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Morphology of healthy leaves and galling leaves in *Pistacia terebinthus* L.

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Abstract. The pistachio is one of the genetic resources under threat of extinction in Algeria, given the combination of stresses of biotic and abiotic nature. Among these biotic factors, the aphids can induce galls on the leaves and hence, change their morphology. The study of morphological changes occurred on the leaves of *Pistacia terebinthus,* L. following gall aphids attack was analyzed in two different sites in the province of Djelfa (Gottiya and Senalba) in Algeria. Ten healthy leaves and ten galling leaves were sampled from ten trees of *P. terebinthus*. Quantitative analysis of morphological variables of healthy and infected leaves has been conducted. T-test showed highly significant differences between infected and healthy leaves of *P. terebinthus* regarding the length, the width of the leaves, the terminal leaflet and the petiole length.

Keywords. Galls – *Pistacia terebinthus,* L. – Quantitative variables – T-test.

***Morphologie des feuilles saines et des feuilles infectées de galles chez* Pistacia terebinthus**

Résumé. *Le pistachier est l'une des ressources génétiques menacée d'extinction en Algérie, vu la combinaison de stress de nature biotique et abiotique. Parmi ces facteurs biotiques, on peut citer les aphides comme insectes ravageurs induisant la formation de galles. L'étude des modifications morphologiques produites sur les feuilles de* Pistacia terebinthus *suite à l'attaque de pucerons gallicoles, a été analysée à l'échelle du peuplement, au niveau de deux différentes stations dans la wilaya de Djelfa. Dix feuilles saines et dix feuilles portant des galles ont été échantillonnées sur dix arbres de* P. terebinthus*, au niveau de deux forêts (*Gottiya *et Senalba) dans la wilaya de Djelfa en Algérie, une analyse quantitative des variables morphologiques des feuilles saines et infectées a été conduite. Le test t montre qu'il existe des différences hautement significatives entre les feuilles infectées et saines de* P. terebinthus *concernant la longueur, la largeur de la feuille et de la foliole terminale ainsi que la longueur du pétiole.*

Mots-clés. *Galles* – Pistacia terebinthus – *Variables quantitatives – Test t.*

I – Introduction

Pistachios, family Anacardiaceae, is a genus of remarkable morphological and genetic biodiversity (Gaussen *et al*., 1982). It is rare and it is endangered in Algeria. This is the result of a chain of interrelated factors such as abiotic and biotic stresses (Belhadj, 2001). The plant-insect relationships have been the subject of extensive studies. If insects are particularly useful for plants, many pests that feed on the plant are sometimes causing irreparable damage (Djazouli, 2010). Aphids attack the pistachio producing galls of different shapes and sizes, causing morphological, anatomical or physiological changes. In this work, a morphological study of infected leaf galls and healthy uninfected leaves of *Pistacia terebinthus* was conducted in order to find out the influence of galling formations on the morphology and size of the leaves.

II – Materials and methods

1. Plant material

Healthy and infected leaves of *P. terebinthus* were collected from two sites within the province of Djelfa in Algeria: (1) Senalba forest (36°42' N, 3°12' W), located about 6 km from the town of Djelfa whith an area of 13,700 ha (Fig. 1), characterized by a continental Mediterranean climate going from cold semi-arid to arid fresh with an average altitude of 1200 m; and (2) Gottiya forest (34°33 'N and 2°48' W) located about 3 km south east of Charef (located about 41 km from town of Djelfa) and extending over an area of 2770 ha at 1320 m mean altitude (Fig. 1), under a semi-arid climate with a cold winter.

The main objective of this study is to investigate the effect of the development of galls on the morphology of *P. terebinthus* leaves. Seven morphological characters (length and width of the leaf, number of leaves, length and width of the terminal leaflet, length/width terminal leaflet ratio and petiole length) were measured (IPGRI, 1998) (Table 1), in ten healthy and ten infected leaves (bearing galls) that were taken randomly on 5 trees from each site.

The data obtained were subjected to statistical analysis using the "Statistica 9 and 10" software. Descriptive and t test analyses were performed.

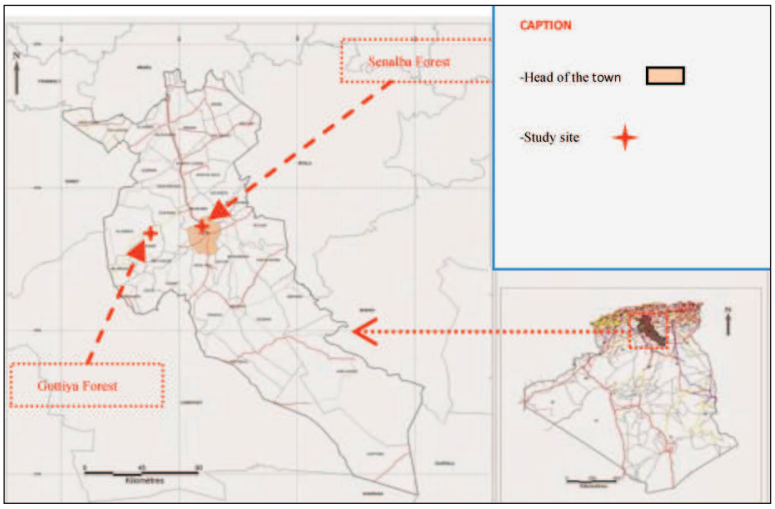

Fig. 1. Geographical location of the sampling sites (Gottiya and Senelba) in the province of Djelfa, Algeria (DPAT, 2012, modified).

III – Results

1. Gottiya Site

The leaf: Leaf length varies between 4.00 to 14.90 cm for healthy leaves and from 3.80 to 16.10 cm for infected leaves. For the width, healthy leaves have an average of 7.15 cm against 7.35 cm for infected ones. The number of leaflets varies between 5 to 11 in healthy leaves and infected leaves (Table 1).

The terminal leaflet: Healthy leaves have a terminal leaflet with an average of 3.75 cm in length and 1.28 cm in width against 3.91 cm in length and 1.29 cm in width for the infected leaves. Infected leaves have a terminal leaflet length / width ratio higher (3,06 cm) than the infected ones (2,96 cm).

The petiole: It is longer for the healthy leaves (2.84 cm) as compared to the infected ones (2.73 cm) (Table 1).

T-test revealed no significant difference between healthy and infected leaves of *P.terebinthus* in Gottiya site for the following characters, length and width of the leaves, the terminal leaflet length/ width ratio and length of the petiole, while a significant difference in the number of leaflets between healthy and infected leaves is registered (Table 1).

Table 1. Characteristics of quantitative variables measured for healthy and infected leaves of *P. terebithus* Mean ± SD ; Min-Max (C.V.%)

Sampling site	Gouttaya			Senalba		
Variables	**Healthy leaves**	**Infected leaves**	**Sig.**	**Healthy leaves**	**Infected leaves**	**Sig.**
1-Leaf length (cm)	10.49 ± 2.35 4.00-14.90 (22.45)	9.77 ± 2.35 3.80-16.10 (24.08)	NS	12.25 ± 3.26 7.10-18.90 (26.61)	8.70 ± 2.07 4.60-12.20 (23.78)	***
2-Leaf width (cm).	7.15 ± 1.57 4.7-10.30 (21.95)	7.35 ± 1.55 4.2-11.20 (21.16)	NS	11.38 ± 2.33 6.80-15.40 (20.50)	9.14 ± 1.51 6.20-13.40 (16.58)	***
3-Number of leaflets	8.40 ± 1.53 5-11 (18.31)	7.64 ± 1.67 5-11 (21.92)	*	7.36 ± 1.56 5-11 (21.21)	7.10 ± 1.32 4-11 (18.71)	NS
4-Terminal leaflet Length (cm)	3.75 ± 0.83 1.90-5.1 (22.14)	3.91 ± 1.12 2.10-6.7 (28.82)	NS	6.18 ± 1.90 3.10-13.80 (30.85)	3.92 ± 1.48 1.50-6.60 (37.73)	***
5-Terminal leaflet width (cm)	1.28 ± 0.27 0.80-1.90 (21.09)	1.29 ± 0.31 0.5-1.8 (24.43)	NS	1.75 ± 0.45 0.70-2.30 (26.03)	1.24 ± 0.39 0.60-1.80 (31.84)	***
6-length/ width of the terminal leaflet ratio	2.96 ± 0.53 1.52-4.36 (18.15)	3.06 ± 0.56 1.90-4.60 (18.50)	NS	3.60 ± 0.82 2.27-6.27 (22.79)	3.12 ± 0.51 2.10-4.00 (16.60)	***
7-Petiole length (cm)	2.84 ± 0.79 2.84-0.79 (27.83)	2.73 ± 0.76 1.20-4.70 (28.10)	NS	3.35 ± 0.94 1.90-5.60 (28.23)	2.39 ± 0.47 1.50-3.30 (20.00)	

**** Significant at the 0.05 level; ** Significant at 0.01 level; *** Significant at 0.001 level.

2. Senalba site

The leaf: Healthy leaves dimensions vary between 7.10 to 18.90 cm in length (an average of 12.25 cm), and from 6.80 to 15.40 cm for the width (an average of 11.38 cm). The infected leaves are shorter (8.70 cm) and narrower (9.14 cm). The number of leaflets varies between 5 to 11 in healthy leaves and between 4 to 11 for the infected leaves (Table 1).

The terminal leaflet: A mean value of 6.16 cm is recorded for the length of the terminal leaflet in healthy leaves against 3.92 cm for the infected ones. Terminal leaflets in healthy leaves have a higher length/width ratio (3.60) than in the infected ones (3.12) (Table 1).

The petiole: It is longer for healthy leaves (2.39cm) as compared to the infected ones (2.73 cm).

The t-test revealed a highly significant difference between healthy and infected leaves of *P.terebinthus* for all the studied characters excepted for the number of leaflets (no significant difference) (Table 1).

IV – Discussion

To provide information on the morphological changes due to the aphids (galls) on the leaves of *P. terebinthus* in Algeria, two sampling sites were selected and a total of seven morphological quantitative characters were measured in this study. The *t-test* allowed to distinguish the existence of discriminating characteristics between healthy and infected leaves in *P.terebinthus.* A noticeable decrease in size of the infected leaves is recorded specially for the length and the width of the leaves, for the terminal leaflet length/width ratio and for the length of the petiole. Aphids cause physiological and metabolic disturbances which produce changes in normal tissue which grows and changes in gall tissue (Wool, 2004). Also according to Shorthouse *et al.* (2005), the galling insects are among the most fascinating herbivores due to their ability to control and redirect the growth and physiology of the attacked body. In our study, the Senalba site showed significant differences for most of the studied characters between healthy and infected leaves, while Gouttaya site did not show significant differences for most of the characters, this difference in the frequency attack can be attributed either to the difference in morphological appearance of *P. terebinthus* trees between the two sites. In fact the foliage of the trees is not similar between the two sites which consequently generates sunshine and a different light and then a different attractiveness groups of aphids.

V – Conclusion

The size of the leaves, the terminal leaflets and the petiole as well as the number of leaflets were all influenced by the galling structures which caused dysfunction and reorientation of the normal development of *P. terebinthus* leaves morphology. This study revealed new insights into the aphid-pistachio relationship as no morphological studies have been conducted previously in Algeria. There are still other aspects to be investigated about this complex relationship, which will allow a better understanding of this species, for its preservation from one hand and for its use in reforestation or improvement programs on the other hand.

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