Double legume cropping consisting of lentils (yellow rows) intercropped with chickpeas (green rows) (Mina Devkota)

Diversified Cropping System: Relay Intercropping of Lentils with Chickpeas (Morocco)

DESCRIPTION

A Diversified Cropping System (DCS) results in a more resilient and productive cropping system. In this case, chickpeas were introduced as a relay intercrop between established lines of lentils. This not only had no negative effect on lentil yields, but also enabled the harvest of an extra crop: chickpeas.

In the semi-arid regions of Morocco, agricultural production varies from year to year, but yields are generally declining because of climate change. Climate change is leading to more irregular rainfall and frequent extreme weather events. Wherever possible, there is a need to intensify agricultural systems to ensure food security while simultaneously increasing resilience.
Cultivating lentils (Lens culinaris) as a sole crop is common practice in rural Morocco. To intensify this cropping system, the International Centre for Agricultural Research Dry Areas (ICARDA) introduced chickpeas (Cicer arietinum) as a relay intercrop into the common lentil production system. Because chickpeas are planted within an already growing crop of lentils, this form of intercropping is termed "relay planting". Importantly, chickpeas do not affect the yields of lentils (0.837 + 0.19 t ha-1 yield in sole vs. 0.808 + 0.159 t ha-1 in intercrop) because they do not significantly compete for water and nutrients. With two crops harvested from the same piece of land, overall farm profits increase. Furthermore, this creates a more resilient production system because the farmer is not dependent on a single crop. Additionally, including chickpeas as a relay-intercrop extends the cropping season and prolongs the period where the soil is covered, consequently protecting it from degradation. An added advantage is that both chickpeas and lentils are leguminous, nitrogen-fixing crops that can improve soil fertility. Also, both crops have high cultural and culinary value locally. However, the technology has potential drawbacks as in years of extreme droughts, chickpeas require supplementary irrigation, especially during establishment. This is often unavailable to local farmers and may result in poor crop establishment and low yields.
In 2020-2022, ICARDA tested this Diversified Cropping System (DCS) on a trial field of half a hectare, in an area with average annual precipitation of 390 mm (based on 40 years of data). The system is implemented as follows. First, the field is prepared by ploughing. In December, lentils are mechanically seeded. Two rows of lentils are planted 15 cm apart. The spacing between each two-row pair is roughly 90 cm. Compound fertilizer is applied during seeding. In January, an herbicide is sprayed to control grassy weeds. The field is mechanically weeded twice, in mid-January and then again in February. Chickpeas are sown at the end of February also in paired lines (two rows 20 cm apart) also with compound fertilizer. Each pair of chickpea lines is planted between pairs of lentils. In March, the plots are manually weeded, and in April, the lentils are manually harvested and mechanically threshed. A single spray of insecticide is applied in April-May. Finally, in June, the chickpeas are mechanically harvested and have an average yield of 1.1 + 0.146 t ha-1.
This documentation illustrates an ICARDA innovation that is accessible since there are no establishment events and costs. This Diversified Cropping System improves a traditional system by introducing an additional crop, resulting in higher farm income and resilience to variable weather.

LOCATION

Location: Merchouch, Khémisset Province, Morocco

No. of Technology sites analysed: single site

Geo-reference of selected sites
- -6.69021, 33.5607

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2021

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

Lentils established and chickpeas seeded as a relay crop (Mina Devkota)

Moroccan farmer holding a chickpea plant (Mina Devkota)

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: legumes and pulses - lentils, chickpeas

Number of growing seasons per year: 1
Is intercropping practiced? Yes
Is crop rotation practiced? No

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

soil erosion by water - Wt: loss of topsoil/ surface erosion

soil erosion by wind - Et: loss of topsoil

SLM group

- improved ground/ vegetation cover

SLM measures

agronomic measures - A1: Vegetation/ soil cover

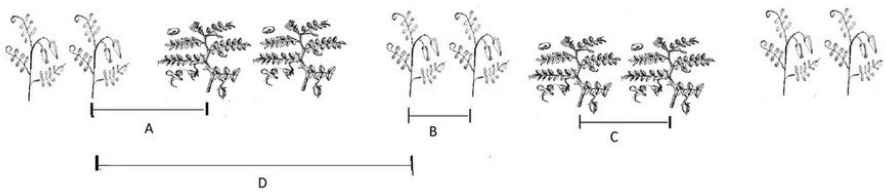
management measures - M2: Change of management/ intensity level, M4: Major change in timing of activities

TECHNICAL DRAWING

Technical specifications

The symbols correspond to the following technical specifications:

A: Spacing between a row of lentil and a row of chickpea= 35 centimetres
B: Spacing between two rows of lentil in the same pair = 15 centimetres
C: Spacing between two rows of chickpea in the same pair = 20 centimetres
D: Spacing between two rows of lentil bordering a pair of chickpea= 90 - 95 centimetres



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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**)
- Currency used for cost calculation: **Moroccan Dirham**
- Exchange rate (to USD): 1 USD = 10.63 Moroccan Dirham
- Average wage cost of hired labour per day: 75

Most important factors affecting the costs
n.a.

Establishment activities
n.a.

Maintenance activities
1. Field Ploughing (Timing/ frequency: Prior to seeding)
2. Lentil Seeding (Timing/ frequency: December)
3. Fertilizer Application (Lentil) (Timing/ frequency: During seeding)
4. Herbicide Application (Lentil) (Timing/ frequency: January)
5. First Mechanical Weeding (Lentil) (Timing/ frequency: Mid January)
6. Second Mechanical Weeding (Lentil) (Timing/ frequency: Mid February)
7. Chickpea Seeding (Timing/ frequency: End of February)
8. Fertilizer Application (Chickpea) (Timing/ frequency: During seeding)
9. Fungicide Application (Lentil) (Timing/ frequency: February-March)
10. Manual Weeding (Chickpea) (Timing/ frequency: March)
11. Lentil Harvesting (Timing/ frequency: April)
12. Insecticide Application (Chickpea) (Timing/ frequency: April-May)
13. Chickpea Harvesting (Timing/ frequency: June)

Maintenance inputs and costs (per 1 Hectare)

Specify input	Unit	Quantity	Costs per Unit (Moroccan Dirham)	Total costs per input (Moroccan Dirham)	% of costs borne by land users
Labour					
Weeding (Lentil)	Person-Days	10.0	75.0	750.0	100.0
Weeding (Chickpea)	Person-Days	10.0	75.0	750.0	100.0
Lentil Harvesting	Person-Days	10.0	75.0	750.0	100.0
Equipment					
Plough	Machine-Hours	3.0	150.0	450.0	100.0
Lentil Seeder	Machine-Hours	1.0	150.0	150.0	100.0
Chickpea Seeder	Machine-Hours	1.0	200.0	200.0	100.0
Sprayer	Machine-Hours	3.0	60.0	180.0	100.0
Weeder	Machine-Hours	2.0	100.0	200.0	100.0
Lentil Thresher	Machine-Hours	2.0	150.0	300.0	100.0
Chickpea harvester	Machine-Hours	2.5	300.0	750.0	100.0
Plant material					
Lentil seeds	Kilogram	45.0	8.0	360.0	100.0
Chickpea seeds	Kilogram	80.0	15.0	1200.0	100.0
Fertilizers and biocides					
Herbicide (for Lentil)	Litre	1.0	170.0	170.0	100.0
Insecticide (for Chickpea)	Litre	0.25	300.0	75.0	100.0
Fungicide (for Lentil)	Litre	0.5	150.0	75.0	100.0
NPK 10:20:20 (for Lentil)	Kilogram	100.0	3.0	300.0	100.0
NPK 10:20:20 (for Chickpea)	Kilogram	100.0	3.0	300.0	100.0
Total costs for maintenance of the Technology				**6'960.0**	
Total costs for maintenance of the Technology in USD				*654.75*	

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
Average annual rainfall in mm: 390.0
typical Mediterranean climate with winter rains
Name of the meteorological station: INRA + ICARDA weather data

Slope
- ☐ flat (0-2%)
- ☑ gentle (3-5%)
- ☐ moderate (6-10%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes

Altitude
- ☐ 0-100 m a.s.l.
- ☑ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.

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

- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

- [ ] 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.

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [x] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [ ] very deep (> 120 cm)

Soil texture (topsoil)
- [ ] coarse/ light (sandy)
- [x] medium (loamy, silty)
- [ ] fine/ heavy (clay)

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

Topsoil organic matter content
- [ ] high (>3%)
- [x] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [ ] < 5 m
- [x] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [ ] good
- [ ] medium
- [x] poor/ none

Water quality (untreated)
- [ ] good drinking water
- [x] poor drinking water (treatment required)
- [ ] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to: ground water

Is salinity a problem?
- [ ] Yes
- [x] No

Occurrence of flooding
- [ ] Yes
- [x] No

Species diversity
- [ ] high
- [ ] medium
- [x] low

Habitat diversity
- [ ] high
- [ ] medium
- [x] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [x] mixed (subsistence/ commercial)
- [ ] commercial/ market

Off-farm income
- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [x] poor
- [ ] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [ ] manual work
- [ ] animal traction
- [x] mechanized/ motorized

Sedentary or nomadic
- [x] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups
- [x] individual/ household
- [ ] groups/ community
- [ ] cooperative
- [ ] employee (company, government)

Gender
- [x] women
- [x] men

Age
- [ ] children
- [ ] youth
- [x] middle-aged
- [ ] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [ ] 1-2 ha
- [ ] 2-5 ha
- [x] 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
- [x] small-scale
- [x] medium-scale
- [ ] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [x] individual, not titled
- [x] individual, titled

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [ ] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [ ] leased
- [x] 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

Overall crop production increased due to the introduction of an additional crop: chickpeas. No yield reduction was observed in lentils as a sole crop.

risk of production failure: increased — ✓ — decreased

Due to the introduction of an additional crop: chickpeas, the risk to complete crop failure was reduced since if one crop fails another exists. This

increases resilience.
If rainfall is evenly distributed throughout the growing season, farmers will get good harvests for both crops. If rainfall occurs in the early season and the late season is dry, farmers will get good lentil harvests but not chickpeas.
Alternatively, if rainfall occurs in the late season with severe drought in the early season, farmers may get complete crop failure of lentils but a good harvest of chickpeas.

product diversity — decreased ✓ increased

Through the introduction of an additional crop: chickpeas, the overall system was diversified.

land management — hindered ✓ simplified

The introduction of additional crops increased the complexity of the system and its management. For example, planting in the standing lentil needs specialized machinery.

expenses on agricultural inputs — increased ✓ decreased

Additional planting material, labor and inputs are required for this cropping system. It may also require supplementary irrigation in the case of late-season drought occurrence.

farm income — decreased ✓ increased

Two crop harvests (both grains and straw) instead of one increases farm income.

diversity of income sources — decreased ✓ increased

Two harvests of different crops: chickpeas and lentils instead of one diversified farming income streams. This system also allows employment opportunities outside of the main crop growing period.

workload — increased ✓ decreased

The introduction of an additional crop complexifies the management and therefore increases the workload.

Socio-cultural impacts

food security/ self-sufficiency — reduced ✓ improved

Having two crops, especially protein-rich legumes promoted food and nutrition security.

SLM/ land degradation knowledge — reduced ✓ improved

Soil coverage for longer times due to the introduction of a second crop later in the season highlights its role in reversing land degradation

Ecological impacts

soil moisture — decreased ✓ increased

There was no significant difference in soil moisture between sole lentils and intercropped lentils (with chickpeas) at the time of lentil harvesting.

soil cover — reduced ✓ improved

Having a second crop later in the season extends the period in which the soil is covered.

soil loss — increased ✓ decreased

Soil coverage mediated by the second crop reduces soil loss due to erosion.

nutrient cycling/ recharge — decreased ✓ increased

Both crops are leguminous meaning that they contribute to the supply of nitrogen to the soil.

Off-site impacts

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 temperature increase — not well at all ✓ very well

seasonal rainfall decrease — not well at all ✓ very well

Season: winter

Climate-related extremes (disasters)

epidemic diseases	not well at all	very well
insect/ worm infestation	not well at all	very well

ADOPTION AND ADAPTATION

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

- [x] 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?

- [x] 0-10%
- [ ] 11-50%
- [ ] 51-90%
- [ ] 91-100%

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

- [ ] Yes
- [x] 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

- Diversified farm income
- Reduces fallow period which helps to improve soil quality
- Reduced risk of complete crop failure

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

- Improved resilience due to diversified crops

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

- Competition for resources (nutrients, water, etc.) between the two crops. → Providing supplementary irrigation/ fertilization.
- Increased complexity and more labour demands of the system → The use of machinery and implementing a seasonal farming plan to distribute the farming tasks throughout the season.

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

- The overall system's higher susceptibility to legume-inflicting pests and diseases → Using adequate pest control/ integrated pest management techniques

REFERENCES

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Rima Mekdaschi Studer
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Resource persons
Mina Devkota - Agronomist
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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_6416/

Linked SLM data
n.a.

Documentation was faciliated by
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

- Diversified cropping systems for sustainable intensification of dryland family farming: https://hdl.handle.net/20.500.11766/66830