Rice growing in the Rice – Legume (lentil) production system at the demonstration site of ICARDA in Odisha (Reena Mehra)

Legumes in rice-based cropping systems (India)

DESCRIPTION

In India, 29 percent of the area cropped with rice remains fallow during the dry "rabi" season. This offers the opportunity to improve farm income and soil health by introducing legumes especially lentils. Diversifying the cropping system in such a way results in higher farm income due to additional crop produce and reduced carbon and water footprints.

In India, monsoon-season “kharif” rice is usually grown between June and November, while in the dry winter “rabi” season (from November to February), farmers keep these lands fallow due to lack of irrigation. Another constraint is a suitable crop with available seed for such a short window. Given the World Health Organization’s recommended pulse (legume grain) consumption of 50 g per capita per day, Odisha state needs to produce more. Here, legumes are grown on approximately 2.1 million hectares and total pulse production is 1.06 million tonnes. This results in an annual deficit of 0.22 million tonnes of pulses and a per capita per day consumption of only 11-23 grams. Odisha is exploring the vast potential for fallow cultivation of legumes.
The International Center for Agricultural Research in the Dry Areas (ICARDA) recognised this challenge and tested the introduction of lentils during the fallow rabi period. This resulted in a diversified cropping system as demonstrated in the following case study from the interior of Odisha, which is hilly with a cool winter season. Rice is the most commonly cultivated crop. The climate (1000-1500 mm of annual rainfall) and loamy-silty soil is suitable for lentils (Lens culinaris) - especially short duration varieties that can grow residual moisture of the rice.
During the 2018-2021 seasons, the lentil-rice cropping system was demonstrated on 165 ha of farmers’ fields involving 1920 farmers. The average yield of lentils was 790 kg/ha which generates traditional net-farm income of around 200 USD/hectare. Lentils have proved to have good potential: rice yields are not reduced and hence, from a cost-benefits perspective, it is a very viable option. Therefore, the state government is now promoting lentils as a fallow crop in rice-based systems in hilly areas with a cool winter season.
Lentil cultivation is as follows. Firstly, lentils are seeded (40 kg/ha) in the second week of November at a spacing of 30 x 5 cm. 3.5 kilogram of biocides (fungicides, herbicides, and pesticides) per ha are required and 50 kilogram of NPK fertilizer per ha is applied. Manual weeding takes around 20 person-days per ha. The lentils are harvested in February, requiring around 15 person-days per ha. Family labour provides for just over half of the field operations and a quarter of the harvest.
To conclude, growing lentils in the fallow period of rice-based cropping systems offers an opportunity to formulate a more climate resilient cropping system that improves soil health and farm income. This also has positive impact on health due to the inclusion of more pulses in the diet.
Data presented is from the bilateral project on pulses development funded by the Department of Agriculture & Farmers Empowerment, Government of Odisha with financial support from RKVY during 2018-2021 and implemented in collaboration with ICARDA. The work acknowledges the contribution of all scientists and team members in the ICARDA India programme: in the field and at headquarters.

LOCATION

Location: Odisha, India

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites
- 85.09982, 20.95265

Spread of the Technology: evenly spread over an area (approx. 1-10 km2)

In a permanently protected area?: No

Date of implementation: 2018

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☑ during experiments/ research
- ☑ through projects/ external interventions

Farmer in an ICARDA demonstration field that is full of lentils (Reena Mehra)

A farmer applying biocides to lentils (Reena Mehra)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ✓ improve production
- ✓ reduce, prevent, restore land degradation
- conserve ecosystem
- protect a watershed/ downstream areas – in combination with other Technologies
- preserve/ improve biodiversity
- reduce risk of disasters
- ✓ adapt to climate change/ extremes and its impacts
- mitigate climate change and its impacts
- ✓ create beneficial economic impact
- ✓ create beneficial social impact

Land use

Land use mixed within the same land unit: No

Cropland

- Annual cropping: cereals - rice (wetland), legumes and pulses - lentils

Number of growing seasons per year: 2
Is intercropping practiced? No
Is crop rotation practiced? Yes

Water supply

- rainfed
- ✓ mixed rainfed-irrigated
- full irrigation

Purpose related to land degradation

- ✓ prevent land degradation
- ✓ reduce land degradation
- restore/ rehabilitate severely degraded land
- adapt to land degradation
- not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

biological degradation - Bc: reduction of vegetation cover, Bq: quantity/ biomass decline

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- improved ground/ vegetation cover
- improved plant varieties/ animal breeds

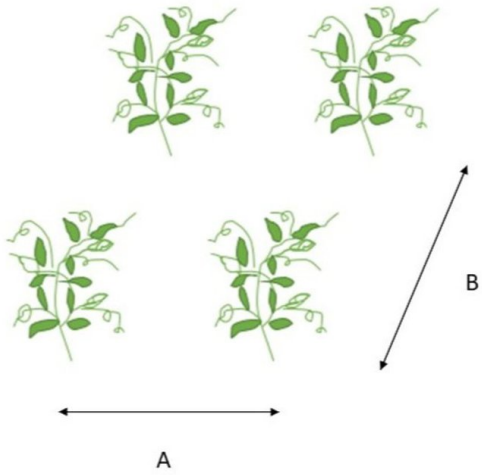
SLM measures

agronomic measures - A1: Vegetation/ soil cover, A5: Seed management, improved varieties, A6: Residue management

TECHNICAL DRAWING

Technical specifications

Lentil:
The plant to plant distance within a row (A) = 10 centimeters
The row to row distance (B) = 30 centimeters



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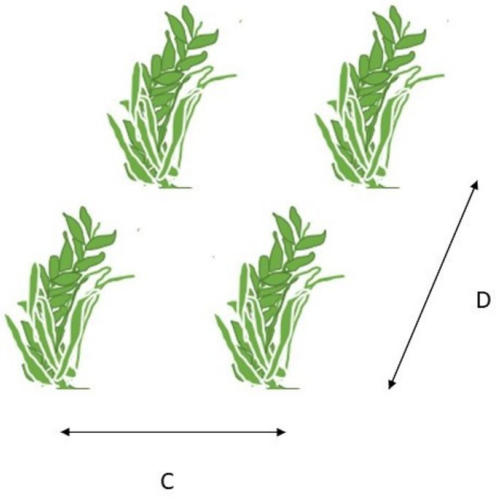
Rice:
The plant to plant distance within a row (A) = 15 centimeters
The row to row distance (B) = 15 centimeters



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ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1 hectare of lentil cultivation**)
- Currency used for cost calculation: **Indian rupee**
- Exchange rate (to USD): 1 USD = 80.0 Indian rupee
- Average wage cost of hired labour per day: n.a

Most important factors affecting the costs

n.a.

Establishment activities

n.a.

Maintenance activities

1. Lentil: Seeding (Timing/ frequency: Second week November)
2. Lentil: Fungicide (Timing/ frequency: First week January)
3. Lentil: Herbicide (Timing/ frequency: Second week December)
4. Lentil: Fertilizer (Timing/ frequency: January)
5. Lentil: Weeding (Timing/ frequency: None)
6. Lentil: Harvest (Timing/ frequency: February)
7. Rice: Seeding (Timing/ frequency: First week of June)
8. Rice: Irrigation (Timing/ frequency: June)
9. Rice: Fertilizer 1 (Timing/ frequency: Directly after seeding)
10. Rice: Fertilizer 2 (Timing/ frequency: 15 days after seeding)
11. Rice: Fertilizer 3 (Timing/ frequency: 90 days after seeding)
12. Rice: Weeding (Timing/ frequency: None)
13. Rice: Harvest (Timing/ frequency: November)

Maintenance inputs and costs (per 1 hectare of lentil cultivation)

Specify input	Unit	Quantity	Costs per Unit (Indian rupee)	Total costs per input (Indian rupee)	% of costs borne by land users
Labour					
Lentil: Weeding	Person-hour	20.0	300.0	6000.0	
Lentil: Harvest	Person-hour	15.0	300.0	4500.0	
Rice: Weeding	Person-hour	6.0	300.0	1800.0	
Rice: Harvest	Person-hour	15.0	300.0	4500.0	
Equipment					
Lentil: Zero-Seeder	Machine-hour	2.5	1200.0	3000.0	
Lentil: Sprayer	Machine-hour	1.0	300.0	300.0	
Rice: Tractor for land preparation	Machine-hour	1.0	1200.0	1200.0	
Rice: Tractor for transplantation	Machine-hour	5.0	1200.0	6000.0	
Plant material					
Lentil: Seed	Kilogram	45.0	105.0	4725.0	
Rice: Seed	Kilogram	25.0	30.0	750.0	
Fertilizers and biocides					
Lentil: Fungicide	Kilogram	0.5	600.0	300.0	
Lentil: Herbicide	Liter	1.5	367.0	550.5	
Lentil: NPK-fertilizer	Kilogram	0.5	150.0	75.0	
Rice: Gromor (first application)	Kilogram	5.0	40.0	200.0	
Rice: DAP (first application)	Kilogram	100.0	35.0	3500.0	
Rice: Potash (2:1 -> first and third application)	Kilogram	90.0	40.0	3600.0	
Rice: Urea (2:1 -> second and third application)	Kilogram	90.0	10.0	900.0	
Other					
Rice: Irrigation after seeding	Liter	3.0	100.0	300.0	
Rice: Irrigation in maturity (if needed)	Liter	10.0	100.0	1000.0	
Rice: Transplantation	Person-hour	19.0	300.0	5700.0	
Rice: Fertilizer	Person-hour	6.0	300.0	1800.0	
Total costs for maintenance of the Technology				**50'700.5**	
Total costs for maintenance of the Technology in USD				*633.76*	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☑ humid
- ☐ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
n.a.

Slope
- ☐ flat (0-2%)
- ☑ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☐ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☑ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☑ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☑ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☐ good
- ☐ medium
- ☑ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☑ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Water quality refers to: ground water

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☐ high
- ☐ medium

Habitat diversity
- ☐ high
- ☐ medium

✓ low

✓ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- subsistence (self-supply)
- ✓ mixed (subsistence/ commercial)
- commercial/ market

Off-farm income
- ✓ less than 10% of all income
- 10-50% of all income
- > 50% of all income

Relative level of wealth
- very poor
- ✓ poor
- average
- rich
- very rich

Level of mechanization
- ✓ manual work
- animal traction
- ✓ mechanized/ motorized

Sedentary or nomadic
- ✓ Sedentary
- Semi-nomadic
- Nomadic

Individuals or groups
- ✓ individual/ household
- groups/ community
- cooperative
- employee (company, government)

Gender
- ✓ women
- ✓ men

Age
- children
- youth
- ✓ middle-aged
- elderly

Area used per household
- < 0.5 ha
- 0.5-1 ha
- ✓ 1-2 ha
- 2-5 ha
- 5-15 ha
- 15-50 ha
- 50-100 ha
- 100-500 ha
- 500-1,000 ha
- 1,000-10,000 ha
- > 10,000 ha

Scale
- ✓ small-scale
- medium-scale
- large-scale

Land ownership
- state
- company
- communal/ village
- group
- ✓ individual, not titled
- ✓ individual, titled

Land use rights
- open access (unorganized)
- communal (organized)
- leased
- ✓ individual

Water use rights
- open access (unorganized)
- ✓ communal (organized)
- leased
- individual

Access to services and infrastructure

health	poor	✓ good
education	poor	✓ good
technical assistance	poor	✓ good
employment (e.g. off-farm)	✓ poor	good
markets	✓ poor	good
energy	poor	✓ good
roads and transport	poor	✓ good
drinking water and sanitation	poor	✓ good
financial services	✓ poor	good

IMPACTS

Socio-economic impacts

Crop production	decreased	increased ✓	Due to an additional crop
crop quality	decreased	✓ increased	
risk of production failure	increased	✓ decreased	Additional crops reduces overall failure
product diversity	decreased	✓ increased	
land management	✓ hindered	simplified	The additional crop requires additional management
demand for irrigation water	increased	✓ decreased	
expenses on agricultural inputs	✓ increased	decreased	the additional inputs for lentil imply extra expenses
farm income	decreased	✓ increased	lentil harvest increase overall farm income
diversity of income sources	decreased	✓ increased	
workload	✓ increased	decreased	cultivation lentils requires more workload

Socio-cultural impacts

food security/ self-sufficiency	reduced	✓ improved	
health situation	worsened	✓ improved	pulses are recommended for a healthy diet

Ecological impacts

soil cover	reduced	✓ improved	lentils provide prolonged soil cover
nutrient cycling/ recharge	decreased	✓ increased	legumes fix nitrogen in the soil

Off-site impacts

water availability (groundwater, springs)	decreased	✓ increased	lentils use the residual water, preventing it from going to the groundwater

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	✓ very positive
Long-term returns	very negative	✓ very positive

Benefits compared with maintenance costs

Short-term returns	very negative	✓ very positive
Long-term returns	very negative	✓ very positive

CLIMATE CHANGE

Gradual climate change

annual rainfall decrease	not well at all	✓ very well

Climate-related extremes (disasters)

local rainstorm	not well at all	✓ very well
drought	not well at all	✓ very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- single cases/ experimental
- ✓ 1-10%
- 11-50%
- > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- ✓ 0-10%
- 11-50%
- 51-90%
- 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- Yes
- ✓ No

To which changing conditions?

- climatic change/ extremes
- changing markets
- labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Increased farm income and cropping intensity
- Improved soil health due to crop rotation
- Better utilization of residual moisture
- Cultivation of new pulse crop
- Improved resilience

Strengths: compiler's or other key resource person's view

- Improved resilience due to diversified crops
- Reduces fallow period which help to improve soil quality
- Improved diet that includes more pulses

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Lentils might require too long growing period → More research in short duration lentils
- Long duration rice makes it difficult to cultivate lentil variety on the correct time → Experimenting with new rice varieties or alternative systems
- Increased farmer workload → The additional income justifies this

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Farmers have to learn this new cultivation method → Investing in farm demonstrations and capacity building

REFERENCES

Compiler
Joren Verbist

Reviewer
Rima Mekdaschi Studer
William Critchley

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Resource persons
Nigamananda Swain - Agricultural Economist
Mehra Reena - Lentil Breeder

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_6489/

Linked SLM data
n.a.

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Institution

- International Center for Agricultural Research in the Dry Areas (ICARDA) - Lebanon

Project

- ICARDA Institutional Knowledge Management Initiative

Links to relevant information which is available online

- Nigamananda Swain, Ashutosh Sarker. (1/8/2021). Variety, Technology and Seed System Development for Pulses in Odisha Project Completion Report. Beirut, Lebanon: International Center for Agricultural Research in the Dry Areas (ICARDA).: https://hdl.handle.net/20.500.11766/67880