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Research Article

Biometrics analysis of the stem fibers of some local Algerian plant species

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Abstract
Studying the biometric characteristics of the stems of plant species has been of great interest to researchers in the wood and paper industry. The use of plant fibers has been widespread in the fields of composites, buildings, insulation, plastics and automobiles. The present study aimed to investigate the biometric characteristics of the stem fibers of local Algerian plant species, viz. Group 1 (*Lygeum spartum* and *Stipa tenacissima*), Group 2 (*Linum usitatissimum* in the greenhouse and *Linum usitatissimum* in natural conditions), Group 3 (*Retama monosperma* and *Retama raetam*) and Group 4 (*Phoenix dactylifera* and *Ricinus communis*). The extraction process was carried out using 1 M NaOH at 60 °C for 48 hours, and the fiber length was calculated for all the species using a micrometer. The fiber length of stems of all the species ranged from 0.36 to 5.18 mm. Then, the difference between each of the two species was approximated using Student's test. The results obtained showed that the t value ranged from 0.50 to 1.79 for Groups 4 and 1, respectively. There was no significant difference between them. These results suggest that these species are promising raw materials for paper production due to their adequate fibre length.

Keywords: Fibers, *Linum usitatissimum, Lygeum spartum, Phœnix dactylifera* , Retama, *Ricinus communis, Stipa tenacissima,*

INTRODUCTION

Many plant species in nature produce fibers that can be used in several fields, but their structure, chemical composition, and properties differ greatly and depend on the type of plant (Melelli *et al*., 2020). Plant fibers are fibrillar biological structures composed of cellulose, hemicelluloses, pectins, and lignin. In relatively small proportions of nonnitrogenous extractives, a crude protein material, lipid, and mineral materials. The proportions of these constituents depend greatly on the plant's species, age, and organs (Negoudi and Khinech, 2015).The grouping of the plant fiber forms a fibrous tissue bundle (Harche, 1985; Chabbert *et al.,* 2006).The use of vegetable fibers has had a remarkable expansion since the twentieth century, with the ascension of biotechnologies that have given rise to new applications of plant fibers, notably in the fields of composites and construction, which in the past used synthetic fibers such as glass and carbon fibers, although their impact on the environment was not ecological. At present, vegetable fibers present a potential solution to satisfy the industries' demand and ensure their development while preserving the environment (Le Troëdec *et al*., 2011). The mechanical, physical, and biochemical characteristics of plant fibers make them very competitive with synthetic fibers. The production cost, mechanical performance and recycling are the main advantages that make plant fibers more competitive than synthetic fibers in the world market (Aizi and KaidHarche, 2015). Previous studies have shown that *Retama monosperma* fibers were used to elaborate gypsum composites designed for the civil engineering field to replace glass fibers as reinforcing materials (Aizi and KaidHarche, 2020).The present study has the main objective of investigating the characterization of fibers of some local Algerian plant species, which have many advantages over their synthetic counterparts, such as lower financial and environmental costs, low density and satisfactory specific mechanical properties.

MATERIALS AND METHODS

The samples of this study were the stems of plants of each Group: Group 1 (*Lygeum spartum* and *Stipa tenacissima*), Group 2 (*Linum usitatissimum* in the greenhouse and *Linum usitatissimum* in the natural conditions, Group 3 (*Retama monosperma* and *Retama raetam*), Group 4 (*Phoenix dactylifera* and *Ricinus communis*), which were collected in February 2020 at the University of Science and Technology of Oran campus (USTO) located in the Oran situated in the semiarid bioclimatic zone.

Fragments of 1 cm length were collected from the young stems *of R. monosperma, R. raetam, L. usitatissimum, L. spartum, S. tenacissima, R. communus,* and *P. dactylifera* and then placed in tubes containing a 1 M NaOH solution. They were placed in a drying oven at 60 °C for 48 hours. The tubes were removed from the drying oven and agitated strongly; this action favoured the separation of the cells. NaOH has a role in dissolving the pectin cement existing in the middle lamella.

A fiber suspension was collected with a Pasteur pipette placed between theslide and lamella and observed with a micrometer.

The morphologies and lengths of the fibers were variable. The photographs were taken with a ZEISS Photo microscope. Thirty (30) fibers for different levels of the species selected were measured with an ocular micrometer for the statistical study.

The statistical analysis was performed to compare the average length of the fibers of each of the two species and to indicate whether there was morphological variability between the fibers of the two species for the different parameters (calculating the averages, variances, and standard deviations) and was calculated by the Excel program. Let X be the variable considered, which represents the value of the fiber length of the species.

The arithmetic average X was the sum of n values divided by n:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n} \quad \text{....Eq.1}$$

where Xi is the value of the length of the stem at a given time.

n is the number of observations.

The present study calculated the mean of the quantity measured on n units and its standard deviation S, which represented the measure of the dispersion of the distribution study. After the average length of stem fibers of each species was determined, it was tested whether the length of these fibers was significantly different. For this, the study used the classic method of comparison of averages for numbers above 30. This test was calculated from the variance of the difference of averages, a method used by Harche (1978) in studying the leaf growth of *Stipa tenacissima*.

Population variance:

$$S^2_K = \frac{\sum_{i=1}^{n_k} X_i^{\,2}}{n} - \bar{X}_k^2, k = 1, 2, ..., 8. \quad \text{..........Eq.2}$$

Standard deviation: S=√□2.

S_1^2: the variance of sample 1.

S_2^2: the variance of sample 2.

X_1: average of sample 1.

X_2: average of sample 2.

Calculation of T:

$$T_1 = \frac{\bar{X}_2 - \bar{X}_1}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad \text{....Eq.3}$$

This expression on the law of Student and Fisher was the comparison between the value of t limit and t observed.

RESULTS AND DISCUSSION

The measurements of 30 fibers from the stems of the studied species (*Retama monosperma, Retama raetam, Linum usitatissimum, Lygeum spartum, Stipa tenacissima, Ricinus communis,* and *Phoenix dactylifera*) showed that they had long and short fibers. The values of the average length expressed in mm of the fibers measured in the stems of the studied species are given in Table 1.

The comparative statistical study of the fiber lengths did not show a great difference in the average fiber length between the stems of each Group, Group 1 (*L. spartum* and *S. tenacissima*), Group 2 (*L. usitatissimum* in the greenhouse and *L. usitatissimum* in the natural conditions, Group 3 (*R.monosperma* and *R.raetam*), Group 4 (*P. dactylifera* and *R. communis*).

First, the present study showed that the fibers measured in the stems of *L. spartum* had an average length of 0.87 mm and that of *S. tenacissima* was 0.75 mm. Similarly, for *L. usitatissimum* (in the greenhouse), the average fiber length in the stems is 1.78 mm and that of *L. usitatissimum* (in the natural conditions) is 1.23 mm. Additionally, for *R. monosperma*, the average fiber length in the stems is 0.90 mm, and that of *R. raetam* is 0.89 mm. For the Spadices of *P. dactylifera*, the average length of fibers in the stems is 0.78 mm and that of *R. communis* is 0.82 mm. The comparative tests of the average length for the stems of each group are shown in Table 2.

The values obtained for all groups were lower than the

Table 1.Length (mm) of the 30 fibers of each species

S. No.	*L. spartum*	*S. tenacissima*	*L.usitatissimum* (in the greenhouse)	*L.usitatissimum* (in the natural conditions)	*R. monosperma*	*R. raetam*	*P. dactylifera*	*R. communis*
1	0.85	1.05	1.61	**0.36**	0.5	0.95	0.57	1.17
2	0.58	0.61	0.51	0.86	0.64	0.9	0.65	0.65
3	0.90	0.5	5.3	1.15	0.58	0.93	0.84	0.47
4	0.43	0.89	0.89	0.46	0.54	0.54	1.01	0.79
5	0.51	0.45	0.69	0.96	1	0.82	0.53	0.65
6	0.93	0.39	2.23	0.61	0.47	0.61	0.83	0.55
7	0.70	0.42	1.37	0.74	0.55	0.76	0.91	0.82
8	0.53	0.58	3.89	0.64	0.9	0.6	1.63	0.49
9	1.17	0.79	0.94	0.82	0.97	0.54	0.62	0.93
10	1.67	1.13	2.2	4.59	0.39	0.6	0.88	0.75
11	1.01	0.71	5.18	0.49	0.49	1.36	0.93	0.45
12	0.74	0.54	2.47	1.74	1.62	1.02	0.48	0.56
13	0.83	0.63	0.57	0.95	0.7	3.43	0.51	0.8
14	1	0.48	1.54	1.46	1.34	0.87	0.84	0.59
15	1.61	0.67	2.9	4.84	3.9	0.54	0.73	0.6
16	0.58	0.6	1.49	0.95	0.7	0.72	0.4	0.71
17	1.02	0.66	3.69	0.86	1	1.69	0.76	0.58
18	1.07	0.63	0.86	3.49	0.75	0.65	0.73	0.5
19	0.93	0.83	0.85	0.96	0.61	0.74	0.75	0.88
20	1.04	0.85	3.05	0.59	0.81	0.86	0.74	0.95
21	0.61	0.82	1.46	1.72	1	0.57	0.62	0.93
22	1.21	0.59	2.5	1.14	0.89	0.49	0.65	1.53
23	0.87	0.79	0.76	0.63	0.65	1.03	0.62	0.87
24	0.48	0.91	1.02	0.7	0.67	1.02	0.8	1.01
25	0.55	0.76	1.04	0.57	0.71	0.94	1.03	0.55
26	0.73	1.09	0.63	1.4	0.46	0.47	0.82	0.88
27	0.88	0.73	0.43	0.97	1.22	0.68	0.58	0.72
28	0.95	1.35	1.03	0.72	1.05	0.6	0.87	1.93
29	0.85	1.07	0.85	0.65	0.89	0.86	1.05	0.76
30	0.77	0.8	1.31	0.86	0.92	0.85	0.73	1.45

Average length of fibre of the species: (*L. spartum:*0.87mm)-(*S. tenacissima:*0.75mm)-(*L. usitatissimum*in the greenhouse:1.78mm)-(*L. usitatissimum*in the natural conditions:1.23mm)-(*R. monosperma* :0.9mm)-(*R. raetam* :0.89mm)-(*P. dactylifera* :0.78mm)-(*R. communis* :0.82mm)

Table 2. Results of the X- means, Variances, standard Deviation of the fibers of species studied and The t- values calculated for each group

	Plant species	X- means	Variances	Standard Deviation	t-value
Group 1	*L. spartum*	0.87	0.088	0.296	1.79
	S.tenacissima	0.75	0.053	0.23	
Group 2	*L. usitatissimum* (in the greenhouse)	1.78	1.764	1.328	1.72
	L. usitatissimum(in the natural conditions)	1.23	1.239	1.113	
Group 3	*R. monosperma*	0.9	0.4	0.633	0.61
	R. raetam	0.89	0.3	0.548	
Group 4	*P. dactylifera*	0.78	0.049	0.221	0.50
	R. communis	0.82	0.113	0.336	

t limit (ts=2) at 5% risk and ddl=58. These results indicated that the observed difference between the average fiber of each group was not significant. The results obtained showed that the length of the fibers of the stem of *L. spartum* varied between 0.43 and 1.67 mm, and the length of the fibers of the stem of *S. tenacissima* varied between 0.39 and 1.35 mm. The length of the stem fibers of *L.*spartum and *S. tenacissima* was similar to those of *S. barbata* and *S. tenacissima,* which have short fibers whose length varied between 0.39 and 1.7 mm (Bounouara, 1988) and *L. spartum* 0.7 to 2.42 mm (Megdad, 1988), so these results permitted the classification of *L. spartum* and *S. tenacissima* as short fiber plants. The stem fiber length of (in the greenhouse) varied between 0.43 and 5.3 mm, and the stem fiber length of *L.usitatissimum* (in the natural conditions) varied between 0.36 and 4.84 mm. The fibers of *L. usitatissimum* (in the greenhouse) and *L. usitatissimum* (in the natural conditions) are classified as medium fibers compared to the fibers of *L. spartum* 0.7 to 2.42 mm (Megdad, 1988), *R. monosperma* and *R. raetam* 0.75 to 3.27 mm (Bokhari, 2004). The length of stem fibers of *R. monosperma* varied was between 0.39 and 3.9 mm, and the length of stem fibers of *R. raetam* ranged between 0.47 and 3.43 mm. The fibers of *R. monosperma* and *R. raetam* were classified as medium fibers, which corroborates the results obtained by Bokhari (2004) and is in comparison to the fibers of Pin and Sapin, which were 2 to 4 mm in length (Martin, 1970).The length of *P. dactylifera* Spadices stem fibers varied between 0.48 and 1.63 mm, and the length of *R. communis* stem fibers varied between 0.45 and 1.93 mm. The spadice fibers of *P. dactylifera* and *R. communis* were classified as short fibers compared to those of to *S. barbata* and *S. tenacissima,* which were 0.39 to 1. 7 mm (Bounouara, 1988) and the fibers of some monocots (wheat, rice, and rye), which are 1.2 mm to 1.5 mm (Youcef, 1991). Previous studies have reported that *Tetraclinis articula* fibres have an average length of 1.25 mm (Kacem, 1991); however, the fiber length of *Chamaerops humilis* rachises ranged from 0.77 to 1.28 mm (Benahmed-Bouhafsoun *et al*., 2007). Recent studies have shown that *Pyrus gharbaina*, *Ammophila arenaria* and *Juncus* maritimus fibre lengths vary between 0.43-0.46 mm, 0.5-0.71 mm and 0.27-0.29 mm, respectively (Ouessai, 2016; Belhadji, 2015; Bouzidi, 2017). In the present study, based on the fiber length value, Group 2 species (*L. usitatissimum* in the greenhouse and *L. usitatissimum* in natural conditions) can be considered a good paper-making material.

The morphological characteristics of the fibers, length and width, are important factors for the mechanical performance of fibers (Aizi and KaidHarche, 2020).The fiber morphology of the different plant species was variable (Fig. 1). They presented a tapered tip (Fig.1 a), pointed end (Fig.1b), festooned (Fig.1c), bevelled walls ends (Fig.1d), and slightly round end (Fig.1f). Similar results have been reported in other studies on *Chamaerops humilis* (Benahmed-Bouhafsoun *et al.,* 2007).

Conclusion

The above results provide useful information about the length of fibers of some species of Algerian plants. The present study concluded that the difference between the mean fiber of each species was not significant. The results indicated that *L. spartum*, *S. tenacissima*, *R. comminus*, Spadices communus, and spadices of *P. dactylifera* palm have short fibers ranging from 0.39 to 1.35 mm. *L. usitatissimum* and Retames have medium fibers ranging from 0.75 to 3.27 mm. Understanding this correlation will help to determine the best conditions for obtaining high-quality fibers to be competitive in the fiber industry. In the interest of further development of the plant fiber industry and to better understand the factors affecting fiber diversity, it is necessary to investigate the relationship between environmental factors

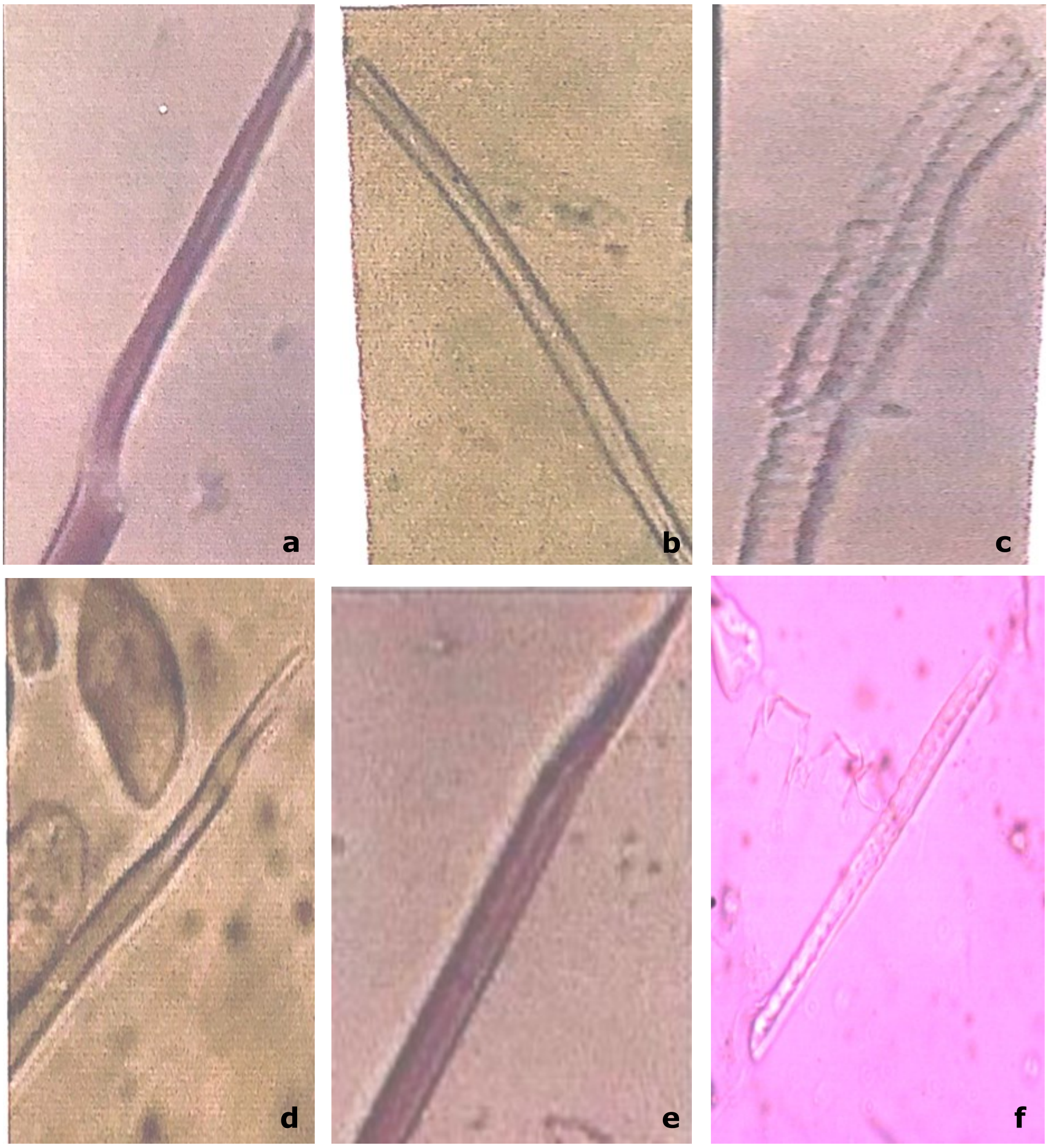

Fig. 1. a-f. *Photomicrograph of fibers showing (a) Tapered tip fiber of L.spartum, (b) Fiber with pointed tip of S. tenacissima, (c) Fiber festooned of L. usitatissimum, (d) Fiber beveled walls ends of R. monosperma, (e) Fiber with a tapered ends of P.dactylifera, (f) Fiber at slightly round end of R.communis (X 2100, Bar on micrographs represents 5µm)*

and fiber properties.

Conflict of interest

The authors declare that they have no conflict of interest.

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