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DETERMINATION OF THE EXTENT AREA OF INTERACTIONS BETWEEN THE OLIVE TREES AND CEREALS IN AN ALLEY CROPPING SYSTEM IN MOROCCO

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ABSTRACT

In an Agroforestry system, interactions between annual crops and perennial ones are complex. In the objective of elucidating the resultant of those interactions on the performances of the system olive tree - cereal crops, barley (*Hordeum vulgare*), durum wheat (*Triticum turgidum*) and soft wheat (*Triticum aestivum*) were cultivated between the rows of olive trees (*Olea europaea*) (10 x 10 m) under rainfed conditions. Cereals were sown according to two orientations: North - South and East –West.

At maturity, assessment of cereals productions (yields and their components) was realized at various distances from olive tree rows. Under the weather conditions of the year (rainfall: 300 mm), the experiment showed that the height of plants (H) of various cereals is the parameter which illustrates the best representation models of its evolution in relation with distance (D) from olive tree row. The cereals with sowing realized according to the orientation East – West were the most successful. The models developed under this orientation were, respectively for barley and durum wheat $H = -5.33D^2 + 56.36D - 110.89$ ($R^2 = 0.74$) and $H = -2.89D^2 + 29.70D - 40.738$ ($R^2 = 0.75$). For cereals sown according to the orientation North – South, the models developed respectively for barley, durum wheat and soft wheat are:
$H = -1.39D^2 + 16.99D - 22.245$ ($R^2 = 0.75$), $H = -2.33D^2 + 27.44D - 56.13$ ($R^2 = 0.73$) and $H = -2.22D^2 + 25.63D - 47.15$ ($R^2 = 0.76$).

Keywords**:** alley cropping, *Olea europaea, Hordeum vulgare, Triticum turgidum, Triticum aestivum,*. Morocco.

INTRODUCTION

In Morocco, agroforestry exists in oasis and also in mountainous regions where in both situations agricultural lands and water resources are scarce. In order to face climatic change, Moroccan government plans the conversion of 1 million ha of cereals to olive tree. In fact, in a previous study, Daoui *et al*. (2012) 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 (Daoui *et al*. 2011).

The objective of this study is the optimization of the production of an alley cropping system basis on olive tree and cereals, this by:

- Determination of extent area of interaction between olive tree and cereals in order to make the association (olive tree and cereals) more profitable.
- Evaluation of productivity of different cereals in an alley cropping system with olive tree.

MATERIALS AND METHODS

A field trial was implemented on 2011-2012 in the Experimental Station of Douyet (National Institute for Agricultural Research INRA, Morocco). Tree cereals (barley (*Hordeum vulgare),* durum wheat (*Triticum durum) and* soft wheat (Triticum aestivum) were sown on row separately between olive trees (*Olea europaea*) planted at the density of 10 * 10 m². Cereal sowing rows were oriented East – West and North South.

At maturity of each cereals, from one tree in front of another, one sample of 1 m long has been collected every third row of sowing according to orientations: For rows oriented East – West, we took 6 samples, of 1 m long on the same row of sowing, in front of olive tree (tree 1 up to the tree 6). Then the average of these 6 samples was calculated and it represents the average of the parameter studied for this row of sowing, and the calculations were done following the same pattern for all the rows going from 1 to 7 where row 1 is located under the sunny side and the row 7 under the shaded side. For rows oriented North – South, we took 4 samples of 1 m long on the same row of sowing in front of olive tree (tree 1 to tree 4). Then the average of these 4 samples was calculated and represents the average of the parameter studied for this row of sowing. Same calculation basis was used for all rows (1 to 7), where row 1 is located under the sunny side and row 7 under the shaded side.

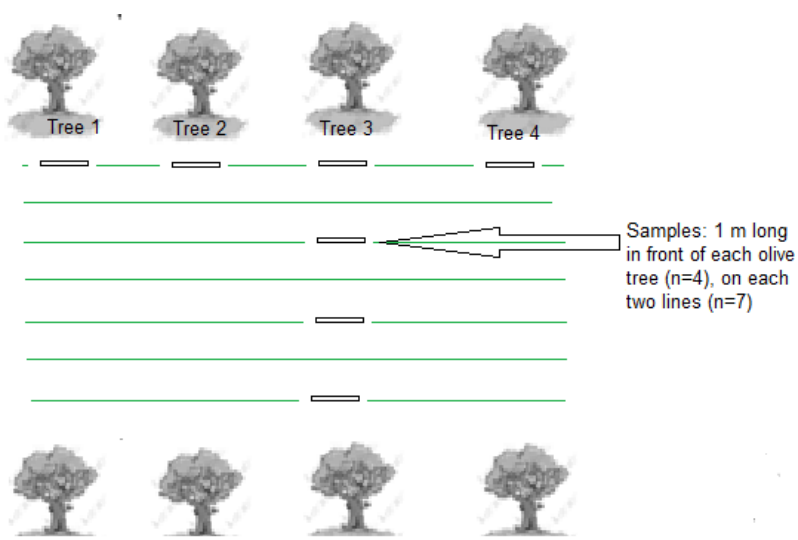

Figure 1. Sampling method

Statistical analysis (ANOVA 1) was performed to evaluate the effect of distance from olive tree on studied parameters. Models of correlation have been proposed according to their significant R^2. Sowing orientations East – West or Norh - South were compared using *S*tudent's t-test.

RESULTS

Climatic condition of the year

The total rainfall recorded during the experiment was 300 mm, while 50% of it was received from October and November. After that, a severe drought was recorded from December to March where only 50 mm of rainfall was received (figure 2).

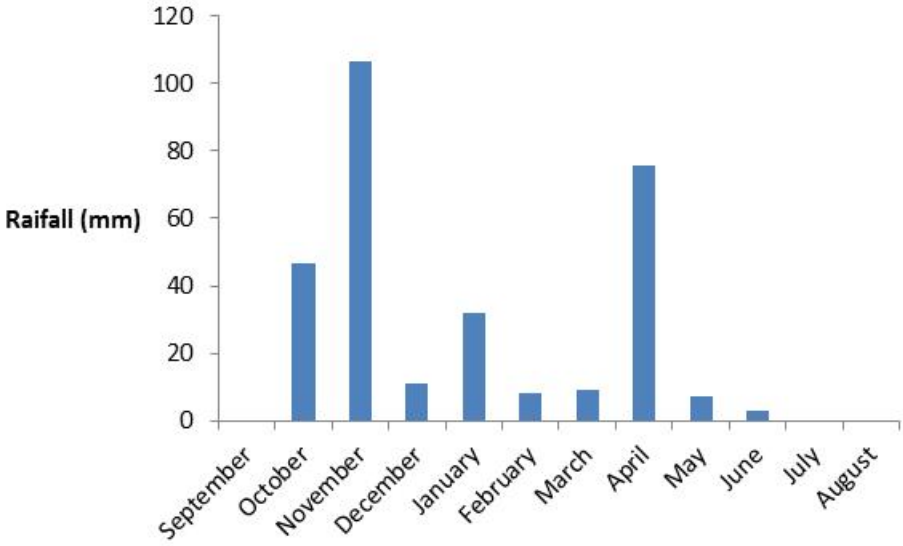

Figure 2. Monthly rainfall (Experimental Station of Douyet, 2011–2012)

All studied parameters present the same tendency than plant height (H) which is discussed in more details in this paper.

Evolution of the height of various cereals by referring to various distances from olive tree and to the orientations of the sowing rows.

Barley

For the NORTH-SOUTH directed rows of sowing, we note that there is a significant effect of the distance between the olive tree and the row of sowing of barley on the variable height of plants. The maximal height about 24 cm is observed at row 4, the minimum of 15 cm is observed for row 2. The evolution plan height of barley, in relation with the distance from olive tree follows a polynomial curve ($y=-1.39x^2 + 16.99x - 22.245$ ($R^2 = 0.75$)).

For rows of sowing directed EAST-WEST, we note that there is a significant effect of the distance between the olive tree and row of sowing of the barley on the variable height of plants. The maximal height about 45 cm is observed at row 7, while for row 1, plants died. The evolution of plant height of barley, in relation with the distance from olive tree, follows a polynomial curve ($y=-5.33x^2 + 56.36x - 110.89$ ($R^2 = 0.74$)).

Durum wheat

For the row of sowing oriented NORTH-SOUTH, plan height of durum wheat was significantly affected by the distance from olive tree. The maximal plan height was about 23 cm observed at row 5 while, the minimum was about 20 cm observed for row 2. The evolution of plant height of durum wheat, in relation with the distance from olive tree follows a polynomial curve ($y: =-2.33x^2 + 27.77x – 56.13$ ($R^2 = 0.73$)).

For the rows of sowing directed EAST-WEST, we note that there is a significant effect of the distance between the olive tree and the row of sowing of the durum wheat on plant height. The maximal height was about 40 cm observed at row 6, the minimum about 20 cm is observed for row 1. The evolution plant height of durum wheat, in relation with the distance from olive tree follows a polynomial curve ($y=-2.89x^2 + 29.70x - 40.738$ ($R^2 = 0.75$)).

Soft wheat

For the NORTH-SOUTH directed rows of sowing, we note that there is a significant effect of the distance from olive tree on plant height of soft wheat. The maximal height was about 30 cm observed at row 7, while the minimum about 15 cm is observed for row 4. The evolution of plant height of soft wheat in relation with the distance from olive tree follows a polynomial curve ($y =-2.22x^2 + 25.63x - 47.15$ ($R^2 = 0.76$)).

For the rows of sowing oriented EAST-WEST, we note that there is a significant effect of the distance from the olive tree on plant height (H) of soft wheat. The maximal height was about 33 cm observed at row 3, while the minimum was about 20 cm observed for rows 5 and 4.

DISCUSSION

As arable land has become scare 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). Scientists demonstrate that agroforestry may have many advantages: diversification of ecosystems, C sequestration, and efficient use of inputs. In Moroccan conditions, 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 marginal land, and fauna and flora (Chryaa and El Mzouri, 2004). The association of olive tree and cereal that dominate in olive tree cultivation by small farmers, should be monitored for a better use of available resources (water, light and nutrient), and also taking advantages from associated crops.

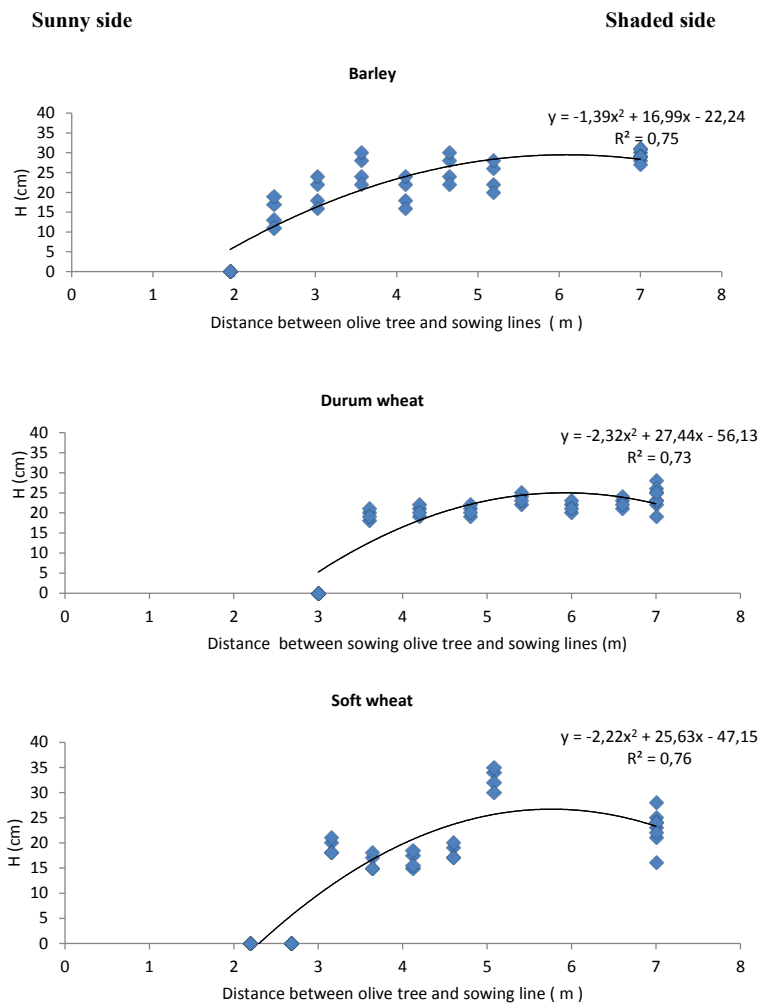

Figure 3. Models of cereals plant height evolution at different distance from olive tree (sowing rows oriented North – South)

So under shaded part, cereal are less affected than the sunny part, probably due to less loss of soil water by evaporation, this indicate that:

1. When water is not limited, alley crop even if under olive trunk, may not suffer from water availability,
2. For olive tree, irrigation could be monitored according to soil water content according to side subjected to more sun light.
3. Soil water under the sunny side could be protected against evaporation by mulching for example.
4. Under rainfed conditions, with limited rainfall, and for a better productivity of the hole system (olive tree and cereals), it should be more profitable to cultivated cereal a part from the olive foliage. Otherwise, both crops may suffer from competition.
5. Sowing rows oriented North South performs more better than sowing rows oriented East - West

CONCLUSIONS

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.

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