Agroforestry Systems in Morocco: The Case of Olive Tree and Annual Crops Association in Saïs Region

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Chapter 19
Agroforestry Systems in Morocco: The Case of Olive Tree and Annual Crops Association in Saïs Region

Khalid Daoui and Zain El Abidine Fatemi

Abstract Climatic change and demography represent important challenges for agronomists. They have to discover more innovative systems and technologies to fulfill food, feeding and energy demands. Such innovations may mime nature and couple advantages from soil biology and plant diversity and mutual advantages between the whole systems: soil—plant and plant to plant and the ecosystems. Forests systems give us examples of natural performances to discover and transfer elsewhere. Because of negative impacts of monoculture oriented intensification, agroforestry (association of perennial—annual crops and livestock) has created an interest in the international scientific community. This Traditional and also natural innovation has many advantages (preservation of biodiversity, diversification of productions, C sequestration, alternative solution for climatic change, enhancing agricultural land profitability, livestock integration, and erosion control). In Morocco such practice is adopted in the mountainous and oasis regions where water and/or land resources are limited. In these locations many crops are mixed and hence their monitoring is complicated. Unfortunately, few scientific studies were dedicated to such system and someone might describe it as primitive, non productive and must be changed. In this chapter focus has been on, the determination of the importance of olive tree and annual crops association in Saïs region, determination of annual crops cultivated between olive trees, agronomic evaluation of the associations, determination of advantages/ disadvantage according to farmers point of view and our observations, and proposition of some technical solutions to perform olive tree—annual crops associations.

Keywords Agroforestry • Biodiversity • Olive tree • Monoculture • Morocco

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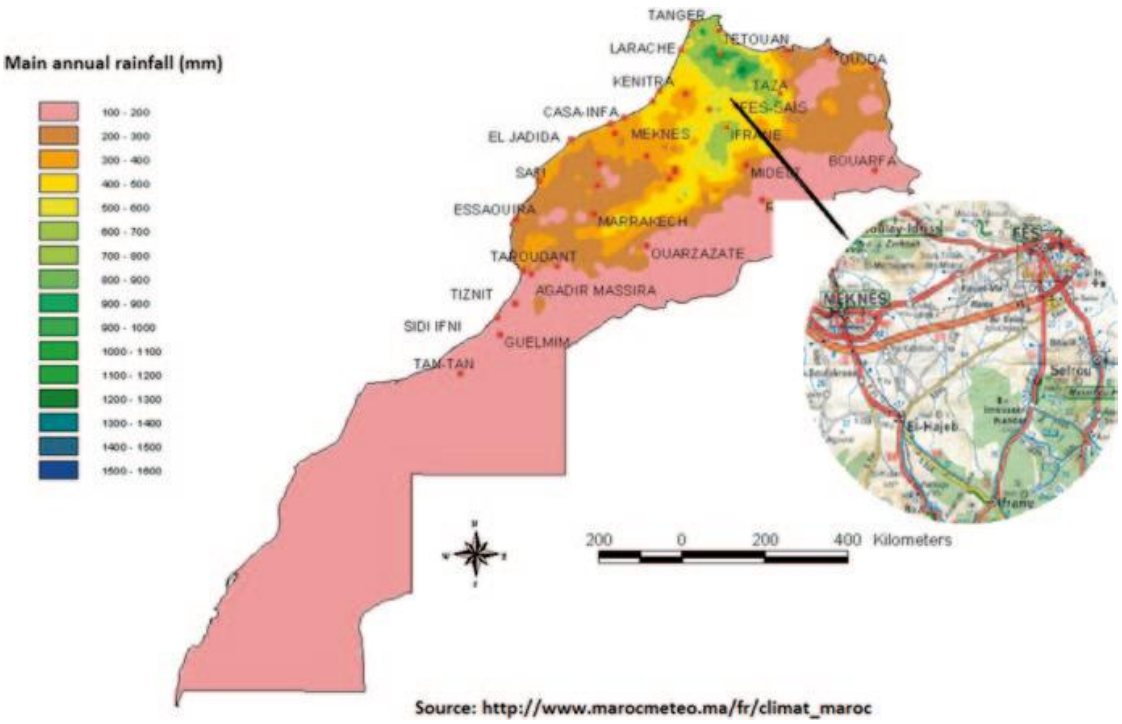

Fig. 19.1 Site location map

19.1 Introduction

Agroforestry which is the association of trees and crops on the same piece of land is a traditional practice. In some cases, man has eliminated forests to establish agriculture; in other situations he has associated many crops (annuals, perennial or both) to investigate narrow lands in his possession. Recently, this practice has created an interest in the international scientific communities who are trying to reintroduce it as 'a new practice' to achieve many benefits it contains. According to Workman and Allen (2004) "Agroforestry is a new way of thinking about and old way of farming". In Morocco, agroforestry exists in oasis and also in mountainous regions where in both situations agricultural lands and water resources are scarce.

Morocco has a Mediterranean climate characterized by cold and rainy winters and hot summers. Annual rainfall varies between 100 and 1,600 mm (Fig. 19.1). The plain Säis, which is localized in the north part of the country, has a favorable climate for rainfed agriculture. The annual rainfall varies between 300 and 600 mm. The main activity in this region is agriculture. Annual crops constitute the main cultivated crops; cereal represents 50 % of covered area followed by legume crops, forages and vegetables. Fruit trees are important where olive and almond trees are dominant. Important water resources are available, but the pressure of agricultural demand is becoming important. Soils are deep and fertile, texture ranges between clay and silt. Soils are moderately rich in organic matter (2.5–3.5 %), poor in phosphorus (< 10 mg P_2O_5 kg^{-1} soil) and rich in potassium (250–350 mg K_2O kg^{-1} soil). The pH is in alkaline range (> 7.00) (http://www.fertimap.ma/map.phtml).

In the Saïs region, the average rainfall passed from 600 mm per year during the period 1960–1980 to 440 mm for the period 1981–2000 (Karrou and Boutfirass 2007). The weather forecast studies show that those conditions are likely to increase with climate change (FAO 2008). To face this situation, Moroccan government plans the conversion of 1 million ha of cereals to olive tree. To achieve this goal we do have to study the actual practice of olive tree in Moroccan agriculture and also to learn from different experiences In fact, during the last decades in Saïs region, introduction of olive trees at locations dedicated to cereal crops pushed farmers to exploit rows between trees by annual crops. The importance of such practice is unknown due the absence of established advantages/disadvantages. It is, therefore, essential to evaluate such importance to sustain political orientation for the extension of olive trees production area.

The adoption and the practice of such system by farmers is a proof of its performance. As scientists we must investigate to learn about farmer's experiences and views. At the end of this investigation we will be in a better position to propose technical solutions in order to make it more profitable by enhancing advantages and reducing disadvantages on the basis of international knowledge and also local scientific experience.

The objectives of this study are to:

- evaluate the importance of olive tree and annual crops association practice in Saïs region
- evaluate advantages and disadvantages of such practice according to farmers perceptions.

19.2 Methodology

To evaluate the importance of agroforestry, including olive tree practice in Saïs region, a prospecting has been made on 2008, covering the region of Meknes—Fes—Imouzer and Bhalil (Fig. 19.1). During the survey we recorded:

- Crop species cultivated between olive tree rows
- Olive tree density
- Distances left between olive tree and the first line of the intercrop.

We also made agronomic observations on fields and interviewed farmers to assess their views about the advantage and disadvantages of this practice.

The total annual rainfall received on 2007–2008, was 334 mm while the main rainfall from 1997 to 2007 was 455 mm.

19.3 Results

The density structures of olive trees in the selected region varies between 6.50×6.50 m (42.25 m^2) to 12.0×9.2 m (110.4 m^2), however, the common density was recorded as 10×10 m = 100 m^2. These densities correspond to a number of trees

Table 19.1 Cultivated species as intercrop on olive according to water irrigation availability

	Cereals	Legume crops	Forage	Vegetables
Rainfed	*Triticum aestivum* *Triticum turgidum* *Hordeum vulgare*	*Vicia faba* *Cicer arietinum* *Lens culinaris* *Phaseolus vulgaris*	*Avena sativa* *Hordeum vulgara*	
Irrigated	*Zea mays*			*Solanum tuberosum* *Allium cepa*

Table 19.2 Plant density and number of trees per hectare

Density	Trees per ha
6.5 × 6.5 m	238
8 × 8 m	156
10 × 10 m	100
12 × 10 m	83

per hectare variant between 83 and 237 trees/ha. The survey revealed that, most of the fields visited comprised of olive trees in association with other crops such as cereals (wheat, maize), forages (barley, oat), legumes (faba bean, chickpea, pea, bean), and vegetables (potato, onion) depending on irrigation availability (Table 19.1).

The distance left between olive tree and the first line of the cultivated crop varies between 0 and 2 m for cereals while it varies between 0.50 and 2.5 m for crops cultivated on more large lines (0.5 m as for legume crops or 0.5–0.7 m for potato or onion) Table 19.2.

According to this situation it is clear that cereals my compete more with olive tree than other crops. Farmers report that legume crops like faba bean, lentils or peas did not affect olive production, while cereals may reduce it. In fact, the first ones could be sown a part from olive trunk. While cereals are sown with no respect to olive tree occupation area (Fig. 19.2), this situation is more pronounced when those crops are hand sowing (Table 19.3).

So, on average, every tree occupies approximately an area of (5×5 m $= 25$ m^2). If we consider one ha of olive tree with a structure density like 10×10 m, which represents 100 trees/ha, this will represent an occupation of 2,500 m^2, the remaining 7,500 m^2 could be used for intercrop between olive alley. This area depends on olive tree structure and age. We estimated that this area will vary between 4,075 and 7,925 m^2 (Fig. 19.3). In this estimation no consideration has been taken for area subjected to negative impacts of both crop on each other, so to determine suitable land part for olive tree and the intercrop.

The exploitation of inter rows depends on farmers. Small ones who try to exploit all land they possess cultivate inter-rows with rainfed crops like cereals or fodder and with irrigated crops like potato and other vegetables when irrigation is possible. While other farmers may cultivate inter-rows mainly during the first years of plantation. In some cases, land may belong to one farmer while the plantation belongs to another, so each one of them will be more interested in one production (crop or olive) than both.

Fig. 19.2 Olive tree associated with different crops; Wheat (**a**), Barley (**b**), Faba bean (**c**), Peas (**d**), Onion (**e**), Potato (**f**)

Table 19.3 Distance (m) left from olive tree trunk to the first line of intercrop

	Minimum	Maximum
Cereals	0	2
Legume crops	0.50	2
Vegetables	0.50	2

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:

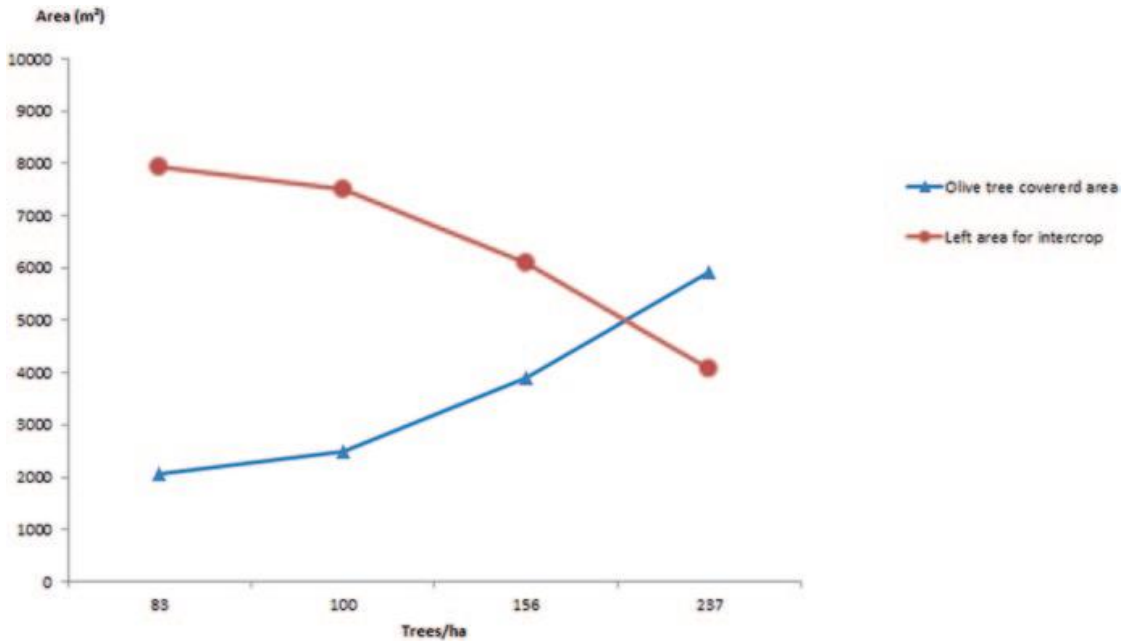

Fig. 19.3 Estimated covered area by olive tree and intercrop according to olive tree density

- Management of olive tree production (plowing, fertilization, weed control …) may be more profitable if it is practiced on crop cultivated 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.

19.4 Discussion

As arable land has become scarce and length of forest fallow periods has declined, simultaneous associations of trees and annual crops have been investigated as alternatives to shifting cultivation systems (Liebman and Staver 2004).

Agroforestry systems exist in Morocco in different parts of the country and are much diversified according to agro climatic conditions where they are implemented and also according to farmer's practices. At national level, few scientific involvements have been made to study these systems as a hole. Chebli et al. (2012) and Chryaa and El Mzouri (2004) demonstrate benefits from introducing fodder shrubs in low rainfall area of Morocco, alley cropping (*Atriplex nummularia* and *Hordeum vulgar*e) permit an increase in yield per unit area, diversification of species; a decrease of feeding cost in addition to the increase of economic efficiency of land with low potential; an improvement of animal performance and a rehabilitation of marginal land and fauna and flora (Chryaa and El Mzouri 2004).

At regional level, in Tunisia for example, Karray et al. (2008) studied the water balance of the olive tree and annual crop association, while Alary et al. (2007) studied modeling impact of spineless cactus in alley cropping. At Mediterranean level,

in Italy Rosati et al. (2012) studied the performance of an agroforestry system basis on organic farming including: olive tree a wild asparagus species (*Asparagus acutifolius*) as an understory crop together with raising meat chicken. At international level, scientists demonstrate that agroforestry may have many advantages: diversification of ecosystems which can preserve and enhance: biodiversity, C sequestration, efficient use of inputs (land, fertilizers, water). Palma et al. (2007) estimate that this practice may reduce soil erosion up to 65 % and reduce nitrogen leaching by about 28 %. In agroforestry the components of the system depend on the same pool of reserve for growth as: sunlight, water and nutrients, so every component of the system will influence the performance of the other component as well as the performance of all the system (Kumar et al. 2006). Mechanization of the inter row crops could damage plantation. Associated crops may shelter special parasites or pests to a component of the couple. Also, association of different crops with different growth cycles and requirements may enhance competitiveness for inputs: sun light, nutrients and water. Allelopathic interactions may occur between associated plants.

Our study indicates that, olive tree is, in most case, not planted alone (Fig. 19.2). The species cultivated in alley are diversified as species and as cultivating techniques. For cereals we do have autumn sown crops like wheat and barley and spring sowing ones like maize which requires irrigation. For those crops we observed that, no area is left between olive tree and intercrop to reduce competitiveness effects on both crops.

For crop cultivated on more large lines, like legume crops or vegetables, competitiveness between olive tree and intercrop may be reduced. More for legume crops, olive tree may benefits from biological nitrogen fixation performed by legume crops. Among, legume we can distinguish also, autumn sowing crops (faba bean, lentils, peas and winter chickpea) and spring sowing like chickpea and beans. For the last ones, competitiveness for water resource may be enhanced as last part of season receives less rainfall.

For vegetables, even if irrigation, which is necessary for their production in our context, may be profitable to olive tree, the risk of pathogen transmission between potato for example and olive tree make this combination less profitable. In fact, Verticillium wilt, caused by the soil-borne fungus *Verticillium dahliae* threatens olive-growing in several Mediterranean Basin countries (Hiemstra and Harris1998) and became the most important threats to potato crops in North America (Rowe and Powelson 2002).

Intercrop may reduce soil erosion, water loss, weeds impact on olive tree and could be an alternative in organic farming for olive oil. In farmers fields we observed that according to olive tree orientation, inter rows crops may benefit from shading that can reduce evaporation. Shading may also enhance grain yield of some crops by enhancing their reproductive cycle (Nasrullahzadeh et al. 2006; Stirling et al. 1990). Genotypic variation for shading adaptation among crop species or among the same specie (Nasrullahzadeh et al. 2006) may exist and could be explored for alley cropping. Aromatic and medicinal plants offer a large genetic diversity among crops more suitable for alley cropping. The cultivation of those crops in association with perennial ones may offer many advantages: diversification of productions, enhancing farmer income (Thakur et al. 2009; Chandelia and Sharma 2009)

Filtered water from rainfall or from irrigation of inter rows crops may profit olive trees reaching deeper horizons. Association of perennial and annual crops may reduce the negative impact of rainfall variation; according to species and their growth cycles, we can choose between those that have different critical growth periods. Minimum tillage (conservation agriculture) could be a good option for crop production in this way we can prevent damage to olive tree roots.

The adoption of olive tree and annual crops association by farmers demonstrate the benefit of such system. So advantages and disadvantages should be evaluated according to scientific and measured data. The conditions (zone, climate, topography …) where the association of perennial and annual crop is used, should be indicated. Also, the species that could be more profitable to be associated as inter rows crop should be named or discovered. Adequate agronomic practices to enhance the profitability of such system should be studied.

19.5 Conclusions

Association of perennial crops and annual is a common practice adopted by farmers and might be more important in future due to land scarcity. Scientific involvement to analyze such system is necessary. Positive and negative interactions should be elucidated to choose more profitable combinations in more adaptable conditions. Association of perennial and annual crop might be an interesting option to face climate change. Also, it could enhance land profitability.

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