Optimization of spatial soil occupation in rainfed intercropping system based on olive trees and annual crops in northern Morocco

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Introduction
Morocco localized in the north of Africa far from Europe by 14 km, is faced to climatic change.
Average annual rainfall ranged from 100 mm in the south to more than 1000 mm in the north.
Impact of rainfall variability and scarcity on annual crops yields
Cereals

Figure 2. Evolution des rendement des principales légumineuses alimentaires

Legume crops

Année

Rendement (t/ha)

FEVE — POIS CHICHE — POIS — LENTILLE
In order to face climatic change, Moroccan government under the GREN MOROCAIN PLAIN plans the reconversion of 1 million ha of cereals to trees as (olive, almond and figus trees) which are more adaptable to drought and rainfall variation.
The facts ?!

Objective: reconversion from cereals to trees

Result: Integration trees into cereals which is the common practice
The need for arable land is crucial
Looking for land to cultivate even if on high slope
Rather than to wait for at least for more than three year olive production, farmers need cereal grain annualy.
Sowing wheat with no respect to olive tree and at harvest time we are looking where are olive trees?!
Ongoing reconversion process under marginal land and with slop ones

The past: olive tree practices

The present: plantation of olive tree on cereal area
Result

Reconversion $\rightarrow$ Integration of olive tree into annual crops

$1\ M\ ha + x\ ha = \text{Agroforestry system}$

System that should be optimized in a global way
Main questions raised

What can we learn from farmer’s practices (advantages and disadvantages)?

Which crops can be mixed with olive trees?

Which kind of practices should be done to optimize the System?
Witch spatio toporal arrangement should be adopted for the system?
Where the associations could be used or recommended according to soil fertility and climatic conditions?
In Morocco AGROFORESTRY is practiced in mountainous and oasis regions where water and/or land resources are limited. In these locations many crops are mixed and their monitoring is complicated.

Unfortunately, few scientific studies were dedicated to such system and someone might describe it as primitive, none productive and must been changed.
Hight Mountain of Atlas: Apple tree luzerne
Midle Mountain of Atlas: Peach – Faba bean
Saïs Plain: Olive tree and Barley Orge
Souss Massa region
Argan trees–Barley-livestok
Saïs: Prunus and potato
North of Morocco: Almond and peas.
In fact, in a previous study, we showed that 75% of farmers growing olive trees are also producing annual crops between tree rows.

Those crops included cereals, legumes, and vegetables.

Cereals are dominant in 50% of land occupation.

Farmers indicated that technical interventions (ploughing, fertilizing) concerns mainly annual crops and then can promote olive tree production.
Although some farmers found that association of olive tree and annual crops may have negative effects on the production of this combination, they adopt it for the following reasons:

- **Management of olive tree production** (ploughing, fertilisation, weed control …) may be more profitable if it is practiced on crop cultivated between between rows.

- **Management of inter rows crops profit also to olive tree.**

- **Plantation of olive tree alone may be subjected to damage due to grazing,** cultivating intercrops may prevent such risk.
### Table 1. Cultivated species as intercrop on olive according to water irrigation availability

<table>
<thead>
<tr>
<th></th>
<th>Cereals</th>
<th>Legume crops</th>
<th>Forage</th>
<th>Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed</td>
<td><em>Triticum aestivum</em></td>
<td><em>Vicia faba</em></td>
<td><em>Avena sativa</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Triticum turgidum</em></td>
<td><em>Cicer arietinum</em></td>
<td><em>Hordeum vulgare</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Hordeum vulgare</em></td>
<td><em>Lens culinaris</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Phaseolus vulgaris</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigated</td>
<td><em>Zea mays</em></td>
<td></td>
<td></td>
<td><em>Solanum tuberosum</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Allium cepa</em></td>
</tr>
</tbody>
</table>
Table 2. Distance (m) left from olive tree trunk to the first line of intercrop

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Legume crops</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>Vegetables</td>
<td>0.50</td>
<td>2</td>
</tr>
</tbody>
</table>
According to farmer’s estimations: legume crops like faba bean do not affect olive production comparatively to cereals (durum or soft wheat or barley). In this second case, olive production is reduced by about 39% when cereals are intercropped between the rows. However, farmer produces an added value of cereals or legume of respectively 9 and 7 qx/ha..
Some Results
Figure 3: Olive yield in intercropping systems with different annual crops under rainfed conditions.

The values marked by the same letters are statistically equal.

**T1:** annual crops sown below tree canopy;
**T2:** annual crops sown from the limit of tree canopy;
**T3:** annual crops sown from the limit of tree canopy with impluviums placed around trees.
Photo 13. Petit pois en intercalaire dans une jeune oliveraie

Photo 14. Fève en intercalaire dans une jeune oliveraie

Photo 15. Fève cultivée dans une oliveraie avec respect d’un écartement convenable
Comparatively to cereal Mechanical weeding during February on winter legume crops may reduce weed competition impact on boat crops and also create water storage structures.
Indirect water harvesting during Winter
Photo 11. Cas du blé, les lignes de semis situées à la limite de la frondaison sont de plus courte taille, moins vigoureuse et moins productives. (ouazzane Mars 2012) 

(Fèvre) 

(Lentille) 

Photos 12. Les plantules sur les lignes de semis situées à la limite de la frondaison sont mortes dans les différents (blé, fève et de la lentille). (Station expérimentale Douyet 2012)

Figure 7. Modèles d’évolution de la production en biomasse (g/m linaire) à différentes distances de l’olivier pour (Lignes de semis Est-ouest) 

Total Biomasse
Figure 3. Models of cereals plant height evolution at different distance from olive tree (sowing rows oriented North – South)
Pour le blé tendre :

\[ y = -1,1601x^2 + 14,186x + 15,092 \]

\[ R^2 = 0,5387 \]

Pour le blé dur :

\[ y = -1,5095x^2 + 13,769x + 20,962 \]

\[ R^2 = 0,52221 \]
\[ y = -2,1286x^2 + 24,142x - 12,875 \]
\[ R^2 = 0,90973 \]

**Rendement grain (g/m linéaire)**

**Distance entre la ligne de semis et l'arbre de référence (m)**

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\[ y = -0,3981x^2 + 4,7697x - 0,9962 \]
\[ R^2 = 0,56815 \]

**Rendement grain / m linéaire**

**Distance entre la ligne de semis et l'arbre de référence (m)**

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*Lentilles*

*Lèvres*

**Rendement grain (g/m linéaire)**

**Distance entre la ligne de semis et l'arbre de référence (m)**
Figure 1: Growing seasons of wheat, faba bean and coriander in relation with fruit and shoot growth of olive tree in intercropping system.
Average annual rainfall ranged from 100 mm in the south to more than 1000 mm in the north.

Table 1. WHERE alley cropping (olive tree and annual crops) may be or not possible regarding annual rainfall.

<table>
<thead>
<tr>
<th>ZONE</th>
<th>Rainfall (mm/year)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES.SAOUIRA</td>
<td>330</td>
<td>Zone where cultivating annual crops between olive trees may affect negatively olive productivity</td>
</tr>
<tr>
<td>ALHOCEIMA</td>
<td>365</td>
<td></td>
</tr>
<tr>
<td>AZILAL</td>
<td>390</td>
<td></td>
</tr>
<tr>
<td>MY YACOUB</td>
<td>457</td>
<td></td>
</tr>
<tr>
<td>SEFROU</td>
<td>474</td>
<td></td>
</tr>
<tr>
<td>TAOUNATE</td>
<td>512</td>
<td>Zone where cultivating annual crops between olive trees may be possible and profitable</td>
</tr>
<tr>
<td>TAZA</td>
<td>534</td>
<td></td>
</tr>
<tr>
<td>KHENIFRA</td>
<td>558</td>
<td></td>
</tr>
<tr>
<td>TETOUAN</td>
<td>598</td>
<td></td>
</tr>
<tr>
<td>LARACHE</td>
<td>616</td>
<td>Zone where cultivating annual crops between olive trees is recommended</td>
</tr>
<tr>
<td>SIDI KACEM</td>
<td>648</td>
<td></td>
</tr>
<tr>
<td>OUAAZANE</td>
<td>655</td>
<td></td>
</tr>
<tr>
<td>CHEFCHAQUEN</td>
<td>1097</td>
<td></td>
</tr>
</tbody>
</table>

Source: http://www.morocmoneo.ma/fr/cimat_maroc
Witch spatial arrangement to propose according to trees and crop requirements and soil fertility?
Figure 1. **HOW to organize olive tree and annual crops in an alley cropping system regarding soil topography.**

- Top low fertility (water and minerals) suggested crops; drum wheat or barley in rotation with peas or winter chickpeas.
- Intermediate: moderate fertility to be maintained and enhanced by avoiding soil erosion.
- Down: good fertility where suggested crops may be soft wheat in rotation with faba bean or other crops that can take advantage from this situation.
In arid and semi-arid conditions, alley cropping may be a good choice to face climatic change.

In fact choosing a better combination of tree and annual crops is necessary. Annual crops should be implemented at least at the limit of tree foliage; otherwise both crops in the association will suffer from competition for water and light.

Conclusions

We are just starting!
Many thanks to my colleagues, farmers, students, technicians etc…