Rice Intensification (SRI)** has shown remarkable capacity to raise smallholders' rice productivity under a wide variety of conditions around the world: from the tropical rainforest regions of Aceh, Indonesia, to the mountainous regions of Baghlan district in Afghanistan, to fertile river basins in India and Pakistan, to the semi-arid conditions of Timbuktu on the edge of the Sahara Desert in Mali. It is thus adaptable to a wide range of agroecological settings.

With SRI management, **yields** are usually increased by 50-100%, but sometimes even more, with reduced requirements for **seed** (by 80-90%) and **water** (25-50%), with less or no requirements for ***inorganic fertilizer*** if sufficient compost can be made and applied, and with little if any need for ***agrochemical crop protection*** against pests and diseases, because SRI plants are healthier and better able to resist stresses such as drought, extreme temperatures, flooding, and storm damage.

More productive, more robust crops of **rice** are being grown by cultivation with:

- **Young seedlings**, planted ***carefully and singly***, giving them **wide spacing**, usually in a ***square pattern*** to give the roots and canopy ***ample room to grow***;
- Keeping the **soil moist** with sufficient water for ***plant roots*** and ***beneficial soil organisms*** to grow -- but not so much as to suffocate or suppress either;
- Adding as much **organic matter** (compost, mulch, etc.) to the soil as possible, so as to 'feed the soil, so that the soil can feed the plant'; and
- **Controlling weeds** with methods that break up the soil's surface and that ***actively aerate the root zone***.

SRI ideas and methods, developed to benefit smallholders growing ***irrigated rice***, have been subsequently adapted to ***rainfed, unirrigated production*** by farmers and various NGO or other professionals working with them, as well as to **larger-scale production**, with methods such as ***direct seeding*** instead of transplanting, and with ***mechanization*** of some operations. From the start, SRI has progressed through **experimentation, careful observation, evaluation, and ongoing innovation** rather than being a set of fixed practices. SRI is thus more of a ***phenomenon***, farmer-centered and biologically-oriented, than a ***technology***.

Fairly soon after SRI principles were understood and its practices mastered, farmers began extending its ideas and methods to **other crops**. NGOs and some scientists have also become interested in and supportive of this extrapolation so that **a process of innovation** has ensued, reported for the first time in this booklet. More information and more details can be obtained from the SRI-Rice website: http://sri.ciifad.cornell.edu/aboutsri/othercrops/index.html

This is not a research report; the comparisons reported here are not experiment station data but instead results systematically assessed from farmers' fields. The differences that have been observed and measured probably have some margin of measurement error; but they are so large and so often repeated that they are certainly significant agronomically.

Innovative management of many crops -- including wheat (SWI), sugarcane (SSI), finger millet (SFMI), mustard (SMI), maize (another SMI), tef (STI), turmeric (another STI), and various legumes and vegetables -- is being grouped under the broad heading of **System of Crop Intensification** (SCI). These are all crops with water management very different from irrigated paddy rice, being essentially ***rainfed*** crops, although most can benefit from some irrigation if it is available.

Colleagues in Ethiopia, working with farmers in Tigray province, most of them entirely dependent on rainfall which is not very reliable, have adapted SRI ideas to a variety of crops under the banner of **'Planting with Space'** discussed below. This is one more offshoot from the original insights that brought SRI into the world. SCI is still 'work in progress.' This report will hopefully encourage others to join in efforts to understand and utilize these potentials.

Sorghum head grown 'with space' in Tigray province, Ethiopia

WHEAT (*Triticum*)

The extension of SRI practices to **wheat**, the next most important cereal crop, was fairly quickly seized upon by farmers and researchers in India, Ethiopia, Mali and Nepal. The most rapid growth and most dramatic results have been in **Bihar state of India**, where 415 farmers, mostly women, tried SWI methods in 2008/09, with yields averaging **3.6 tons/ha**, compared with 1.6 tons/ha using usual practices. The next year, 15,808 farmers used SWI with average yields of **4.6 tons/ha**. In the past year, 2011/12, the SWI area in Bihar was reported to be 183,063 hectares, with average yields of 4.5 tons/ha. With SAWI management, net income per acre from wheat has been calculated by PRADAN to rise from Rs. 6,984 to Rs. 17.581.

About the same time, farmers in **northern Ethiopia** started on-farm trials of SWI, assisted by the Institute for Sustainable Development (ISD), supported by a grant from Oxfam America. The differences in plant performance were very evident as seen below. Seven farmers in 2009 averaged **5.45 tons/ha** with SWI methods, the highest reaching 10 tons/ha, followed by a larger set of on-farm trials in South Wollo in 2010, with average SWI yields of **4.7 tons/ha** with compost and **4.9 tons/ha** with urea + DAP. (The 4% increase in yield with inorganic fertilizer was not enough to justify the cost of purchasing and applying fertilizer.) The control plots averaged **1.8 tons/ha**.

Comparison of wheat panicles in Gembichu woreda, Ethiopia:
usual methods on left, 39 grains; SWI on right 56 grains

In 2009, farmer trials with SWI methods were started in the **Timbuktu region of Mali**, where it was learned that transplanting young seedlings was not as effective as direct seeding (because they were desiccated and chilled by the cold winter winds). But getting a 10% higher yield with a 94% reduction in seed (10 kg/ha vs. 170 kg/ha), and a 40% reduction in labor and a 30% reduction in water encouraged farmers to continue with their experimentation.

Comparison of SWI panicles on left and conventionally grown wheat panicles on right, from 2009/10 trials in Timbuktu region

In 2010/11, trials in Mali were more ambitious, evaluating a number of different methods of crop establishment, including direct seeding in spacing combinations from 10 to 20 cm, line sowing, transplanting of seedlings (closer to the original methods of SRI), and control plots, all on farmers' fields. Compared to the control average (2.25 tons/ha), the transplanting method and 15x15 cm direct seeding gave the greatest yield response, **5.4 tons/ha**, an increase of 140% increase.

Establishment method	Yield (t/ha)	% compared to control
10 cm x10 cm	**4.33**	92
10 cm x 15 cm	**5.22**	132
15 cm x 15 cm	**5.41**	140
20 cm x 20 cm	**4.9**	118
Line hand (20cm)	**4.26**	89
Line mach (20cm)	**5.13**	128
Seedlings	**5.41**	140
Control	**2.25**	0
5 farmers	**2.45**	9

SWI evaluations have also been done in the **Far Western region of Nepal** by the NGO Mercy Corps under the EU-FAO Food Facility programme in 2010. The control level of yield was **3.4 tons/ha** with local variety and local practices. Growing a modern variety with local practices added 10% to yield, 3.74 tons/ha, while with SWI practices the same variety raised yield by 91%, with a yield of **6.5 tons/ha**.

Farmer in Muzzafarpur district, Bihar state, showing difference between plants of same variety when using SWI management methods (on left). As with SRI, these methods promote root growth and beneficial soil organisms, resulting in more tillering, larger panicles and more grains as seen above.

[URL for SWI manual]

MUSTARD (RAPESEED/CANOLA) (*Brassica*)

Farmers in **Bihar state of India** have recently begun adapting SRI methods for growing **mustard** (aka rapeseed or canola). In 2009-10, 7 women farmers working with **PRADAN** and the government's **ATMA** in Gaya district started with a version of SRI practices which gave them an average mustard seed yield of **3 tons/ha** instead of their usual **1 t/ha**.

Next year, 283 women farmers who used SMI methods averaged **3.25 tons/ha**. In 2011-12, 1,636 farmers practiced SMI with an average yield of **3.5 tons/ha**. Those who used all of the recommended practices with care averaged 4 tons/ha, and one reached a yield of **4.92 tons/ha** as measured by agricultural technicians. With SMI, farmers' costs of production have been reduced from **Rs. 50** per kg of grain to just **Rs. 25** per kilogram.

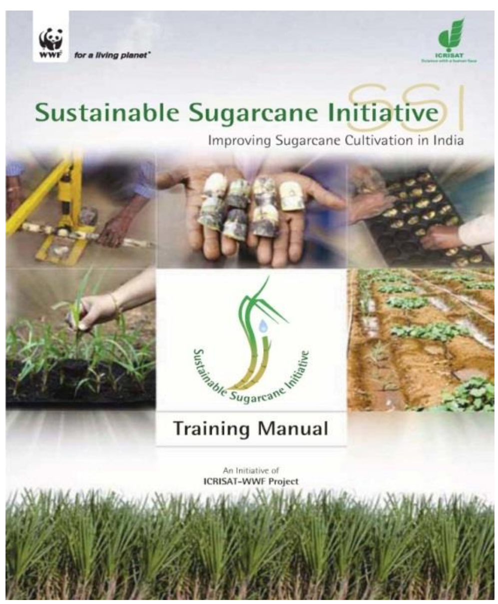
SMI mustard plot on land in Bihar village, India

[the lower picture will be superimposed into the lower left- or right-hand corner of the above picture, with the larger picture above made bigger] **[URL for SMI manual]**

SUGARCANE (*Saccarum officinarum*)

Farmers in **Andhra Pradesh state of India** shortly after they began using SRI methods in 2004 began also adapting these ideas and practices to their **sugarcane** production. Some farmers got as much as three times more yield, cutting their planting materials by 80-90% as done with SRI, and introducing much wider spacing of plants, using more compost and mulch to enhance soil organic matter (and control weeds), with sparing use of irrigation water and much-reduced use of chemical fertilizers and agrochemical sprays.

By 2009, there had been enough testing, demonstration and modification of these initial practices, e.g., cutting out the buds from cane stalks and planting them in soil or other rooting material to produce health seedlings that could be transplanted with very wide spacing, that the joint Dialogue Project on Food, Water and Environment of the **World Wide Fund for Nature** (WWF) and the **International Crop Research Institute for the Semi-Arid Tropics** (ICRISAT) in Hyderabad launched a ***'sustainable sugarcane initiative'*** (SSI). The project published a manual (below) that described and explained the suite of methods derived from SRI experience that could raise cane yields by 30% or more, with reduced requirements for water and for chemical fertilizer.



The director of the Dialogue Project, Dr. Biksham Gujja together with other SRI and SSI colleagues established a *pro bono* company **AgSRI** in 2010 to disseminate knowledge and practice of these ecologically-friendly innovations among farmers in India and beyond. The above manual and an updated SSI training manual published in 2012 are both available on the AgSRI website: www.agsri.com. *Outlook Business* published a feature article on AgSRI's initiative: http://business.outlookindia.com/article.aspx?282020 (Sept. 2012). See also: http://www.springerlink.com/content/fg32x113058rh413/?MUD=MP

The first international activity of AgSRI has been to share information on SSI with sugar growers on the Camilo Cienfuegos production cooperative in **Bahia Honda, Cuba**. The pictures below show the first crop at 10.5 months. A senior sugar agronomist, Lauro Fanjùl from the Ministry of Sugar, when visiting the cooperative to inspect its SSI crop, was amazed at the size, vigor and color of the canes, noting that they were 'still growing.'

FINGER MILLET (*Eleusine coracana*)

Some of the first examples of SCI came from farmers in several states of **India** who applied SRI ideas to finger millet (*ragi* in local languages) or who by their own observations and experimentation devised a more productive cropping system for finger millet that utilized SRI principles.

The NGO **Green Foundation** in Bangalore in the early '00s learned that farmers in Haveri district of Karnataka State had devised a system for growing *ragi* that they call ***Guli Vidhana*** (square planting).* Young seedlings are planted in a square grid, 2 per hill, spaced 18 inches (45 cm) apart, with organic fertilization. One implement that they use stimulates ***greater tillering and root growth*** when it is pulled across the field in different directions; and another ***breaks up the topsoil*** while weeding between and across rows. In contrast with conventional methods which yield around **1.25 to 2 tons/ha**, with up to 3.25 tons using fertilizer inputs, *Guli Vidhana* methods yield **4.5 to 5 tons/ha**, with a maximum yield so far of 6.25 tons.

Yedekunte intercultivating implements used by Haveri farmers to weed and also break up the soil between and across the rows for their *Guli Vidhana* crop of finger millet. Rows are spaced 18 inches (45 cm) apart. This ox-drawn weeder, by aerating the soil, stimulates root growth and enhances crop yield significantly.

* http://www.google.com/#hl=en&output=search&sclient=psy-ab&q=Guli+Vidhana+in+Ragi&oq=Guli+Vidhana+in+Ragi&gs_l=hp.3...1487.4871.0.5879.20.10.0.0.0.0.1297.2073.6-1j1.2.0.les%3 Beesh..0.0...1.1.9 SKQMUYukCg&pbx=1&bav=on.2,or.r_gc.r_pw.r_qf.&fp=5988fe0ce707769a&biw=1210&bih=597

In **Jharkhand state of India**, rainfed farmers working with the NGO **PRADAN** began experimenting with SRI methods for their finger millet (ragi) in 2005. Usual yields there were 750 kg to 1 ton/ha with traditional broadcasting practices. Yields with transplanted SFMI have averaged **3-4 tons/ha**. Costs of production per kg of grain are reduced by 60% with SFMI management, from **Rs. 34.00** to **Rs. 13.50**. In **Ethiopia**, one farmer using her own version of SRI practices for finger millet achieved a yield as high as **7.6 tons/ha**.

Differences in plant size and in size of panicles induced by SFMI management
[URL for SFMI manual]

MAIZE (*Zea mays*)

Growing **maize** with SRI concepts and methods has not been experimented with very much yet; but in **northern India** the **People's Science Institute** in Dehradun has worked with smallholders in Uttarakhand and Himachal Pradesh states to improve their maize production with adapted SRI practices.

No transplanting is involved, and no irrigation. Farmers are planting 1-2 seeds per hill with square spacing of 30x30 cm, having added compost and other organic matter to the soil, and then doing three soil-aerating weedings. Some varieties they have found performing best at 30x50 cm spacing. The number of farmers practicing this kind of SCI went from 183 in 2009 on 10.34 hectares of land, to 582 farmers on 63.61 ha in 2010. With these alternative methods, the average yields have been **3.5 tons/hectare**, 75% more than their yields with conventional management, which have averaged **2 tons/hectare**.

Because maize is such an important food crop for many millions of food-insecure households, getting more production from their limited land resources, with their present varieties or with improved ones, should be a priority.

Maize crop in Uttarakhand state grown with adapted SRI practices

TURMERIC (*Curcuma longa*)

Farmers in Thambal village, Salem district in **Tamil Nadu state of India** were the first to establish an SRI Farmers' Association in their country, as far as is known. Their appreciation for SRI methods led them to begin experimentation with the extension of these ideas to their off-season production of **turmeric**, a rhizome crop that gives farmers a good income when sold for use as a spice in Indian cooking.

The president of the SRI Farmers' Association, Mr. P. Baskaran, has written a manual on this new 'STI,' available at: (URL)

With this methodology, planting material is reduced by more than 80%, by using much smaller rhizome portions to start seedlings. These are transplanted with wider spacing (30x40 cm instead of 30x30 cm), and organic means of fertilization are used (green manure plus vermicompost, Trichoderma, Pseudomonas, EM, etc.). Water requirements are cut by two-thirds. With yields 25% higher and with lower costs of production, farmer's net income from their turmeric crop can be effectively doubled. It is reported that farmers in Cambodia have applied SRI ideas to **ginger**, another rhizome crop, but we have no detailed information on this.

P. Baskaran showing the mixing of organic inputs with coco-peat for filling the cups in which turmeric seedlings are grown for use in STI turmeric production

TEF (*Eragrostis tef*)

Adaptations of SRI ideas for the increased production of **tef**, the most important cereal grain for Ethiopians, started in 2008-09 under the direction of Dr. Tareke Berhe, at the time director of the Sasakawa Africa Association's regional rice program, based in Addis Ababa. Having grown up in a household which raised tef and then writing theses on tef for his M.Sc. (Washington State University) and PhD. (University of Nebraska), Berhe was thoroughly knowledgeable, both practically and theoretically, with this crop.

Typical yields for tef grown with traditional practices, based on broadcasting, are about **1 ton/ha**. The seed of tef is tiny -- even smaller than mustard seed, about 2500 seeds making only 1 gram -- so growing and transplanting tef seedlings seemed far-fetched. But Berhe found that transplanting young seedlings at 20x20 cm spacing with organic and inorganic fertilization gave yields of **3 to 5 tons/ha**. With small amendments of micronutrients (Zn, Cu, Mg, Mn), these yields could be almost doubled again. Such potential within the tef genome, responding to good soil conditions and wider spacing, had not been seen before. Berhe is calling these alternative production methods the **System of Tef Intensification** (STI).

Pictures from Dr. Berhe's presentation on 'Recent Developments in Tef: Ethiopia's Most Important Cereal and Gift to the World,' Cornell, July 2009.

In 2010, with a grant from **Oxfam America**, Dr. Berhe conducted STI trials and demonstrations at Debre Zeit Agricultural Research Center and Mekelle University, major centers for agricultural research in Ethiopia, and good results gained acceptance for the new practices. He is now serving as an advisor for tef to the Ethiopian government's Agricultural Transformation Agency (ATA), with support from the Bill and Melinda Gates Foundation.

This year, 7,000 farmers are using STI methods in an expanded trial, and another 100,000 farmers are using less 'intensified' methods based on the same SRI principles, not transplanting but having wider spacing of plants with row seeding. As with other crops, the tef genome is quite responsive to management practices that do not crowd the plants together and that improve the soil conditions for abundant root growth.

Transplanted tef ready for harvest

Field of growing young tef plants

LEGUMES: Pigeonpeas (Red Gram - *Cajanus cajan*), Lentils (Black Gram -*Vigna mungo*), Mung Beans (Green Gram -*Vigna radiata*), Soya Beans (*Glycine max*), Kidney Beans (*Phaseolus vulgaris*), Chickpeas (*Cicer arietinum*)

That SRI principles and methods could be extended from rice to wheat, finger millet, sugarcane, maize, and even tef was not so surprising, since these are all monocotyledons, according to botanical classification, and members of the broad category of grasses or grass-like plants whose stalks and leaves grow from their base. That mustard would respond very well to SRI kinds of management was unexpected, because it is a dichocotyledon, i.e., a flowering plant with its leaves growing from stems. It is now being found that a number of **leguminous crops**, also dicotyledons, can benefit from practices inspired by SRI experience.

Farmer in Karnataka state of India holding a **pigeonpea** (red gram) plant grown with adapted SRI practices. The NGO **Agriculture-Man-Environment Foundation** in Bangalore reports yields are being increased by 70%, from the usual 800-900 kg/ha to 1.5 tons/ha with modifications in management. See: http://sri.ciifad.cornell.edu/aboutsri/othercrops/otherSCI/InKarnSCIRedGram_AME2011.pdf

The ***Bihar Rural Livelihoods Support Program***, Patna, has reported tripled yield from **mung bean** (green gram) with SCI methods, raising production on farmers' fields from **625 kg/ha** to **1.875 tons/ha**.

With adapted SRI practices, the ***People's Science Institute*** in Dehradun reports that small farmers in Uttarakhand state of India are getting:

- **65% increase for lentils** (black gram), up from 850 kg/ha to 1.4 tons/ha;
- **50% increase for soya bean**, going from 2.2 tons/ha to 3.3 tons/ha;
- **67% increase for kidney beans**, going from 1.8 tons/ha to 3.0 tons/ha;
- **42% increase for chickpeas**, going from 2.13 tons/ha to 3.02 tons/ha.

No transplanting is involved, but the seeds are sown, 1-2 per hill, with wide spacing – 20x30cm, 25x30cm, or 30x30 cm for most of these crops, and as much as 15/20x30/45cm for chickpeas. Two or more weedings are done, preferably with soil aeration to enhance root growth. Fertilization is organic, applying compost augmented by a trio of indigenous organic fertilizers known locally as PAM (*panchagavya*, *amritghol* and *matkakhad*). *Panchagavya* is a mixture of five products from cattle: ghee (clarified butter), milk, curd (yoghurt), dung and urine, which particular appears to stimulate the growth of beneficial soil organisms. Seeds are treated before planting with cow urine to make them more resistant to pests and disease. This production strategy is certainly 'intensive' but the households are seeking to get maximum yield from the small areas of land available to them. The resulting crops are more robust, resistant both to pest and disease damage and to adverse climatic conditions.

SCI lentils in Uttarakhand

SCI soya beans in Uttarakhand

Pictures from presentation on 'Addressing Food Security in the Western Himalayan Region through System of Crop Intensification,' People's Science Institute, Dehradun, Jan. 2012

VEGETABLES

The extension of SRI concepts and practices to vegetable has been a farmer-led innovation, most developed in **Bihar State of India**. The **Bihar Rural Livelihoods Promotion Society** (BRLPS), working under the state government and with NGOs such as PRADAN leading the field operations, and having financial support from the IDA of the World Bank, has provided as rubric for promoting and evaluating SCI efforts among women's self-help groups to raise their vegetable production.

Women farmers in Bihar have experimented with planting young seedlings widely and carefully, placing them shallow into dug pits that are back-filled with loose soil and organic soil amendments such as vermicompost. Water is used very precisely and carefully. While this system is labor-intensive, it increases yields greatly and benefits particularly the very poorest households. They have access to very little land and water, and they need to use these resources with maximum productivity and little cash expenditure.

Tomatoes under SCI Management

Brinjal under SCI Management

Below are data and observations from a background paper for a
National Colloquium on System of Crop Intensification (SCI), Patna, March 2, 2011:
http://www.brlp.in/admin/Files/Concept%20Note%20on%20National%20Colloquium%20on%20SCI.pdf

Differences between yields of chillies, tomatoes and brinjal (eggplant) through System of Crop Intensification (SCI) and conventional methods, Bihar, 2010-11

	Unit	No. of smallholders	Conventional practices	SCI practices	Increase
Chillies	Kgs/plant	69	1.5-2.0	4.5-5.0	170%
Tomatoes	Kgs/plant	168	3.0-4.0	12.0-14.0	270%
Brinjals	Kgs/plant	42	5.0-6.0	10.0-12.0	100%

Conclusion from background paper: "It is found that in SRI, SWI & SCI, the disease & pest infestations are less, use of agro chemicals are lesser, requires less water, can sustain water-stressed condition; with more application of organic matter, yields in terms of grain, fodder & firewood are higher."

PLANTING WITH SPACE

These innovative systems of crop management are each a little different, but they all got their impetus from experience with the System of Rice Intensification (SRI). With upland crops, reducing the flooding of fields through irrigation management is not an issue. But soil aeration that promotes root growth and the abundance of aerobic soil organisms is part of the strategy.

The NGO **Institute for Sustainable Development** (ISD) in Addis Ababa working with farmers in the northern Ethiopian province of Tigray has adapted SRI ideas under the rubric of 'planting with space,' described in a booklet on the web: www.isd.org.et/Publications/planting%20with%20space.pdf

Farmers have begun adapting and using the methods of transplanting young seedlings, carefully and widely spaced in a square pattern, with abundant use of compost or other organic matter and with soil-aerating weeding, for a wide range of their crops: wheat, finger millet, maize, sorghum, barley and tef; several legumes; onions, chillies, tomatoes, lettuce, cabbage, often with intercropping of grains.

Where this process will end, nobody knows, but farmers are gaining confidence in their ability to get 'more from less' and to provide for their families' food security while enhancing the quality of their soil resources and also buffering their crops against the temperature and precipitation hazards of climate change.

Farmer and son in Tigray, Ethiopia show the high tillering capacity obtained from tef plants with transplanting (father) compared to broadcast sowing (son). Photo: Courtesy of Dr. Hailu Araya, Institute for Sustainable Development

This booklet has been prepared by the SRI International Network and Resources Center (SRI-Rice), which is located in the Cornell International Institute for Food, Agriculture and Development (CIIFAD), Cornell University, Ithaca, NY 14853. SRI-Rice is supported by a generous gift from Jim Carrey's Better U Foundation. More information is available on the SRI-Rice website: http://sri.ciifad.cornell.edu

Cultivating Rapeseed / Mustard with SRI Principles:

A Training Manual

Foreword

In 2009-10, the Agricultural Technology Management Agency (ATMA) and PRADAN initiated a program to use SRI methods in rapeseed cultivation. Initially, there were 7 women farmers from Gaya district who started the experiment. In 2011-12, the Sir Dorabji Tata Trust (SDTT) extended support for this innovation effort, so that about 1,600 farmers were able to use SRI methods for rapeseed that season.

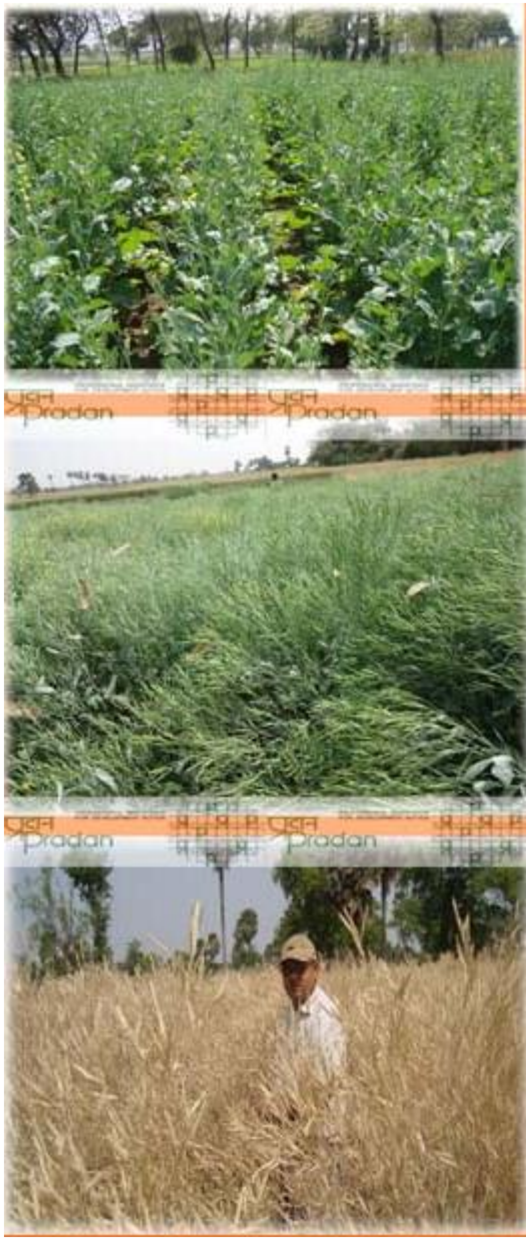
This manual has specific steps for cultivating rapeseed/mustard with SRI methods. It should be equally useful for farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves and to gain more financially.

How is rapeseed cultivated with SRI methods?

The following core principles of SRI for rice are applied in SMI rapeseed cultivation:

- **Low seed rate**: Only 50 to 250 grams per acre
- **Priming** of seeds with seed selection/treatment
- **Preparing nursery** with treated/sprouted seeds
- **Transplanting seedlings** when they are about 8 to 12 days old and have only 3-4 leaves
- **Wide and uniform spacing of single plants** across the field
- **Aerate the soil** while suppressing the weeds using mechanical rather than chemical means
- **Other practices** in crop husbandry are similar to normal methods

The yield achieved by applying SRI principles is ***about double that achieved with conventional methods***. Farmers from Gaya and Nalanda districts of Bihar have reported yields of 2.5 to 3.0 tons per hectare, or more.



Seed varieties and seeding rates

Seed selection

There is no specific preference for any particular variety of seed, but it is always better to use newer seeds, while getting rid of older ones.

Seeding rate

The quantity of seeds to be used depends upon the length of the crop cycle of the variety chosen. If the variety is of **longer duration**, the quantity of seeds required is less; whereas for **short duration** varieties, the seed requirement is greater, as shown below.

Duration of the variety	Spacing (in cm)	Seed rate (grams)
Less than 100 days	30 x 30	250
100-120 days	45 x 45	200
120-130 days	60 x 60	125
130-150 days	75 x 75	75

Priming of seeds and seed treatment

- Put the seeds into a ceramic or non-metallic pot with half a liter of warm water having a temperature of about 60^0 Celsius. Stir the mixture so that any damaged or underdeveloped seeds float on the surface. Remove these, keeping just the heavier seeds for use.
- Pour into the pot a mixture of cow urine, jaggery (coarse sugar), and vermicompost, in roughly equal proportions. Leave the seeds to soak in the mixture for 6-8 hours. The warm water should be about double the quantity of seeds being prepared, while the other materials should each be about half the quantity of the seeds. So, for example, if the amount of seed is 250 grams, the lukewarm water should be about 500 ml, and each of the other items should be about 125 grams.
- After 6 to 8 hours, separate the seeds from the mixture and add a small amount of *Trichoderma*, a beneficial microorganism that supports plant growth and health. Then put the seeds onto a cotton cloth and tie it up around them. The rate for adding *Trichoderma* should be 4 grams per kg of seed, so 1 gram of this microorganism additive would be sufficient for 250 grams of seeds.
- Keep the seeds this way for about 8 to 10 hours to let them germinate. Time will vary depending on local climatic conditions.
- Once the seeds have germinated, plant the sprouted seeds in the raised nursery beds, described next.


Seed


Warm water


Vermicompost


Jaggery


Cow urine

Nursery preparation

Prepare a raised seedbed in a field such as is generally used for vegetable cultivation. The area of the seedbed will depend upon the seed variety used; a smaller area is enough for a longer-duration variety; a larger area is needed for a shorter-duration variety.

Duration (in days)	Area of the nursery (in square meters)
Less than 100	60
100-120	50
120-130	30
130-150	20

- Mix the soil of the seedbed with **vermicompost** (2 to 2.5 kg per square meter) and **carbofuran** (2 to 2.5 grams per square meter).
- The bed should be **4 to 6 inches above the ground level**, and the width of the bed should be **one meter**.
- If there is more than one nursery bed, a **channel** of one-foot width should be dug between the two beds.
- The soil should be **moist** when putting in the sprouted seeds, and the sprouted seeds should be at a **depth of one-half inch**, keeping a spacing of about 2 X 2 inches between the sprouted seeds.
- Cover the seeds with **vermicompost** and spread a mulching of paddy **straw** over the bed.
- Each morning and in the evening, spray or sprinkle **water** on the nursery for gentle irrigation.
- **Transplant the young plants between 8 to 12 days**.

Field preparation

Plough the field beforehand 2-3 times, so that the soil is well pulverized. If the soil moisture is insufficient, provide some supplementary irrigation before tilling the land. In addition, remove the weeds from the field.

- Mark the places in the field where the mustard seedlings should be planted, using a spade or a rake or a hoe to designate the proper spacing in a square grid pattern; follow the spacing instructions above according to the variety.

- At each marked place, dig a small pit, **6 inches** in diameter and **8-10 inches** in depth. Leave the pits open, exposed to natural sunlight for 2-3 days.

- After 2-3 days, apply 300-400 grams of the mixture described below in the pits, one by one.

- Usually for an acre of mustard crop planting, start by mixing 8 tons of **compost** with 1.5 kg of ***Trichoderma***, then mixing this with soil collected from and near the pits, and putting this mixture into the pits. For an acre, use about 27 kg of **di-ammonium phosphate** (DAP) and 13.5 kg of **potash** (MOP) which are mixed into the soil and compost put into the dug pits. The pits should be nearly filled up with all these materials, with soil generally comprising about 50% of what goes into the pit. Before transplanting, each of the pits should be kept or made moist.

Transplanting with SRI methods

- Before transplanting, irrigate the nursery approximately 2 hours in advance to moisten the soil for removing the plants.
- Carefully uproot the seedlings, keeping the soil intact; if possible use a trowel or spade that gives support to the soil, so that it remains intact with the roots.
- Transfer the uprooted seedlings to the main plot in the next 30 minutes, before the roots and soil can dry out.
- Transplant the seedlings at a shallow depth in the pits.
- Irrigate the pits manually with a sprinkler/sprayer for the first 3-5 days. This helps in establishing the plants in the main plot.
- This system requires more work and care, but the results more than compensate for the added effort.

Care of the field up to 30 days after transplantation

- Irrigate the field with first irrigation on the 15th day after transplantation. Apply a dose of urea (27 kg per acre) on the 16th day when there is still moisture in the field. It is better to apply urea close to the roots of the plants.

- On the 20th day, remove any weeds by hoeing in between the rows. Mix about 0.4 ton of vermicompost (VC) and 3 kg of phosphate-solubilizing bacteria (PSB) per acre into the soil using a dry weeder or spade. The timing of this 1st weeding and application can vary depending on local agro-climatic conditions.

- Irrigate the field for a second time on the 30th day, and do a second round of weeding and hoeing. During hoeing, mix 13.5 kg per acre of Biozyme (a biofertilizer) into the soil for further enrichment of the soil biota.

Care of the field 35-50 days after transplantation

- The plants begin growing faster from 30 days after transplantation. Therefore, the plants need more moisture and nutrition. Hence, on or about the morning of the 35th day, apply a dose of urea (13.5 kg per acre) near the roots of the plants and irrigate the field for the third time.

- About 3-5 days after the third irrigation, or about 40 days after transplanting, along with a third weeding/hoeing, apply 13.5 kg of potash (MOP) to the soil. Use a weeder or spade to break up the soil and to **earth up some soil around the base of the plants**, as is usefully done with potatoes, i.e., up to one foot. This promotes more root growth.

Care of the field from 50 days after transplantation

- The plants grow very fast beyond 50 days after transplanting. The stems, branches and leaves are growing and thickening at this time.

- Aphids should be managed effectively at this time. At the start of the reproductive stage, the plants begin flowering, and subsequently, the siliqua (pod) formation and grain filling take place. In this period, the crop is most susceptible to pest attacks. Therefore, care and attention are required all the time, keeping an eye out for such problems.

- For proper growth and grain filling, irrigate the plot on 60th, 80th, 100th and 120th days after transplanting. Irrigation timing depends on the agro-climatic conditions. If irrigation is not provided on or about these days, there will be drastic reduction in the yield of the crop.

Differences between SRI and conventional methods for mustard/rapeseed cultivation

Description	*Traditional methods*	*SRI methods*
Seed rate	5.5 kilograms	125-300 grams (>95% reduction)
Priming of seeds and seed treatment	Not done	With jaggery, cow urine, warm water, and vermicompost
Planting method	Broadcasting	Transplanting
Plant spacing	Irregular	From 30 x 30 cm up to 75 x 75 cm
Sprouting of seeds	One week after broadcasting in the field	Nursery bed is sown sparsely with sprouted seeds
Weeding and soil work	Not done	On 15th , 25th and 40th days after planting
Irrigation	2 to 4 times	5 to 6 times
Branches per plant	1 to 3	8 to 20
Leaves	Narrow, with less total area	Wider, with more total leaf area
Stems	Thin	Thick
Roots	Fairly shallow	Deeper, more than 1 ft in ground
Yield per acre	0.4 ton	1.2 to 2 tons
Seed weight per plant	10 to 25 grams	150 to 300 grams

Yields achieved with SRI methods

During 2009-10, the 7 women farmers from Gaya district who applied SRI principles to rapeseed produced, on an average, **1.2 tons per acre** compared to **0.4 ton** achieved with traditional methods (3 tons per hectare vs. 1 ton).

During 2010-11, 273 farmers from Gaya and Nalanda districts had **1.3 tons per acre** on average. This increased to **1.4 tons per acre** when SMI was done by 1,636 women farmers in 2011-12.

Those farmers who applied all the principles of SRI and who gave six irrigations achieved an average yield of **more than 1.6 tons per acre** (4 tons per hectare).

The maximum yield achieved so far by adopting SRI principles was **1.97 tons per acre**. This was triple the 0.67 ton achieved with the traditional methods.

Cost estimates for cultivation of rapeseed (per acre in Indian rupees)

			Trad'l. methods		SRI methods	
	Unit	Price/unit	No. units	Cost	No. units	Cost
Seed	Kilogram	80	5.5	440	0.25	20
Priming of seeds and seed treatment						
Materials (jaggery, cow urine, warm water, vermicompost)	lump sum	30	0	0	1	30
Labor	man hour	15	0	0	1	15
Nursery preparation	man days	100	0	0	0.5	50
Seeds and nursery preparation				**440**		**115**
Field preparation						
Ploughing (rent for plough and buffalo)	unit	400	2	800	2	800
Labor	man days	100	2	200	2	200
Pit digging	man days	100	0	0	4	400
Field preparation				**1,000**		**1,400**
DAP	kilogram	15	27	405	27	405
MOP	kilogram	7	27	189	27	189
Urea	kilogram	7	55	385	55	385
Biozyme	kilogram	30	0	0	13.5	405
PSB	kilogram	65	0	0	6	390
Vermicompost	kilogram	5	0	0	400	2,000
Nutrient inputs				**979**		**1,974**
Irrigation applications	number	200	3	600	6	1,200
Labor	man days	100	3	300	6	600
Manual irrigation	man days	100	0	0	4	400
Irrigation costs				**900**		**2,200**

continued..

	Unit	Price/unit	Trad'l. methods No. units	Trad'l. methods Cost	SRI methods No. units	SRI methods Cost
Weeding and soil work	man days	100	2	200	26	2,600
Weed control	Total			**200**		**2,600**
Plant protection						
Chemical and pesticides	lump sum	200	1	200	1	200
Labor	man days	100	1	100	1	100
Rent of sprayer	lump sum	100	1	100	1	100
Crop protection costs	Total			**400**		**400**
Harvesting	man days	100	13.5	1,350	6	600
Threshing and packaging	man days	100	13.5	1,350	27	2,700
Harvesting costs	Total			**2,700**		**3,300**
Rent of the land	lump sum	4790	1	4,790	1	4,790
Interest on fixed assets	lump sum	45	0	0	1	45
Interest on current assets	lump sum			377		558
Depreciation on equipment				0		355
Capital costs	Total			**5,167**		**5,395**
Total operational costs				**18,405**		**36,921**
Management costs (10% of total)				1,841		3,692
Costs of production				**20,246**		**40,613**
Revenue from production						
Grain yeld	Rp/Kg	35	400	14,000	1,600	56,000
Dry matter (straw, fodder, etc.)	Rp/Kg	2	950	1,900	4,050	8,100
Gross revenue				**15,900**		**64,100**
Net profit				**-4,346**		**23,487**
Production cost per kg of grain				**50.6**		**25.4**

Disease management

Infected roots

Club Root: ***Plasmodiophora brassicae***

Symptoms : Affected plants look stunted. Pale green or yellow leaves develop, and later the plants die untimely.

Non-chemical management:

1. Apply long-term crop rotation (four years) with non-host crops
2. Destroy all cruciferous weeds
3. Avoid growing in fields with previous history of disease occurrence
4. Avoid growing mustard in acidic soils
5. Treat the soil with *Trichoderma*

Infected leaf

Downy Mildew: ***Peronospora parasitica***

Symptoms : Grayish white irregular necrotic patches develop on the lower surface of leaves. The affected inflorescence does not produce any siliqua or seed. The extent of damage is 17-32 % in mixed infection.

Non-chemical management:

1. Destroy the diseased crop residue
2. Follow crop rotation at least in three years
3. Varieties of *Brassica napus* groups are resistant to this disease
4. Timely sowing and use of healthy certified seeds
5. Application of potash in recommended doses reduces the disease index

Chemical management: Spray the crop with Mancozeb 75 % W.P. @ 2 gm per liter of water at the onset of the disease for 2 to 3 times with an interval of 10 days. Treat the seeds with 6 gm of Metalaxyl (Apron) per kg seed, followed by single spray with Metalaxyl (Ridomil MZ) at 2.5 gm/liters at 60 days after sowing.

Disease management

Infected stem and siliquae

Powdery Mildew: ***Erysiphe cruciferarum***

Symptoms : Dirty white, circular, floury patches on either side of the leaves. Under cold and cloudy environmental conditions, entire leaves, stems and siliquae are affected.

Non-chemical management:

1. Clean the field
2. Destroy crop residues
3. Application of potash in recommended doses reduces disease index.

Chemical management: Spray the crop with soluble sulphur @ 3 gm/liter of water at the onset of the disease and repeat it after 15 days if necessary or apply sulphur dust @ 30kg/ha. If required, use 12 kg per acre of land. Apply Dinocap or Tridemorph @ 1ml per liter of water.

Infected leaf

White Rust: ***Albugo candida***

Symptoms : White creamy-yellow raised pustules appear on the leaves, which later coalesce to form patches. Swelling and distortion of the stem and floral parts results in 'stag head.' In humid weather, mixed infection of white rust and downy mildew can develop on stag head structures.

Non-chemical management:

1. Use healthy certified seeds and follow crop rotation
2. Destroy crop residues of the last year, particularly stag heads of previous crop.
3. Avoid over-irrigation.

Chemical management: Spray the crop with Mancozeb 75 % W.P. @ 2 gm per liter of water at the onset of the disease. Repeat the spray after 15 days interval or spray with Metalaxyl @ 2.5 gm/liter of water. Treat the seeds with Apron SD-35 @ 6g/kg seed or Thiram @2.5 gm/kg seed.

Insect pest management

__Mustard aphid__: ***Lipaphis erysimi***

Damage : Both nymph and adults suck the sap from tender leaves, buds and pods. Curling may occur for infested leaves; and at advanced stage, plants may wither and die. Plants remain stunted, and sooty molds grow on the honeydew excreted by the insects. The infected field looks sick and blighted in appearance.

Non-chemical management:

1. Early sowing before 20th October reduces the damage
2. Grow aphid-tolerant varieties like Pusa Kalyani, Laha 101, C. 294, R.L.M. 84, and R.P. 09
3. Regular surveillance of pests and defenders, especially for aphids
4. Conserve native natural enemies like *Poxy nerids*, *Syrphids* and *C.carnea*
5. Ladybird beetles (*Cocciniella septem, Punctata, Menochilussex maculata, Hippodamia variegata* and *cheilomones vicina*) are the most efficient predators of the mustard aphid. Adult beetle may consume an average of 10 to 15 adults/day
6. Predatory bird *Motacilla cospica* is actively feeding on aphids in February-March. Therefore, provide bird perches @ 8-10/acre
7. Spraying of NSKE 5% or other neem formulations at recommended doses

Chemical management: Spraying should be done only when insect population is more than economic threshold level (ETL). Spraying should be done in the evening to avoid damage to pollinators. Spray the crop on as-needed base with either Oxydemetons methyl (Metasystox) or Dimethoate (Rogor) @ 400 ml/acre, or Imidacloprid (Confidor) 17.8 SL @ 50-60 ml/acre, or Thiamethoxam @ 50-60 g/acre.

Insect pest management

__Larger Moth__ **(Leaf webber):** ***Crocidolomia binotalis***

Damage : Newly hatched larvae feed gregariously initially on the chlorophyll of young leaves and later on older leaves, buds and pods; they make webbings and live within. Severely attacked plants are defoliated. Seeds in the pods are also eaten away.

Non-chemical management: Collection and careful destruction of the larvae at gregarious stage while on surveillance. Spraying of NSKE 5% or other neem formulations containing 300 ppm Azadirachtin@ 1 liter / acre. Spraying of BT formulation (Dipel, Delfin, Biodart, Halt, Bioasp, Biolep etc.) @ 400 gram/acre during evening hours at 7-10 days intervals from appearance of the pest.

Chemical management: Spray Endosulfan, Triazophos, or Monocrotophos @ 400 ml/acre or Carbaryl @ 800 gram/acre is effective.

__Diamondback Moth__: ***Plutella xylostella***

Damage : Caterpillars feed on the foliage and make it white and papery. The leaves look withered but in later stages it may be eaten up completely. Caterpillars also bore into pods and feed on developing seeds.

Non-chemical management: Install eight to ten pheromone traps to control the adult males. Conserve its natural enemies like Cotesia plutellae and Diadegma insulare as they are an important parasitoid for diamond back moth. Spraying of NSKE 5% or other neem formulations containing 300 ppm Azadirachtin @ 1 liter /acre. Spraying of BT formulation (Dipel, Delfin, Biodart, Halt, Bioasp, Biolep etc.)@ 400 gram /acre during evening hours at 7-10 days intervals from appearance of the pest.

Chemical management : Spray Fipronil 5 SC (Regent) or Chlorfenapyr (Rampage) 10 SC or Triazophos 40 EC (Hostathoin) @ 400 ml/acre or Flufenoxuron (Cascade 10 WDC) @ 120 ml/acre.

Insect pest management

<u>**Cabbage Head Borer**</u>**:** ***Hellula undalis***

Damage : Caterpillars initially mine the leaves and make it white and papery. Later they feed on leaves and bore into stems; entrance hole is covered with silk and excreta.

Non-chemical management: Collection and careful destruction of the larvae at gregarious stage on leaves twice a week. Spray NSKE 5% or other neem formulations containing 300 ppm Azadirachtin @ 1 liter /acre. Spray BT formulation (Dipel, Delfin, Biodart, Halt, Bioasp, Biolep etc.) @ 400 gram/acre during evening hours at 7-10 days intervals from appearance of the pest.

Chemical management: Spray Ethofenprox @ 200 ml/acre, Endosulfan, or Triazophos @ 400 ml/ acre two to three times at an interval of ten days.

<u>**Mustard Sawfly**</u>**:** ***Athalia lugens proxima***

Damage: Initially the larva nibbles on leaves, later it feeds from the margins towards the midrib. Feeding results in drying up of seedlings and failure to bear seeds in older plants. The yield loss is up to 5 -18 %.

Non-chemical management: Maintain clean cultivation. Apply irrigation in seedling stage because most of the larvae drown to death. Collect and destroy grubs of the sawfly in morning and evening. Conserve *Perilissus cingulator* (a parasite of the grub). Use of bitter gourd seed oil emulsion as an anti-feedant. Spray NSKE 5% or other neem formulations containing 300 ppm Azadirachtin @ 1 liter /acre.

Chemical management: Spray the crop with Endosulphan 35 EC, or Quinolphos 25 EC or Triazophos 40 EC @400 ml/acre.

Children in front of SMI field in Gaya District, Bihar

Dr. O.P. Rupela, ICRSAT scientist standing with village boy in front of SMI field in Gaya district, Bihar

This training manual has been prepared by PRADAN (Gaya) with financial assistance from ATMA (Gaya). It contains experience gained through working with farmers from Gaya and Nalanda districts. There have been regular consultations with the Indian Council for Agriculture Research (ICAR), Patna, on cost estimates and financial calculations. Disease and insect management information has been drawn from pamphlet on "Growing Crops with SRI Principles" published by Livolink Foundation of Bhubaneswar, Odisha. The authors thank all the mentioned organizations for their support. Special thanks go to SDTT, Mumbai, for replicating the method elsewhere.

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INSPECTION OF A VIGOROUS FIELD OF SRI-INSPIRED MUSTARD CROP

Prepared by: Anil Kumar Verma (Team Leader, PRADAN, Gaya) and
Pramod Gorai (Subject Matter Specialist - SRI methods, PRADAN Gaya)

STI -- Sustainable Turmeric Initiative:
An Innovative Method for Cultivation of Turmeric (*Curcuma longa*)

Why farmers are switching to STI?

- Turmeric cultivation is simplified in accordance with basic principles of SRI
- Production of healthier seedlings
- Maintenance and enhancement of the long-term fertility of the soil
- Conservation/saving of soil, water, and electricity
- Reduction in the seed material needed from turmeric rhizomes
- Improvement in the social and economical status of farming community

CULTIVATION PRACTICES

Land preparation:

While preparing the nursery for turmeric production, at the same time we cultivate a green manure crop (*Daincha*) in the main field. While preparing the land, the usual tillage operation may be adopted. Farmyard manure (FYM), neem cake, basal fertilizers, and micronutrients are applied to the soil as recommended.

Beds should be prepared – 15 cm in height and 120 cm in width, and a convenient length – with at least 30cm spacing between the beds. In the case of irrigated crops, ridges and furrows are prepared, and the seedlings are planted on the top of the bed. Spacing generally adopted is 40 cm between rows and 30 cm between plants, compared with 30 cm by 30 cm with standard methods.

Planting materials:

With this new methodology, we use sections of seed rhizomes weighing 20 to 35 grams each. For an acre, 180 kg of seed rhizomes are needed (usually there are 30 to 50 rhizomes per kg, with single rhizomes having a length of 7 to 9 cm, and a perimeter of 7 to 8 cm). Single rhizomes are cut into 3 to 4 pieces, each having 2 rings with a bulged portion. In a single rhizome, 8 to 10 rings are seen. We need about 22,000 pieces per acre (55,000 per ha).

Seed Treatment:

Fungicide (any type) - 2 gms / one liter of water
Insecticide (any type) - 2 mls / one liter of water
Urea - 5 gms / one liter of water
The fungicide used is organic, so no inorganic fungicides are used.

The above materials are soaked in water for half an hour, after which they are kept for warming in air-tight gunny bags for eight days in a protected area. This should initiate the germination, which starts earlier in the bulged portions that protrude outward.

PRO-TRAY FILLING:

Farmers fill the trays in which seedlings are to be raised with coco-peat, vermi-compost, some Effective Microorganisms (EM) solution, *Trichoderma viridae*, *Pseudomonas*, and a mixer. Then the trays are filled with partially-germinated seed, and the remaining space in the pits is filled with the above mixer of coco peat. Then the trays are kept under a shade net for 40 to 45 days. The usual daily maintenance activities are taken to ensure proper growth.


TRANSPLANTATION:
After 40 days, we plant the seedlings in the main field with the support of drip irrigation and fertigation. Spacing between rows for STI is 40 cm between rows, and 30 cm between plants, while conventional spacing is 30 cm by 30 cm, as noted above. We have to protect the crop properly and carefully from pests and diseases through organic and inorganic methods. The materials used are listed in the comparative cost accounting below.

YIELD:
From a well-maintained crop, we get nearly 25 quintals (dried weight) per acre. This is **12.5 tons per acre**, which is 25% more than what is achieved with conventional production methods, 10.0 tons per acre.

WHAT ARE THE CONNECTIONS WITH SRI?

These practices were inspired by the experiences that Thambal farmers have had with using the System of Rice Intensification (SRI). Turmeric is a very different plant from rice, but some of the basic ideas for SRI turn out to relevant for turmeric even though it is a rhizome-based crop.

1. For SRI, the planting material is reduced drastically, as with SRI -- by more than 80%.

2. Spacing between the plants is reduced, although not as much as with SRI; for STI, the plant-to-plant distance one-third greater than in conventional turmeric cultivation.

3. Fertilization is not much different; but organic fertilization is increased as green manure (*dhaincha*) is applied to the crop, and the crop protection materials used are all organic.

4. Irrigation applications are reduced by two-thirds, which is effective because of the plants' greater root growth and the better structure of the soil with more organic management.

5. STI requires more careful management as with SRI, but the results are very worthwhile.

COST COMPARISON OF CONVENTIONAL vs. STI

The main factor driving or limiting farmers' turmeric cultivation is their cost of cultivation. The crop generally requires more cost and more care than others. In the previous two years, farmers got more income because of higher price; but this year they face heavy losses because of lower prices. Still, STI reduces the loss for farmers as yield is more with 20% less cost. The significant improvement in farmers' net income from turmeric production with STI methods is seen below.

COMPARATIVE COSTING: Cost of cultivation of turmeric (one acre model)				
Cost/acre	STI		Conventional	
Item of expenditure	Quantity/unit	Cost (Rs.)	Quantity/unit	Cost (Rs.)
OPERATIONS (labour)				
Clearing of field	2	600	2	600
Ploughing	16	6,400	16	6,400
Trench/bedmaking	2	600	2	600
Carrying & application of manure	8	1,500	8	1,500
Rhizome treatment & planting	15	3,750	15	3,750
Irrigation costs	13 (drip irrigation)	3,900	40	12,000
Intercultural operations (hoeing, weeding)	36	5,400	48	7,200
Harvesting (labour)	50	12,500	50	12,500
Transport from field to stockyard	5	1,500	4	1,200
Boiling of fingers (Rs. 60/quintal)	125	7,500	100	6,000
Drying of fingers	12	2,100	10	1,800
Polishing/packaging (Rs. 50/quintal)	25	1,250	20	1,000
Total		**47,000**		**54,550**
MATERIALS				
Planting material (Rs. 12/kg)	180	2,160	1,000	12,000
Farmyard manure (Rs. 1,000/ton)	8	8,000	8	8,000
Basal fertilizer	5 kg micro-nutrients	300	5 kg micro-nutrients	300
	2 liters Biocure F2	550	2 liters Biocure F2	550
	2 liters Biocure B2	550	2 liters Biocure B2	550
	1.5 liters Bionematon	525	1.5 liters Bionematon	525
	5 kg Vam plus	430	5 kg Vam plus	430
	NPK	2,700	NPK	2,700

Top dressing	5 kg micro-nutrients	300	5 kg micro-nutrients	300
	Bionematon	525	Bionematon	525
	NPK	3,800	NPK	3,800
Neem cakes (anandham + aboorvam)	320 kg	4,000	320 kg	4,000
Mulching material (green manures, etc.)	20 kg	1,000		
Plant protection	Cumasin (anti-fungal, anti-bacterial) 5x Florigene (growth promoter) 2x EM (Effective Microorganisms) + Trichoderma viridae 6x Trenching with Trichoderma viridae (Symbion-K, Symbion-S) 2x	6,250	Chemical sprays 5x: Quinalphos, Monocropto-phos, Dithane M-45 Corbentzin, Fytolon Acephate 4x Trenching with borate + blue copper 2x	12,230
Fuel wood for boiling		3,000		2,500
TOTAL		34,090		48,500
OPERATIONAL + MATERIAL COSTS		**81,090**		**103,050**
Saving with STI methods	***Rs. 21,960***			

ECONOMIC EVALUATION

	STI	Conventional
Revenue @ Rs.17/hg	Rs. 212,500 (12.5 tons/acre)	Rs. 170,000 (10 tons/acre)
Costs of cultivation/acre	Rs. 81,090	Rs. 103,050
Net income/acre	Rs. 131,410	Rs. 66,950
Added income from STI	***Rs. 64,460***	

This increased income of Rs. 60,000+ is because of our inspiration from SRI experience!

MONITORING OF THE STI CROP:

Scientists from the KVK (Farmer Science Centre), Dr. Manickam from Tamil Nadu Agricultural University, staff from the Horticulture Department, and company officials from T. Stanes have all been visiting and monitoring the crop from the beginning of the season up to the harvesting. They have monitored the various stages:

1. Seed selection
2. Nursery preparation
3. Transplantation
4. Control of pests and diseases
5. Harvest

Dr. Manickam, TNAU, and P. Baskaran, Thambal SRI Farmers Association

Conclusion:

This year I have plans to cultivate STI on 0.5 acre and to cultivate turmeric conventionally on another 0.5 acre, so that I can analyze both results easily and record any missing data. Confidently I can say that in the future, turmeric cultivation may develop along SRI lines and improve the economic status of the farmers.

Like with SRI and SSI, in STI there is productivity from 100% of the plant population along with **seed saving, labour saving, water saving, and power saving,** etc. So this initiative can give farmers the right way to get more profit from their efforts. With any support that I may get, the crop results from the experiments this year and previous years would be disseminated to the farmers in the District through a district-level conference.

Information provided by P. Baskaran, Thumbal, Salem District, Tamil Nadu
(baskarantbl@gmail.com)

PROFESSIONAL ASSISTANCE FOR DEVELOPMENT ACTION

प्रदान Pradan

Cultivating Wheat with SRI Principles: A Training Manual

Foreword

In 2008-09, Bihar Rural Livelihood Promotion Society (BRLPS, promoted by the World Bank and the Government of Bihar) along with the Agricultural Technology Management Agency (ATMA), took an initiative working with the NGO PRADAN, Nalanda branch, to promote *the use of SRI methods in wheat cultivation*.

Farmers of Gaya and Nalanda districts who have benefitted by using SRI methods in their paddy cultivation, adapted the principles in wheat. The manual contains the experience of farmers, which is expected to be useful for farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves and to gain more financially for their food and family security.

What is cultivation of wheat with SRI methods?

The following core principles of SRI developed for rice are applied in SWI wheat cultivation:

- **Low seed rate**: Use only 10 kg per acre
- **Priming of seeds** with seed selection/treatment
- **Wide and uniform spacing of single** plants set out in a square pattern in the field, 8 inches in between rows and also between plants (20cm X 20cm)
- **Aerating of the soil** 2 or 3 times by suppressing weeds mechanically rather than chemically or by hand

The other practices in crop husbandry are similar to those used with the usual methods of wheat cultivation.

The yields achieved by applying SRI principles are ***at least double those achieved with conventional methods***. Farmers from Gaya and Nalanda districts of Bihar have reported average yields of 3.5 tons per hectare, or more. With all the practices used well, the average is 6.5 to 8 tons, up to 12.6 tons with best use. By last year, farmers in about 300 villages had started applying SRI/SWI methods in their cultivation of wheat.

Seed varieties, seeding rates per acre and material requirements for priming of seeds

Seed selection

With SWI, there is no specific preference for any particular variety of seed, but it is better to use fresher seeds, while getting rid of older ones.

Seeding rate

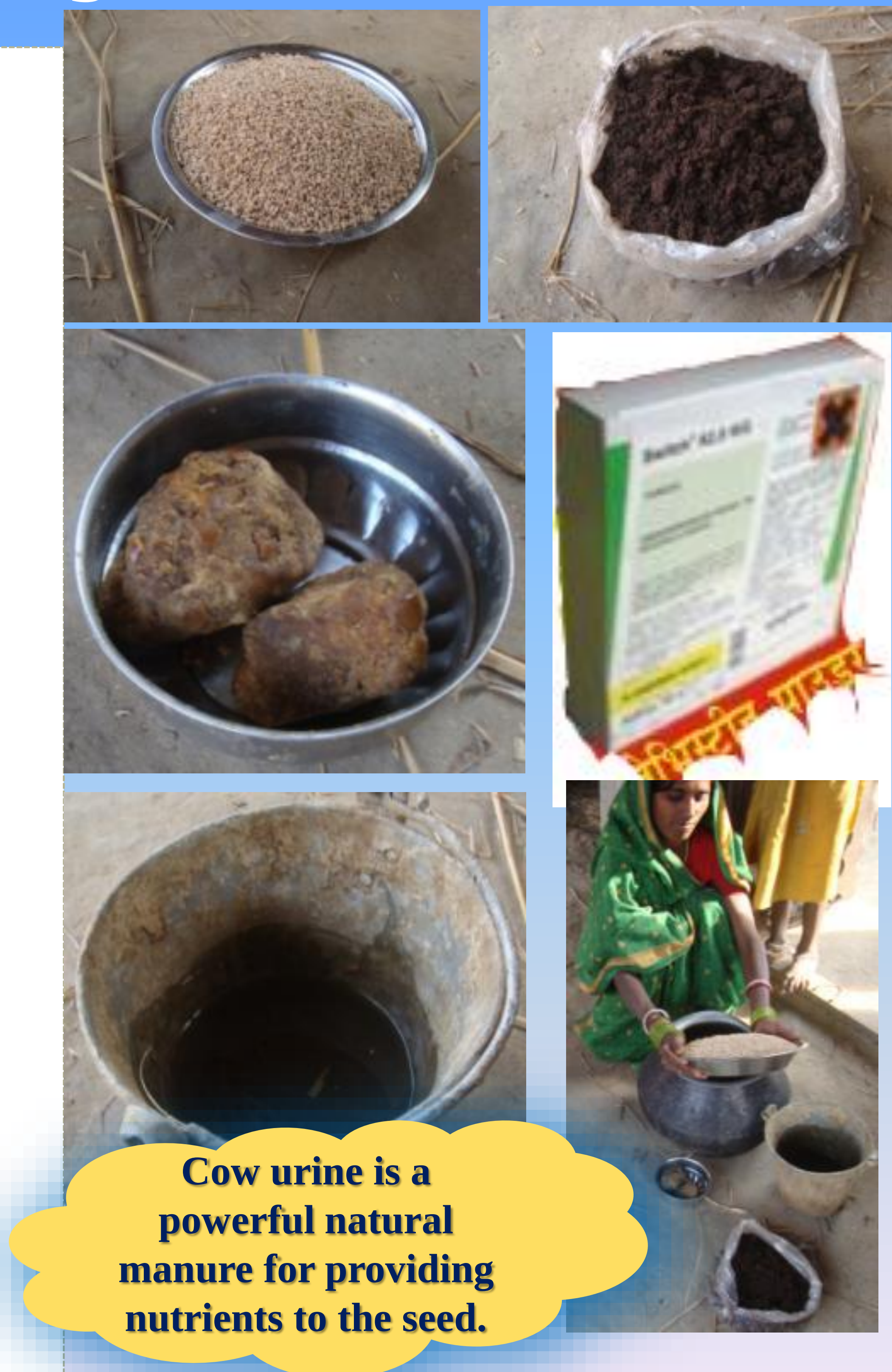
Only 10 kg per acre (25 kg per hectare)

Needed for priming of seeds :

The following materials are required for priming of seeds for 1 acre:

- 10 kg of seeds
- 20 liters of warm water
- 5 kg of vermicompost
- 4 kg of jaggery (coarse sugar)
- 4 liters of cow urine
- 20 gm of *Bavistin* broad spectrum systemic fungicide containing Carbendazim (50% WP)

Priming of seeds ensures protection for the crop from diseases.



Priming of seeds and seed treatment

- Remove any pebbles and mud particles from the seeds
- Heat the water to about 60 degrees Celsius
- Put the seeds in to the warm water
- Remove all floating seeds and particles from the water
- Add vermicompost, jaggery and cow urine in the water and leave the mixture for 8 hours
- Recover the good seeds from the water and throw away the solution water
- Mix *Bavistin* with the seeds and put them inside a moist gunny bag for 12 hours for the seeds to sprout.

Such priming of seed helps in the good growth of the plant and provides strength .

Field preparation

- Field preparation is similar to the usual methods for wheat cultivation.
- 2 tons of farmyard manure (FYM) or 0.4 ton of vermicompost should be applied per acre. This is necessary as the stand-alone use of chemical fertilizers reduces the productivity of the soil over time.
- If the soil moisture is insufficient, provide some supplementary irrigation before tilling the land.
- Apply 27 kg of di-ammonium phosphate (DAP) and 13.5 kg of potash (MOP) in the soil before the last ploughing.
- Plough the field well, so that the soil is well pulverized for easy root growth.

Sowing with SRI methods

- Before sowing, ensure moisture in the soil by irrigating the field if necessary.
- Create a shallow channel of 1 -1.5 inches depth with a spacing of 8 inches between the rows and plants.
- Place 2 sprouted seeds in the marked places at a distance of 8 x 8 inches between them. After placing the seeds, cover them with soil.
- After one week, fill any gaps in the field where germination has not occurred by putting a sprouted seed into the marked place.

Care of the field from the 15th day after sowing

• Irrigate the field (first irrigation) on the 15th day after sowing. This is needed as root development starts after this. If the soil is not moist, the plant will not develop its roots and becomes stunted.

• Apply a dose of urea (40 kg per acre) and vermicompost (0.4 ton per acre) on the 16th day, when there is still moisture in the field.

• On the 18th day, remove any weeds by hoeing or by using a weeder in between the rows. This will remove unwanted weeds which grow vigorously after irrigation and application of manure.

Mechanical weeding helps the plants by aerating the soil, helping the roots to grow, and enhancing roots' moisture and nutrient uptake from the soil.

Care of the field from the 25th day

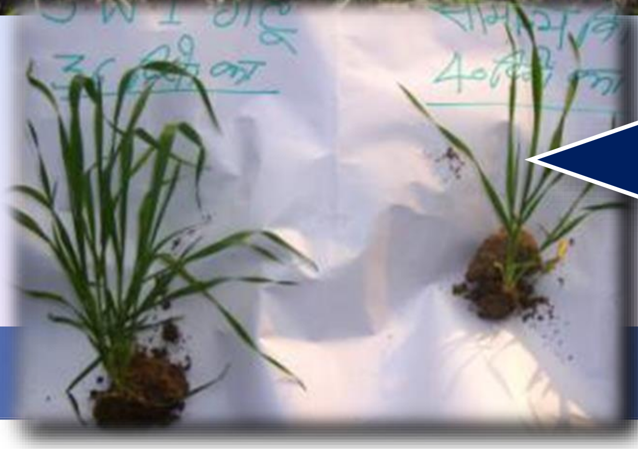
Irrigate the field for a 2nd time on the 25th day, after which time the plant starts tillering profusely and hence there is a need for more moisture and nutrients.

After 2-3 days of 2nd irrigation, do a second round of weeding and hoeing. This is to control the growth of weeds after irrigation.

Difference between 25 days old plant grown in SRI and normal method

Care of the field from 35^{th} to 40^{th} day

- Irrigate the field for the third time between 35^{th} and 40^{th} day, after which the plants grow still faster and tillering process continues. Therefore, there is more need of moisture and nutrients.
- Apply a dose of urea (15 kg per acre) and 13 kg of **potash** (MOP) immediately after irrigation.
- 2-3 days after the third irrigation, remove any weeds by hoeing or with a weeder in between the rows. It will remove unwanted weeds , help in aeration of the soil and help the plants to grow faster.

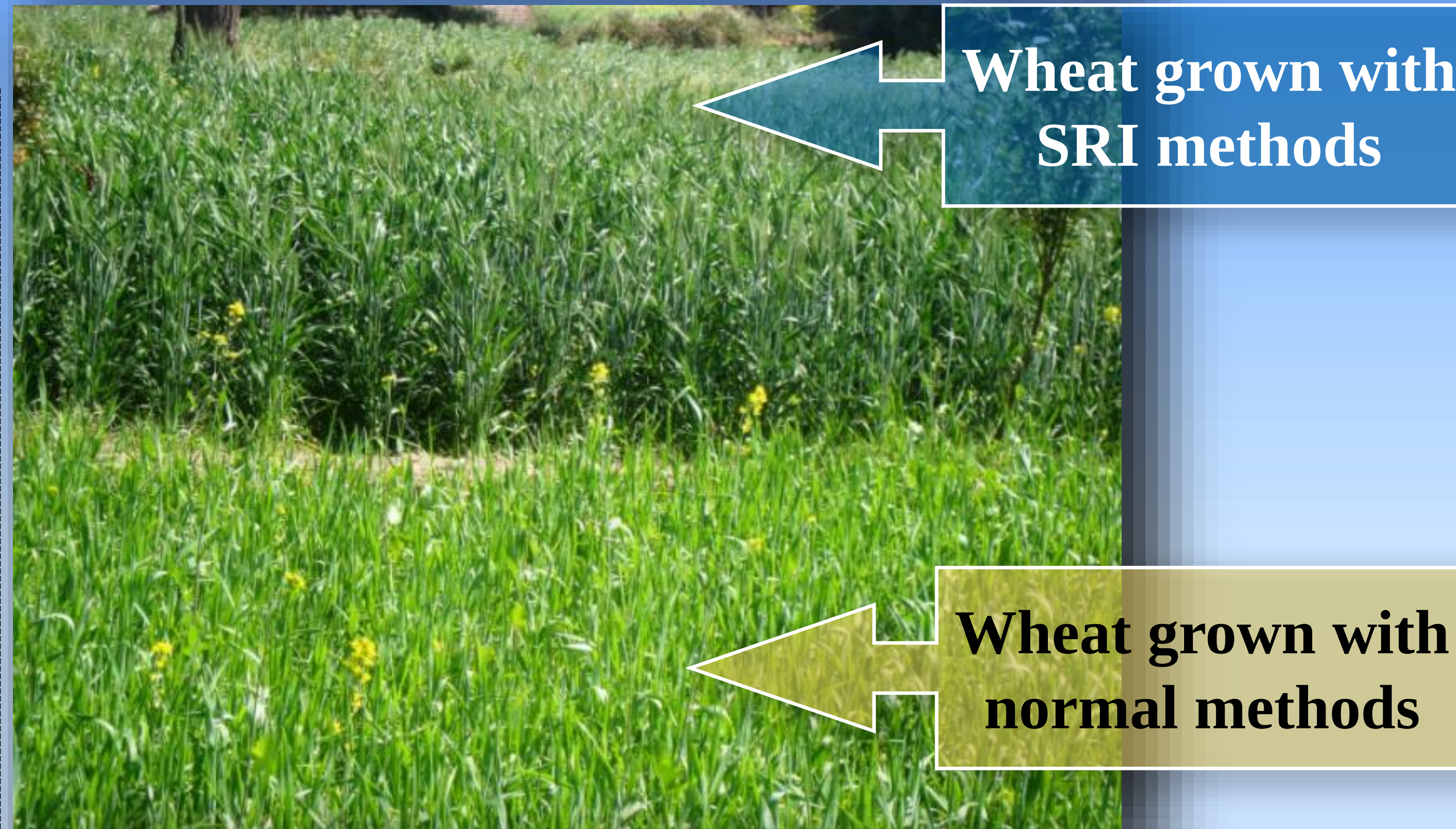


40 days old plant s: SRI vs. normal methods

For proper growth and grain filling irrigate the plot on 60th, 80th and 100th days after sowing.

Further, the irrigation depends on the soil and agro-climatic conditions.

If irrigation is not provided during flowering and grain filling, there will be drastic reduction in the yield of the crop.



Flowering and grain filling is very important stage for the crop. There should not be any dearth of water during this phase.

Comparison of SWI plant on left and regular wheat plant on right

Wheat yields achieved with SWI methods

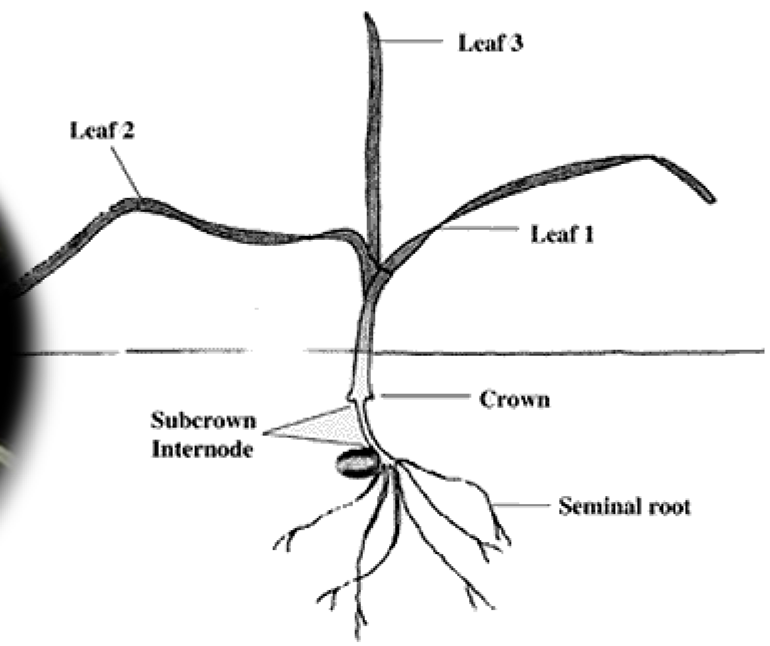
Already during 2009-10, 15,808 women farmers in Gaya and Nalanda districts applied SRI principles in their cultivation of wheat.

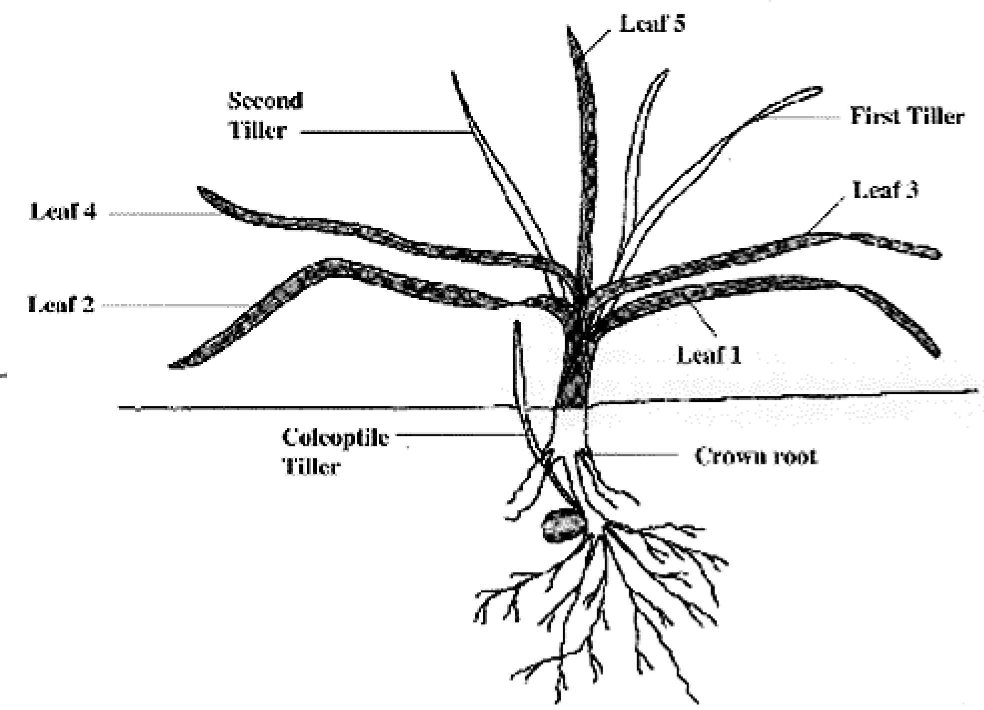
Farmers there using SWI methods averaged **1.82 tons per acre** compared to **0.8 ton** through usual methods (i.e., 4.6 vs. 2.0 tons per hectare).

Maximum wheat yield with SRI principles was **4.1 tons per acre** (10.25 tons per hectare), > 3x the maximum yield with traditional methods (1.1 tons per acre). In Bihar, organic SWI has reached 5.43 tons/acre (13.57 t/ha).

The yields achieved show that SRI methods are better than the usual methods.

Why yields are better with SRI methods?





To understand this, we need to understand the roots of the plant and their functions:

- **Seminal roots are initiate d after germination of the seeds and move downwards into the soil in search of nutrients and water. If the soil is not moist and becomes hard, then it becomes difficult for the roots to go very deeply into the soil.**
- **Crown roots which develop about 20 days after sowing spread out horizontally for nutrients and water. If the soil is hard ,the young plants cannot spread out their root network for acquiring water and nutrients.**

This stunting effect on plants induced due to hard soil is known as the Bonsai Effect.*

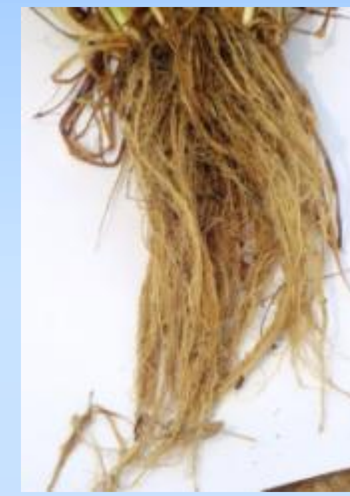
- **Sometimes the roots are destroyed with the attack of a fungus named *Pithium*.**

* http://www.soil.ncsu.edu/lockers/Gruver_J/PDF%20files/soil%20conditions%20and%20plant%20growth.pdf

**Australian Journal of Plant Physiology* 14(6) 643 - 656 Full text doi:10.1071/PP9870643 © CSIRO 1987

Traditional methods

SRI methods



- Mechanical weeding applied with SRI methods loosens the soil and helps in aeration. This helps to control weeds, helps roots to grow, and enhances moisture and nutrient uptake from the soil.
- Priming of seeds ensures protection for the crop from diseases.
- Cow urine is a powerful natural manure for providing nutrients to the seed.
- Planting far apart means that each seedling has lots of light and plenty of space to obtain nutrients and water.

Cost estimates for cultivation of wheat (per acre in Indian rupees)

Material / Activity			Traditional methods		SRI methods	
	Unit	Price per unit	No. units	Total	No. units	Total
Seed	kg	15	50	750	10	150
Priming of seeds and seed treatment Materials (jaggery, cow urine, warm water, vermicompost)	lump sum	165	0	0	1	165
DAP	kg	12	27	324	27	324
MOP	kg	6	27	162	27	162
Urea	kg	6	55	330	55	330
Vermicompost	kg	4	0	0	400	1600
Sowing	man days	100	0.5	50	2	200
Irrigation	number	200	5	1000	5	1000
Weeding and soil work	man days + machine cost	170	0	0	2	340
TOTAL COSTS				2,616		4,271
GROSS REVENUE (grain sales)	ton	12000	0.8	9600	1.821	21852
NET PROFIT				6,984		17,581
PRODUCTION COST per kg				3.27		2.35

Some important points to apply SRI methods

- Only **10 kg seed** per acre
- **Priming** of seeds with seed (warm water, and *Bavistin*)
- **Wide and uniform spacing of single plants** in the field (8 inches in between rows in a square pattern)
- Use of **2 sprouted seeds** per marked intersection of lines.
- **Aerate the soil** while suppressing the weeds mechanically (2 or 3 times) rather than chemical weed control or by hand.
- **Irrigate** the field during flowering and grain filling.

SRI methods are intended to help small and marginal farmers with limited resources to produce more for themselves and to gain more financially.

Removing SWI seedlings from nursery at 15 days

Transplanting 15-day SWI seedlings in field


Thank you

Cultivating Finger Millet with SRI Principles: A Training Manual

Based on the experiences of farmers affiliated with the PRADAN rural development program in Chhattisgarh & Jharkhand States and with the SRI Consortium, Chhattisgarh, India

प्रदान Pradan PROFESSIONAL ASSISTANCE FOR DEVELOPMENT ACTION

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Foreword

PRADAN has been instrumental in introducing SRI methods to small and marginal farmers in the rural poverty pockets of eastern and central regions of India. The focus has been mainly on cereals such as paddy and wheat. Finger millet is one of the important food grains for tribal households in the central region in India.

SRI principles have been creatively adapted to suit the cultivation practices for finger millet, making it possible to produce 3-4 times more crop than with farmers' traditional practices, without depending on new varieties. It does use small amounts of purchased inputs along with mostly organic inputs.

This manual has specific steps for cultivating finger millet with SRI methods. It should be useful for both farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves with their available resources and to gain more financially.

Differences between SRI and conventional methods for finger millet cultivation

Description	Traditional methods	SRI methods
Seed rate	5 kg	500 g
Priming of seeds and seed treatment	Not done	With jaggery, cow urine, warm water, and vermicompost
Seedbed	Flat bed, no specification	40 sq m for 1 acre, raised bed
Planting method	Broadcasting/transplanting	Square transplanting 20-25 DAS in nursery
Plant spacing	Irregular	10″ x 10″ in square pattern
Weeding and trolling	Not done	15th, 25th and 40th days after planting
Irrigation (in rabi)	2 times	4 times
Branches per plant	1 to 3	8 to 10
Fingers per tiller	3-4	7-8
Stems	Thin	Thick
Roots	Fairly shallow	Deeper, > 1 foot into ground
Yield per acre	0.4 ton	1-1.5 tons
Yield per hectare	1.0 ton	2.5-3/75 tons

Seed selection, priming, and treatment

There is no specific preference for using any particular variety of millet seed, but it is always better to start with newer seeds rather than use older ones. Various varieties that are being used in the area now are:

- ***Early-maturing varieties*** – can be used in less-productive soils
- ***Birsa Gourav / A404*** – an improved variety for better yield (duration 110-115 days)
- ***VK 149*** – drought- and disease-resistant (duration 95-100 days)

Seeding rate: 300-400 gm per acre; it is recommended to carry out the ***priming of seeds*****:** soaking seeds in water, and then mixing in 2.5-3 gm/kg of Carbendazim (Bavistin) with the seeds, and leaving the mixture for 24 hours

Seed treatment with *Bijamrita* -- A natural solution for effective protection against pest, diseases and fungi: Wrap 5 kg of cow dung in a large cloth and bind it by tape. Put it in 20 liters of water for up to 12 hours. Take one liter of water and add 50 gm of lime to it and let it stabilize overnight. Next morning, squeeze all of the liquid in the bundle of cow dung out of the bundle and into a bucket, compressing it at least thrice, so as to collect a concentration of cow dung. Add a handful of soil to this liquid solution and stir it well. Then add 5 liters of cow urine or human urine to the solution and add the lime water, stirring all together, making what is called *Bijamrita*. Spread this solution on the seeds of any crops, treating these seeds well by hand, drying them well, and using them for sowing. The micro-organisms and nutrients added this way will make the seedlings that emerge more vigorous.

Nursery preparation

Nursery material: Sow the treated seeds in a nursery with planting material as a mixture of sand, soil and compost (1:1:1).

Area of nursery: 40 sq. meters for every one acre to be cultivated.

Dimensions of the nursery bed: 1 meter with the length appropriate for the desired nursery area. Bed should be **9 to 12 inches above ground level**.

Timing for sowing nursery: 1st to 3rd week of July.

Sowing of seeds: Put the seeds into nursery soil at a **depth of 1/2 inch**, and keep the spacing about 3 to 4 inches between the seeds.

Care for seeds: Cover the seeds with **vermicompost**, and then sprinkle ***Jiwamrita*** regularly over the nursery to keep the soil functioning well.

Preparing ***Jiwamrita*** **(organic manure):** Put 10 liters of water in a barrel and add 5 kg of cow dung and 5 liters of cow urine to the water. Then add: 250 g of jaggery (raw unrefined sugar), 250 g of pulse flour, and a handful of soil from the bund of the field or termite soil; and stir the solution well. Let it ferment for 48 hours in the shade, and it will be ready for use after this. To use, add 1 liter of solution to 20 liters of water at the time of use.

For every 1 acre of land, use 200 liters of this diluted solution.

Field preparation




- Plough the field 3 times; 2 of these ploughings should be done within an interval of 8-10 days in between during the nursery preparation.
- Sprinkle *Jiwamrita* over the field to moisten the soil and preserve the organic matter.
- After ploughing the field, make it level using a wooden leveler.
- For transplanting, mark lines on the field in a square grid pattern, at a distance of 10 inches apart, one direction being perpendicular to the gradient; wooden markers can be used for lines.
- When transplanting, the plants should be spaced at a distance of 10 x 10 inches
- Furrows and ridges can be made on the field's surface with a cycle wheel or hoe.

Transplanting with SRI methods

- 4-5 days before removing plants, spray the nursery with the fungicide Mancozeb 75 % W.P. @ 2 gm / liter
- Transplant the seedlings from the nursery into the main field when they are only 15-25 days old.
- Before transplanting, irrigate nursery for approximately 2 hours in advance, to moisten and loosen the soil for removing the plants easily if the soil is dry in that time.
- Carefully uproot the seedlings, keeping the soil intact around the roots; if possible lift them out with a trowel or spade as this gives support to the soil and helps to keep it intact with the roots.
- Transfer the uprooted seedlings to the main plot within the next 30 minutes, before the roots and soil can dry out. The spacing will be 10x10 inches by using rope oir marker.
- Transplant the seedlings at a shallow depth in the pits; do not press or injure the roots while placing the seedlings at the intersection of planting lines.

Weeding and trolling

- Remove any weeds by hoeing with a cycle hoe or with a hand weeder in between the rows. This removes unwanted weeds and also aerates the soil, helping the plants to grow faster. This should be done 3 times at intervals of 10-15 days.
- Sprinkle *Jiwamrita* after weeding; mix 1 liter of *Jiwamrita* preparation with 10 liters of water, instead of using undiluted solution.
- After weeding, pull a straight round pole or bamboo over the plants, bending them over gently. This gentle 'trolling,' by bending the plants over at the base, will stimulate the growth of more tillers & roots from the plant.

Manure and fertilizers

Cow dung manure or compost: 2 tons/acre applied 15-20 days before July transplanting

Chemical fertilizer – apply N:P:K (24:20:12) @ urea 36 kg, DAP 43 kg and MOP 20 kg per acre

- Before preparing furrow and ridge: 12 kg urea + 21.5 kg DAP + 10 kg MOP
- 15-20 days after transplantation -- during 1^{st} weeding: 12 kg urea + 21.5 kg DAP
- 35-40 days after transplantation -- during 3^{rd} (last) weeding: 12 kg urea + 10 kg MOP

Micronutrients: magnesium (20 kg per acre) and calcium (6 kg per acre) or dolomite limestone (40 kg per acre). Apply these micronutrients 20-25 days before transplantation in the field, or 25-30 days after transplantation by sprinkling.

On right: local variety with traditional management; in center, A404 with SRI modified management; and on left, A404 with good SRI modified management

Pest and disease management using chemical methods

- **Blast**
  - Seed treatment, mixing 2.5 gm/kg of *Carbendazim* (Bavistin) for at least 30 minutes.

- **Seedling blight**
  - Spray *Mancozeb* 75 % W.P. @ 2 gm per liter in the nursery 15 days before sowing, or 15 days after transplantation.

- **Downy mildew**
  - Spray the crop with *Mancozeb* 75 % W.P. @ 2 gm per liter of water at the onset of the disease, or when symptoms are seen in 5-10% of the plants.

- **Stem borer**
  - Use *Regent* granules or its liquid form in the amount of 7 kg/acre. 1 ml of the chemical should be mixed with 2 liters of water.

Non-chemical pest and disease management

- **Neem Solution** -- for sucking pests & mealy bug

  Add 100 liters of water to a large container along with 5 liters of cow urine. Add also 5 kg of cow dung to this. Crush 5 kg of neem leaves, making a pulp from them, and add this into the pot. Stir the solution and let it stabilize for 24 hours. Stir this solution twice a day by any stick. Filter the liquid through a cloth and spray the filtered liquid (100 ml added to 5 liters of water) for controlling the above pests.

- **Multi-Purpose Solution** -- for sucking pests, pod borers, fruit borers, etc.

  In a pot, add 10 liters of cow urine in it. Crush 3 kg of neem leaves, making a pulp, and add this into the pot. Then add the following tree or plant leaves, ground into a pulp: 2 kg of custard apple leaves, 2 kg of papaya leaves, 2 kg of pomegranate leaves, 2 kg of guava leaves, 2 kg of *Lantana camara* leaves, and 2 Kg *Datura stramonium* leaves (use *Lantana camara* and *Datura* leaves if available). Boil the mixture until it is 1/5th of previous amount. When it is cooled, leave it for 24 hours. Filter the liquid through a clean cloth. Spray the filtered liquid (100 ml in 5 liters of water) for controlling the above pests.

Non-chemical pest and disease management

- **Fiery Solution** -- for leaf roller, stem borer, fruit borer, and pod borer
  - Put 10 liters of cow urine in a pot and add 1 kg of tobacco by crushing it in the urine. Add 500 gm of green chilies and garlics separately. Further, add 5 kg of neem leaf (*Azadirachta indica*) to the mixture.
  - Boil the mixture until it is only $1/5^{th}$ of the previous amount. When it is cooled, leave it for 24 hours.
  - Filter the liquid through a clean cloth.
  - Spray the filtered liquid (100 ml added to 5 liters of water) for controlling the above pests.

Non-chemical pest and disease management

- Ingredients for **pot solution** -- for controlling borer pests, fungi, and flies

Sl.No	Items	Amount
1.	Cow dung (deshi cow)	1kg
2.	Cow urine	2 liters
3.	Neem (*Azadiracta indica*)	1 kg
4.	Akanda (*Calotropis zygantia*)	1 kg
5.	Karanja (*Pongamea pinnata*)	1 kg
6.	Jaggary/ molasses	50 gm
7.	Plus a handful of termite soil	-

Process of preparation for pot solution

- Mix all the ingredients in an earthen pot, then cover it with a jute cloth and keep it in a dark place for 7 days.
- Extract the liquid from the pot after 7 days and dilute it with water.
- Use 15 ml of the extract per liter of water for mature plants, and 25 ml per liter of water for small plants.
- On every 7th day thereafter, keep adding 2 liters of cow urine to the leftover solid material in the earthen pot, to be able to use it over the period of next 6 months.
- This solution is very effective against borers, flies and contact fungus.

Comparison of representative panicles:
SFMI on left and conventional management on right

Expected results

- SRI-Millets can give yields of 3-4 tons/ha whereas the yield with traditional farmer practices is only 0.75-1 ton/ha.
- Thus by using of SRI principles with finger millets, farmers can easily double their yield.
- With good use of the methods, even more increase is possible.

Cost-benefit analysis for cultivation of millet for one acre (in INR)

			Traditional method		SRI method	
Components	**Unit**	**Price per unit**	**No. of units**	**Cost**	**No. of units**	**Cost**
Seed(if purchased)	Kg	30	5	150	0.5	15
Priming of seeds and seed treatment						
Materials (jaggery, cow urine, warm water, vermicompost)	Lump sum	30	0	0	1	30
Labor	PH	16.5	0	0	1	16.5
Nursery preparation	PD	132	0	0	0.5	66
Seeds and nursery preparation				**150**		**127.5**
Ploughing for field preparation (rent for plough and buffalo)	Rent per unit	400	2	800	2	800
Labor	PD	132	2	264	2	264
Marking & transplantation	PD	132	1.5	198	3	396
Field preparation				**1,262**		**1,460**
DAP	kg	15	43	645	43	645
MOP	kg	10	20	200	20	200
Urea	kg	10	36	360	36	360
FYM	kg	3	1,000	3,000	2,000	6,000
Jiwamrita	kg	5	0	0	10	50
Nutrient inputs				**4,205**		**7,255**
Irrigation applications (in rabi)	number	200	2	400	4	800
Labor	PD	132	3	396	6	792
Irrigation costs				**796**		**1,592**

Cost-benefit analysis (continued)			Traditional method		SRI method	
Components	**Unit**	**Price per unit**	**No. of units**	**Cost**	**No. of units**	**Cost**
Weeding and trolling	Per day	132	15	1,980	8	1,056
Weed control	Total			1,980		1,056
Plant protection						
Chemical and pesticides	Lump sum	200	1	200	1	200
Labor	Per day	132	1	132	1	132
Rent of sprayer	Lump sum	100	1	100	1	100
Crop protection costs	Total			432		432
Harvesting	Per day	132	13.5	1,782	6	792
Threshing and packaging	Per day	132	13.5	1,782	20	2,640
Harvesting costs	Total			3,564		3,432
Operational costs	Total			12,389		15,355
Management costs (10% of total)	Lump sum			**1,239**		**1,535**
Total cost of production	INR			**13,628**		**16,890**
Value of production	INR	20/kg	400	**8,000**	1,250	**25,000**
Net profit	INR			**-5,628**		**8,110**
Production cost per kg of grain	INR			**34.07**		**13.51**

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Cultivating Cole Crops

The term “cole crops” refers to waxy-leaved Brassicas of European origin, of the species *Brassica oleraceae*. Cabbage is the most widely grown and easy to grow of the cole crops. Cabbage varieties are available that mature in as little as 60 days or as much as 120 days from transplanting. The early and mid-season varieties are generally better suited for fresh market sales where small heads of 3 to 4 lbs are desired. A number of excellent cauliflower and broccoli varieties are available which range in maturity from 55 to 95 days for cauliflower.

Cauliflower is relatively difficult to grow compared to cabbage. Failure to head properly and poor curd quality are common problems. For successful production of cauliflower, a fertile, moist soil relatively high in organic matter and nitrogen is needed. Cauliflower buttoning is the premature formation of curd, and since the curd forms very early in the plant’s life, the leaves are not large enough to nourish the curd to a marketable size. Conditions that reduce the vigor of the plant and retard vegetative growth, such as cold temperatures at transplanting, appear to encourage buttoning.

Cole crops are known for its rich source of vitamin A and C. It also contains minerals including phosphorus, potassium, calcium, sodium and iron. However, the nutritive value of important cabbage is given in table below.

In general, Cole crops are used against such ailments as gout, diarrhoea, cocliac trouble, stomach trouble, deafness and headache. Cabbage juice is said to be a remedy against poisonous mushrooms and is also used as a gargle against hoarseness. The leaves are used to cover wounds and ulcers and also recommended against a hangover. Cole products are eaten in the raw state as well as cooked. Investigations in different countries like Japan and USA, suggested that there may be some especially protective properties against human bowel cancer in these vegetables (Ross, 1983).

Soil

Cabbage can be grown on nearly all soils with a good winter supply. Early crops are best grown on light soils, while late crops thrive better on heavier soils that are more retentive of moisture. On heavy soils, plants grown more slowly and the keeping quality is improved. Well-drained sandy loam to clay loam soils is suited for the crop. The soil should be fertile and well drained. The field should be getting adequate sunlight across the dimensions. These vegetables are very hardy crops and can be grown even in adverse conditions like in soil having high pH. These crops thrive best on deep loam or sandy loam soil with pH 6- 6.5, rich in organic matter and good drainage. In acidic soils mix 40 to 45 kg of lime in the soil (for 10 decimal land); if it does not rain afterwards, irrigate the field to stabilize the pH.

Varieties

Cabbage	Cauliflower
Green Challenger (Seminis), Kranti, 139 (Mahyco)	Barkha,Don 175(Seminis)NS 84 (Numdhari), Anand, Prakash (Kuwari)

The above varieties are suitable hybrid crops for the central plateau region of India.

Sowing Time and Seed Rate

Though generally grown in the winters (Rabi crop), these can be grown in the Kharif season. The most profitable season to plant the crop is July for the Kharif crop, and as it is generally a cool season crop, sowing is to be done from Aug-Nov. Only about 10 grams of seeds (for each of these vegetables) are required to raise the seedlings for 10 decimal area.

Rising of Nursery

Block of 7 feet length, 3 feet wide and 0.5 feet (6 inches) height are prepared. Sow the seeds 1 cm deep in rows 3 inches apart, and maintaining a distance of 2 inches between two plants. Cover the seeds with the mixture of well rotten manure and fine soil and press it well. Cover the beds with wheat husk or clean dry grass. Do watering with fine rose-can in morning and evening. Water stagnation in bed causes damping off. Remove the water husk or dry grass after the seeds have germinated. Apply a solution of Blue copper (3 gm), or Ridomil (1 gm) along with Actara (1gm) in 3 litres of water and spray to prevent against rotting and pest infestation (cabbage- 15 days, cauliflower- 10 days)

Transplanting

The seedlings are ready in 20 to 22 days for transplanting, when they attained a height of 08-10 cm with 2 to 4 leaves. Harden the seedlings by withholding irrigation. Uproot the seedlings carefully without injury to the roots. The soil should be thoroughly prepared by ploughing 4 to 5 times before transplanting the seedlings. The soil of the seed bed should be in good tilth, not liable to crusting, free from diseases and weeds. If necessary, the seed bed may be disinfected by soil drenching or sterilization. Manuring should be restricted to FYM (or cow dung manures) @ 2-3 tonnes/acre. If necessary, both phosphorous and potash may be added @ 20-30 kg and 60-80 kg/acre respectively. Nitrogen should be added judiciously since over-application will induce the seedlings to be lanky.

Transplanting should be done during evening hours followed by irrigation. Firmly press the soil around the seedlings. Spacing depends upon the fertility status of soil, type of verities and suitability of the season. In general 45 (1.5 feet) ×45 (1.5 feet) cm spacing is kept for non-spreading type varieties. In order to produce large curds, earth up the plant one month after transplanting. Mulching with polythene increases the yield. Paddy husk can also be used as mulch where as straw mulch is not good.

Cabbage	**Cauliflower**
	

Irrigation

Irrigate the field as per the need of crop. Timely irrigation is quite essential for good growth, flowering, fruit setting and development of fruits. Higher yield may be obtained at optimum moisture level and soil fertility conditions. In plains irrigation should be applied every third to fourth day during hot weather and every 7 to12 days during winter. Irrigation is given before top dressing if there is no rain. The field should be regularly irrigated to keep the soil moist during frosty days.

Care after days after transplanting

Cabbage	**Cauliflower**
10-12 Days while doing the first weeding	**10-12 Days while doing the first weeding**
Apply 4 kg of 10:26:26 (NPK) fertilizer on the field	Apply 4 kg of DAP and 4 kg of MOP on the field
	
10-12 days after the first weeding (second weeding)	**15-16 days after the first weeding (second weeding)**
Apply 6 kg of 10:26:26 (NPK) fertilizer on the field	Apply 2 kg of Urea, 4 kg of DAP, and 2 kg of MOP
	
12-15 days after second weeding (third weeding)	**15 days after second weeding (third weeding)**
Apply 5 kg of 10:26:26 (NPK) fertilizer along with 2 kg of Urea	Apply 4 kg of Urea


Cover the roots with soil extracted from the furrow and deepen it for drainage


Look after the plants atleast for 1 hour in the field


Other suggestions regarding fertilizer application

Fertilizer: An e.g. of fertilizer application (kg/acre) remember 100 decimal of land is equal to an acre of land/

Fertilizer	Total	Basal – Fertilizer	Top Dressing
Manure	30,000	30,000	-
Urea	200	100	100
Single Super phosphate	150	150	-
Potassium	150	150	-

These vegetables require a good amount of manures and fertilizers for high yield. The fertilizer dose depends upon the fertility of soil and amount of organic manure applied to the crop. After the application of the fertilizer cover it with the soil extracted from the furrow and deepen it for drainage.

It is better to use urea instead of Ammonium Sulphate where the soil is relatively acidic. If the soil is boron deficient, 5 –10 kg/ha borax should be applied before land preparation.

For basal fertilizer, manure should be applied into the rows before chemical fertilizer.

Side-dressing schedule:

1st application: - should be applied in a circle around the young plant after it recovers from transplanting.

2nd application: - should be applied in bands on the shoulders of the beds 2 weeks after 1st application.

3rd application: - should be applied on both sides of the furrow during the early development of the head

It is recommended to spray 0.4% urea solution on the leaves every 7 days when the head starts to form.

Management

Irrigation: Cabbage and cauliflower cannot tolerate drought. Therefore irrigation should be applied frequently and evenly, especially in the head developing period. Irrigation should be applied following the first and the second side dressing. It is better to keep a little water in the furrow in the hot season. But drainage must be carried out in the rainy days.

Pruning: It is necessary to remove the side shoots as soon as possible.

Weeding

The field should be kept weed-free, especially in the initial stage of plant growth, as weeds compete with the crop and reduce the yield drastically. Frequent shallow cultivation should be done at regular interval so as to keep the field free from weeds and to facilitate soil aeration and proper root development. Deep cultivation is injurious because of the damage of roots and exposure of moist soil to the surface. Two-three hoeing and the earthening-up are required to keep the crop free of weeds. Hand weeding and hoeing are done to control weeds.

Herbicide can be used for weed control in the field. It is recommended to apply:

1. 50% Enide (WP) 3-4 kg per hectare at the dilution of 1:350-400.
2. 44.5% Treflan (EC) 4-6 Liters per hectare at the dilution rate of 1:150-200.
3. 33% Stomp (EC) 3 Liters per hectare at the dilution rate of 1:300.

Chose only one of above herbicides, spray it on beds and in furrows evenly before transplanting. The concentration and dosage of herbicides should be observed strictly and they must be tested before using.

Mulching: Straw mulching should be applied after transplanting to prevent soil erosion during the rainy season.

Harvest

Cabbage is usually harvested when the heads reach full size and are firm. However, for the early market heads are harvested as soon as they have attained sufficient size since price is usually more important then size. In harvesting the heads are cut with a large knife then are placed along the rows with the stem – side up. Pack the heads when the cuts are dry.

For cauliflower

0-10	2 gram of Bavistin in one litre of water	Protect the young plants from rotting
11-12	3 grams of Blue Copper or Enterocol in one litre of water	Protection from leaf blight
20-22	1 gram of Krocin AG in 5 litres of water	Leaf and stem rotting
30-32	3 grams of Blue Copper + 1 gram of Krocin AG in 5 litres of water	Leaf and stem rotting

32-35	3 grams of Multiplex Kitchen Garden in one litre of water	Do not mix this with any other chemical
40-42	Rimon (0.5 gm) per litre of water or 1 ml of Fame in 4 litres of water + 2.5 grams of Saaf in one litre of water	To protect from leaf eating pests
42-45	3 grams of Multiplex Kitchen Garden in one litre of water	Do not mix this with any other chemical
50-52	Rimon (0.5 gm) per litre of water or 1 ml of Fame in 4 litres of water+ 1 ml of Contaf in a litre of water+ 1 gram of Krocin AG in 5 litres of water	To protect from leaf eating pests and Jhulansna
60-62	1 ml of Tracer/ Nuvan in a litre of water + 2.5 grams of Saaf in one litre of water	To protect from leaf eating pests and Jhulansna
15/30	3 grams of Boron / Agribor / Solubor per litre of water	For mitigating Boron deficiency
	1 ml of Teepol/ Sandovit in a litre of water	To increase the strength of the above chemicals

Note: The above information is provided based on research and field observation. Variations in local condition may affect the information and suggestions contained above and for which the company should not be held liable. In case of doubt, it is recommended to carry out ordinary trial production in order to test local growing condition in different seasons and area.

Specific Pest, disease and Insect management

Crop stage	Management	Activities
Pre-sowing*	**Nutrients**	Add well rotten farm yard manure (FYM) @ 8- 10 t/acre or vermicompost @ 5 t/ acre treated with *richoderma*spp. and /or *Pseudomonas*sp @ 2 kg/acre. Incorporate at the time of field preparation 1 week (vermicompost) or 2 to 3 weeks (FYM) before transplanting.
	Weeds	• At the time of field preparation, adopt stale seed bed technique to minimize the weeds menace in field. • Keep the nursery weed free by hand pulling of the weeds. • Black plastic mulch prevents entry of light, which restricts germination of weed seeds and growth.
	Resting stages of pests and nematodes	• Deep summer ploughing • Soil solarization: Cover the beds with polythene sheet of 45 gauge (0.45 mm) thickness for three weeks before sowing for soil solarization which will help in reducing the soil borne pests. • Apply neem cake @ 100 kg/acre at the time of transplanting for reducing nematodes and borer damage. • In nematode severe area apply carbofuran3% CG @ 20,000 g/acre
	DBM	• Cultural control: • Removal and destruction of plant remnants, stubbles, debris after harvest and ploughing the field. • Trap crop: Sowing 2 rows of bold seeded mustard as a trap crop for every 25 rows of cabbage to attract moths to mustard. Plant the first row 12 days before transplanting and the second row 25 days after transplanting • Grow intercrops such as tomato, garlic, coriander and carrot in alternate rows with cabbage

Crop stage	Management	Activities
Seed Sowing/ Transplanting stage*	**Nutrients**	• Before sowing, soil testing should be done to find out the soil fertility status. Nutrient should be provided as per soil test ecommendations. • For varieties apply 32 kg N/acre in three equal splits. The first one (33.3%) at the time of transplanting as basal dose. • For hybrids apply 48 kg N/acre in three equal splits. The first one (33.3%) at the time of transplanting as basal dose. • For varieties apply entire quantity of P and K @60 and 40 kg /acre, respectively, at the time of sowing. • For hybrids apply entire quantity of P and K @90 and 60 kg/acre, respectively, at the time of sowing. • Micronutrient deficiency should be corrected by foliar application. • Biofertilizers: For seed treatment with Azotobacter and phosphorous solubilizing bacteria (PSB) cultures @ 8-10 g/kg seed • For seedling root dip treatment with Azotobacter and phosphorous solubilizing bacteria (PSB) cultures @ 250 g /acre seedlings
	Weed management	• Keep the nursery weed free by hand weeding. • Avoid carrying weed seedlings along with cabbage seedlings.
Sowing/Planting*	**Black rot**	Cultural control: • Crop sanitation • Resistant varieties: • Crop rotation for 2-3 years with non- cruciferous crops
	Damping off	Cultural control: • Quality seed and a chemical or heat pasteurized planting medium should be used. • Excessive watering and poorly drained areas of field should be avoided • Use raised beds: more than 15cm height is better for water drainage or use pro trays for raising seedlings Chemical control: • Soil drench with captan 75% WP @ 1000 g in 400 l of water/acre • Treatment with captan 75% WP @ 20-30 g/kg seed.
	Alternaria leaf spot	Cultural control: • Long rotations (3 years) without crucifer crops or cruciferous weeds such as wild mustard. • Plant later plantings upwind of earlier plantings. • Allow for good air circulation (i.e. wide spacings, rows parallel to prevailing winds, not close to hedgerows). Chemical control: • Spray zineb 75% WP @ 600-800 g in 300- 400 l of water/acre or mancozeb 75% WP @600-800 g in 300 l of water/acre
Applying *Trichoderma* as seed and nursery treatment and *Pseudomonas fluorescens* as seed, nursery treatment and soil application (if commercial check for label claims. However, products are used, biopesticides produced by farmers for own consumption in their fields, registration is not required).		
Vegetative stage	**Nutrients**	Top Dressing • Apply second dose (33.3%) 30 days after transplanting and irrigate the crop immediately after fertilizer application. • Micronutrient deficiency should be corrected by foliar spray of

Crop stage	Management	Activities
	Weeds	• Weeding and hoeing should be done once within 20-25 days after transplanting and second time 45 days after transplanting. Deep hoeing should be avoided. Mulching with black Low Density • Polyethylene (LDPE) sheets of 30micron thickness by burying both the ends into the soil to a depth of 10 cm will avoid weed growth.
	DBM	Cultural control: • Install pheromone traps @ 4-5/acre for monitoring. Chemical control: • Spray flubendiamide 20% WG @ 15 g in 150 l of water/acre or lufenuron 5.4% EC@ 240 g in 200 l of water/acre or spinosad2.5% SC @ 240–280 in 200 l of water/acre or indoxacarb 15.8% EC @ 106.4 ml in 200–400 l of water/acre or emamectin benzoate 5% SG @ 60- 80 g in 200 l of water/acre or fipronil 5% SC @ 320–400 ml in 200 l of water/acre. (last spray should be 15 days before harvesting).
	Cabbage borer	Cultural control: • Collect and destroy caterpillars mechanically in the early stages of attack. Chemical control: • Malathion 50 EC @ 600 ml in 200-400 l of water/acre..
	Cabbage leaf webber	Cultural control: • Remove and destroy the webbed leaves with caterpillars within. Set up light traps @ 1/acre. Biological control: • Conserve parasitoids such as Cotesia crocidolomiae etc.
	Cabbage Aphid	Cultural Control: • Install yellow sticky traps, yellow water pan traps @ 12/acre to monitoralates (winged adult). Chemical control: • Foliar spray with dimethoate 30% EC @264 ml in 200-400 l of water/acre or fenvalerate 20% EC @ 120-150 ml in 240-300 l of water/acre or phosalone 35% EC • @ 571 ml in 200-400 l of water/acre or acetamiprid 20 % SP @ 300 ml in 200-240l of water/acre.
	Tobacco caterpillar	Cultural control: • Field sanitation and rouging • Repellant plants: Ocimum/Basil • Setting up light traps for adults @ 1/acre. • Erecting of bird perches for encouraging predatory birds such as mynah, drongo etc. • Use of ovipositional trap crops such as castor @ 250 plants/acre and collection of larvae from flowers • Installing pheromone traps @ 4-5/acre for monitoring insect activity Chemical control: • Spray trichlorfon 5% GR @ 300 g/acre or thiodicarb 5% GR @ 300g/acre or chlorfluazuron 5.4% EC @ 600 ml in 200 l of water/acre

Crop stage	Management	Activities
	Cabaage butterfly	Cultural control: • Fine-mesh netting in nursery will stop butterflies from reaching the crop and lay eggs. Collect and destroy eggs or caterpillars mechanically by hand-usually on the underside of the leaves. • Intercropping cabbages with Nasturtium results in fewer eggs laid on cabbage by the butterflies.
	Club rot diseases	Cultural control: • Use disease free seedlings • A pH slightly above neutral (usually about pH 7.2) helps to minimize disease • Add hydrated lime to soil to increase pH to 7.2 (6 weeks before planting @ 1.5 t/ac) • Avoid excess irrigation
	Downy mildew	Cultural control: • Destruction of infected plant debris • Avoid of thick sowing and excessive moist conditions • Use a 3- year rotation without cruciferous crops • Avoid overhead irrigation • Allow for good air movement (i.e. wide spacing, rows parallel to prevailing winds,not close to hedgerows)
	Powdery mildew	Cultural control: • Destruction of infected plant debris • Maintain proper spacing
	White rot	Cultural control: • Sanitary measures and destruction of weeds • Crop rotation with non-cruciferous crops
	Black rot	• Same as in seedling stage
	Alternaria leaf spot	• Same as in seedling stage
	DBM and other lepidopteran insects	• Same as in vegetative stage
Head state	**Nutrients**	• The third dose (33.3%) 50-60 days after transplanting and if they are long duration varieties third dose at 75-80 days after transplanting. Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.

Package of practice for goat rearing

Livestock, especially goats have been the most significant contributor to the livelihoods of poor and marginalized rural families of society, especially women where it not only enhances their food security, but also acts as a liquid cash to meet most of their cash flow needs including emergencies. The poorer is the family higher is its relevance in their life. That is why goats are called poor man's cow. Small livestock has been a woman's asset and has largely taken care of by her, especially in small herd sizes from three to seven.

This activity has high regeneration potential and thus, within a small period a sizable increase in herd size can be attained to earn a substantial income from this intervention if the mortality can be checked and some improved rearing practices can be ensured. In the absence of control over mass mortality the families lack confidence to make the investments to rear the goats at a business scale and thus leave them to grow on their own at the sub-optimal level. This situation calls for the need of a systematic intervention to control the mass mortality of livestock in order to help poor families make decent income.

In Professional Assistance for Development Action (PRADAN)'s programme areas, goat rearing is predominantly a livelihood activity for relatively poorer households. In the east and central India, goat rearing is characterized by high morbidity and mortality due to inadequate access to health care services, poor breed selection and unscientific husbandry and rearing practices resulting in lower incomes.

Goat-rearing is the preferred activity of poor families for the following reasons:

- The goat being a small animal, goat-rearing is a manageable activity, requiring a comparatively small area.
- The capital investment is very low; therefore, a poor family can start the activity easily.
- The gestation period of a goat is comparatively less (about six months) and the kids grow fast.
- During drought or when there is an epidemic, the risk in goat-rearing activity is comparatively lower than for larger animals. Because goats can survive on shrubs during droughts, the price usually is reasonable. Should one or two goats die, there would be a comparatively lower economic impact on the family, than if a cow or a buffalo were to die.
- Male and female kids of goats are sold at the same rate, whereas cows and buffaloes are not.
- The goat, the parts of a goat's body/the products prepared from the goats' produce, etc., are saleable in the market and many cottage industries are based on goats and the goat-rearing activity.
- The goats are ready for pregnancy in nine months. There is, therefore, scope for breed improvement.

As per the study undertaken by The Goat Trust[1] in 317 sample villages, across six states, some of the key problems and challenges faced in goat-based livelihoods are:

- Grazing is the only source of feed and fodder for goats. No additional supplementation is provided. Insufficient grazing of goats due to decreasing land area; this has an adverse impact on productivity.
- Due to the lack of proper shelter, predation of goats by wild animals is a major problem. In addition, there are frequent diseases due to the cold and rainy season.
- Absence of preventive practices and first-aid at the village level, leading to high mortality and morbidity of goats. Vaccination and deworming was never practiced. In many remote villages vaccination is still considered a taboo.

[1] An NGO working extensively with the goat farmers across India, based at Lucknow, Uttar Pradesh

- Due to the low cost of goats, goat-rearing, as an activity, does not attract the interest of the banking and insurance companies, and financial linkages remain weak.
- Standardize production processes such as feed, low-cost housing design and feed preservation have been weak. Context-specific, pro-poor production technology needs to be developed.
- There is no standard pricing system for goats. The lack of collective marketing becomes a barrier to developing goat-rearing.
- Delay in the castration of unviable bucks leading to inbreeding, and frequent abortions and the birth of weak and unhealthy kids susceptible to endemic diseases. The non-availability of good quality bucks was another constraint that emerged during group meetings.

Equally important is the fact that goat-rearers are usually poor, illiterate, marginalized and unorganized. Goat farming has been an occupation of the aged, the widows and the destitute families, and hence pro-poor systems and sensitivity need to be integrated into the programme to address the issues.

There are many unique drivers of the goat rearing activity:

- The return of investment is very high. The cost of vaccination and de-worming is minimal in comparison to the potential benefit of the same.
- Whether it is the initial investment or the cost of services, both are very low and can be easily affordable even by the poorest section of the community including destitute.
- The outcome of vaccination and de-worming can be easily verified within a very small time period. It is not very complex. It does not require high education or exposure and thus can be easily understood by poor as well as the illiterate community. It does not require high technical expertise to execute.
- It can be initiated at any time of a year. Thus provided flexibility in term of initiating the programme whenever community gets ready to start as goats are already kept by the farmers.
- Usually a woman looks after the goats in a family and thus has a fair say or control on the income from these assets.
- Through this activity a number of village youths, including women can be engaged as entrepreneurs in the locality and can make decent earnings of about Rs 1,500 to Rs 2,000 per month throughout the year spending about 10-15 days in a month while continuing to operate from their home without getting disengaged from existing livelihood activities.

Selection of the farmer who can take-up the activity

- This is an activity with potential for Rs. 8000.00 (after the gestation period equaling first year) and increasing to 18-20,000/- per annum additional income. This should be an attractive proposition for the selected rearer.
- This livelihood scheme presumes that vibrant SHGs exist in the area, members of which would participate in the activity.
- All the villages should nearby forests; goat rearing will be promoted only in a cluster where Joint Forest Management initiatives have taken root.
- Homestead land where shed is to be constructed should not be waterlogged, damp.
- There should be an adult person capable of taking the herd out to graze on a daily basis and take care of the herd.
- The farmer should have 0.1 acre fallow land (with no use in agriculture) of their own for raising fodder or the area should have abundant open common waste lands suitable for grazing.
- The plot of land should be fenced by the rearer using thorny bushes backed with live fencing as his/ her contribution to the initiative.

- The activity has minimum gestation period of two years (though optimal weight gains in the second or third year) before some returns can be generated.

Goat shed

- Construct shed on dry and properly raised ground.
- Avoid water-logging, marshy areas.
- In low lying and heavy rainfall areas the floors should be preferably elevated and cemented. The floor can have cemented, slope to enable draining out of urine/ wastes.
- The shed should be made with bamboo sticks.
- Height of the shed should 3ft from the floor and the minimum 6ft gap between shed and roof.
- The shed should consist of minimum two windows and one door with the lighting.
- Bucks should be housed in individual pens.
- Provide proper shade and cool drinking water in summer.
- Proper drainage system of dung and urine and every day clean with phenyl.
- Avoid overstocking or crowding.
- Give adequate space for the animals (given in the table below).

Space requirement of goats

Sl. No.	Type of goats	Space requirement Sq.mt.per head	Maximum No. of animals per pen
1	Adult doe	1.00	60
2	Milch doe	1.68	Individual pens
3	Buck	3.4	Individual pens
4	Kids	0.4	75

A cost estimate and design is given as annexure, which can be made according to local conditions.

Selection of Goat breeding stock and its management

- Before purchase the new stock, first vaccinate all the existing animals to avoid disease attack.
- Purchase the stock from a reliable breeder or from the nearest livestock market or locally available within the ideal time period. Avoid purchasing during peak period of rainy and winter.
- Animals in good health and having good physical features must be purchased in consultation with the veterinarian.
- Purchase animals which are ready to breed and in the prime stage of production (by seeing the age-dental ratio calculation).
- Identify the newly purchased animals by suitable identification mark.
- Vaccinate the newly purchased animals against the diseases. Keep the newly purchased animals under observation for about 15 days and then mix with the existing flock. After the purchase of the animals, they should be kept in quarantine from the existing flock and if possible all separately to avoid any infectious disease, which is standard for any animal rearing, practice. It reduces mortality and provides scope for identification and damage control for the rearer and reduces risk of heavier financial loss. Animal if infected with any disease or having anomaly can be instantly considered for cull or sale at a price, which would reduce loss.
- Unproductive animals should be culled promptly at the age of 6 years and above and should be replaced by the newly purchased animals or farm born one.
- Animal with first or second parturition having only two teeth should be preferred.
- Animals are to be bred at the interval of 8-9 months for maximum productivity.

Feeding of the Goat

A goat does not like to graze on the ground like a sheep or cow, Goats like feeding at knee height up to head height, so they like to feed above the ground, often standing on their hind legs and resting their front legs up on the bush or the goat house wall. Goats need to be able to drink fresh water at all times. All reproductive and productivity parameters like kid mortality, kidding interval and kidding rate are mostly attributed to poor and inadequate feeding of the goats. So the major management practices should be

- They eat a lot of different plants/feeds. But they know what they want to eat.
- They prefer some plants/feeds to the other.
- They even prefer different parts of the plant so they will eat leaves and flowers and not pods or stems, within the same plant.
- They get bored when fed the same feed every day.
- They can be wasteful. Only eating some of the plants. For example, given un-chopped feeds like the grass they pull it out of the ground, eat the leaves only and do not eat the stem.
- Are clean feeders, and will not eat dairy feeds, which are not fresh nor dirty feed e.g. plants or leaves with mud splash from rain.
- Ensure Bushes/shrubs for browsing by animals in a regular time period on each day.
- Green leguminous fodders should be offered to kids from 15 days onwards.
- Provide salt and water to kids at all times.
- Special feeding, care of illness goats and new born kids.
- Avoid for free grazing practice in peak rainy period and during winter taken outside after the early morning hour to avoid the dew factor.
- Care should be taken to meet the nutrient requirements as recommended.
- Feed only clean, fresh and dry fodder.
- Clean the feeding trough and water bucket every day.
- Give lots of different feeds such as grasses and legumes, tree leaves and fresh kitchen remains.
- Give chopped mixed feeds to make sure the goat eats everything and does not waste feed.
- Feed goats, at least 3 times a day and at the same time every day.
- Put some feed in the feed trough or rack or hang up some feed to be eaten overnight.
- Dusty feeds and concentrates should be wetted a little.
- Provide fresh and clean water daily. There should always be water in the bucket.
- Provide a Mineral Lick [block] always to all goats.
- In the absence of good quality green fodders, concentrates must be considered to replace them.
- Kids should be fed colostrum up to 5 days of age. Later on they can be put on Kid starter rations.
- Green leguminous fodders should be offered unprepared, to kids from 15 days onwards.
- Additional concentrates should be given to bucks and does during breeding season.

Animal performance monitoring

The following data is recorded to evaluate the performance of the animals.

- Initial body weight at zero day of each animal.
- Fortnightly body weight during the period of fattening of each animal.
- Final body weight of each animal at the time of sale.
- Average daily total feed offered.
- Average daily fodder offered.
- Date and dose of deworming and vaccination and health record of animals.

Care during pregnancy

In advanced stage of pregnancy the does must be transferred to separately earmarked space for kidding within the main shed after thoroughly disinfecting it. Avoid taking outside for grazing at the advance stage, which may lead to abortion. After kidding, the does should be provided with warm bran mash for two days.

Care of kids

- Take care of newborn kids by providing guardrails.
- Treat / disinfect the naval cord with tincture of iodine as soon as it is cut with a sharp knife.
- Protect the kids from extreme weather conditions, particularly during the first two months.
- Male kids should be castrated for better quality meat production and their docile nature.
- Vaccinate the kids as per the recommended schedule.
- Wean the kids at the age of 8 weeks.
- Proper selection of kids on the basis of initial body weight and weaning weight should be initiated by maintaining appropriate records.
- Additional feed requirements of lactating does must be ensured.

Health Care

Vaccination

Vaccination is one of the most effective means of controlling diseases on the farm. The vaccination schedule can be finalized in consultation with the local veterinarian based on the threat of diseases the following vaccines are commonly available for goats.

- Entero-toxemia
- Foot and mouth disease (FMD)
- Peste des petites Ruminants (PPR)

Deworming

The infestation of roundworms, tapeworms, and lungworms can cause heavy financial loss. The most commonly occurring internal parasitic infestations in the area of operation should be identified. The commonly used dewormers are Albendazole and Fenbendazole.

Parasite Removal

External and Internal parasite removal is one of the important functions, which should be regular by application of the Ivermectin type of medicine. Injections and bolus are available for using Ivermectin, which is a broad-spectrum anti- parasite drug.

First Aid training

The animal rearers should be trained properly regarding treating and providing first aid in emergency. Some indicative items should be

- Tympani / Bloat treatment through the needle
- Deworming
- Treating minor wounds
- Feeding Management

These are considered primary elements, yet are life threatening ones, which would be greatly reduced with training and feed management as a component.

Things to remember for to reduce Goat diseases

- Be on the alert for signs of illness such as reduced feed intake, fever, abnormal discharge or unusual behaviour.
- Consult the nearest veterinary aid centre for help if illness is suspected.
- Protect the animals against common diseases.
- In case of an outbreak of contagious diseases, immediately segregate the sick animals from healthy one and take necessary disease control measures.
- Deworm the animals regularly.
- Examine the faece of adult animals to detect eggs of internal parasites and treat the animals with suitable drugs.
- Provide clean and uncontaminated feed and water for minimising the health disorders.
- Strictly follow the recommended vaccine schedule.

Fodder Cultivation

Each rearer can develop minimum 0.1 acre of land for cultivating fodder

- Two species of trees Luciana leucocephala (Subabool), Gliricidia (both are hardy, can survive in a rain fed condition and have the good coppicing ability) and a variety of grass Stylo hamata, Bersem is recommended.
- Some supplementing mineral fodders also are provided to the castrated male kids for the high growth rate and to the pregnant females for the quality of kidding.

Marketing Arrangement

- At the starting stage, individual rearers or group would directly sell in the market after knowing the actual body weight and price of the live goat.
- A central coordination office/ para-vet at cluster level could keep track of the mature goat available with different rearers and accordingly guide buyers.
- Daily / weekly whole sale landing prices at the target markets may have to be tracked later for setting sale price.
- Purchase prices of goat and sale price widely varies across the year and it may decide by the activity groups.

Problem (Effect)	Cause	Solutions
High mortality/morbidity in goats	Financial and non-financial constraints to adopt improved practices. Less access to first-aid services and lack of knowledge	• Introduce a community based service provider to educate goat rearers • Introduce community insurance
Genetic degradation/low quality of goats	Lack of focus on improved buck breeding in goats	• Create awareness and set up a breeding service • Provide selective kids nursery
Feed scarcity and seasonal stress	Low awareness about alternative feed and non-existence of fodder cultivation and preservation	• Develop pastures for grazing • Conduct a Participatory rural appraisal (PRA) -based analysis of feed seasonality, kidding seasonality and disease analysis • Develop a short- and long-term plan
Low share of producers in consumer-level meat price growth	Absence of a transparent system for price estimation of goats. Skewed information accessibility	• Introduce a live body weight-based pricing estimation • Conduct seller-buyer interface workshops

Integrated Fishery and Duck rearing

The prototype of integrated duck, fish rearing, along with vegetable cultivation in a farm pond based ecosystem is unique as PRADAN promotes in-stitu moisture conservation by construction of farm ponds in paddy fields to protect kharif paddy against dry spells and support an extra crop in winter. Even though the farm pond could protect the paddy crop against dry spells, the farmers did not invest much in chemical measures to control pest attack in the paddy fields. Moreover, small and marginal farmers go for wage employment in nearby areas to meet their regular expenses even during the cropping season. Thus, they are not able to take good care of their crops even when the water is ensured. So to help them take full advantage of the pond and go for improved paddy cultivation, regular cash income needs to be ensured. To supplement the income of farm pond owner; duck rearing, vegetable cultivation, and fishery were introduced. This would not only reduce the production cost of both duck and fish, but also would increase paddy production.

This has potential fringe benefits of an integrated system such as:

- Fish utilizes the feed spilled by ducks and eat their droppings directly by some fishes.
- Ducks keep aquatic plants in check.
- The duck gets its required quantity of water from the fish pond.
- Ducks increases the pond productivity by releasing the nutrients from the pond bottom soil through dabbling the pond bottom mud.
- From the same places at the same time duck meat & eggs and also the fish can be produced.
- Duck get 50- 75% of their total feed requirement from the pond itself in the form of aquatic weeds, insects, mollusks, etc. which do not form the food of the fish.
- Ducks would gain weight faster with weeds in the ponds, as juvenile frogs, tadpoles, and dragonfly larvae are good sources of food for the birds;
- The fish yield would increase as many predators of fry and fingerlings are eaten by ducks and duck dropping going directly into the pond; providing C, N, and P; stimulate the growth of natural food organisms of fish. (Precaution: Ducks can swallow a fish with a body weight below 4 g. So fish-cum-duck integration should only be practiced in fingerling ponds.
- Duck act as a self manuring machine which helps in saving the expenditure involved in labour in applying manure in the pond.

Objectives of the prototype

Integrated fish farming is a system of producing fish in combination with other agricultural/livestock farming operations centred on the fish pond. The farming sub-systems e.g. fish, crop and livestock are linked to each other in such a way that the byproducts/wastes from one sub-system become the valuable inputs to another sub-system and thus ensures total utilization of land and water resources of the farm resulting in maximum and diversified farm output with minimum financial and labour costs.

Pond

The pond is the first and foremost thing in this integrated system in which a small pond is required for a rural setting. The pond should have high enough ridge around to protect the fished from predators and prevent toxic/ chemical mixed water from the nearby fields to enter inside. The pond should be dug at a place, where there is high probability where the water will remain year round long. If the pond is constructed on medium or up land, the depth of water is shallow, which is a hindrance in the growth of the fishes in the pond. Sandy soil is not suitable for fish pond; the best suited to sandy clay and clay soils. Any pond that retains 2–3 meters water can be considered as suitable. However, the determining factor is the water depth in dry season. Minimum of 1.5m (5 to 6 feet) of water depths is essential even during the summer season. If there is any change in the depth of water in the fish pond is seen then it should be corrected. The excess water from the pond can be removed through pumping or through the use of outlet in the embankment. If the water depth is reduced, then from a nearby source it should be filling up.

The pH of the water should be maintained at 6.5 to 7 (neutral water, neither acidic, nor alkaline).

The basic management practices in integrated fish ponds are pond preparation, daily routines, sampling, harvesting, and health care.

Pond preparation

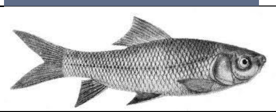
- In a pond with 5 decimal area, sow 200-300 grams of pulses (any kind of pulse); while at a 3 to 4 leaves stage, till the pond and assimilate the organic matter in the soil. Doing this would increase the nitrogen content in the soil.
- It is wiser to remove the predatory fishes which might be there in a pond with standing water. These predators should be removed from the pond before the introduction of the fish fingerlings. These fishes can be taken out by draining the pond, or with the help of fishnets. Another good way of dealing is to apply 100 kgs of Mahua (*Madhuca indica)* oil-cake in the water. This helps in killing the fishes, and these killed fishes can be consumed at home or can be sold at the market. The biggest advantage in applying the oil cake is it converts into fish feed,
- 20 days after the application of Mahua oil-cake, apply 10 kgs of lime when the pond is filled with water. Liming helps in maintaining the pH of fish pond water. This helps in increasing the natural productivity of the pond. Liming also helps in maintaining the cultured fish stock disease free. It is done based on the soil and water pH.
- After 4-5 days, apply 4 baskets of fresh cow dung along with water in the pond.
- After 7 to 10 days after this apply 200 grams of DAP and 300 grams of Urea in the pond.
- After 6 to 7 days (application of the fertilizers), the colour of the water in the pond would turn green as the planktons would be ready in the pond, which is a good time to introduce the fingerlings. As this is an integrated system with ducks, small fishes have the danger of being consumed by the ducks, so refrain from introducing small fishes.

Species selection of fish

Species should be selected according to the feeding zone/ layers and compatibility. The considerations for selection of the species are

- The selected species should be compatible with each other;
- The species and their combined ratio should be adjusted according to the amount of feed stuff and manure;
- As far as possible the species should fast growing;
- Selected fish should be hardy and resistant to common diseases and parasites;
- The species should be able to tolerate low oxygen levels and high organic content in the water.

The species combination and stocking ratio may vary according to the local requirements, water level, and possibilities. Considering the environmental condition which allows only a short period for growing of fish, stocking of ponds with yearling is always best to get a good return. But it is not possible for farmers to get yearling in sufficient quantity as and when they required or it may not be possible for them to get it. Therefore, fish fingerling i.e. 10- 15 cm size fish seed is the best stocking material in the stocking pond. The fingerlings of over 10 cm size should be stocked, as the smaller ones are likely to be preyed upon by the ducks. Some alterations can be made on the stocking density and species ratio depending upon the pond conditions and availability of fish seed. In a pond of 1000 square meter area 600 fish fingerlings can be stocked

Feeding zone	**Species**		**Suggested stocking ratio**		
Surface feeder	Catla		240-250	180-200	120-140
	Silver Carp				60-80
Mid-water feeders	Rohu		180-200	180-200	120-140
	Grass carp				120-140
Bottom feeders	common carp known as China rohu			120-140	120-140
	Mrigal		180-200	120-140	60-80
			600	600	600

for a pond of five decimal size the above stocking ratio should be half of the above mentioned figures.

Stocking the fish

Fish fingerlings quality depends upon the quality of brooders; therefore, farmers should collect the fish seed from a known source or hatchery.

With the integrated system of fishery-cum- duck rearing, the fish fingerlings should be stocked 15-20 days after the birds are introduced. This is because the bird droppings enrich the pond and increase the growth of fish food organisms (i.e. Phytoplankton and zooplankton). As mentioned earlier, the right time of fish stocking is when the colour of the water turns green.

Stocking of fish seed in the stocking pond should be done in the morning or evening hours, when the water is cooler. Before stocking the fish seed is needed to be conditioned. Through conditioning the fish seed is adjusted to the new environment. It may require from a few minutes to hours time. First the container carries the fish seed are placed over the surface water of the fish pond for the few times where the fishes will be stocked. This helps in bringing the temperature of the container water to the pond water temperature. Then slowly a little amount of water from the pond to be stocked is introduced into the container having the fish seed and acclimatized them. This process may be repeated for 2- 3 times on need basis. After conditioning fish seed from the container to the pond, which is to be stocked is released slowly. This helps in minimizing the mortality of fish seed in the pond immediately after stocking.

- In the north and north - western States of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes.
- In the south, coastal and north - eastern States of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

Fertilizing the pond for natural feed production

Fertilization increases the natural food availability in the pond. It is believed that manuring alone can increase the production of the pond by 75%. At the same time fertilization creates many environmental problems like- dissolved oxygen concentration depletion, phytoplankton bloom, higher ammonia level, etc. Already mentioned that the duck excreta is rich in nitrogen and phosphorous. Therefore, there is no need of using extra fertilizer as mentioned above in this type of integrated farming. Duck dropping contains 81% water, 0.91% nitrogen and 0.38% phosphorous. Ducks are given free range from 9 AM to 5 PM. In the pond and the excreta released during this period are easily mixed with pond water and fertilize it. Again duck droppings voided during night at the duck house are collected and applied to the fish pond in the morning hours to fertilize the pond water. Duck dropping act as a good fertilizer which helps in producing fish feed i.e. Phytoplankton & zooplankton in fish pond. So application of extra fertilizer and feed to fish pond for raising fish is not needed. This cuts the cost of fish production by 60%. One duck voided about 125- 150 grams. excreta in a day. When the phytoplankton bloom is seen over the surface water of fish pond then application of duck droppings to the pond should immediately be suspended.

Apart from natural food most of the cultured fish species can take artificial feed. Feeding alone can increase the production from ponds by 4 times. Some other fish-feed can be introduced to the fish such as groundnut oil cake, rice husk, this given in equal proportions depending upon the weight of the fish. However, it is better to depend upon the natural feed (i.e. Plankton), which reduces cost and increase profitability.

Recommended feeding practice (if natural feed is not available)

- 1st month: for the first fifteen days: 5% of the body weight of the fish
- 1st month: for the second fifteen days: 4% of the body weight of the fish
- 2nd month: for the first fifteen days: 3% of the body weight of the fish
- 2nd month: for the second fifteen days: 1-2% of the body weight of the fish

The fish-feed is given through a small hole of bamboo basket/ jute bag hung over a specific place over the pond. This is kept under the Sun to protect it from fungal infection.

Maintaining the water quality in the pond

Poor water quality has been recognized as one of the main factors responsible for the occurrence of disease problems in aquatic animals. The incidence and severity of infectious diseases are very often dependant on the quality of the environment in which the animal lives. In other words the quality of the environment can indicate the health status of animals. Thus, the first and foremost important step in controlling infectious diseases is by maintaining the best quality environment possible in the culture unit.

Removal of unwanted aquatic weeds

Unwanted aquatic weeds are needed to be removed from fish pond as it reduces the pond productivity. These unwanted aquatic weeds could be removed manually, mechanically, chemically and biologically. Manual removal method is better. Chemicals used in the removal of aquatic weeds from fish pond are: i) 1.2-4 D or 2-4 D Ester at the rate of 5-6 kg/Ha ii) Simazine at the rate of 0.5 tp1.0 mg/lit water for floating weeds like Eichornia, duck weed and Algae type, iii) Super phosdphate at 500mg/lit pond water for submerged weed like hydrilla, valisnaria etc. Some time a thick layer of algal bloom of brown or green colour is seen over the water surface of pond. This can be removed from fish pond by using a piece of split bamboo followed by liming based on water pH. Chemicals like copper sulphate @0.1- 0.5 mg/lit. of water also helps in controlling this bloom. Noxious gases and the effect of other substances of pond bottom mud can be reduced by repeated netting or by moving a rope through the pond bottom mud.

Turbidity of pond water

This is occurring when there is more clay content in the soil of fish pond or it may cause due to overgrowth of phytoplankton. This reduces the primary production in ponds, causes oxygen depletion in the pond water, reduce growth of cultured fish and also cause mortality of cultured fishes due to asphyxiation. Normally, small fishes and eggs suffer from this water quality problem. To control this water quality problem, apply filter alum at the rate of 10-40 mg/ litre of water. Actual quantity can be determined by putting alum in a glass of turbid water. After applying alum liming should be done as per the water pH as mentioned in the corrective measures of water pH.

Dissolved oxygen (DO)

Dissolved oxygen range in the stocking pond should be in between 5- 8 ppm. Dissolved oxygen depletion normally occurs in the morning or in the late night hours. If the depletion of DO occurs in the pond, then the fishes will come to the surface of water and try to gasp air from the atmosphere. In that case feeding and fertilization in the pond should immediately be stopped. Supply water from a nearby source. Turbulent the water with the help of a split bamboo. Harvest the table size fish and reduce the density of fish in the pond.

If the DO concentration is increase than its normal range, then "Gas Bubble Disease" may occur. Normally it is seen in the noon and afternoon hours. Fish fry and fingerlings are mostly affected due to entry of gas bubbles in the arteries of fish and finally fish may die. Supply of water from a nearby source having less DO concentration, transferring the affected fish to a nearby pond, etc. are the remedial measures. Keeping the ducks in the pond aerates the pond as it is required; otherwise swimming in the pond and mechanical aeration also helps.

Phytoplankton bloom

The sudden increase of population of certain planktonic algal group as thick mass in water is called phytoplankton bloom. It is identified by the deep green or blue green or reddish green colour of the pond water. During the day time phytoplankton produces excess oxygen and during night and cloudy days they absorb dissolved oxygen from the water for their respiration resulting dissolved oxygen depletion and fish mortality. The death and decay of algae also cause dissolved oxygen depletion. The reason for this algal bloom in pond water is the presence of excess nutrients in water. Therefore, if this problem encountered in the fish culture pond, then supply Duck droppings to the pond should immediately be cut off and the remedial measures should be taken as mentioned in the case of algal bloom cited in the renovation measures of a pond which cannot be dried.

Changes in water temperature

It leads to loss of appetite of cultured fish. Fish will also show poor growth and they become susceptible to diseases. If the water temperature changes to a markable level, then supplying feed and fertilizer to the pond should immediately be stopped. Replenishment of water from a nearby source, harvesting the table size fish, etc. are some of the corrective measures to be taken for it.

Harvesting management

After 7- 8 months of growing cultured fishes reach marketable size. The grass carp and silver carp becomes 1 kg size in 7- 8 months cultured period. To reach 750 gm to 1 kg rohu, cattle, mrigal, it needs about 1 a year growing period. When the cultured fish reaches 750 gm to 1 kg in weight, then they are harvested from the pond. The harvesting may be done by removing the complete stocks of cultured fishes or by removing the only table size (750 gm to 1 kg) fishes partially based on market demand. In case of partial harvesting the numbers of fish harvested from a pond is replenished with equal numbers of small fishes from nursery ponds of the farm. This helps in getting more money.

Duck rearing

In this method of integrated approach, in which the egg laying ducks are fed at the same rate as on land and kept at a relatively high density per unit of pond area. Therefore, higher amounts of manure and uneaten duck feed (estimated to be 10 %) usually fall into the fish pond and consequently higher fish yields can be obtained. However, the high priced balanced feed is required to maintain the egg production, resulting in relatively higher cost of production, which is difficult to be compensated by the sale of eggs in rural areas.

The kind of duck to be raised must be chosen with care since all the domesticated races are not productive. The important breeds of Indian ducks are Sylhet Mete and Nageswari. The improved breed, Indian runner, being hardy has been found to be most suitable for this purpose, although they are not as good layers as exotic Khaki Campbell. The most potential egg layer species of duck is the Khaki-Campbell (*Anas platyrhchos*) duck. It has two varieties: with white and brown colours. The adult female is 1.8–2 kg, while the male is 2.2–2.5 kg. Under intensive rearing system they are able to lay above 300 eggs/year. The weight of the eggs varies between 60 and 70g. The female start to lay at the age of 23–26 weeks and able to continue laying until 360–380 days old.

Egg laying by ducks depends upon many factors, including breed and strain, but good management contributes considerably towards the achievement of optimum egg-flesh production.

The ducks do not need elaborate housing since they remain in the pond most of the day. A low-cost night shaker made of bamboo or any other cheap material should be available in the area either on the pond embankment or on the water surface. The house should be well-ventilated and so designed that the washings are drained into the pond.

About 25 (minimum 15, maximum50) ducks are sufficient to fertilize a pond of 500 m² i.e. 5 decimal ponds; this number only needs a (house) floor area of 13 to 14 m². About 3-4-month old ducklings are kept in the pond after giving them necessary prophylactic treatment and safeguarding measures against epidemics. As these ducks can also be kept in the paddy fields if the area of the pond seems little small.

Nursing of young ducklings

Day-old ducklings require controlled environment (temperature, feed, drinking water and space) up to 2–3 weeks. Pelleted starter feed is provided in demand feeders, with clean water in pots which are designed to allow access to the beak only, preventing the ducks from getting wet. Air temperature should be maintained around 30–32°c. After the third or fourth day, ducklings are released into a small enclosed pen during good weather and provided with shallow splashing pools to acclimatize them. Special care should be taken to prevent food sticking to the heads and backs of the ducklings.

Although the duck is a waterfowl, water for swimming is not absolutely essential at any stage of duck rearing. Since ducks may not be able to swim at first, they should be allowed in shallow water for a few hours for the first few days to stimulate the development of the preen gland and allow the duckling to water proof its feathers.

Feeding the ducks

The ducks can find natural food from the pond. Duckweed (*Lemna minor*) is also preferred by ducks. Daily 125–130 g supplementary feed per duck seems sufficient for the adult layers when they have enough natural feed in the pond.

Ducks prefer wet mash due to the difficulties in swallowing dry mash. Initially the duckling should be fed 4–5 times a day. Later it can be decreased until twice a day. For adults 10cm feeder length can be used for each duck. If feeding on the pond is not possible, then drinkers should be placed next to the feeders. Feeders and drinkers should be cleaned every day and dried to prevent from contamination. In daily feeding, it is better to feed the ducks by the same person.

They will need very little supplementary feed which can come from household wastes, such as kitchen leftovers, rice bran, broken rice and spoiled cereals, if any. Alternatively, a balanced feed may be purchased and given at 50 to 100 grams /bird/day. The feed is given twice in a day, first in the morning and second in the evening. The feed is given either on the pond embankment or in the duck house and the spilled feed then drains into the pond. Water must be provided in the containers deep enough for the ducks to submerge their bills, along with the feed. The ducks are not able to eat without water. Ducks are quite susceptible to afflatoxin contamination; therefore, mouldy feeds kept for a long time should be avoided. The ground nut oil cake and maize are more susceptible to *Aspergilus flavus* which causes aflotoxin contamination and may be eliminated from the feed.

Common duck weed	Azolla	Water hyacinth
		

Along with feed ducks should be fed with chopped green vegetables. Feeding the ducks with manganese sulphate at the rate of 10 mg/ kg feed and also with Vitamin.- A (Elvitone or Vimarel, etc.) along with drinking water gives encouraging results from duck rearing practice.

Egg laying

Duck start laying eggs when they become 7 months old. Each duck lay about 90- 100 numbers of eggs in every year. They lay eggs from the late night to about 9 a.m. So they are allowed to go into the ponds after 9 a.m. For laying eggs they need a nest. Therefore, some nest made of bamboo or wood or with tin is provided in the duck house by keeping some straw or hay inside the nest. When the ducks become 18 months aged then there egg laying capacity is reduced, therefore, after the duck become 18 months old they are sale out and a new stock of ducklings are introduced into the duck house after giving all prophylactic treatments against viral diseases of ducks and after disinfecting the duck house and the materials that are going to use in the duck rearing practices

Health care

Ducks are subjected to relatively few diseases when compared to poultry. The local variety of ducks are more resistant to diseases than other varieties. Proper sanitation and health care are as important for ducks as for poultry. Prevention is better than cure is the best formula for duck farming. The transmissible diseases of ducklings and ducks are- duck cholera, duck hepatitis, duck virus, keel disease etc. Ducks should be vaccinated against all viral diseases.

Disease infected duck can easily be identified by a farmer by careful looking for them, listening to sound produced by ducks, observing the reduction in daily feed intake, etc. A disease infected duck becomes listless, less bright eyes and also watery discharge comes out of the eyes and the nostrils. Sneezing and coughing sound from the duck house is warning tone for the coming disease. Always isolate the disease infected duck from the groups and it should not be allowed to go into the fish pond. Treatment of diseased ducks should be done by a trained Veterinarian.

Harvesting

The eggs are collected every morning. After two years, ducks can be sold out for flesh in the market. About 2,000 – 3,000 eggs and 30 - 35 kg of duck meat is obtained. The ducks start laying at the age of 24 weeks. The eggs are collected every morning as the ducks lay eggs only at night. The ducks lay eggs for two years, after which they should be culled.

PACKAGE OF PRACTICE FOR AMRAPALI MANGO IN 0.5 ACRE OF LAND

This Package of Practice (PoP) for mango cultivation has been designed by drawing PRADAN's experience in the Chhotanagpur plateau of Gumla district. As physiographic condition can vary across different regions in India, the package of practice may be varied accordingly. However, the basic essence of plant establishment and management should remain the same.

The objective of this livelihood model is to create an additional asset for the family, as mango based orchards, which gives income every year. The orchard can be easily managed by the family and be able to generate sufficient income to keep the family interested to do intercultural practices. Marginal lands which were poorly used for cultivation of paddy or other millets in the upland or waste land previously can be converted to a mango orchard

This has been designed keeping in mind that a facilitator in the village could use from day one for carrying out the activity and use this manual as a guide. The learning targets for farmers/ Facilitators / Community Resource Person from this pamphlet are:


Source: http://horti.agropedia.in/content/varieties-mango-amrapali

Amrapali mango prototype for smallholders (0.2 ha with 50 plants)

Yield- 8-10 tonnes/ ha = 2 to 3 tonnes/ hh

Market price- Rs. 15 to Rs. 20 per kg

Cumulative return in 10 years- about Rs.1.4 lakh

Land requirement- 2,000 square meters upland with deep soil (irrigation facility an advantage)

Labor- 2 persons who can stretch during the initial 3 years (else can hire one person during cluster of activities)

Capital requirement-
1st Year- Rs. 29,000
2nd Year- Rs. 5,000
3rd Year- Rs. 6,000

Gestation period- 3 years

- Recognize good husbandry practices in mango orchards;
- learn proper propagation of mango seedlings;
- learn proper diversification in mango orchards;
- learn proper management of mango pests and diseases.

Mango production in India

Mangifera indica – the common mango or Indian mango commonly cultivated in many tropical and subtropical regions, and its fruit is distributed essentially worldwide. As per the National Horticulture Board in India, mango is cultivated on 2.5 million hectares of land with a production of 18 million tonnes as per the 2012-13 figures.

The cultivar **Amrapalli** (Parents: Dashehari x Neelum) is precocious, distinctly dwarf, highly regular and prolific in bearing and has good fruit quality. This is a cultivar with a future since it has been found to fit into the concept of high density orchard, which will lead to higher plant density per unit area, better management and manifold increase in yield. Average fruit weight is 225 gm/fruit. Both the varieties have been developed by IARI, New Delhi.

PROSPECTS AND STRENGTHS OF ADOPTING AMRAPALI MANGO CULTIVATION

- The variety with high yielding capability and small gestation period of three years is in line with the initiatives of both government and private sectors in terms of production, processing and marketing support;
- Once productive, the yield is approximately 2 to 3 metric tonnes per year with an additional income of about Rs. 20,000 to Rs. 30,000 per half an acre of land.
- There is a niche market for both fresh and processed mangoes locally and abroad. The export market is expanding;
- Technologies from propagation to post-harvest handling has been tested, verified and adopted nationwide.

Amrapali mango production can be an important economic activity with the potential to improve food and income security for smallholders. Strategies are, therefore, needed to minimize risks associated with mango production and improve the productivity of mango orchards. Amrapali mango cultivation can have application across most of the agro-climatic zones in the country. This is a horticulture based livelihoods model, a cropping system that has been set up to be naturally suited to smallholder with access to assured irrigation, who have limited resources but can produce much more from these resources with inputs of modern technology.

AGRO-CLIMATIC REQUIREMENTS

Amrapali variety is well adapted to tropical and sub-tropical climates. It thrives well in almost all the regions of the country, but cannot be grown commercially in areas above 600 m. Wet and Tropical Climate of Jharkhand is suitable for growing mango plantations. Clear sky, dry climate and temperature rise in the region during January-February induces early fruiting and ripening.

SOIL REQUIREMENT

Cultivation of Mango can be done in the Upland having sandy loam soil with moderate to high water retention capacity. This type of land is used for cultivation of finger millet, coarse grains or upland rice with low productivity during the Kharif season. These coarse grain / millets can be cultivated as intercrop in the mango orchard. The major consideration while choosing areas under mango cultivation is to have a good soil cover (about one metre) to retain moisture and nutrients and offer robust anchorage. It is seen that in case of moisture stress the yield of mango goes down. However, farmer with irrigation infrastructure can take mango cultivation.

THIS MODEL IS IDEALLY SUITED TO

Factors that should be taken into consideration while selecting families who can adopt this model of mango plantation as per the following requirements of land, labour, and capital.

LAND

The farmers who can benefit most from mango cultivations who have at least 0.5 acres of uplands with deep soils, and have access to irrigation in the sub tropical climate Most of the marginal and small holders have this kind of land available, it is preferable to have a water source nearby. It is preferable to combine land of four to five farmers for creating a large patch and hence saving on various aspects of labor and inputs associated with a solitary orchard. In the central Indian plateau, it is found that members from a single family tree own contiguous patches. Since this involves common fencing, a laggard farmer within the contiguous plot is forced to take up plantation. Other factors such as warding of animals as well as establishment of the orchards are easier in a contiguous patch. Since most of the farmers in the village have taken up plantation, fear of theft of fruits, grazing etc, are largely taken care of by community peer pressure. More so, it starts to develop as a cluster, impacting and influencing new farmers to this activity.

LABOUR

Amrapali mango cultivation requires two members of the family who can stretch in early three years to meet labour requirement of one extra labourer. This is because the activity will start in cluster and at the same time all the work will start so labour supply will be in crisis. In this situation if the family has one surplus person power, the family will be able to manage the entire task in time otherwise he will have to import labour from other nearby villages. A family with five members can contribute parttime labour to ensure upkeep of the orchard.

Since Amrapali cultivation has a gestation period of 3 years, the farmer might lose interest in the activity without taking proper care of the orchard which might once again turn into a fallow land. So to retain the interest of the farmer it is advised to take intercrop like vegetable and pulses among the row spaces of the mango. Taking intercrop not only gives additional income, but also helps the orchard in attaining better growth and more yield and less diseases and pest attack.

CAPITAL

The activity requires at least Rs. 1,500 in initial years for intercrops; will require Rs. 5,000 to maintain orchards. Details about has been given at the end of the document.

1.1 PLANT ESTABLISHMENT AND MANAGEMENT

WORKING OUT A LAYOUT FOR THE PLANTATION: The layout should be done in the month of February. First pit should be dug three metres away from the corner. The pit to pit distance should be six metres away from each other. These pit diggings should start from a corner and not from the middle of the field.

FENCING: It is the most critical of the pre –plantation schedule. The major consideration here is the community interest and mobilization for the plantations undertaken. If community could devote one person purely after the first rain, then fencing could be adequately done in time for it to be a-live one. Usually, just after the first rains, farmers are very busy in ploughing of their lands for paddy. Getting them to make a live fence at the same time is a back breaking exercise. Finding adequate fencing material nearby is also other considerations.

There is thus, two ways it could be approached. Complete the dry fencing before planting grafts, or live fencing just after the rain starts.

Live Fencing: The best material to be used should be "Putush" botanically called *Lantana camera*, which is local weed available and could be planted in rains and tied with bamboo strips. Gradually these develop as good fences. The other is. "Sinduar" etc. These get established during the rain and later are supplemented by regular gap filling. *Lantana camera* is preferred as it is a thorny species which does not allow any cattle inside the fence.

Dry Fencing: The fencing material should be any dry branch available, tied in strips with bamboo. This could be done with bamboo, dried up twigs, branches from forest trees etc. Bamboos and other wooden logs are required to support the fence. If dry fencing is complete before rains, during the rains live fencing would be supplemented with dry fencing.

TIME OF PLANTING: The best time for planting is during the monsoon (June-July) when there is sufficient moisture in the atmosphere. The planting should be preferably done in the evening, otherwise if the day turns out to be unusually hot or dry, the plants may wither due to excessive loss of water.

PROCUREMENT OF PLANTING MATERIAL: Usually the mango saplings come in two types of packings based upon the method of sapling raising at nursery. Straw packing-seedling are raised in nursery and uplifted and packed in straw. Poly packing-seedlings are raised in poly pack from the start.

The rate of the reliable grafts in straw packing is Rs. 20/- per plant at the site. While for poly pack the rate varies from Rs. 22-25/saplings. Care should be given that the seedling should be of uniform variety (i.e. no varietal mix). The age of the graft should be of 2 years with minimum two branching. Care should be given to identify the older graft by looking at the density (width of it).

INPUT REQUIREMENT AND DEALINGS

Bone meal- is provided by many companies in packets and adheres to quality and quantity standards, in bulk purchase it would come down to less than Rs. 10/kg.

Neem Khali- Usually procured from Chatissgarh from oil seed mills, Packed in loose gunny bags, Quality & Quantity standards both needs to be monitored and ensured. Finding a bulk amount requires dealing with many dealers.

Vermi-compost- Since the requirement is very high @ 10-15 kg /pit, finding, ordering and stocking this is a challenge. Transporting from far away centre is a problem as well as time consuming affair. Orders placed well ahead in time are utmost necessity. Producing vermicompost from farmers should be given priority, but ensuring the available quantity as well as quality in time should be adequately explored. Usually the rate varies from Rs 4-4.5/kg.

Bone meal

Neem Khali

Vermicompost

FIELD PREPARATION

Pit size of 1m x 1m x 1m is to strictly done. Usually the lower portion of the pit is thinner in dimension. Providing a 1mtr length of stick to the farmer and ensuring the bottom width at 1 mtr is essential. When external labor is sought for digging, this usually happens. It usually becomes a shape of an inverted trapezium instead of the 'cube' desired.

Pit digging should start as early as possible. Usually a person could dig comfortably in loose / murram/ red soil 3- 4 pits of 1 cubic m each per day.

While digging, keep the topsoil and the subsoil separately. Make one feet of soil heap separately of three heaps. While filling the pits, the top fertile soil should go into bottom of the pit.

The pit should get at least 30 days of sun drying for exposing harmful soil borne diseases and pests to sunlight, providing better aeration in the future rooting zone and making the soil looser for early root growth.

After one month of sun drying of pits are filled up with neem oil cake, bone meal and vermicompost and soil. Before filling of pits Chlorpyriphos application should be done to kill termites. Spray should be done all along the line of the pits and on the bottom. These filled pits are then left for a month time so that the above mentioned fertilizer mixture become well decomposed and are become easily available to plants.

For a pit the requirement of input mixture is.

Sl No	Particulars	Amount
1	Neem oil cake	1kg
2	Bone meal	1kg
3	Vermicompost	10-15kg
4	Chlorpyrifos	3ml/lit

PLANTING: It is to be ensured that utmost care should be taken while transporting plants to field and not give any shock or ham to the plants.





While planting the mango sapling the straw or the polythene cover should be gently removed using sharp blades. The earthen ball of the plant are kept in between of the pit and little water (approx 500ml) should be poured in the pit and then the soil are dropped and gently pressed with legs holding the plant stem in between hands. This will ensure straight planting of mango sapling and adding water and pressing the soil will remove soil borne fungus and early root establishment. It is to be ensured that in a day's time all the plants should be planted as keeping the plants at home or at field will lead to mortality of plants also keeping at home will leads to severe termite attack on tender stems of plants. Light mulch (about 10 cm) may be applied, but not too close to the seedling stem in order to avoid attracting fungus and insects. Continuous watering is needed for proper establishment.

IRRIGATION: During the first year when the plants are very young with shallow root system, they should be watered every 2-3 days in the dry season. Trees in the age group of 2-5 years should be irrigated at 4-5 days interval. The irrigation interval could be increased to 10-15 days for 5-8 years old plants during dry season. When trees are in full bearing stage, generally 2-3 irrigations are given after the fruit set. Profuse irrigation during 2-3 months proceeding the flowering season is not advisable.

NUTRITION:

Good quality vermicompost should be applied in the orchard for nutrition of the plants. The per plant requirement is about 10 to 15 Kg of Vermicompost. This can be procured from the market or can be prepared by the farmer at their own backyard.

a) Quantity of fertilizer: Providing manure to the mango plant starts right from planting operation in the orchard. First application is made at the time of filling of the pits. Fertilizer application during the first year of planting may be given as 100 grams N, 50 grams P_2O_5 and 100 grams K_2O per plant. Above dose should be increased every year up to 10 years in the multiple of first year's dose. Application of 50 kg well-decomposed organic manure should be given yearly to create proper soil physical environment.

b) Time of fertilizer application : Fertilizers may be applied in two split doses, one half immediately after the harvesting of fruits in June / July and the other half in October, in both young and old orchards, followed by irrigation if there are no rains.

c) Method of fertilizer application: First of all, the weeds should be removed from basins. The mixture of recommended dose of fertilizers should be broadcast under the canopy of plant leaving about 50 cm from tree trunk in old trees. The applied fertilizer should be amalgamated well up to the dept of 15 cm soil.

TRAINING AND PRUNING: Normally, mango trees require very less or no pruning. However, the training of the plants in the initial stages is very essential to give them proper shape. Especially when the graft has branched too low, the process of training becomes very important. At least 75 cm of the main stem should be kept free from branching and the first leader / main branch may be allowed after that. The main branches should be spaced in such a way that they grow in different directions and are at least 20-25 cm apart; otherwise there are chances of breakage due to smaller crotch angles and heavy top.

By following the above practice and after giving proper shape to the trees, there will be very less scope for future pruning except removal of diseased, pest infested or dried shoots / wood.

PLANT PROTECTION

PESTS

HOPPERS

Large number of nymphs and adult insects puncture and suck the sap of tender parts, thereby reducing the vigour of the plants. Heavy puncturing and continuous draining of the sap cause curling and drying of the infested tissue. They also damage the crop by secreting a sweet sticky substance which encourages the development of the fungus commonly known as sooty mould which affects adversely the photosynthetic activities of the leaves. A low population of hoppers has been recorded in mango orchards throughout the year but it shoots up during February-April and June-August. Shade and high humidity conditions are favourable for their multiplication. Such conditions usually prevail in old, neglected and closely planted orchards. The female hoppers lay 100-200 eggs on mid rib of tender leaves, buds and inflorescence. In summers the total life cycle occupies 2-3 weeks.

Three sprays of 0.15 per cent Carbaryl or 0.04 per cent Monocrotophos or 0.05 per cent Phosphomidon or 0.05 per cent Methyl Parathion have been found very useful in controlling the pest population. First spray should be given at the early stage of panicle formation. The second spray at full length stage of panicles but before full bloom and the third spray after the fruits are set and have attained pea stage are recommended.

To manage mango hopper pest, avoid dense planting and keep the orchard clean by regular ploughing and removal of weeds. Pruning of overcrowding and over lapping branches should be done in the month of December. Chemical spray is to be minimized necessary. Neem products may be included in the management schedule of the pest. The use of insect growth regulator Buprofezin (0.0125 %) is also suggested as one of the sprays.

MEALY BUG

It is another major pest of mango in India and widely distributed along the Indo-gangatic plain. Adults and nymphs suck the plant sap and reduce the plant growth, destroy inflorescence and causes fruit drop. Mealy bug excretes honey dew, a sticky substance, which facilitates the development of sooty mould fungi. The female insect crawls down in the month of April/May to lay the eggs in soil. The eggs hatch in the following month of November/December and crawls up the tree.

Control: (i) Mechanical: Polythene (400 gauge) bands of 25 cm width fastened around the tree trunk have been found effective barrier to stop the ascent of nymphs to the trees. The band should be fastened well in advance before the hatching of eggs, i.e., around November - December. (ii) Chemical: Application of 250 g per tree of Methyl Parathion dust 2 per cent or Aldrin dust 10 per cent in the soil around the trunk kills the newly hatched nymphs which come in contact with the chemical. Spraying of 0.05 per cent Monocrotophos or 0.2 per cent Carbaryl or 0.05 per cent Methyl Parathion have been found useful in controlling early instar nymphs of the mealy bug.

SHOOT GALL PSYLLA

Infestation of this pest results in formation of green conical galls in leaf axis. The pest becomes active from the month if August and galls dry after emergence of adults in the month of March. The eggs are laid in the midrib as well as on lateral axis of new leaves in March/April, nymphs emerges during August/September and feeds on adjacent buds which later turn in to hard green conical gall. Galls are more prominent during September/October and infested plants usually devoid of flowers and fruits. There is only one generation of this pest in a year The pest can be managed by avoidance of new planting in humid region, removal and destruction of infested plant parts and use of Monocrotophos (0.05%) or Imidachlopid (0.005%) or Propanophos (0.05%) at fortnightly intervals.

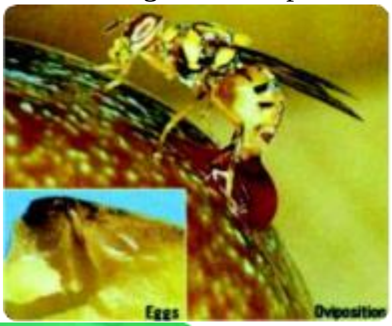
SCALE INSECTS

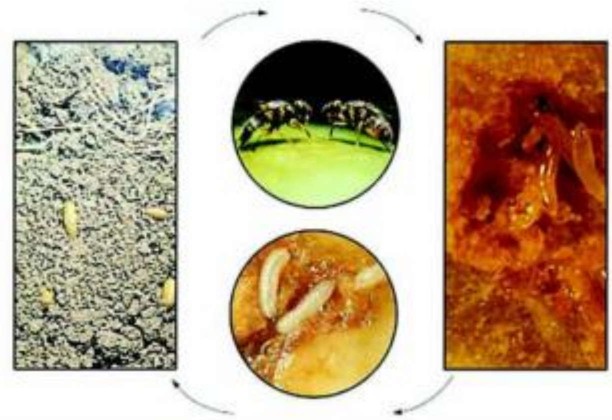
The nymphs and adults of pest suck the sap of leaves and other tender parts which results in reduction of vigour of plants. Scale also secrets honeydew which facilitates in development of sooty mould on different plant parts. Pruning and destruction of infested plant parts and spraying with Monocrotophos (0.05) or Imidachlopid (0.005) or Propanophos (0.05%) at an interval of 21-days found effective in population reduction of this pest.

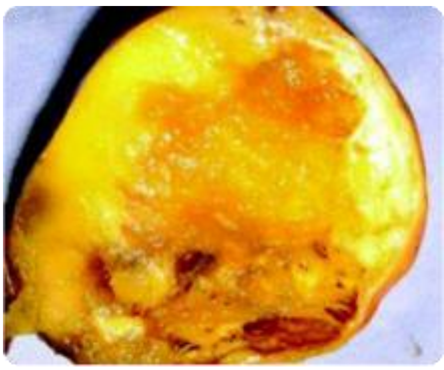
Insect pests of mango, viz. mealy bug, hopper, midge, fruit fly could be managed through IPM schedule involving banding of tree trunk with alkathene (400 gauge) and drenching with *Beauveria bassiana* (2 g/l) during first week of January and first spray with Neem Seed Kernel Extract (5%) in first week of February followed by second spray of imidadoprid (0.005%) when panicles are of 5 to 7 cm size and third need based spray with Propanophos (0.05%) after fruit set.

FRUIT-FLY

The female insert eggs in small clusters inside the mesocarp of the mature fruits and after hatching larvae feeds on the pulp which appears normal from outside but finally drops down. The maggots pupate in soil and flies start emerging from April onwards with maximum population during May to July which coincides with fruit maturity. Collection and destruction of infested and dropped fruits ploughing of orchards, use of trap bottle containing 100ml watery emulsion of methyl euginol (0.1%) + Malathion (0.1%) during April-June) reduce the infestation of this pest. Wooden traps prepared with sex hormone and insecticide has also been found effective against the pest. Bait spray of Carbaryl (0.15%) + protein hydrolysate (0.1%) or molasses at 21 day intervals starting from first week of April found effective in control of adult flies. Early harvesting of mature fruits, selective and need based bait spray and hot water treatment of harvested fruits before storage showed promising result.







BIOLOGICAL CONTROL

Green and Red ants are beneficial for the plants who eat away the eggs and larvae of harmful pests such as scale insects, mealy bug etc. However, if the number increases they prove harmful and destroy the plant and fruits; in that case these should be removed from the plant by hand or by spraying of pesticide.




MANGO MALFORMATION

The disease produces two types of symptoms, i.e., vegetative and floral. Vegetative malformation is more pronounced on young mango seedlings and plants. The affected plants develop swollen abnormal vegetative growth with short internodes. Leaves are small, narrow and often produced on the top of seedlings in clusters, giving it a bunchy appearance. The characteristic symptoms of the floral malformation are compact and clustery appearance of flowers. The flower buds transform in vegetative form and leaves. The flower bud seldom opens and remains dull green in colour. Some malformed panicles are not compact but both types of malformed panicles do not bear fruit. Mango malformation can be minimized with removal of malformed panicles and its destruction, removal of late December and early January flowers and application of NAA (200 ppm) in the first week of October.


BIENNIAL BEARING

The term biennial, alternate or irregular bearing generally signifies the tendency of mango trees to bear a heavy crop in one year (On year) and very little or no crop in the succeeding year (Off year). When a tree produces heavy crop in one season, it gets exhausted nutritionally and is unable to put forth new flush thereby failing to yield in the following season. The problem has been attributed to the causes like genetical, physiological, environmental and nutritional factors.

For overcoming biennial bearing, deblossoming is recommended to reduce the crop load in the 'On' year such that it is balanced in the 'Off' year. Proper maintenance of orchard by way of effectively controlling pests and diseases and regular cultural operations may also result in better performance of the tree every year. Soil application of Paclobutrazol (PP^{333}) or @ 4 - 5 g per tree in the month of September resulted in early flowering with higher fruit set and yield. It may be applied every year for regular fruiting, particularly in young trees. The time of application may vary according to fruit bud differentiation.

COST BENEFIT ANALYSIS OF MANGO ORCHARD IN 0.5 ACRE

By conservative estimates the total production in 10 years from an only mango plantation in half an acre of land is about Rs. 1. 4 lakh. This income is only from the sale of fruits at a market rate of Rs. 18 per Kg, it does not take into account of inflation and future appreciation in mango prices. Whereas the total expenditure for the gestation period is about Rs. 40 thousand, where the initial investment is high due to the provision of irrigation facility.

The production per plant as per year and income per year is given as per the table below:

Year	1	2	3	4	5	6	7	8	9	10	Total
Production (in Kg)	-	-	-	450	675	675	900	1,125	1,350	2,500	**7,675**
Price per Kg				18	18	18	18	18	18	18	**18**
Income per year (in Rs.)	-	-	-	8,100	12,150	12,150	16,200	20,250	24,300	45,000	**138,150**

The cost per year for cultivation of mango is provided in the table below (amount in Rupees).

Item	Unit	Unit size	Quantity	Unit cost	1st Year amount	2nd year amount	3rd year amount
Cost of fencing with local material	running meter	1.0	130.0	20.00	2,600.0	0	0
Pit digging (3'x3'x3')	Cu ft	27.00	50.0	1.64	2,214.0	0	0
Pit filling and plantation for mango plantation							
Vermicompost	Kg	10.00	50	6.00	3,000.0	0	0
Bonemeal	Kg	1.00	50	12.00	1,200.0	0	0
NPK	Kg	0.15	50	11.00	82.5	0	0
SSP	Kg	0.10	50	7.00	35.0	0	0
Chlorpyrifos	ML	2.00	50	0.50	50.0	0	0
Saplings	Numbers	1.00	50	40.00	2,000.0	0	0
Labour for pit filling	Labour day	0.05	50	100.00	250.0	0	0
Planting of saplings	Labour day	0.04	50	100.00	200.0	0	0
Mortality replacement @ 10%	Numbers	1.00	5.0	40.00	0.0	200	0

Item	Unit	Unit size	Quantity	Unit cost	1st Year amount	2nd year amount	3rd year amount
1st Interculture Operation for mango plantation							
NPK (10:26:26)	Kg	0.15	50.0	11.00	82.5	220.0	275.0
Labour	Labour day	0.05	50.0	100.00	250.0	505.0	505.0
Watering	Labour day	0.04	50.0	100.00	200.0	404.0	404.0
Growth hormone/Insecticide	ML	1.00	50.0	0.50	25.0	50.0	50.0
2nd Interculture Operation for mango plantation							
NPK (10:26:26)	Kg	0.15	50.0	11.00	82.5	220.0	275.0
Labour	Labour day	0.05	50.0	100.00	250.0	505.0	505.0
Watering	Labour day	0.04	50.0	100.00	200.0	404.0	404.0
Growth hormone/Insecticide	ML	1.00	50.0	0.50	25.0	50.0	50.0
3rd Interculture Operation for mango plantation							
NPK (10:26:26)	Kg	0.15	50.0	11.00	82.5	220.0	275.0
Labour	Labour day	0.05	50.0	100.00	250.0	505.0	505.0
Watering	Labour day	0.04	50.0	100.00	200.0	404.0	404.0
Growth hormone/Insecticide	ML	1.00	50.0	0.50	25.0	50.0	50.0
4th Interculture Operation for mango plantation							
NPK (10:26:26)	Kg	0.15	50.0	11.00	82.5	220.0	275.0
Labour	Labour day	0.06	50.0	100.00	300.0	505.0	505.0
Watering	Labour day	0.05	50.0	100.00	250.0	404.0	404.0
Growth hormone/Insecticide	ML	1.00	50.0	0.50	25.0	50.0	50.0
provision for crates	Numbers	1.00	3.0	350.0	0.0	0.0	1,050.0
13,962	4,916	**5,986**					
Well-shared by 4 neighbouring families /through LI or cost of each share/ purchase of water lifting devices					15,000	0	0
Grand Total					**28,962**	**4,916**	**5,986**
Total cost across 3 year							**39,864**

ANNEXURE: MONTH WISE ACTIVITY LISTING FOR MANGO CULTIVATION

Activity Calendar for the first year

Month	Activity	Time Period	Deadline	Remarks
January onwards	Beneficiary Selection			
	Exposure to the activity	1 day		
	Plot/Patch selection			
	Layout of each plot			Half hour for half acre of layout
March	Pit Digging	30 days	30th April	1 labour man-day- 4 pits
	Sun drying of pits	30 days	30th May	
March- Apr	Training 1- Concept & Visioning			One Day Module
April- May	Termicide Spray in pits (Dursban- Cypermythin)		30th May	Drenching the side walls of the pit too
April- May	Leaf composting in the pits		30th May	Just after sun drying and before termicide spray
Apr- May	Training 2- Dry Fencing & Pit filling			One Day Module
April - May	Dry Fencing		15th June	Ensure it, critical factor
June	Compost mixing, Pit Filling & Termicide spray		15th June	Adequate rain after pit filling for cooling down bone meal.
July/Aug	Transplantation and Watering	1 day	15th August	Variable on rains
July/Aug	Fungicide Spray- (Saaf-Carbendizum+Mancozeb)			Preventive from fungal attack, a week after transplantation
July/Aug	Live Fencing to supplement the dry fencing	15 days	End Aug	After transplantation, live fencing
Sept	Fungicide Spray		End Sept	Preventive Fungal attack, a month after 1st spray
Sept	1st Interculture and Watering	3 days	15th Sept	
Oct	2nd Interculture and Watering	3 days	15th Oct	Before temperature drops
Nov	Blue Copper (Copper Oxide) Pasting on stem .	3 days	15th Nov	Prevent skin drying/bark splitting and fungal attack
Dec	Watering, Staking to the plant			Winter- low temp
Dec	Fencing Repair			Fencing Repair very critical- otherwise disaster!!
Jan	Watering, Fencing Repair			Every 15 days
Jan	Training 3- Interculture, Watering, Repair Fencing, Basin Preparation		30th Jan	One Day Module
Feb	Watering			Every 15 days
Mar	Mulching with Karanj, Neem dry Leaves			Look out for Karanj dry leaves fall, acts as termicide
Mar	Watering			Every week watering from March onwards
Mar	3rd Interculture (DAP, Potash) and Watering, Basin Preparation, Mulching	3 days		Good effect on plant's growth if ensured, ensure watering every week and interculture
Mar	Growth hormone- Multinol	1 days		If effect is not seen after interculture 3, one flush in summer in plant now should be seen
Apr	4th Interculture and Watering, Mulching	3 days		Good effect on plant's growth if ensured, ensure watering
May	5th Interculture and Watering, Mulching			Only if sufficient water available/optional

ACTIVITY CALENDER FOR 1-3 years

January	• Spray insecticide for ***mealy bug*** control (sevin) • Fence repairing • Staking • Irrigation • Manual removal of diseased and insect infested leaves and branches
February	• Deflowering by pinching flowers • **Punning** (disbudding) • Application of termicide (Biflax TC) • Spray of Systemic insecticide • Mulching with leaves
March	• Interculture • Fertilizer application in ring full dose of P and K, 1/3 of nitrogen • Irrigation twice in a week • Deflowering • Mulching with leaves • Application of termicide (Biflax TC) • Spray of Systemic insecticide for ***Leaf gall***
April	• Application of termicide (Biflax TC) • Irrigation • Spray insecticide for ***mealy bug*** control
May	• Application of termicide (Biflax TC) • Irrigation • Spray insecticide for ***mealy bug*** control
June	• Interculture
July	• Foliar spray of Micronutrient • Training and pruning (Central opening) • Application of fertilizer • Spray of Systemic insecticide for ***Leaf gall*** • Lime application @ 3kg/meter square at three years interval
August	• Spray the leaves with fungicide (Saaf / Companion / sixer)) • Spray sevin for ***shoot tip borer*** management
September	• Spray the leaves with fungicide • Spray sevin for shoot tip borer management • Application of termicide (Biflax TC)
October	• Weeding or interculture • Fertilizer application • Application of termicide (Biflax TC) • Spray the leaves with fungicide • Spray of Systemic insecticide for ***Leaf gall***
Nov	• Overall follow up • Intercrop management
December	• Blue copper pasting @ 2gm/lit water to prevent from pathogen attack • Termicide application(Biflax TC) • Spray insecticide (sevin) for mealy bug management • Spray of fungicide(Saaf / Companion / sixer) • Irrigation • Manual removal of ***shoot gall psylla*** • Manual removal of diseased and insect infested leaves and branches • Cover young plants with thatch to prevent from frost injury

ACTIVITY CALENDER FOR BEARING MANGO ORCHARD

4th year onward

January	• Spray insecticide for ***mealy bug*** control (sevin)/management of scale insect • Fence repairing • Staking • Stop irrigation for flower bud initiation • Manual removal of diseased and insect infested leaves and branches • Management of hopper – Spray insecticide (Endocel/Regent/Confidor) • Spray of fungicide for powdery mildew control (Kawach/thiovit) • Zinc and boron spray (albore/agribore and Zinc sulphate 2-3 gm/lit of water
February	• Stop irrigation for flower bud initiation • Spray of fungicide for powdery mildew control • Management of hopper – Spray insecticide (Endocel/Regent/Confidor) • Application of termicide (Biflax TC) • Spray of Systemic insecticide • Mulching with leaves
March	• Interculture • Fertilizer application in ring full dose of P and K, 1/3 of nitrogen • Irrigation twice in a week • Spray of fungicide for powdery mildew control • Mulching with leaves • Application of termicide (Biflax TC) • Spray of Systemic insecticide for ***Leaf gall*** • Application of planofix @ 9ml/15 lit of water
April	• Application of termicide (Biflax TC) • Irrigation • Spray insecticide for ***mealy bug*** control • Thinning of fruit
May	• Application of termicide (Biflax TC) • Irrigation • Spray insecticide for ***mealy bug*** control • Application of fungicide for shooty mould control • Installation of pheromone trap (Nomate capsule) • Spray of .2% sevin one month before fruit maturity for fruit fly management • Spray Blue copper @ 3g/lit of water or kawach @1g/lit of water for anthracnose management
June	• Interculture • Bagging Of fruits • Harvesting • Desaping • Fruit treatment with ethylene for uniform colour development and ripening • Packaging
July	• Foliar spray of Micronutrient • Training and pruning (Central opening) • Application of fertilizer • Spray of Systemic insecticide for ***Leaf gall*** • Lime application @ 3kg/meter square at three years interval • Harvesting • Desaping • Fruit treatment with ethylene for uniform colour development and ripening • Packaging • Pruning • Cutting bearing shoots
August	• Spray the leaves with fungicide (Saaf / Companion / sixer)) • Spray sevin for ***shoot tip borer*** management

September	• Spray the leaves with fungicide • Spray sevin for shoot tip borer management • Application of termicide (Biflax TC)
October	• Weeding or interculture • Fertilizer application • Application of termicide (Biflax TC) • Spray the leaves with fungicide • Spray of Systemic insecticide for ***Leaf gall*** • Intercropping
Nov	• Overall follow up • Intercrop management
December	• Blue copper pasting @ 2gm/lit water to prevent from pathogen attack • Termicide application(Biflax TC) • Spray insecticide (sevin) for mealy bug management • Spray of fungicide(Saaf / Companion / sixer) • Irrigation • Manual removal of ***shoot gall psylla*** • Manual removal of diseased and insect infested leaves and branches • Prevent plants from frost injury

Package of practice for improved Pigeon pea cultivation

PRADAN has been instrumental in introducing improved methods to small and marginal farmers in the rural poverty pockets of eastern and central regions of India. The focus has been mainly on cereals such as paddy and wheat. Pigeon pea is one of the important food grains for tribal households in the central region in India. Improved principles have been creatively adapted to suit the cultivation practices for pigeon pea, making it possible to produce 3-4 four times more crop than with farmers' traditional practices.

This manual has specific steps for cultivating pigeon pea with improved methods. It should be useful for both farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves with their available resources and to gain more financially.

Advantages of Pigeon pea cultivation

Pigeon pea is an important source of food protein, generally grown under low input and risk-prone marginal environments with repeatedly low and unstable yields. With the continuously growing population, the protein availability in the poorer pockets of the country is less than one-third of its normal requirement and stagnation of yield, the protein availability to the masses is likely to decline further. As cererals are given importance in the context of a developing nation, pigeon pea can be cultivated on the uplands as a cash crop. With unstable yields and high market demand, this crop can prove to be economically beneficial for smallholders with uplands. It has longer storage potential and has proven to be beneficial for increase in soil fertility.

Present constraints in cultivation of pigeon pea

The current yield of pigeon pea from a hectare of land is about 1.1 tons in Odisha, which has almost half the yield achieved in Bihar. This stems from various issues such as:

- Use of low quality seeds;
- improper crop management practices;
- very high plant density;
- erratic rainfall and sunshine;
- lack of awareness about soil nutrient management;
- cultivation in low productive land;
- lack of care during pest and disease attack.

Selection of land and soil

Tolerates a wide range of soils, from sands to heavy black clays. Tolerates a wide range of pH, but the most favourable range is pH 6.5 to 8.0. It does not grow well in saline soil, but can withstand drought reasonably well.

Climate

This plant is very heat-tolerant with preferably hot moist conditions. The plant grows at temperatures above 35°C under adequate soil conditions of moisture and fertility. It does not tolerate frost, but will grow in temperatures to just above frost level.

Seed variety and seed rate

There is no specific preference for using any particular variety of millet seed, but it is always better to start with newer seeds rather than use older ones. Various varieties that are being used in the area now are: Maruti, Asha etc. One acre of land requires about 4 to 4.5 kg of seeds for sowing.

Land Preparation

Land preparation for pigeon pea requires at least one plowing during the dry season followed by 2 or 3 harrowings. The "summer" plowing helps in minimizing the weed flora and to conserve moisture. Well-drained soils are necessary for good root and nodule development. Contour beds or a ridge-and-furrow system are useful in preventing water logging by draining excess surface water, and in preventing soil erosion. Organic manure may be applied during the last harrowing along with 100 kg of Single Super Phosphate (SSP), 14 kg of Murate of Potash (MOP), 17 kg of Urea may be applied. In acidic soils 2-4 t ha-1 of lime or dolomite is incorporated 3-4 weeks before sowing to neutralize the acidity. In light soils, a basal application of Aldrin 5% dust @ 30 kg ha-1 prevents termite infestation.

Sowing Time

In the rainfed and dry areas pigeonpea are sown with the onset of the monsoon. Earlier sowing gives higher yields in India. When sowing extra-early and early-maturing varieties in the 1st fortnight of June, the field is available for post rainy season crops by the end of November. Therefore, sowing should not be delayed beyond June.

The sowing of medium and late-maturing varieties, under rainfed conditions, should be done during June or July at the onset of the monsoon. This should be preferably before the 2nd week of July. Late sowing causes considerable reduction in yield due to photoperiodicity and excessive soil moisture stress which coincides with the reproductive growth The post rainy season sowing in India should be done in September. In sowings later than 15 October, yields drastically decline

Seed treatment with *Bijamrita* -- A natural solution for effective protection against pest, diseases and fungi: Wrap 5 kg of cow dung in a large cloth and bind it with tape. Put it in 20 litres of water for up to 12 hours. Take one litre of water and add 50 gm of lime to it and let it stabilize overnight. Next morning, squeeze all of the liquid in the bundle of cow dung out of the bundle and into a bucket, compressing it at least thrice, so as to collect a concentration of cow dung. Add a handful of soil to this liquid solution and stir it well. Then add 5 litres of cow urine or human urine to the solution and add the lime water, stirring all together, making what is called *Bijamrita*. Spread this solution on the seeds of any crops, treating these seeds well by hand, drying them well, and using them for sowing. The micro-organisms and nutrients added this way will make the seedlings that emerge more vigorous.

Seed treatment with chemicals

20 ml of Rhizobium and Phosphobacterin should be addedwithn water to treat one kg of seed. 5 gm of Trichoderma may be mixed with a kg of seed to increase immunity against pest and disease attacks

Spacing between plants

Plant spacing depends on maturity duration and cropping system. The spacing between the plants should be 2 feet each and row to row difference should be maintained at 2.5 feet.

Seed sowing (Sole, Intercropping)

Weed Management

Pigeonpea is a slow-growing crop and mostly cultivated during the rainy season. The crop suffers from early weed infestation. Therefore, it is necessary to keep the crop weed-free during the early growth period (4-6 weeks). This should be done mechanically and if possible, it should be incorporated into the soil for making nutrients available for the young plant. Remove any weeds by hoeing with a cycle hoe or with a hand weeder in between the rows. This removes unwanted weeds and also aerates the soil, helping the plants to grow faster.

Nipping

Preparation and application of Jeevamrita

Ingredients (for 1 acre)

Water - 200-250 litres

Cow dung - 10-15 kgs

Cow Urine - 3-4 litres

Jaggery - 1-2 kgs

Soil under a tree or un-disturbed location from the same land - 2-3 handfuls

Mix all of them and keep them in a shade for 3-4 days. Stir the mixture once a day. Apply the mixture when the ground is wet for the plants. This is an excellent culture for enabling the exponential increase of beneficial microbes. During the time of flowering and milking apply 250 gm of Jeevamrita per plant. The solution should 1:20 for Jeevamrita and water respectively.

Pest and disease management

Pod Borer (*Helicoverpa armigera*)

This is widely distributed and is the most injurious pest of early and medium maturing varieties. The larvae, after hatching, feed on tender leaves and twigs, but at pod formation they puncture pods and feed on developing grains. The caterpillars are green with dark brown, grey lines along the sides of the body.

Control Measures

Summer ploughing to expose the hidden stages of the pest to natural predation.

- Installation of Harmigera pheromone traps at 3-4traps /acre.
- Fixing of bird perches with branched tree twigs to attract predatory birds for insect predation. Sow redgram mixed with pundi or local sorghum for attracting birds.
- Hand collection of grownup larvae of the pod borer by manually shaking the plants and dislodging them.
- First spray can be taken up with Thiodicarb 75 WP 0.6 g or Profenophas 50 EC 2 ml or methomyl 40 SP 0.6 g per litre of water to control eggs
- Second spray with spraying of 5 per cent neem seed kernel extract
- Third spray with viral pesticide, HaNPV at 100 LE /acre along with 0.5 per cent jaggery and 0.1 per cent boric acid.
- 

Severe infestation

If the infestation is severe, new insecticide molecules like 0.3 ml indoxacarb 14.5 SC or 0.1 ml spinosad 45 SC or 0.75ml Navaluron 10 EC or 2.5ml chlorpyriphos 20 EC can be applied. For one hectare area around 500 litres of spray solution is recommended.

Selecting and storing the seeds for future use

It is wiser to store seeds to use for the next sowing/ season. To identify good seeds, locate the healthy plants and areas of the field. Allow 7 to 10 days more for the plants to mature its seeds. After harvesting the seeds keep the seeds under the open sky for 2 to 3 days to absorb heat during the day and moisture during the nights. When the pod opens up after 4 to 5 days, harvest the seeds. Clean the seeds by removing dust and particles, to check the quality of the seeds put between your teeth and test the firmness which will give a sound. From these seeds select heavier and bigger seeds to be used for next season / sowing.

Keep the seeds either in an earthen pot or polythene, to keep away moisture from the seeds, put the seeds under sun in every 40 to 45 days. Never keep the pigeon peas seeds near stored paddy or near the kitchen and smoke. Sand can be mixed with seeds to soak extra moisture from the seeds. Put dried *Begana,* bottle gourd, lemon leaves and ash (all about 250 gm) with the seeds to avoid pest and disease attacks.

Cost Estimates for cultivation of pigeon pea on one acre of land

Item	Unit	Quantity	Cost (Rs)
Seed	kg	4	320
Manures and fertilisers:			
Lime/Dolomite	kg	320	1280
FYM/ Vermicompost	Cartload	4	
SSP	kg	100	1000
MOP	kg	16	160
Urea	kg	17	170
Micronutrient foliar Sprayer	ml	500	200
Rhizobium and Phosphobacterin	gm	200	30
Plant protection chemicals:			
Chloropyriphos for termite control.e.g.(Dursban)	ml	1000	500
Carbendazim for seed treatment e.g Bavistin	gm	10	7
Systemic inseticide for controling pod fly e.g Fipronil (Regent)	ml	250	500
Rimon/for Pod borer Management	ml	250	300
Pheromon traps for Pod borer motitoring	Traps	5	125
Labour			

Item	Unit	Quantity	Cost (Rs)
Tractor for 3 plough	Hours	2	1400
Sowing	Persondays	5	500
Weeding and Interculture	Persondays	20	2000
Harvesting	Person days	10	1000
Thrasing & storing	Person days	10	1000
Pesticide application	Person days	5	500
Cost total:			
			10992
Revenue:			
Grain Yield	kg	500	30000
Revenue total(Rs)			19008
Rhizobium amd Phosphobacterin are mixed with seed with cold Rice gruel (Maand) just before sowing			
Spacing based on duration of variety. Short duration spacing should be 30 cm Plant to plant and 45 cm row to row.			

Package of practice for backyard poultry

In the tribal dominated areas, it has been observed that agriculture (settled or shifting) and livestock found to be two most important livelihood sources of most of the families. Further it is found that the families who have managed to live a comparatively better life do earn substantially either from agriculture or from livestock sector alone or from both.

Small ruminants especially backyard-poultry birds, Sheep and Goat has been the most significant contributor to the livelihoods of poor and marginalized rural families of society, especially women in large part of our country. These ruminants not only enhance their food security but also act as a liquid cash to meet most of their cash flow needs including emergencies. The poorer is the family higher is its relevance in their life. That is why probably Poultry birds are called the poor women's ATM and goats are called poor women's cow. While income from agriculture activities is more controlled by men, both practice and income in small ruminants-based livelihoods is largely found to be under control of women.

Thus any development strategy aiming to address/redress income poverty in these areas need to have due consideration to small-ruminant based livelihoods promotion along with agriculture in an integrated manner. Further it should be promoted as a large scale income generation intervention considering its potential and significance to most of the poorer families in the area including women and destitute.

PRADAN's Experience:

PRADAN with its mission to promote livelihoods of poor rural community has been continuously engaging in promoting small holder livestock-based livelihoods with poorer community. The followings are two distinct learning experiences which collectively provides a way forward to in promote small ruminant based livelihoods promotion strategy to address poverty issues of rural poor.

Objectives

- Provide robust livelihood option to marginal and landless rural families
- Enhance income of Rs.15,000 – Rs. 25,000 per annum per families
- Promote producer's organization to ensure availability of livelihood services to rural women sustainably

Criteria for area and beneficiary selection

- Villages in contiguous patch with all weather connecting road
- Poultry shed plots should be 20 meter away from home, at higher elevation to facilitate proper drainage and aerated
- Rearers (women) in her working age (18-45), preferably from SHG having small land for shed
- Physically challenged or women headed family will get the priority

Indigenous poultry birds which scavenge around for food around a backyard are an important part of the households in many parts of India. This is more evident in the eastern and central states such as Odisha, Jharkhand, West Bengal, Chhattisgarh, and Madhya Pradesh. The birds fulfil the protein requirements of the family, further in some societies the birds are culled during festive occasions. As the indigenous poultry birds do not produce large quantity of eggs, the rearers find it financially beneficial to hatch the eggs and sell the young birds at a premium. As there is no cost involved for these birds who feed on their own, it acts as a safety net for poor smallholders. The eggs, young live birds, and selling meat provide extra income for the household.

Shed for the birds

The birds need a shed for safekeeping during nights, and when needed. In some places, the shed is made with locally available materials such bamboo, wood, and soil. The birds scavange around in the day time and return to the shed in the evening. The shed is important as it protects the birds from predators and wild animals. The older birds are kept on a elevated shelf (*Bhadi* in Odia), above the younger birds on the ground. Efforts should be ensured to make the place clean and dry. The birds can be kept in a bamboo container, which makes it easier to transfer the birds when needed.

Construction of the poultry shed

- The shed should be prepared with the locally available wood and bamboo;
- The shed should be prepared such that it protects the birds from heat, rain, and storms. However, it should be well ventilated;
- In order to keep the shed clean, the door must be wide enough for this;
- A bird needs an area on one square feet, overcrowding should be avoided.

Shed for birds for laying eggs

A clean and dry place is required for birds to lay their eggs. A bamboo container or a used paper carton can be used for such purpose; clothes, paddy straw, or leaves can be used to provide warmth to the birds for laying eggs. The above materials prevent the eggs to break. Each bird needs a place of their of own to hatch the eggs. These sheds should be placed in a palce which should be free from external dangers and predators.

Upkeep of the sheds

The sheds should be cleaned at a regular interval; this can be once a week which prevents the birds from many diseases. The bushes near the shed should be cleared in order to keep the snakes away from the shed. Applying ash or lime on the floor of the shed reduces the infestation of lice and teaks. The shed should be constructed adjacent to living wall to prevent theft and predation. The bird droppings can be used as organic manure, which increases the productivity many a times.

Food and water

The indigenous birds scavenge around for their food requirements; they eat green grass, insects and cereals. The birds get enough cereals during the harvesting season. These birds require some protein or other food during the other parts of the year.

Farmers generally give rice polish, rice bran, and uncooked vegetable extracts to the birds. These kind of food must not be stale in nature and should be provided in a designated place. The food should be given at aplace where they can be protected from thieves, dogs, eagles, and other predators. The flock size should be reduced during the period where there is scarcity of food. When needed the food should be given at the farmer's own premises to avoid skirmishes with neighbours.

Younger birds get little food when they go out for scavenging, hence it is recommended that they should be provided with the food iniside the house/ shed only. These young ones can be provided with rice bran, rice polish, powdered maize, and clean drinking water. After hatching the young birds should be fed until they attend the 21^{st} day.

Termites are a good source of protein for the birds. Torn clothes, gunny bags, vegetable extracts can be kept on a mound so that the termites can grow fast and the birds can feed on them.

A mature birds requires 75 grams of extra food apart from the food they eat while scavenging, also they require 200 ml of fresh water daily. Water requirement goes up during the summers. The pot where water is given should have a large opening which is easily available in the rural areas.

Egg hatching

Birds start laying eggs, when they are 6 to 7 months old. A single bird lays about 10 to 12 eggs at a point of time (3 to 4 times a year). To hatch the eggs, the mother bird sits on the eggs for 21 days. At that point of time, the bird goes out for food and water for very little amount of time. Hence, at that point food and water should be provided near the bird.

The growth and productivity depends upon the warmth provided during the first 3 to 4 weeks after the birds come out of their eggs. A mother bird can provide warmth to about 10-15 chicks at a time. If the number of chicks is more, then artificial heating can be provided by lighting a bulb.

While removing the eggs, make sure that the mother bird is not around and should be done when it is dark(night or evening). Always leave an egg behind, so that the mother bird keeps laying the eggs. Only fresh and fertile eggs should be hatched and the rest can be removed. For quality breeding two roosters are required for 12 to 15 hens. A healthy bird lays about 12 to 15 eggs and hatches about 10-12 eggs.

Light test of the eggs

In order to test the growth of the embryo inside the egg, a light test helps determine whether to keep the egg for hatching or remove it for adequate heating. When the motherbird starts hatching the eggs, after 6 to 8 days if the egg is placed before the light of a candle, torch light or electric bulb; the blood vessels and embryo can be seen inside the egg. The eggs which does not have any embryo can be removed and consumed. After 17-18 days another examination would determine if the embryo is dead or alive (blood vessels attached), and the dead ones can be removed.

Storing the eggs

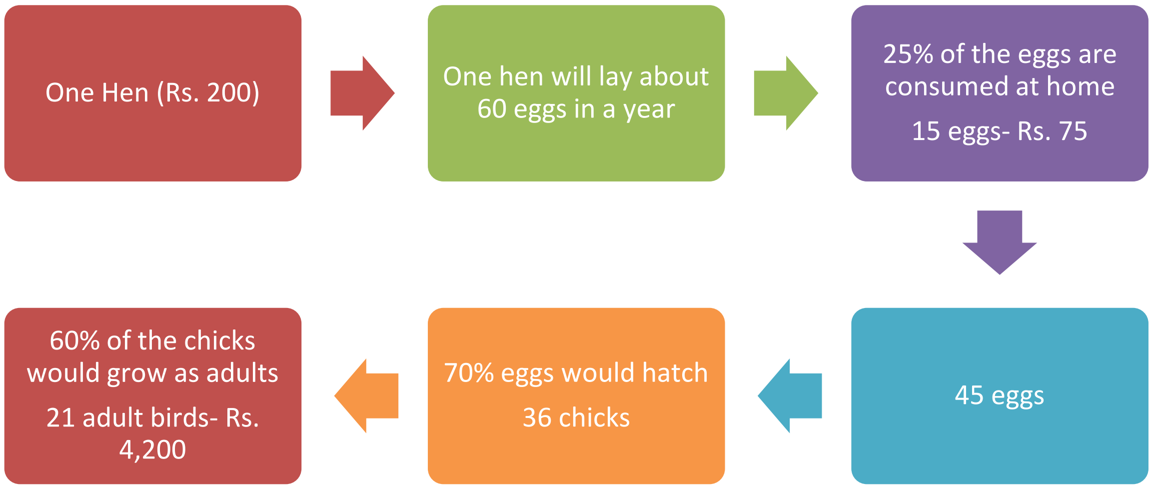
If the bird has not sat on the eggs for hatching, the eggs can be used for consumption. As suggested earlier, the eggs which does not have an embryo can be used after conducting a light test during 6^{th} to 8^{th} day after laying of the eggs. The eggs should be stored at a cold, dry place with enough insulation. If putting in a carton, layers of paper and clothes should be given for safekeeping of eggs. The broken eggs should be boiled to the optimum for consumption. Stale eggs float on water, and hence are unfit for consumption. For longer shelf life the eggs can be kept in a refrigerator or oil can be applied on the shell. Before consumption the eggs should be cleaned and washed properly. However, the eggs should never be washed and cleaned while storing, which shortens the shelf life.

Role of women in backyard poultry

Most of the chores related to backyard poultry is undertaken by the women. This includes taking care of the bird while hatching, storing and placing the eggs, feeding and providing water, and putting the birds in the night in the shed. Male are involved only when eggs or the bird is sold. However, the money earned from this is used for household expenses and makes the women self-sustainable.

Financial side of backyard poultry

Many of the household expenses is met by selling eggs, and meat; however the activity is considered as non mainstream (***anakruta***). As this activity is continuous, a certain flock should be maintained and extra birds should be sold in the market. Selling the entire flock at one go should be avoided.



Poultry diseases and management

COMMON VIRUS DISEASE OF POULTRY

Ranikhet disease, also known in the West as Newcastle disease is a contagious and highly fatal daises of flows. In spite of the notable work done towards its control, this disease still ranks as one of the most serious virus diseases of poultry. The disease occurs in almost all countries and usually assumes a server form affecting birds of all ages. Mortality in flows varies from 50 to 100 per cent.

Ranikhet disease is largely a disease of flows, but it also effects turkeys, pigenosn, grows, ducks, geese, koel pheasants, guinea-flows, partridges and doves. hedgehogs have been suspected as reservoirs of the disease. The disease is also suspected to cause conjunctivitis among laboratory workers and persons handling infected birds.

Symptoms

The symptoms vary according to the age of the affected birds. The first symptoms usually observed in young birds are sneezing, gasping and often droopiness. It is in this stage of the disease that the manifestations rather closely resemble those of infections bronchitis. Within a short time after appearance of respiratory symptoms, deaths occur in a flock in quick succession and in increasing numbers from day to day.

Among growing birds and in adult sudden deaths occur in a dew instances, and are followed by a number of birds showing respiratory symptoms. The affected birds are full and depressed with ruffled feathers. These symptoms are accompanied by diarrhea, characterize by the passing of a watery stool with an offensive smell. There is profuse salivation. The saliva often accumulates in the mouth and obstructs respiration, which results in the production of gurgling disused birds may be soft - shelled and deformed. In turkeys the disease runs a very mild course. In adults, in particular, it may pass unnoticed except for some dullness, loss of appetite and other minor symptoms.

Treatment and Prevention

At present there is no effective treatment of any value. Proper housing and general good care are indicated in an effort to shorten the duration and severity of the infection.

An early recognition of the disease and application of struck sanitary measures are of great value in the control of the disease. Some important measures for its prevention are ; slaughtering of all apparently ailing birds, segregating of in - contact in group of 10 to 15 each; removal of all infective materials such as droppings, residues of poultry cleanliness ; and provision of separate attendants for each group of birds.

The poultry farm should be at a distance from place of traffic. All newly purchased birds should be kept in segregation from not less than 10 days before taking them into the farm. The poultry runs should be ploughed from time to time and lime applied thereon as a general disinfectant. As far as possible the pens and runs should be made inaccessible to free - flying birds by providing a barrier of wire - netting.

Control

Control of Ranikhet diseases can be effect with judicious application of sanitary and vaccination measures. The possibility of entry and spread of infection is considerably reduced through the maintenance of flock on deep little system and stopping all unauthorized entries, even of human beings, into the battery brooders. Disposal of fowl carcasses by burning or deep brutal to reduce the scope of carrion-eating birds like crows, kites and vultures perching near fowl pens or poultry farms helps to resume the hazards of this infection. Two types of vaccines are available in India, one for the adult birds an another for younger birds or body chicks. The virus strain for Ranikeht disease vaccine used for adult birds age over weeks was evolved at the Indian veterinary Research Institute. The vaccine consists of freeze - dried virus grown in chick embryos. Vaccination of birds 6 weeks old and above confers immunity for 1 to 3 years. Care should be taken to vaccinate bird's not carrying heavy coccidian infection. Birds with heavy worm infection or coccidiosis are not protected even with a good vaccine. There are sometimes complications side reactions following vaccination. There are sometimes complications side reactions following vaccination with 'Mukteswar' strain of Ranikhet disease vaccine. These consist on inco-ordination of limbs and sometimes paralysis in 1 to 3 per cent to the vaccinated birds. The reactions may become more acute if the birds are affected with roundworms, coccidiosis or are weak on account of malnutrition.

Vaccination programme for layer type chicken

Age	Disease	Vaccine	Route
1. 1 day	Marek's	HVT vaccine	I/M
2. 5-7 days	RD	Lasota/F	Occulonasal
3. 10-14 days	IBD	IBD Live	Drinking water
4. 24-28 days	IBD	IBD Live	Drinking water
5. 8th week	RD	R2B/RDVK	S/C
6. 16-18 week	RD	Killed/Live	S/C

(Source: www.vuatkerala.org)

Fowl Pox

- Fowl pox is a common, slow spreading, widely prevalent, contagious viral disease of poultry.
- This is characterized by wart like growth over the non-feathered parts of skin and mucosa of the upper respiratory and digestive systems.
- Disease affects birds of all ages.
- Economically very important as it can cause poor weight gain, drop in egg production in layers and mortality.
- It has no zoonotic importance.

Causes

- Disease is caused by an avipoxvirus, which is relatively resistant to common disinfecting procedures and can survive in dried scab for years.

- Virus does not penetrate intact skin. Some break in the skin is required for the virus to enter the epithelial cells, replicate and cause disease.
- Disease spreads mechanically through direct contact, where contaminated materials soil the abraded/lacerated skin, by mosquitoes and other biting insects.
- In a contaminated environment, aerosols (droplets) generated from feather follicles and dried scabs carry the virus and spread the disease.
- It can be transmitted by the respiratory tract.
- During vaccination, the individuals may transfer the virus from affected to healthy birds.
- Deposition of virus in eyes, through lachrymal duct it goes to larynx and causes upper respiratory tract infection.
- Disease is frequently observed during rainy and winter seasons with persisting overcrowding and unhygienic conditions.
- Disease remains a problem for a long time, in farms where multiple age birds are maintained, even after preventive vaccinations.

Clinical symptoms

- This disease is manifested clinically in one of the two forms, cutaneous or diphtheritic or both.
- Poor weight gain and drop in egg production in layers is always significant.
- In cutaneous form (dry pox), lesions in the form of scab appears on the comb, wattles, eyelids, external nares, corner of the beak and other non-feathered parts of the body.
- Lesions on eye may affect the bird's vision or close both eyes affecting the ability of the bird to reach feed and water leading to starvation and deaths.
- Papule —> vesicles —> pustules —> crust/scab —> scar formation.
- In cutaneous form, flock mortality is usually low rarely exceeding 25%.
- In diphtheritic form (wet pox or fowl diphtheria), initially small nodules are formed on the mucous membrane of mouth, oesophagus and trachea.
- Later on, these nodules become yellow cheesy in nature, thereby, forming a diphtheritic membrane on these organs causing obstruction, interference with feeding and difficulty in breathing with mortality up to 50%.

Gross lesions

- Lesions initially start as nodular area with blanched appearance (papule)
- It becomes enlarged and yellowish (pustules) terminating into thick, dark scab.

Prevention and control

- Two types of vaccines (pigeon pox and fowl pox vaccines) can be used for vaccination.
- Pigeon pox vaccine is less pathogenic and can be used on chickens at any stage by wing web method and it produces immunity for 6 months therefore revaccination is required.
- Fowl pox vaccine produces solid immunity, usually carried out at 6-8 weeks of age by intramuscular route or wing web method.
- Successful or effective vaccination can be judged by takes, where examination of vaccinated birds after 7-10 days of vaccination, show swelling or a scab at the site of puncture or vaccine application.

- Absence of takes indicates poor potency of the vaccine, presence of maternal antibodies and improper vaccination.
- In such cases, revaccination with new batch/ lot of vaccine should be done.
- During disease outbreak, affected birds if less than 30% should be segregated immediately and the remaining birds must be vaccinated at earliest possible.
- Standard sanitation and strict biosecurity measures can control the fowl pox.
- Disinfection of premises with sodium hydroxide (1:500), cresol (1:400) and phenol (3%) proved beneficial in control of fowl pox.

Deworming
Birds should be dewormed starting from one week prior to R2B/RDVK vaccination and repeated at 3-week intervals so as to give a total of 4 dewormings before housing at 18 weeks of age. Piperazine compounds, albendazole, mebendazole etc. can be used against round worms. Against tape worms, Niclosamide, Praziquintel, Albendazole can be used.

While medicating through drinking water, it should be done by mixing the required quantity of medicine in the quantity of water that chicks normally consume in 4 hours time (say approximately 6 litres per one hundred, 6 week-old chicks, per day). Additional water should be given only when all the medicated water is consumed by the chicks.

Ectoparasites

The birds should be dusted or dipped and houses fumigated as soon as there is indication of ectoparasites. The following may be used for dusting and dipping. Dipping should be avoided on rainy days. Head dipping has to be avoided.

1. Tick tox – synthetic pyrithrine compound. Dose – as per manufacturer's instructions
2. Butox – Deltamethrin compound. Dose – as per manufacturer's instructions

In addition to these, general measures of sanitation such as keeping young stock away from adult stock, keeping the poultry houses and equipments clean, prohibiting visitors into the poultry house, proper disposal of dead birds, prevention of entry of rodents and other birds into the pen and periodical culling will greatly help in checking diseases.
(Source: Dr.Acharya, Handbook of Animal Husbandry)

Disease Management

Disease, etiological agent and species affected

Pullorum disease -(*Salmonella pullorum*)
Important symptoms
Chicks hatched from infected egg, moribund or dead chick may be seen in the incubator. Sometimes disease is not seen for 5-10 days. Peak mortality during second or third week. Affected birds may exhibit a shrill cry when voiding excreta, which is white or greenish brown. Infection spread within the flock for a long time without any distinct signs. Reduction in egg production, fertility and hatchability.
Specimens to be collected
Ailing bird or freshly dead birds, or spleen, liver and intestine on ice from dead birds.

Diagnosis
Isolation and identification of organism from diseased birds, whole blood agglutination using coloured antigen (not for turkey), tube agglutination test, ELISA, post mortem lesions. In adult, abnormal ovary with misshapen, discoloured ova, pedunculated with thickened wall.

Control / Treatment
No treatment is likely to effect complete elimination of carrier from infected birds.
Sulphadiazine, Sulphamerazine, sulphapyrazine, Sulphamethazine are the most effective in chicken (not in turkey poults). Furazolidone is effective. Also chloramphenicol, colistin and apromycin are effective. No vaccination practised and all positive birds may be disposed off by slaughter. Birds recently vaccinated

with *S. gallinarum* (9R) may give low titre. Since Tran ovarian transmission of organism is there, only eggs from salmonella free flock should be used for hatching.

Extra

1. There is no entry or exit barrier. That means anybody including the poorest families irrespective of the initial stock size can avail this service and benefit . Similarly one can also decide to exit out of this service at any time.
2. The return to investment is very high. The cost of vaccination and de-worming of poultry birds and shoats is very minimal in comparison to the benefit potential of the same.
3. The investment is relatively also very low. Whether it is the initial investment or the cost of services, both are very low and can be easily affordable even by the poorest section of community including destitute.
4. The result is clearly visible and efficacy of the services can be easily traced. The outcome of vaccination and de-worming can be easily verified within a very small time period. It is not very complex. It does not required high education or exposure and thus can be easily understood by poor as well as illiterate community.
5. It can cover a large number of families simultaneously and can cover each and every family in the area. This way it can strengthen village collectiveness.
6. It can be initiated at any time of a year. Thus provided flexibility in term of initiating the program whenever community gets ready to start as poultry and goats are already kept by the fe/male farmers.
7. It is relatively very low risk proposition. Thus it is suitable to poorest section. It is not affected by natural calamities largely.
8. This will also contribute towards the nutritional security of poorer families.
9. Because of high liquidity nature of poultry birds and shoats a poor family can rely on it to meet any sort of its emergency needs.
10. Usually women look after the poultry birds and shoats in a family and thus have fair say or control on the income from these assets.
11. This program can be administered in any rural area whether hilly tribal pockets or plain areas and do not require high technical expertise to execute.
12. The investment in the program per family is very low and thus can be easily supported by existing government programs(by making a project investment of about Rs 15 lakhs we can support about 5000 families)
13. Project establishment period is comparatively low. i.e. a two year project can establish a sustainable system to cater the livestock service system in an area in long run.
14. This would further strengthen the efforts of animal resource department by the way of grooming and availing village level cadres who will bridge the gap between community and the department.
15. This intervention will make community more aware about health issues of their own as well as of their children.

16. Through this project a number of village youths including women can be engaged as entrepreneurs in the locality and can make decent earnings of about Rs 1500 to Rs 2000 per month throughout the year spending about 10-15 days in a month while continueing to operate from their home without getting disengaged from existing livelihood activities.

Cultivation of Tomato, Eggplant, and Chilly in 0.05 acre (5 decimal) of land

PRADAN has been instrumental in introducing improved methods to small and marginal farmers in the rural poverty pockets of eastern and central regions of India. Vegetables such as tomato, chilly, and eggplant etc. are important source of nutrition for tribal households in the central region in India. Most of the households in the region are involved in cultivation of such vegetables. PRADAN has been trying to improve the productivity in such crops by providing technical inputs and proper management methods. These improved principles have been creatively adapted to suit the cultivation practices for the vegetables, making it possible to produce 3-4 four times more crop than with farmers' traditional practices. Most of the vegetables, being short duration crops, fit very well in the intensive cropping system and are capable of giving very high yields and very high economic returns to the growers besides providing better health standards to the people.

This manual has specific steps for cultivating vegetables with improved methods. It should be useful for both farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves with their available resources and to gain more financially.

GENERAL DESCRIPTION

These three vegetables are known as fruit vegetables. All of these are warm season crops, and may be grown in controlled conditions which maintain an optimum temperature, and can be grown almost all the year round in milder climate like that of peninsular India.

Tomato is one of the most popular and widely grown vegetables in the world. Tomatoes were introduced in India by English traders of East India Company in 1822. Today, around 10 million 5tonnes of tomatoes are produced in the country with Uttar Pradesh, Karnataka, Maharashtra, Punjab and Haryana being the major producers. The fruits are used as salad, cooked as well as processed for soup, juice, ketchup, puree, paste and powder.

Egg plant is one of the most common and popular vegetables in India. A number of cultivars of this indigenous vegetable are grown throughout the country. Consumers have varied preference over its colour, size and shape, which are cooked in various ways.

Chilli is one of the most important commercial vegetable crops of India and besides vegetable valued as spices, condiments sauces and pickles. India is largest producer of 6,07,375 ton of dry chillies. Andhra Pradesh, Maharashtra and Karnataka are major chilli producing states in India and accounting 75 per cent of the countries chili area.

CLIMATE AND SOIL REQUIREMENTS

Climate:

These vegetables are warm season crops and are very susceptible to frost. Cool nights and short summers are unfavorable to its satisfactory yields. It requires a long growing season with a high average day and night temperatures. Its seed germinates well at 25 °C temperature. A daily mean temperature of 13-21^0C is most favorable for successful production.

Soil and its Preparation:

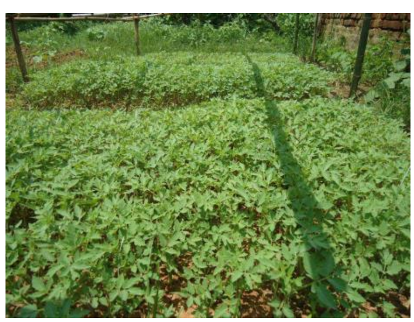
These fruit vegetables can be grown in all types of soil varying from light sandy to heavy clay. Light soils are good for an early yield, while clay-loam and silt-loam are well suited for higher yield. Loam and sandy soil of normal and higher status are best suited for vegetable cultivation. The soil should be fertile and well drained. These vegetables are very hardy crops and can be grown even in adverse conditions like in soil having high pH. In acidic soils mix 15 to 20 kg of lime in the soil, if it does not rain afterwards, irrigate the field to stabilize the pH.

Since the crop remain in the field for a number of months. The soil should be thoroughly prepared by ploughing 4 to 5 times before transplanting the seedlings. Bulky organic manures like well rotten cow dung or compost should be incorporated evenly on the soil.

Sowing Time and Seed Rate:

These vegetables can grow thrice during the year. The sowing time is May-June, August- September and December- January, Only about 5 gms of seeds (for each of these vegetables) are required to raise the seedlings for 5 decimal area.

Rising of Nursery

Block of 5 feet length, 3 feet wide and 0.5 feet (6 inches) height are prepared. Add 30 kg (2 baskets) well rotten farmyard manure in each bed; along with 50 grams of *Trichoderma* and 2 kg of vermicompost. Sow the seeds 1 cm deep in rows 3 inches apart, and maintaining a distance of 2 inches between two plants. Cover the seeds with the mixture of well rotten manure and fine soil and press it well. Cover the beds with wheat husk or clean dry grass. Do watering with fine rose-can in morning and evening. Water stagnation in bed causes damping off. Remove the water husk or dry grass after the seeds have germinated. Prior to sowing seeds are treated with fungal culture of ***Trichoderma viride*** (4 gm/ kg of seed) or Thiram (2gm/ kg of seed) to avoid damage from damping-off disease. After the break of monsoon, drench the soil around seedlings with ***Trichoderma viride*** as a precaution against damping off disease. Germination of seeds and growth of plants in nursery slow because of low temperature during November- January. The seedlings should be protected from cold winds and frost by proper covering. The small low cost poly-houses may be used to raise the seedling in the winters.

Season	**Time of sowing**	**Time of transplanting**
Kharif	2nd week of June	July-August
Rabi	End of September	October-November
Summer	2nd week of January	February

Transplanting

The seedlings are ready in 4-5 weeks for transplanting, when they attained a height of 08-10 cm with 3 to 4 leaves. Harden the seedlings by withholding irrigation. Uproot the seedlings carefully without injury to the roots. Transplanting should be done during evening hours followed by irrigation. Firmly press the soil around the seedlings. Spacing depends upon the fertility status of soil, type of verities and suitability of the season. In general 75 (2.5 feet) ×75 (2.5 feet) cm spacing is kept for non-spreading type verities and 75-90×60-75 cm for spreading type varieties. Treat the roots of the young plant with a solution of *Trichoderma* (2 gram) and water (500 ml), for two minutes. Providing staking or support of bamboo sticks to the individual plants or adopt trellises system for training tomato plants.

Irrigation

Irrigate the field as per the need of crop. Timely irrigation is quite essential for good growth, flowering, fruit setting and development of fruits. Higher yield may be obtained at optimum moisture level and soil fertility conditions. In plains irrigation should be applied every third to fourth day during hot weather and every 7 to12 days during winter. Irrigation is given before top dressing if there is no rain. The field should be regularly irrigated to keep the soil moist during frosty days.

Inter-Culture and Weed Control

The field should be kept weed-free, especially in the initial stage of plant growth, as weeds compete with the crop and reduce the yield drastically. Frequent shallow cultivation should be done at regular interval so as to keep the field free from weeds and to facilitate soil aeration and proper root development. Deep cultivation is injurious because of the damage of roots and exposure of moist soil to the surface. Two-three hoeing and the earthening-up are required to keep the crop free of weeds. Hand weeding and hoeing are done to control weeds. Black plastic mulch is also an effective method to control weeds. Black polythene mulch prevents entry of light, which restricts germination of weed seeds and growth. Pre-emergence application of Fluchloralin (75 gram for 5 decimal) coupled with one hand weeding 30 days after transplanting is effective for control of weeds. Staking is another cultural practice which helps to keep branches upright and protect from wind damage. If support is not provided, then heavily bearing branches may break.

Manuring & Fertilizer application

These vegetables require a good amount of manures and fertilizers for high yield. The fertilizer dose depends upon the fertility of soil and amount of organic manure applied to the crop. For a good yield, 10 baskets (or a cart load for 5 decimals) of well-decomposed FYM is incorporated into the soil. Generally, application of 200 kg N: 150 kg P: 150 kg K per hectare is recommended for optimum yield. Out of the total doses, 25 % of N and 100 % of P & K is applied as basal dose. Remaining 75 % of N is applied in three equal split doses. The first split dose of N is applies 20 days after transplanting. The second dose is given just before the onset of flowering whiles the third after the first picking/harvesting. The Requirement of DAP and MOP is calculated accordingly.

INSECT AND PEST MANAGEMENT

These vegetables are attacked by a number of insect pests and nematodes during various stages of crop growth in most of the tropical countries including India. The extent of losses caused by these pests depends on season, variety, soil and other factors like crop rotation.

Some of the important ones are briefly described below.

Fruit and shoot borer (*Leucinodes orbonalis*)

Fruit and shoot borers are the most destructive pest of eggplant. It also Damages potato and other Solanaceous crops. This pest is active throughout the year at places having moderate climate but it is adversely affected by severe cold. The damage by this insect starts soon after transplanting of the seedlings and continues till harvest of fruits. Eggs are laid singly on ventral surface of leaves, shoots, and flower-buds and occasionally on fruits.

The pest is polyphagous in nature. The full grown larvae are greenish with dark broken grey lines along the side of body. They measure about 35-45 mm long. The moth is large and brown with V-shaped speck and dull black border on the hind wings. The larvae feed first on leaves and fruiting bodies and later on, they bore into the fruits, completely eating away the internal contents. In young plants, appearance of wilted drooping shoots is the typical symptom of damage by this pest; these affected shoots ultimately wither and die away.

Control

- Collect and destroy the damaged tender shoots, fallen fruits and fruits with bore holes to prevent population buildup.
- Avoid continuous cropping of eggplant crop and ratooning.
- Use light traps @ 1/ha to attract and kill insects.
- Grow varieties with long and narrow fruit in endemic area.
- Spray *B. thuringiensis* var kurstaki @ 1.5 and 2 ml / lit of water.
- Avoid using synthetic *pyrethroids* as they cause resurgence of sucking pests.
- Uproot and burn old plants before planting new plants since they harbour pest and carry over infestation.
- Spray any one of the insecticide starting from one month after planting at 15 days interval. Carbaryl 50% WP 2 g/litre + wettable sulphur 50% WP 2 g/litre. Endosulfan 35 EC 2 g /litre + Neem oil 2 ml / litre. Quinalphos 25 EC 2 ml /litre + Neem oil 2 ml / litre. NSKE 5% as soon as attack is seen and repeat the spray after 15 days.
- Avoid using insecticide at the time of fruit maturation and harvest.

Similar management may be applied for Stem borers.

Aphids (*Lipaphis erysimi*)

The nymphs and adults are louse like and pale greenish in colour. This pest is very active from December to March when various cruciferous and vegetable crops are available in the fields. The damage is caused by nymphs and adults by sucking cell sap from leaves, stems, inflorescence or the developing plants. They are seen feeding in large numbers, often covering the entire surface. Owing to feeding on cell sap, the vitality of plants is greatly reduced. The leaves acquire a curly appearance.

Control

Spray the crop with Malathion (0.1%) or Endosulfan (0.05%) or Monocrotophos (0.05%)

Jassids (*Amrasca bigutella***)**

The nymphs and adults are very agile and more briskly forward the side ways. Adults are about 3 mm long and greenish yellow during summer, acquiring a reddish tinge in the winter. Nymphs and adults remain in large numbers and suck the sap from the under surface of the leaves. While feeding, they inject the toxin saliva into the plant tissues. The leaves shows symptoms of hopper burn, such as yellowing upward curling, bronzing and even drying of leaves. The crop becomes stunted and often in highly susceptible varieties it cause complete mortality of the plants.

Control

Spray Carbaryl (0.1%) or Endosulfan (0.05) or Phosphomidon (0.04%) at 10 days interval.

Root Knot Nematodes

These are the most common plant parasitic nematodes (*Meloidogyne* spp. i.e. *incognita, javanica*) in India and infestation of these nematodes is common in eggplant. The root knot nematode damage is more harmful to seedling than to older plants. These nematodes infest the roots and cause root galls. The affected plant becomes stunted and the leaves show chlorotic symptoms. Infestation of these nematodes greatly hampers the yield of the crop.

Control

- Deep summer ploughing.
- Follow crop rotation
- Grow resistant verities like Black beauty, Banaras Giant.
- Incorporate Carbofuran or phorate @ 25 kg/ ha in the soil.

Spotted beetle

- Collect and destroy adult beetle, grubs and pupae.
- Shake plants to dislodge grubs, pupae and adults in a pail of kerosenated water early in the morning or collect them mechanically and destroy.
- Spray Carbaryl 50% WP 2 g/litre + wettable sulphur 2 g/litre or endosulfan 35 EC 2 ml / litre or Malathion 50 EC 2 ml /litre.
- Emulsify 1 litre of Neem oil with 60 g of khadi soap dissolved in ½ litre of water, dilute emulsion by adding 20 litre of water, and then mix about 400 g of well crushed garlic and spray.
- Mix diflubenzuron invariably with endosulfan 0.07% or chlorpyriphos 0.05% and spray on the crop

Ash weevil

- Collect and destroy adult weevil.
- Apply Lindane 1.3 D before planting @ 25 kg/ha In endemic areas apply Carbofuran 3G @ 15 kg/ha at 15 days after planting.
- Spray Carbaryl 50 WP 3 g/litre + wettable sulphur 2 g/litre or Endosulfan 35 EC 2 ml/litre or Malathion 50 EC 2 ml /litre.

Brown leaf hopper

- Rogue out infected plants as soon as they appear in the field and completely destroy them.
- Before transplantation dip the seedlings in 0.2% Carbofuran 50 STD solution to control the insect vectors.
- Spray 4-5 g at 10 days interval with Methyl Parathion 0.5% or Dimethoate 0.3% on Monocrotophos 0.5% or Endosulfan 0.5%, which reduces the population by nearly 95% in field.

INTEGRATED PEST MANAGEMENT FOR TOMATO

Helicoverpa armigera

- Collect and destroy the infected fruits and grown up larvae.
- Grow less susceptible genotypes Rupali, Roma, Pusa red Plum.
- Grow simultaneously 40 days old American tall marigold and 25 days old tomato seedling at 1:10 rows to attract *Helicoverpa* adults for egg laying.
- Setup Pheromone trap with Helilure at 15/ha and change the lure once in 15 days.
- Six releases of T. chilonis @ 50,000/ha per week coinciding with flowering time and based on ETL.
- Release *Chrysoperla carnea* at weekly interval at 50,000 eggs or grubs / ha from 30 days after planting.
- Spray HaNPV at 500 LE/ha along with cotton seed oil 300 g/ha to kill larvae.
- Spray endosulfan 35 EC 2 ml/litre or Carbaryl 50 WP 2 g/litre or B. thuringiensis 2 g/litre or Quinalphos 2.5 ml/litre.
- Do not spray insecticides after maturity of fruits.
- Encourage activity of parasitoid *Eucelatoria bryani, Campoletes, Chelonus* etc.,

Leaf miner

- Spray NSKE 3%
- Collect and destroy mined leaves

Spodoptera litura

- Plough the soil to expose and kill the pupae.
- Grow astor along border, irrigation channel as indicator or trap crop.
- Flood the field to drive out hibernating larvae. Set up light trap at 1/ha or pheromone trap at 15/ha with pheroclin SL lure.
- Destroy egg masses and grown up larvae. Spray SlNPV at 250 LE along with teepol 1ml/litre in evening hrs.
- Spray Chlorpyriphos 20 EC 2 litre/ha or Dichlorvos 76 WSC 1 litre/ha or Endosulfan 35 EC 1.2 litre/ha or NSKE 5%, spray insecticide during evening hrs.

- Prepare poison bait with rice bran 5 kg, jaggery 0.5 kg, Carbaryl 0.5 kg, water 3 litre/ha, spread the bait in evening hrs.

Whitefly

- Uproot and destroy the diseased leaf curl plants
- Remove alternate weed hosts.
- Use nitrogen and irrigation judiciously.
- Use yellow sticky trap to attract and bill insects.
- Spray FORS 2% / neem oil 0.5% along with teepal 1 ml/litre (or) Methyl demeton 0.25% (or) Phasalone 0.7% (or) Endosulfan 0.7% along with FORS 1%.
- Apply systemic insecticide in early stage and contact insecticide in later stage for vector control.
- Apply insecticide in the early morning as adults are less active.
- Encourage activity of parasitoids Eretmocerus mesii and predator coccinellids, Brumus and Chrysoperla.

Thrips

- Collect and destroy the damaged leaves and twigs and uproot the diseased plants.
- Use yellow sticky traps at 15/ha to attract and kill insects.
- Release first instar larvae of *Chrysoperla carnea* @ 10,000/ha and encourage coccinellid predator.
- Spray Methyl Demeton 25 EC 2 ml/litre, Dimethoate 30 EC 2 ml/litre or Endosulfan 0.7% or Phosalone 0.9% to control vector.

INTEGRATED PEST MANAGEMENT FOR CHILLI

- Basal application of neem cake @ 100 kg/ha, release of Trichogramma chilonis@ 5 cc/ha on 40,47,54 and 61 DAS and T.japonicum on 67,74,81 and 88 DAS and spraying NSKE 5% at 50% ETL controlled the major pests of Semi-dry Paddy
- Neem oil 1% or neem cake extract 5% is effective in controlling chilli aphids
- Dimethoate 0.03% or neem oil 1% or neem cake extract 5% is effective in controlling chilli thrips
- Dicofol 0.03 % or Phosalone 0.07% is effective in containing yellow mites in chilli
- Ethanolic or Hexane extract of Neem Seed Kernel at 1% are effective in controlling aphids and thrips in Chilli

MAJOR DISEASES

Important fungal and bacterial diseases affecting the crops in India are as follows:

FUNGAL DISEASES

Alternaria Blight (*Alternaria spp.)*

Causes characteristic spot on the leaf with concentric rings. Affected leaves may drop off. It may also infect fruits that turn yellow and may drop off prematurely.

Control

- Follow long term crop rotation with non solanaceous crops.
- Grow resistant varieties

- Provide proper drainage
- Drench the soil with a mixture of Bavistin (0.1%)

Damping Off: (*Pythium* **spp.,** *Phytophthora* **spp.,** *Rhizoctonia* **spp.,** *Sclerotium* **spp.,** *Sclerotinia* **spp.)**

Both the Pre-emergence and Post-emergence damping-off symptoms are seen in diseased state. The germinating seeds are infected by fungi at the initial stages. The infection later spreads to hypocotyls basal stem and developing roots. The Post-emergence damping off phase is characterized by infection of the young, juvenile tissues of the collar at the ground level. The affected seedlings become pale green and brownish lesions are found at the collar region, resulting in bottling and topple over of seedlings.

Control

- Avoid over-watering.
- Drench the beds with Captan or Thiram @0.4% at 5-7 days after germination.
- Fumigate the soil with Formalin (7%) by drenching 10-15 cm deep soil.
- Give hot water treatment to seeds (52˚C for 30 minutes)
- Treat the seeds with Captan or Thiram @ 3g/kg seed.

BACTERIAL DISEASES

Bacterial Wilt (*Pseudomonas solanacearum)*

The characteristic symptoms include wilting of the foliage followed by collapse of the entire plant. The wilting is characterized by dropping and slight yellowing of leaves and vascular dis-colouration. Drying of plants at the time of flowering and fruiting are also characteristic to the disease condition. The infected cut stems pieces when dipped in water, a white milky stream of bacterial oozes coming out which is the diagnostic symptom for bacterial wilt.

Control

- Follow crop rotation with non-solanaceous crops like Cabbage, Cauliflower, Mustard etc.
- Rogue out the infected plants and destroy them
- Raise nursery in disease free beds.
- Soil fumigation with Formalin at 7% before sowing.
- Seed treatment with Streptocycline (150 ppm) for 90 minutes.

Viral Disease

Mosaic. Leaves of affected plants exhibit mottling with raised dark green areas. Blisters are formed on the leaves and size of leaves reduced. The virus is transmitted through seeds and by aphids.

Control

- Collect the seeds from virus free plants.
- Rough out the infected plants from the field.
- Spray Dimlethoate (0.05%) or Monocrotophos (0.05% at 10 days interval.

Harvesting

The brinjal fruits are harvested when they attain full size and colour but before start of ripening. Tenderness, bright colour and glossy appearance of fruit is the optimum stage of harvesting of fruits.

When the fruits look dull, it is an indication of maturity and loss of quality. Pick tomato at pink stage at an interval 3-5 days. Chillies should be harvested when matured.

Organic Management as tried out in Balaghat of Madhya Pradesh by PRADAN

Work	**Requirement**	**Description**	**Day**
Seed	**5 gm**		
Nursery dimensions		Block of 5 feet length, 3 feet wide and 0.5 feet (6 inches) height are prepared	Day before planting in nursery
Rotten Farm Yard Manure	2 baskets	Mix the FYM and Vermicompost in the nursery bed	
Trichoderma	50 grams		
Vermicompost	2 kg		
Planting in nursery			0
Seed	5 gram	Sow the seeds 1 cm deep in rows 3 inches apart, and maintaining a distance of 2 inches between two plants.	
Mulching the seeds		Cover the seeds with the mixture of well rotten manure and fine soil and press it well.	
Irrigation		Water the nursery bed after sowing with a can	
Trichoderma	4 gram	Prior to sowing seeds are treated with fungal culture of ***Trichoderma viride*** (4 gram) or Thiram (2 gram) to avoid damage from damping-off disease; when they are 15 days old to control the spread of viral and fungal disease.	
Covering the		Cover the beds with wheat husk or clean dry grass. Remove the water husk or dry grass after the seeds	

Work	Requirement	Description	Day
nursery		have germinated.	
Irrigation		Do watering with fine rose-can in morning and evening. Water stagnation in bed causes damping off.	Daily
Removing the mulching		Remove the water husk or dry grass after the seeds have germinated.	5 to 6
Neemastra	30 ml per litre	Cater pillar resistant, spray with 2 litres of water	15
Agneyastra	30 ml per litre	Cater pillar resistant, spray with 2 litres of water (after the sighting of the caterpillars)	15
Pot solution (handi Khad)	1 litre	Along with 4 litres of water	20
Transplanting			30
Rotten Farm Yard Manure	10 baskets	Take 10 baskets of well rotten FYM	0
Trichoderma	250 gram	Mix the Trichoderma in the FYM	
Removing the plant		Water the nursery bed to moisten a bit and then carefully remove the plants	
Treating the roots of the young plant	2 gram Trichoderma	Treat the roots of the young plant with a solution of Trichoderma (2 gram) and water (500 ml), for two minutes.	
Manuring the field	Vermicompost 80 kg	In each pit apply 200 grams of vermicompost	
Preparing rows and transplanting	350 plats	In general 75 (2.5 feet) ×75 (2.5 feet) cm spacing is kept for non-spreading type verities and 75-90×60-75 cm for spreading type varieties.	
Neemastra	400 fML	Mix with 15 litres of water and spray over the leaves.	12
Pot solution (ahandi khad)	10 litres	Mix it with 30 litres of water and put a glass of the solution around each plant.	20
Neemastra	400 fML	Mix with 15 litres of water and spray over the leaves.	30
Pot solution (ahandi khad)	10 litres	Mix it with 30 litres of water and put a glass of the solution around each plant.	30
Agneyastra	30 ml per litres	Mix 450 ml of Agneyastra with 15 litres of water and spray when 5 to 10 bugs start to appear.	
Pot solution (handi	10 litres	Mix it with 30 litres of water and put a glass of the	40

Work	Requirement	Description	Day
khad)		solution around each plant.	
Pheromone trap	4 traps	To prevent fruit and stem borers	
Neemastra	400 ml	Mix with 15 litres of water and spray over the leaves.	50
Growth enhancing hormones	1 ml per litre of water	Prepare solution of water 10 (litres) and 10 ml of the hormone an spray	55
Agneyastra	30 ml per litres	Mix 450 ml of Agneyastra with 15 litres of water and spray when 5 to 10 bugs start to appear.	
Pot solution (handi khad)	10 litres	Mix it with 30 litres of water and put a glass of the solution around each plant.	50 to 60
Growth enhancing hormones	1 ml per litre of water	Prepare solution of water 10 (litres) and 10 ml of the hormone an spray	65

Creeper cultivation on Trellis

PRADAN has been instrumental in introducing improved methods to small and marginal farmers in the rural poverty pockets of eastern and central regions of India. Cucurbits such as bottle gourd, bitter gourd, ridge gourd, sponge gourd etc. are important source of nutrition for tribal households in the central region in India. Most of the households in the region are involved in cultivation of such creeper plants. PRADAN has been trying to improve the productivity in such crops by providing technical inputs and proper management methods. These improved principles have been creatively adapted to suit the cultivation practices for the creepers, making it possible to produce 3-4 four times more crop than with farmers' traditional practices

This manual has specific steps for cultivating cucurbits with improved methods. It should be useful for both farmers and village extension workers. It is intended to help small and marginal farmers with limited resources to produce more for themselves with their available resources and to gain more financially.

Cucurbits

Cucurbits are warm season crops which grow best during periods of warm nights and warm days. Cucurbit crops are similar in their appearance and requirements for growth. They are prostrate, sprawling vines, usually with tendrils. Each vine bears many large, lobed leaves. On all cucurbits, except for the bottle gourd, the flowers are bright yellow.

Preferred land for doing trellis based creeper cultivation

For cultivation of cucurbits uplands is preferred, where there should not be any water logging and proper channels must be made to drain out excess water.

Soil and climate requirements

Cucurbits require full sun to grow well, the soil pH should be neutral or slightly alkaline soil with a pH of 7.0. Soil types that contain clay can be improved by adding organic matter. Organic manure can be added to improve heavier soils.

Land Preparation

If you are unsure of the fertility of your soil, get a soil test. This will inform you of nutrients that are present in the soil, as well as the soil pH. This can be done in a Krishi Vigyan Kendra.

After proper ploughing of the soil, layout should be made for sowing of seeds. The lay out should be as per the following

Distance from pit to pit (for bottle gourd): 5-6 feet X 5-6 feet

Distance from pit to pit (for ridge gourd, bitter gourd, and sponge gourd): 3 feet X 4 Feet, 4 feet X 4 feets

Size of the pit: 1 foot X 1 foot X 1 foot

For good growth, work vermicompost or compost into the pits before planting. Spread the organic matter to a depth of 2 inches and work it into the soil 6-8 inches deep. If limited organic matter is available, concentrate it in the area where the seed is expected to be planted. The pits should be covered with half soil and half cow dung along with 200 gm of concentrated Jeevamrita along with two gm of Thimate.

Variety of seeds for different creepers to be used

Type	**Seed variety)**
Bottle gourd	Varad (Mahyco), Pratima (Sangro), Sarda (Semenis), CBH-10 and CBH-8 (Century)
Cucumber	Malini (Semenis), Sedona (Mahyco), Green Log (Mahyco), Vardaan (Rajendra), Hybrid 2 (Century), NS 470 (Namdhari)
Ridge gourd	Praveen 5000, Surekha (Mahyco), Pallavi (Sangro), Gourav (Sangro), NS 471 (Namdhari), Rinu (Sarada)
Bitter gourd	Chaman (Nunhems), Vivek (Sangro)
Sponge gourd	Nutan (Sangro), Harita (Mahyco)

Seed rate:

2 to 3 seeds are required to be sown in each pit. The seed requirement according to the type of cucurbits is as per below

Type	Number of pits	Seed requirement (in gm)
Bottle gourd	121	40-50
Cucumber	272	25-30
Ridge gourd/	272	70-90
Bitter gourd	272	100-120
Sponge gourd	272	????

Priming of seeds and nursery preparation

The seed should be kept in the water for at least 12 hours and then put inside vermicompost or rotten organic manure until it sprouts (1 to 3 days). Fill a black polythene tube with 3 parts soil, 1 part vermin compost / organic manure, and 1 part husk. The sprouted seeds should be put inside this tube. 2 ml of *Saaf* in one litre of water should be sprayed. Adequate water should be given to maintain the moisture level in the tube for vigorous growth. The polythene tubes should be staked as a nursery and covered with a transparent polythene sheet to maintain warmth for faster growth.

Care of the plants on 15^{th} day

Spray fungicide such as Entrocol (3 ml per litre of water) in the nursery on 15^{th} day (not later than the 18^{th} day). Alternatively use 10 ml of Pot Solution (*Handi Khad)* with 10 litres of water for spraying. Also, 500 ml of filtered Jeevamrita along with 10 litre water should be sprayed on the nursery.

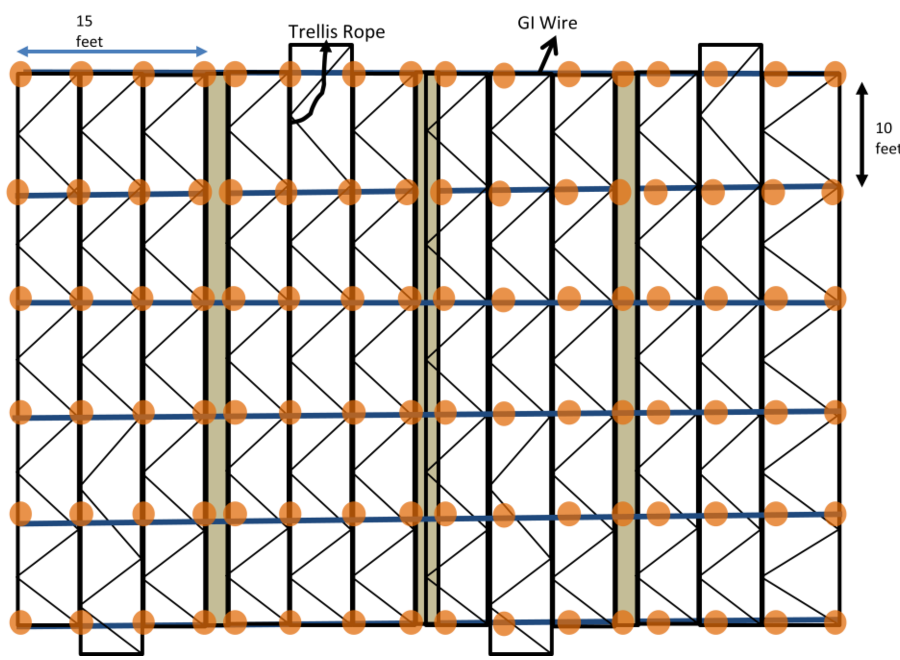
Planting (15th to 25th day after nursery preparation)

The plantation should be done on the pits during 15th to 25th day after putting the seeds in the polythene tube.

Construction of trellis

While growing creepers, preparation of trellis needs special attention. Vines of these creepers grow on the trellis is required for the vines to grow. Trellis can be made in various ways. Probably the most important point to be kept under consideration while preparing the trellis is to estimate the combined weight of the plant and its fruits. For example the trellis for bitter gourd can be just few string tied on to few nails on the wall, as these are lightweight. Whereas the cucumbers, bottle gourd and pumpkin require much strong trellis. Whereas if you look at the trellis supporting the Indian Spinach it's little thicker strings which are again tied on to nails on the wall This requires very close observation of the plant at the growth stage on a day to day basis.

The construction of the trellis should happen simultaneously alongside the pit as per the following diagram.



The estimates for construction of such trellis in 10 decimil of land is as per following

Length of Trellis: 70 feet

Width of Trellis: 50 feet

Number of Bamboo poles along length: 16 numbers

Number of Bamboo poles along width: 6 numbers

Item	Unit	Quantity	Unit cost	Amount (Rs)
Bamboo poles 6' high (4.5 feet above GL and 1.5 Feet below GL)	Numbers	96	15	1440
GI wire	Kg	3	60	180
Trellis Rope (white Fibre)	kg	2	225	450
Fibre wire (Used for Knitting Fishnet)	kg	4	290	1015
Labour	Person days	4	100	400
Total				**3485**

Pictures of erected trellis

Fertilizer application on 2/3 leaves stage

Chemical fertilizer should be applied in each of the pits when the plant gives rise to two to three leaves. Prepare a mixture of fertilizers comprising 3kg of DAP, 2 kg of MoP, in each pit, put 35 gm of the mixture and cover the soil.

Fertilizer application after first weeding (10th day)

The weeding should be done on the 10th day after transplanting. Chemical fertilizer should be applied in each of the pits when the first weeding is done. Prepare a mixture of fertilizers comprising 3kg of DAP, 2 kg of MoP, and 4 kg of Urea (10:26:26), in each pit, put 45 gm of the mixture and cover the soil.

Care of the plants on 20th day

After 7 days spraying of above fungicide another management is necessary to get rid of fire flies. 2 ml of Desis can be mixed with a litre of water and sprayed. The organic method is to spray a solution of cow urine and water (1:10) respectively for effective management.

The weeding should be done on the 20th day after transplanting. Chemical fertilizer should be applied in each of the pits when the first weeding is done. Prepare a mixture of fertilizers comprising 3kg of DAP, 2 kg of MoP, and 5 kg of Urea (10:26:26), in each pit, put 45 gm of the mixture and cover the soil. Irrigate the plants as per the requirement.

Care on 25th day

Spray a solution of *Chamak (3 gm)/* Boron (2gm) in one litre of water to prevent fruits from cracking and better flowering.

Care of the plants on 30th day

After 30 days of transplanting a mixture of 100 ml of Pot Solution in 5 litres of water along with 10% filtered Jeevamrita (500 ml in 5 litres of water) should be sprayed over the plants. Apply 4 kg of Urea at the plants.

Care of the plants on 45th day

Spray a solution of *Chamak (3 gm)/* Boron (2gm) in one litre of water to prevent fruits from cracking and better flowering.

Alternatively after 45 days of transplanting a mixture of Chily, and Ginger in 5 litres of water along with 10% filtered Jeevamrita (500 ml in 5 litres of water) should be sprayed over the plants.

Care during flowering and fruiting in plants

During flowering and fruiting in the plants, sour buttermilk solution (500 ml in 15 litres of water) should be sprayed. Repeat the procedure after a fortnight.

Alternatively, apply Zyme Gold (1 ml per litre of water) during this period and repeat the procedure after 15 days.

After harvesting twice apply 4 kgs if Urea, repair the drainage channels and if needed irrigate the field.

Care of the plants on 60th day

After 60 days of transplanting a mixture of *Pot solution/ Garlic,* Chily, and Ginger solution/ *Bramhastra/ Agneyastra/ Neemastra* (100 ml in 5 litres of water) in 5 litres of water along with 10% filtered Jeevamrita (500 ml in 5 litres of water) should be sprayed over the plants.

Care of the plants on 75th day

After 75 days of transplanting a mixture of *Pot solution/ Garlic,* Chily, and Ginger solution/ *Bramhastra* (100 ml in 5 litres of water) in 5 litres of water along with 10% filtered Jeevamrita (500 ml in 5 litres of water) should be sprayed over the plants. Note down the day of application.

Care of the plants on 90th day

After 90 days of transplanting a mixture of *Garlic,* Chily, and Ginger solution (100 ml in 5 litres of water) in 5 litres of water along with 10% filtered Jeevamrita (500 ml in 5 litres of water) should be sprayed over the plants.

Pest and disease management for Cucurbits

		Spray Desis (2.8 EC) 1 ml/ Regent (5 SC) 1.5 ml per litre of water
		**Fire fly** Spray Sevin2 gm per litre of water in the evening for effective management of Fire fly
		**Fruit fly** Spray Sevin2 gm+ 25 gm of jaggery per litre of water in the evening or by use of Pheromone trap for effective management of Fruit fly
	**Leaf miner** To prevent infestation of leaf miner during the rainy season spray a solution of Ektara (1 gm) in 3 litres of water.	

<table>
<tr><td></td><td colspan="2">Fungal infection
Spray a solution of Blue copper (3 gm)/ Ridemil (1gm) per litre of water for management of fungal infection.</td></tr>
<tr><td></td><td colspan="2">Murjha wala disease
For management of this spray Blue Copper (15 gm)+ Krosin AG 1gm in 5 litres of water at the roots</td></tr>
<tr><td></td><td></td><td>Powdery mildew
For management spray a solution of Bayleton @ 1 g/ litre water / Saaf or SIxer (2 gm/litre water) twice with an interval of 7 days</td></tr>
<tr><td></td><td></td><td>Downy mildew
For management spray a solution of Aliette 2-3gm/litre of water or Sectin 3-4gms/litre water / Saaf or SIxer (2 gm/litre water) twice with an interval of 7 days</td></tr>
</table>

		**Mosaic and leaf** सिकुड़ना After 10 days of transplanting, spray a solution of Conofeeder (1 ml)/ Ektara (1 gm) in 3 litres of water at an interval of 10 to 15 days

Cost and revenue

Costs:			
Item	Unit	Quantity	Price(Rs)
Seed:			
	gm	15-100	350
Manures and fertilisers:			
FYM/ Vermicompost	Kg	2 cartload/1Q	
DAP	Kg	10	250
MOP	Kg	5	50
Urea	Kg	6	60
Plant protection chemicals:			
Micronutrient Supplement e.g. - Kithchen garden mixture	gm	100	50
Boron Supplement e.g. Solubor/ Boron-19	gm	50	30
blue Copper/Nag Copper or Contact systemic fungicide (Mancozeb+carbrndazim) e.g SAAF/Sixer	gm	100	75
Antibiotic(Streptomycin+tetracycline) e.g.Plantomycin, Krocin Ag	gm	10	50
Spreader/ Sticker e.g.Teepol/Sandovit	gm	50	40
Insecticide(Fipronil) to manage Fruit fly and red pumpkin beetle.-: Sevin	gm/ml	50	250
Irrigation:			
8 Irrigation	hr	10	500
Labour:			
	md	10	1,000
Cost total:			

			2,605
Revenue:			
Yield	Kg	1,200	
Price	Kg	6	7,200
Revenue total:			
			7,200
Return			
			4,595