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Evaluation of the impact of water stress and irrigation on carob tree two year seedlings in Northeast of Morocco

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ABSTRACT

The carob tree planting was done with two year seedlings. The effect of irrigation on the annual growth of the carob tree was similar in parts conducted in irrigated or kept dry. After three years of culture, seedlings reached a height of 55.7 ± 15.5 cm in the irrigated part against 53.4 ± 22.4 cm in the dry part. The survival rate was 93% under irrigation and 86% in the dry part. These two results are more superior to those obtained in the plantations of the Forestry Administration whose levels during the 2011-2012 year, did not exceed 30%[15].

KEYWORDS

Carob tree;
Water stress;
Irrigation;
Growth;
Height;
Mortality.

INTRODUCTION

The carob tree (Ceratonia siliqua L.) is a sclerophyllous legume belonging to the subfamily of Caesalpiniaceae. It is present mainly in the Mediterranean in marginalized and calcareous soils[18]. Pods and seeds are mainly used in food, cosmetics and pharmaceuticals[5,27]. Morocco is the fourth producer country of carob in the world contributing to 8% of world production. Although presented as having a high resistance to hot and cold bioclimates, to water stress compared to other Mediterranean species[21,22], and to salt stress[9,10], it is a difficult manageable species in reforestation areas. The balance sheets of foresters suggest very significant failures. The success rate of carob tree plantations does not exceed 30% in the best cases, between 10 and 30% overall. Our work therefore plans to test the effect of irrigation on the annual growth of the carob tree whose seed used in planting had an age of two years. Planting was followed for three years (2010-2013).

MATERIELS AND METHODS

Plant materiel and study area

Carob tree two year seedlings were raised in the Zegangane forest nursery in polythene bags of dimensions 25 cm height, 12 cm section, and 60 microns thick. The mixture of breeding substrate is composed of 55% loam, 15% from the forest soil and 30% sand. The study was conducted in an experimental plot of average altitude of 115 m and located in the region of Nador (Northeast Morocco). Precipitation and maximum and minimum temperatures of the study area are reported in TABLE 1.

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TABLE 1 : Some climatic characteristics of the study area

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
T°C min*	7,7	8,2	9,2	11	14	17,3	20	20,5	19,2	14,7	11	8,3	13,4
T°C max	17,2	17,3	18,8	19,7	22	25,7	28	29	27,2	24	20,7	18,7	22,3
Rainfall (mm)	22	72	20	49	4	0	0	0	33	16	60	45	320

***Source: Ait Aguil[1]**

Experimental procedure and applied treatment

Two distinct parts were each planted with 42 plants aged two (repeats). The treatment is to drive one of the two parties under irrigation, the other under dry conditions (only the natural supply of rainwater). In the first part, the provision of additional water was conducted during the first two years, at a rate of twice a month and when water needs are felt (during the warmer months). In addition, the presence of accompanying vegetation, because it fundamentally alters the growth conditions can influence the crisis transplantation[7]. The maintenance performed is limited to hoeing around the plants and weeding, all made after extensive weed. No nutrient has been brought to avoid possible reactions with the terms of the water regime. The plants used are healthy and vigorous and obtained using a systematic sampling (every 1.5 m). Planting took place at the beginning of March 2010, the recommended period for planting carob tree spreads between February and March[2]. Planting was carried out after a rainy period and on rich soil, been idle for five years. Planting holes have dimensions of 50 x 50 x 50 cm and the density is set to 1.5 x 2 m.

Data collection and statistical analysis

The data collected yearly till the third year of planting carob tree, focused on mortality (alive plants) as well as the height of the latter (taken with a tape measure). For each of the four measurement periods, an analysis of the success rate of plants (proportions of the two terms of the hydrological regime: irrigated or stress) was performed by using the chi-squared test[11]. The effect of water regime on the height growth of carob tree seedlings was evaluated by using the Student t test for comparison of two means[17].

RESULTS AND DISCUSSION

Survival of seedlings

Planting is a trauma for the young plants crossing, for one or more years, a transplantation crisis[7]. It can result in mortality and growth losses. The number and survival rate of seedlings for each of the four years and both water regimes are shown in TABLE 2.

After a year of planting carob tree, the success rate is about 93% in the irrigated part against 86% in the dry one. These rates are still very high and of the same level as those obtained for planting with seed carob aged only one year[14]. However, they remain much higher success rates in plantations made by the forestry administration whose values rarely exceed 30%[15]. Maintenance of hoeing and weeding work has certainly contributed to the increased success rate in our experimental plot. Indeed, weeding, made in a young plantation of oak, have reduced the mortality rate by 15% on average[7].

TABLE 2 : Number and survival rate of carob tree seedlings

Water regime	After plantation	Year 1	Year 2	Year 3
Irrigated: number	42	39	35	30
Rate (%)	100	92.9	83.3	71.4
Stress: Number	42	36	33	30
Rate (%)	100	85.7	78.6	71.4

During this first year, it can be inferred that the observed mortality is twice higher in the dry part compared to irrigated (TABLE 2). The rate of plants remained alive continues to decrease with time. During the second year, it is still higher than in irrigated. After pressure from the provision of additional water in the irrigated, the number of plants remained alive in the third year is the same number in both parties. This allows concluding that the maintenance of irrigation reduces the mortality of the planted seedlings.

The chi-square test for equality of two proportions for each of the four measurement periods is reported in TABLE 3.

TABLE 3 : Chi-square test for equality of two survival proportions (irrigated # dry)

Period	After plantation	Year 1	Year 2	Year 3
Chi 2 value	0	1,12	0,31	0
Probability	1	0,29	0,58	1

TABLE 4 : Shapiro-Wilk normality test for carob tree heights

Period	After plantation		Year 1		Year 2		Year 3	
Water regime	Irrigated	Stress	Irrigated	Stress	Irrigated	Stress	Irrigated	Stress
Sample size	42	42	39	36	35	33	30	30
Value	0.97	0.97	0.97	0.98	0.96	0.95	0.96	0.92
Probability	0.40	0.42	0.44	0.69	0.26	0.11	0.41	0.04

As a result, the success rate achieved for the four measurement periods, did not differ significantly between the two water regimes (all probabilities exceed the 5%threshold). These results are consistent with those obtained by El Asri et al[14] in a plantation with carob for one year old seedlings for planting. It can be inferred that the water regime has no statistically significant effect on the success rate of carob tree plants.

Seedling height

The comparison between the average heights of the two water regimes (irrigated and dry) is based on the application of the Student t test. This involves checking certain application conditions: the independence of samples, the random variable follows a normal distribution and equal variances of the two samples. However, the condition of normality is not essential for adequate samples of about 30 individuals. Despite this, the results of the normality test of Shapiro-Wilk[25] are reported in TABLE 4 for the four measurement periods.

The assumption of normality of the distributions of carob tree heights is accepted for both water regimes and all periods except for year 3 under stress. However, given the large sample size during the three years of cultivation of carob tree, using the Student t test is still possible. Regarding the condition of equality of variances, the results of equality of the two variances of Levene[16], for the four measurement periods, are shown in TABLE 5.

TABLE 5 : Levene test of equality of variances for carob tree heights

Period	After plantation	Year 1	Year 2	Year 3
Sample size	84	75	68	60
F value	0.02	1.92	3.06	3.46
Probability	0.88	0.17	0.08	0.06

It follows that the hypothesis of equality of the variances of the two water regimes is accepted for the four measurement periods. The Student t test is based on the combination of the two variances. The results of this test are reported in TABLE 6.

This table shows that the average heights corresponding to the two treatments of the water regime were not statistically different in the three years of cultivation of carob (all probabilities obtained for the four measurement periods are higher than 5%, level of significance). These findings are different from those obtained by El Asri et al[14] in a carob tree planting with the difference in age of plant planting that was one year instead of two years subject of this work. The height differences between the two terms of the water balance is between -0.67 and 1.50 cm. TABLE 7 shows the average heights in both parts and the four measurement periods.

TABLE 6 : Student t test of equality of mean carob tree heights

Period	After plantation	Year 1	Year 2	Year 3
Mean difference: Irrigated - stress	0.29	-0.67	1.44	1.50
Student t value	0.21	-0.28	0.39	0.30
Probability	0.84	0.78	0.70	0.77

TABLE 7 : Evolution of carob tree height (cm)

Year	Hauteur	Number of observations	Minimum	Maximum	Mean	Standard deviation
Year 0	Irrigated	42	18	42	28,5	6,3
	Stress	42	18	42	28,2	6,2
Year 1	Irrigated	39	17	59	39,6	9,5
	Stress	36	15	66	40,3	12,0
Year 2	Irrigated	35	26	72	48,7	12,8
	Stress	33	17	82	47,2	17,4
Year 3	Irrigated	30	25	85	54,9	15,7
	Stress	30	20	93	53,4	22,4

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Preliminary analysis shows that before planting the two samples have approximately the same average height: 28.5 ± 6.3 cm for irrigated and 28.2 ± 6.2 cm for the dry part.

Yearly height growth

On average, annual growth was 9 cm/year for all parties combined and for the three years of culture. It is three times less than that obtained in the work of El Asri et al[14]. It can be deduced that the smaller the age of the plant at planting is, the higher the annual growth will be. Similarly, we can see that the annual growth rate decreases with time. For both parts, it is 12 for the first year, 8 for the second year and 7 cm/year for the third year. Annual growth is about the same and evolves in the same way in both parties. This confirms the conclusions reached in the work of Collet et al[7]: During the first two years, the competition for water was not the major factor in the reduction of growth in a young oak grove.

CONCLUSION

The study shows that the effect of irrigation on height growth is not significant on both the success rate after planting on the survival of seedlings. Planting with seedlings of two years allows timbermen to save more water, especially in areas where water is lacking. The work of hoeing and weeding favored the survival of these plants. In fact, the vegetation has a very adverse effect on the recovery and initial growth of seedlings and many studies have shown that the intensity of the transplantation crisis depends on the ability of plants to restore a functional root system after transplanting. The enlargement of the carob tree in reforestation programs in Morocco could be done without any problem management works are conducted at appropriate times.

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