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Study of the effect of irrigation on the growth of carob plants in eastern Morocco: planting with seedlings a year

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1 SUMMARY
Carob, *Ceratonia siliqua* L., is a typical Mediterranean forest tree. In Morocco, it is used as protection against soil erosion and animals eat its fruit. The objective is to study the effect of irrigation on the survival and growth of seedlings of carob. Two water regimes (irrigation and water stress) were evaluated with 42 plants for over four periods: just after planting, then at the end of each year for three consecutive years. The study shows that the additional water supply resulted in survival rates (after a year of growth) higher than for the situation under water stress, but these differences are not statistically significant, at least until the end of the third year after planting. These survival rates were 88% in irrigated against 76% under water stress. In contrast, the study shows that irrigation has a significant effect, P-value between 1 % and 3 %, on the growth of seedlings of carob, namely their height. Initially, there was no significant difference between the two treatments, but this difference arose and becomes significant at the end of the first year and will continued over the next two years. The mean difference (irrigated-dry) increased by 7 cm at the end of the first year, 15 cm at the end of the second year to 19 cm at the end of the third year. It can be concluded that the addition of extra water has no significant effect on the survival rate, but it has a clearly significant effect on plant growth (height). Therefore, irrigation during the first two years twice a month would be highly recommended for better growth of the carob tree.

2 INTRODUCTION
The carob tree (fig.1) (*Ceratonia siliqua* L.) is a sclerophyllous leguminous tree species widely cultivated in the Mediterranean basin (Correia *et al.,* 2005; Talhouk *et al.,* 2005). It is an agro-forestry-pastoral species cultivated for ornamental (in gardens and farms by agriculture) and industrial purposes, such as industry paper, inks, textiles, pharmaceuticals, cosmetics, (Ait Chitt *et al.,* 2007) and as feed for livestock (locust beans, leaves) and food for human consumption (Ramon-Laca and Mabberley, 2004). The carob consumed by humans is the dried (and sometimes roasted) pod, and not the 'nuts' or seeds. Carob is mildly sweet and is used in powdered, chip, or syrup form as an ingredient in cakes and cookies, and as a substitute for chocolate. (Konté, 2007). The carob has-been grown as a dryland crop in Cyprus for centuries and has long-been a leading agricultural export (the carobs were collected, stored, and exported in vast quantities) (Davies, 1970). In Morocco, it is set for a protective purpose and its fruit is traditionally used as animal feed (Benabid, 2000). However, carob planting is much neglected and

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has not had the attention it deserves in reforestation programs (Sbay *et al.,* 2005).

Fig. 1: Carob trees (A); flowers (B) and fruits (C and D).

The balance sheets of these plantations during the companion (2011-2012) have reflected almost total failure (HCEFLCD, 2012). In recent years, this species has been the subject of several actions for its development (Sbay *et al.,* 2005). In order to contribute to the improvement of our knowledge face of the provision of irrigation, this study aims to test the effect of water supply on height growth in a young plantation of carob conducted in two ways of water regimes, stress, and irrigation.

3 MATERIALS AND METHODS

3.1. Plant material and study environment: The used Carob plants were one year old and came from the Segangane forest nursery in the region of Nador, northeast of Morocco. They were raised in polythene bags with dimensions of 25 cm, 12 cm square, and 60 microns thick. The substrate used was composed of a mixture of 55% loam, 15% of soil from forestry origin and 30% sand (HCEFLCD, 2008). The study was conducted in an experimental plot, located in the region of Nador on an average altitude of 115 m. The area is an extension of the Rif's chain and where small mountains dominate large depressions more or less flat and open to the Mediterranean Sea (Daki, 2003). The climate is Mediterranean; the average annual precipitation is about 345 mm (Ait Aguil, 2005). The average temperature is 18.6 ° C with a minimum of 6.3 ° C (January) and a maximum of 32.3 ° C (August) (MCEF, 2002).

3.2 Experimental protocol and planting: The experimental plot was divided into two parts; each planted with 42 one-year-old plants (repetitions). Systematic sampling (every 1.5 m) along the length of the boards was adopted to represent all existing heights in the nursery. The plants were sorted and carefully selected to be healthy and vigorous. Planting took place in early March 2010 (Sbay *et al.*, 2007; Ait Chitt *et al.,* 2007). It was conducted in holes measuring 50 x 50x 50 cm and preceded by a rainy period, which allowed different plants to take advantage of moist soil conditions. Given the short growing period (3-4 years) and the slow growth of the carob tree, the density was set at 1.5 x 2 m. In Morocco, the densities used were 100 (10x8) or 200 (8x8) plants per hectare (Ait Chitt *et al.,* 2007).

3.3 Treatment applied and data collection: The two parts were conducted differently: one irrigated (providing additional water) and one dry (only when it rains). Providing additional water was made during the first two years twice per month. Maintenance work, hoeing and weeding around the plants were carried out after any outbreak of weeds. The mortality rate or its complementary, the survival rate, and plant height (taken with a tape measure) were measured just after planting and at the end of each year for the first three years.

3.4 Statistical Analysis: Regarding the survival rate of carob plants, comparison of proportions between the two water regimes (irrigated or stress) for each of the four measurement periods was performed by using the chi-square test for equality of two proportions (Dagnelie, 2011). As for the effect of water regime on growth in carob plant height, it was tested for each of the four measurement periods, by using the Student *t* test for comparison of two means (Levine and Stephan, 2005).

4 RESULTS AND DISCUSSION

4.1 Survival rate of plants: Table 1 summarizes the number and survival rate of carob plants among the 42 initial plants in the two water regimes (irrigated and stress) for the four measurement periods (just after planting and the following three years). These rates are plotted in Figure 1. The timing of planting is extremely useful for a good recovery of planted seedlings. Planting in wet soil conditions, respect of the period from planting and weeding performed resulted in survival rates of 100% after transplantation under the two water regimes. After a year of growth, the success rate of planting was 88% for both water regimes, which is a good result compared to all species planted, the most adapted to Moroccan conditions. In this country, the survival rate during the 2011-2012 campaign, varied between 10 and 30% (HEFLCD, 2012). However, in Portugal, seedling survival and growth of carob were very high with over 95% in a revegetation experiment (Clemente *et al.,* 2004). From the year 2011, the carob was separated in the final assessment of reforestation. Before, it was always placed in the category of other species. The widespread use of the carob tree in reforestation areas may therefore be sufficient if watering is provided and minimum good agricultural practices are observed. The difference between the two water regimes will be noticed only at the end of the second year. For the latter and for the third year, the survival rate under irrigation, is identical to that recorded during the first year (88%), while it drops to 76% under drought stress for the two years in question. On average, after three years of cultivation, the mortality rate was 12% under irrigation leading to a success rate of 88%. By contrast, under dry conditions, the mortality rate was two times higher than in irrigated (24%) leading to a survival rate of 76%. In what follows, the analysis concerns only living plants, plants dead during the course of the experimentation have not been replaced.

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Table 1: Number and survival rate of carob plants.

Water regime	After plantation	Year 1	Year 2	Year 3
Irrigated: Number Rate (%)	42 100	37 88.1	37 88.1	37 88.1
Dry: Number Rate (%)	42 100	37 88.1	32 76.2	32 76.2

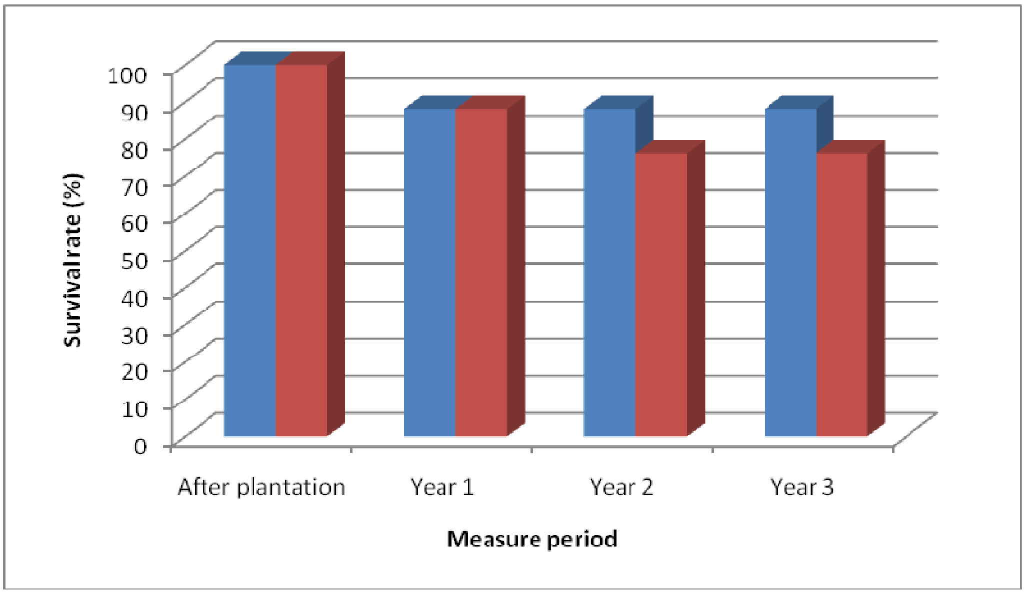

Figure 1: Survival rate of carob plants depending on the water regime.

In order to formally test whether the survival rates differ significantly between the two water regimes, we realized the two chi-square test of equality of two proportions for each of the four measurement periods. The results are reported in Table 2.

Table 2: Chi 2 test chi of the equality of two proportions.

Water regime	After plantation	Year 1	Year 2	Year 3
Chi 2 value	0	0	2.03	2.03
Probability	1	1	0.15	0.15

The results in Table 2 show that there is no statistical significant difference (all probability exceed the 5% level) between the survival rate of carob plants corresponding to the two water regimes, whatever is the measure period. It can be inferred that the water regime has no statistical significant effect on the survival rate of carob plants.

4.2 Plant height: The application of the Student *t* test for comparison of two means requires checking two conditions: the normality of distributions and the equality of the two variances or homoscedasticity. However, the condition of normality is not essential and becomes secondary when samples have large size (about 30). Nevertheless**,** the normality test of Shapiro-Wilk (1965) was performed. Regarding the condition of equality of the two variances, it is not essential when sample sizes are equal. Since this is not our case (sample sizes ranging from 69 to 84), this condition must be verified by using statistical tests such as Levene (1960). In addition,

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it is always possible to make a *t*-test even in the case of significant differences between the two variances, using a different formula. The results of the normality test are summarized in Table 3, while those of equality of the two variances for the four measurement periods are shown in Table 4.

Table 3: Normality test of Shapiro-Wilk for carob plant height.

Time	After plantation		Year 1		Year 2		Year 3	
Water regime	Irrigated	Dry	Irrigated	Dry	Irrigated	Dry	Irrigated	Dry
Sample size	42	42	37	37	37	32	37	32
Value	0.95	0.96	0.96	0.94	0.96	0.93	0.94	0.96
Probability	0.07	0.13	0.18	0.05	0.20	0.03	0.04	0.27

The assumption of normality of the distributions of carob plant heights is accepted for 6 of the 8 possible combinations of the four measurement periods and two water regimes and is not rejected at the 5% for the second year under stress and for the third year under irrigation. However, even with this rejection, the Student *t* test can still be used because of the sufficient sample size (ranging from 32 to 42). Table 4 shows that the hypothesis of equality of the two variances, corresponding to the two water regimes, is accepted for the four measurement periods. In this case, the *t*-test is based on the combination of the two variances. The results of this test are reported in Table 5 and the average heights in Figure 2.

Table 4: Levene test of equality of two variances for carob plant height.

Time	After plantation	Year 1	Year 2	Year 3
Sample size	84	74	69	69
F Value	0.09	0.34	0.00	0.65
Probability	0.76	0.56	0.98	0.42

Table 5 shows that the average heights corresponding to the two water regimes (irrigated and stress) are not statistically different before planting (probability 0.94 >> 5%) whereas they have become significantly different from the first year (probability 0.03 <5%) and continued to be for the next two years (probabilities of 0.01 and 0.02 <5%). Height differences, negligible before planting (0.05 cm), increased over the years from 7.30 cm in the first year and 14.88 cm in the second year to finally reach 19.02 cm in the third year (Figure 2).

Table 5: Student t test of equality of mean heights of carob plants.

Time	After plantation	Year 1	Year 2	Year 3
Mean difference: Irrigated-dry	0.05	7.30	14.88	19.02
Student *t* value	0.08	2.29	2.75	2.45
Probability	0.94	0.03	0.01	0.02

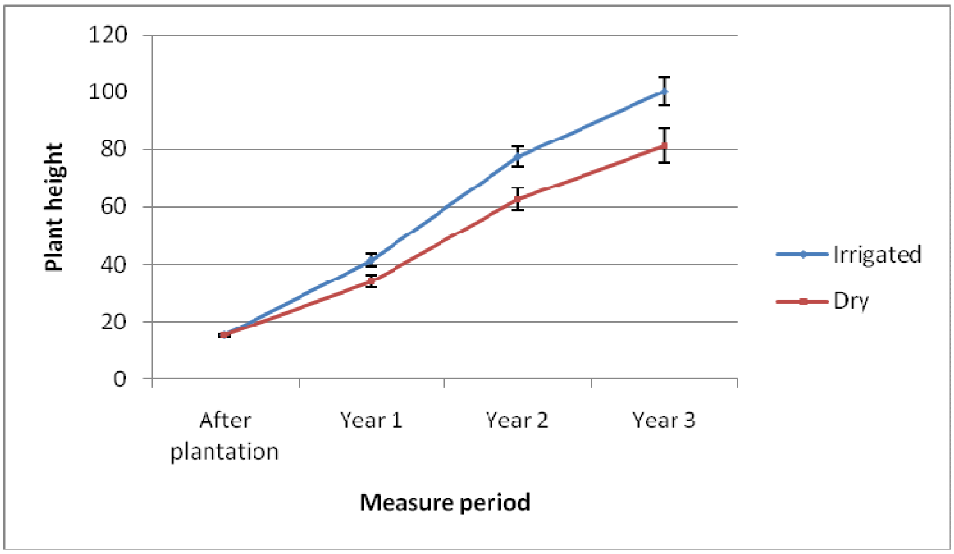

Figure 2: Mean height of carob plants following the two water regimes during the 4 measure periods.

For the first three years of cultivation, the annual height growth was respectively 23, 33 and 21 cm/year, or 26 cm/year on average for the two combined water regimes. However, this growth differs from one regime to another; annual growth has averaged 28 cm/yr under irrigation against 22 cm/year only under dry conditions that is more than 27% due to the effect of irrigation. These results show that the addition of extra water could therefore improve the heights of the carob tree. However, during the third year, the removal of the water supply has caused a drop in levels of growth, without affecting mortality in the irrigated part.

5 CONCLUSION

The study showed that carob planting could be successful with higher rates of success of planting. The survival rate of 88% is very encouraging for the expansion of plantations in carob reforestation in Morocco. The additional water is needed for a good start of seedlings after transplanting. It reduces mortality and accelerates the annual growth of the carob tree. The choice of the period and the time of planting, in addition to running minimum of cultural practices (hoeing and weeding) must be observed.

6 REFERENCES

Ait Aguil F., 2005 : Contribution à l'étude de la biodiversité de la flore fongique des forêts marocaines : cas des Basidiomycètes du Rif Oriental et des Gastromycètes de la Mamora. Thèse de Doctorat. Université Ibn Tofail, Kenira, Maroc, 139 p.

Ait Chitt M., Belmir H., Lazrak A., 2007: Production de plants sélectionnés et greffés de caroubier. Transfert de technologie en agriculture. MAPM/DERD. Bulletin mensuel d'information et de liaison du PNTTA, n° 153,

Clemente A.S., Werner S., Máguas C., Cabral M.S., Martins-Loução M.A. et Correia O., 2004. Restoration of a limestone quarry: effect of soil amendments on the establishment of native Mediterranean sclerophyllous shrubs. J. Soc. Ecol. Restor., 12: 20 – 28.

Correia Pedro José et Martins-Loução A.M., 2005. The use of macronutrients and water in marginal Mediterranean areas:

the case of carob-tree. Field Crops Research**,** 91:1–6

Dagnelie P., 2011. Statistique théorique et appliquée. 2: Inférence statistique à une et à deux dimensions. 3ème édition. De Boeck : Louvain-la-Neuve, Belgique.

HCEFLCD, 2012. Bilan définitif des reboisements 2011-2013. Eaux t Forêts, Rabat, Maroc.

Konté I. 2007. Diversité phénotypique et moléculaire du Caroubier (*Ceratonia siliqua* L.) et des bactéries endophytes qui lui sont associées. Thèse de Doctorat, Université Mohammed V, Faculté des Sciences, Agdal, Rabat, Maroc, 196p.

Levene H., 1960. In Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling, I. Olkin *et al.* eds., Stanford University Press, pp. 278-292.

Levine D.M. and Stephan D.F., 2005. Even you can learn statistics. Prentice Hall: Upper Saddle River, USA.

Ramona-Laca L. and Mabberley D.J., 2004. The ecological status of the carob-tree (Ceratonia siliqua, L.) in the Mediterranean. Botanical Journal of the Linnean Society, 144: 431-436.

Sbay H. et Abourouh M. 2005 : Apport des espèces à usages multiples dans le développement durable : cas du pin pignon et du caroubier. Communication # 3.18. Centre de la Recherche forestière. Rabat. (**www.planbleu.org**), 8p.

Shapiro S.S. and Wilk M.B., 1965. An analysis of variance test for normality (complete samples). Biometrika, 52: 591 – 611.

Talhouk S.N., Van Breugel P., Zurayk R., Al-Khatib A., Estephan J., Ghalayini A., Debian N., and Lychaa D., 2005. Status and prospects for the conservation of remnant semi-natural carob *Ceratonia siliqua* L. populations in Lebanon. Forest Ecology and Management, 206: 49 – 59.