

Original Research Article

Climatic effects in seed shape of castor bean (*Ricinus communis* L.) grown in Tunisia

ABSTRACT

Aims: Seed size, shape and colour intensity were compared in castor bean (*Ricinus communis* L.) grown in the field in twelve locations corresponding to four climatic regions in Tunisia.

Study design: Seeds were obtained from plants grown in the field in twelve locations corresponding to four climatic regions in Tunisia.

Place and Duration of Study: Samples were taken in summer 2014 from plants growing spontaneously

Methodology: Size is estimated as the area of the seed images. Shape is measured by the roundness and J index that gives the percent of similarity of the figure plane of a seed with an ellipse. Colour is measured as gray intensity in seed images.

Results: Among the parameters indicating seed shape, roundness varied more than J index. Values of J index were superior, thus J index describes better than roundness the shape of *Ricinus communis* seeds. Seed size and colour presented higher variation than magnitudes concerning shape indicating that shape is more conserved in *Ricinus communis* seeds, than size or colour.

Conclusion: Differences in size and shape were found among the climatic regions. Reduced size and J index values were observed together with increased values of roundness in seeds obtained from the population grown in the dessert.

Note: Review paper may have different types of subsections.

Keywords: [*Ricinus communis*, seeds, shape, diversity, Tunisia.}

1. INTRODUCTION

Castor bean (*Ricinus communis* L.; figure 1) is the unique species of the genus *Ricinus* in the family Euphorbiaceae. Traditionally used in agriculture, the seeds are a source of lipid reserves, secondary metabolites and fuels in the pharmaceutical and oil industry [1]. The first mention of *Ricinus communis* as a laxative can be traced back to 3500 year-old Egyptian papyrus scrolls [2]. The seeds are poisonous containing 2.8–3% toxic substances such as ricin, a potent inhibitor of protein synthesis, and agglutinin-1 [3,4].



Figure 1: *Ricinus communis*; From top to bottom and left to right: adult plant, floral bud, leaves, flower, inflorescence fruits and seeds.

Ricinus communis ($2n = 20$) is native to north eastern Africa and the Middle East, but it has escaped cultivation to become a naturalized species and a weed under tropical and subtropical climates [5]. The plants grow well in diverse ecosystems ranging from cool temperate (moist to wet) through tropical desert to wet forest life zones. They support high temperatures, but seeds may fail to set above 38°C . The crop tolerates annual precipitation of 2.0 to 42.9 dm, temperatures of 7.0 to 27.8°C and soil pH of 4.5 to 8.3. Plants require 140–180 days growing season and are readily killed by frost [5, 6]. Castor bean is a hardy crop, easy to establish on the field, drought resistant, tolerant to different soil types [1]. It was naturalized in Tunisia, where it exists from the North to the South in spontaneous state

37 occupying marginal soils, urban areas and agricultural land. Castor bean plants grow at a
38 fast rate when situated in full sun and provided with ample fertilizer and water.

39 Anastasi et al. [7] registered a seed yield of 7.65 ton/hectare and seed oil content of 45% for
40 a Tunisian genotype cultivated in Italy. Perdomo et al. [8] report oil yields in the range
41 between 40 and 54% in Tunisian genotypes. The major fatty acid, ricinoleic acid,
42 representing between 74 and 86% of the total [9].

43 Different results concern variation at the morphological and molecular levels in *Ricinus*
44 *communis*. Plants range from short-lived dwarf annuals to large perennials developing into
45 small trees. The tree and short-internode types are commonly referred to as giant and dwarf
46 castor types respectively [10].

47 Goodarzi et al. [11] analyzed the diversity of 12 Iranian accessions and showed a low
48 genetic diversity. Other studies show limited molecular diversity [12, 13, 14]. The low
49 observed heterozygosity values suggest the predominance of autogamy, with a mixed
50 mating system, being both self- and cross-pollinated by wind [15]. Also, based on
51 polymorphism analysis by ISSR and RAPD markers respectively, Wang et al. [16] and
52 Lakhani et al. [17] suggest high genetic diversity of castor bean germplasm.

53 Seed morphology may give information useful in the phenotypic characterization and
54 phylogenetic relationships between varieties and cultivars. The seeds are characterized by
55 high variability essentially in colour, size, weight and shape. Colour varies from red, white,
56 grey, faint chocolate to purple and high variation is exhibited by the surface area [18],
57 hundred-seed weight showed a wide range of variation from 11.6 to 59.1 g [19].

58 Accurate geometric description of seeds requires the comparison with geometric figures that
59 resemble seed images. The approach has been developed in the model plant (*Arabidopsis*
60 *thaliana*; [20]) as well as in the model legumes, *Lotus japonicus* and *Medicago truncatula*
61 [21]. In *Capparis spinosa* the comparison of seed images with the cardioid curve was helpful
62 to describe differences between two subspecies. Higher variation in seed shape was found
63 in populations of *Capparis spinosa* Subsp. *spinosa* than in Subsp. *rupestris* [22]. In *Jatropha*
64 *curcas* a relationship was found between yield and seed size and shape, lower yields being
65 associated with smaller seed size and poorer adjustment of the seed to morphological
66 models [23]. In *Rhus tripartita*, lower values of J index were obtained in plants grown in the
67 desert regions than for those grown in mediterranean climates [24].

68 In *R. communis*, high phenotypical variability is observed in the seeds [18], that also
69 represent the interesting part of plant, as oil source. This work presents the variations in
70 size, shape, and colour of seeds in plants of Castor bean grown in thirteen locations in
71 Tunisia. In the analysis of seed shape, the model applied for the geometric description has
72 been an ellipse.

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75 2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

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77 2.1. Plant material

78 Seeds were obtained in summer 2014 from plants growing spontaneously in 12 locations in
79 Tunisia (figure 2; Table 1). For the analysis, 50 seeds per plant were used. The number of
80 plants used per location oscillated between 1 and 8.

81 **Table 1. Name and main characteristics of the sites of origin of the populations used**
 82 **in this study.**

Population	Abbreviation	Latitude (N)	Longitude (E)	Altitude (m)	Bioclimate	Soil
Nefza	NEF	36°58' 36.53"	9°03' 51.01"	34	Humid and Sub-humid Upper a nd inferior semi-arid	Silt-sandy
Mateur	AGH	37°01' 51.80"	9°52' 51.67"	23		
Mornag	MOR	36°41' 40.78"	10°18' 21.19"	52		
Sidi Bou Ali	BAL	35°57' 05.03"	10°28' 17.92"	20		
Souassi	SWA	35°20' 20.77"	10°32' 24.30"	55		
Bouthady	BTH	35°04' 10.43"	10°15' 56.32"	124	Upper and inferior arid	sandy
Gabes	GAB	33°52' 23.25"	10°07' 40 04"	46		
Matmata	MAT	33°32' 25.81"	09°57' 95.03"	375		
Ksar Jedid	KSJ	33°18' 03.93"	10°17' 37.84"	208		
Mednine	MED	33°21' 40.50"	10°28' 59.44"	100		
Ghomrassen	GHO	33°03' 32.33"	10°19' 35.01"	93	Saharan	
Kebili	KEB	33°38' 44.94"	8°59' 38.66"	45		

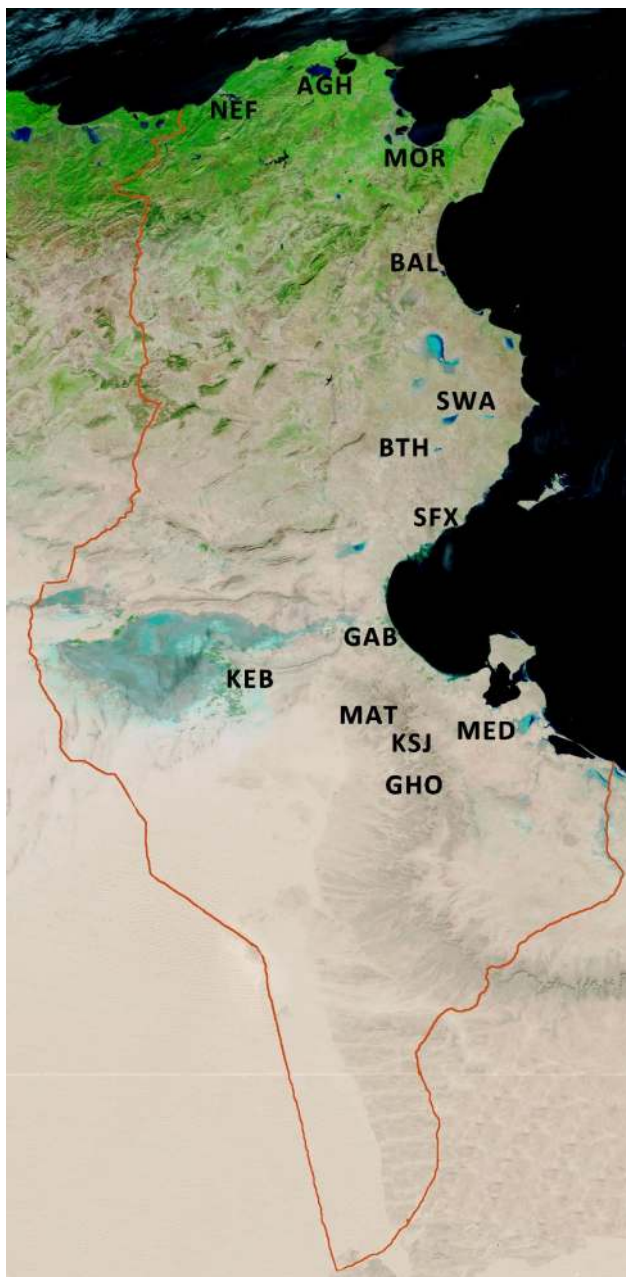
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89 **Figure 2:** Map of Tunis showing the localization of the populations used in this study.

90 **2.2. Image capture**

91 Images of the seeds were obtained with a scanner ScanJet 5300 C (HP).

92 **2.3. Seed size**

93 The analysis includes area, perimeter and weight of 50 seeds per individual.

94 **2.4. Seed morphology**

95 Roundness is a measure of the similarity between a plane figure and a circle given by

96
$$I = 4 \frac{\text{area}}{\pi \times A^2}$$

97

98 Where A is the length of the major axis. It ranges from zero to one giving the value of 1 for
99 circles and it is a useful magnitude as a first approximation to seed shape. It is preferred
100 here to circularity index [25], because the latter is very sensitive to alterations in the margin
101 of the figure.

102 J index measures the degree of similarity of a plane figure with an ellipse. An ellipse can be
103 defined as the locus of all points that satisfy the equation $\frac{a^2}{x^2} + \frac{b^2}{y^2} = 1$

104 Where (x, y) are the coordinates of any point on the ellipse, and (a, b) are the radius on the x
105 and y axes respectively.

106 Seed images of *R. communis* were adjusted to an ellipse whose relation between the major
107 and minor axes (a and b) equals 1.43. The ratio was chosen after measuring the ratios
108 between axes in a sample of seeds. J index was defined previously for quantification of
109 Arabidopsis seed shape in comparison to a cardioid [20], and here is used to measure the
110 adjustment of seed shape to the ellipse. To obtain J index, composed images containing an
111 ellipse and the seed (fig. 3) were elaborated for each seed with the software Corel
112 PaintShop Pro X5. The ellipse was drawn with CorelDRAW X6. Area quantification was
113 done with Image J (Java Image Processing Program).

114 Quantification of the adjustment was done in each seed as a proportion between the areas
115 in two regions: The common region in the ellipse and the seed image (area C), and the sum
116 of total regions of both images, the seed and the ellipse (figure 3). The index of adjustment
117 (J index) is defined by:

118
$$J = \frac{\text{area}(C)}{\text{area}(C) + \text{area}(D)}$$
 ,

119 Where area (C) represents the common region and area (D) the regions not shared. Note
120 that J index ranges between 0 and 100, and decreases when the size of the non-shared
121 region grows. It equals 100 when ellipse and seed image areas coincide, i.e., area (D) is
122 zero. J Index was calculated for a total of 1491 seeds (table 4).

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Figure 3: Seeds of *Ricinus communis* showing the method used in the calculation of J index. To obtain J index, composed images containing an ellipse and the seed were elaborated for each seed with the software Corel PaintShop Pro X5. The ellipse was drawn with CorelDRAW X6. Area quantification was done with Image J (Java Image Processing Program).

Quantification of the adjustment was done in each seed as a proportion between the areas in two regions: The common region in the ellipse and the seed image (area C), and the sum of total regions of both images, the seed and the ellipse (figure 3). The index of adjustment (J index) is defined by:

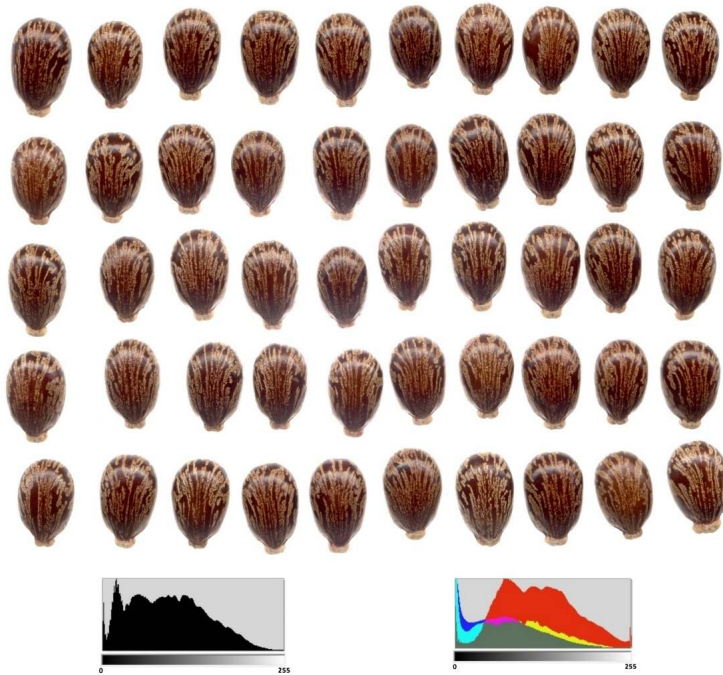
$$J = \frac{\text{area (C)}}{\text{area (C) + area (D)}}$$

Left: Above: Seed; Below: Ellipse used as model.

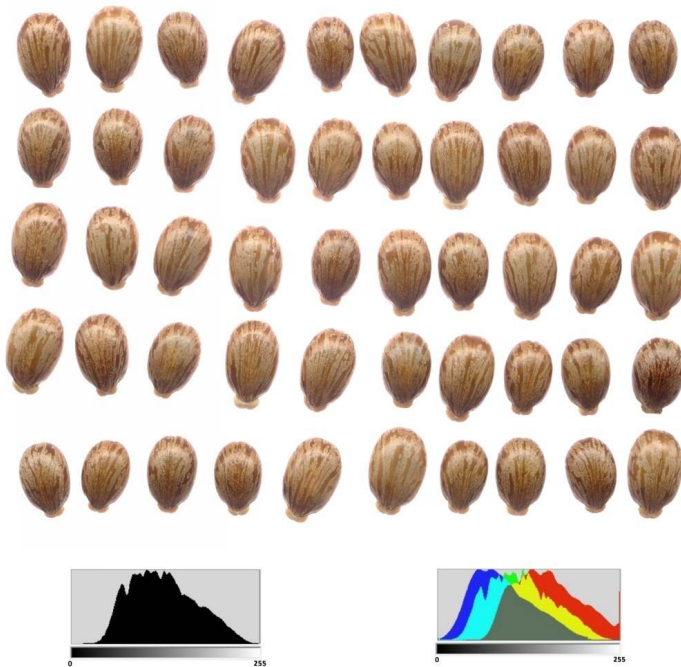
Right: Above: Ellipse is superimposed to seed image showing total Area: area (C) + area (D); Below: Shared area between seed image and ellipse: area (C) is delimited by a white space.

2.5. Seed colour

Intensity of grey and RGB values were obtained with CorelDRAW X6. The RGB colour model is one of the most common ways to encode colour in computing and diverse programs may give for each image the relative contribution of each of the three colours (Red, Green and Blue). The corresponding histograms were obtained with Photoshop CS3 (Figure 5a and 5b).



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153 a)



154
155 b)

156 **Figure 5:** Seeds of MED (a) and BAL (b) and histograms showing gray and RGB values
157 obtained with Photoshop.

2.6. Statistical analysis

Analysis of variance (ANOVA) was applied to the comparison of magnitudes between plants as well as to the comparison between different populations. Magnitudes analyzed are those related with seed size (area, perimeter, weight of 50 seeds) and morphology (Circularity index, J index). The statistical analyses were made with the software IBM SPSS Statistics version 21. In the comparison between populations, ANOVA was done with the populations having five or more plants. Post-hoc analysis was carried out using Tuckey test (samples of similar sizes).

3. RESULTS AND DISCUSSION

Table 2 presents a summary of the results concerning area of seed images, roundness, J index, and gray values in the upper and lower sides of the seeds. The data are analyzed in detail below. The description follows a similar schema for all magnitudes and includes: 1) A general view of the data distribution in all seeds, 2) A description of the data per plant, 3) A description of the data per populations and 4) The comparison among climatic regions (table 2).

Table 2: Summary of the results. The data correspond to those populations in which five or more plants were analyzed. A) Summary of area, weight and roundness. B) Summary of J index and C) Summary

A

Climatic región	Number of plants	Area (mm ²)	weight	Roundness
Humid and sub-humid	446	1.04 ^a	0.49 ^a	0.65 ^b
Upper and inferior semi arid	500	1.11 ^c	0.51 ^b	0.65 ^b
Upper and inferior arid	1600	1.14 ^d	0.54 ^c	0.64 ^a
Saharan	300	1.07 ^b	0.48 ^a	0.68 ^c

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B

Climatic región	Number of plants	J index
Humid and sub-humid	226	0.87 ^b
Upper and inferior semi arid	250	0.87 ^b
Upper and inferior arid	800	0.87 ^b
Saharan	150	0.85 ^a

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C

Climatic región	Number of plants	Value Gray (Upper)	Value Gray (Lower)
Upper and inferior arid	32	108 ^a	95 ^a
Upper and inferior semi arid	10	112 ^a	100 ^a
Humid and sub-humid	9	112 ^a	101 ^a
Saharan	6	128 ^b	127 ^b

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3.1. Seed size (area of seed image)

Seed size was estimated as the area corresponding to the seed images. The mean area in all seeds is of 1,12 cm² and the values oscillate between 0,73 and 1,60 cm² (Table 3).

Table 3: Area values (mm²) per images of seeds in 12 populations.

Population	Number of plants	Mean	Standard deviation	Min	Max
NEF	196	1.10 ^d	0.093	0.89	1.34
AGH	250	1.00 ^b	0.082	0.78	1.20
MOR	350	1.19 ^e	0.140	0.87	1.60
BAL	150	0.95 ^a	0.089	0.73	1.14
SWA	300	1.27 ^f	0.107	1.00	1.56
BTH	350	1.00 ^b	0.108	0.74	1.26
GAB	300	1.04 ^{b,c}	0.088	0.84	1.36
MAT	50	1.07 ^{c,d}	0.073	0.92	1.26
KSJ	50	1.37 ^g	0.095	1.10	1.53
MED	300	1.18 ^e	0.074	1.00	1.43
GHO	250	1.25 ^f	0.077	1.04	1.51
KEB	300	1.07 ^{c,d}	0.099	0.85	1.30
Total	2846	1.12	0.145	0.73	1.60

Mean values per plant oscillate between 0.91 cm² and 1.37 cm² and the range of variation in a single plant oscillates between 0,17 and 0,60 (not shown).

Differences between plants were found in all populations except in BAL (not shown).

Per populations (table 3), the minimum area values correspond to BAL (0.95), AGH and BTH (1.00) and maxima to KSJ (1.37), SWA (1.27) and GHO (1.25). Differences were found between populations with BTH and AGH having lower area values and SWA and GHO higher (table 2).

The comparison among climatic regions reveals four groups with lower area values in the humid and sub-humid regions, followed by the dessert, the upper and inferior semi arid, and finally larger seeds in the upper and inferior arid region (table 2A).

204 **3.2. Roundness**

205 A summary of the results for roundness is presented in Tables 2 and 4. Mean roundness in
206 all seeds is 0.65. The values oscillate between 0.53 and 0.85 (table 4).

207

208 **Table 4: Roundness per images of seeds in 12 populations.**

Population	Number of plants	Mean	Standard deviation	Min	Max
NEF	196	0.64 ^{b,c}	0.02456	0.57	0.70
AGH	250	0.66 ^e	0.02684	0.59	0.85
MOR	350	0.66 ^{d,e}	0.02870	0.56	0.75
BAL	150	0.64 ^{b,c,d}	0.01931	0.61	0.70
SWA	300	0.63 ^{a, b}	0.02944	0.56	0.73
BTH	350	0.63 ^a	0.02297	0.53	0.71
GAB	300	0.64 ^{b,c}	0.02354	0.54	0.69
MAT	50	0.62 ^a	0.03124	0.56	0.72
KSJ	50	0.65 ^{b,c,d}	0.02187	0.60	0.68
MED	300	0.65 ^{c,d}	0.01762	0.60	0.69
GHO	250	0.68 ^f	0.02546	0.60	0.77
KEB	300	0.68 ^f	0.02887	0.60	0.77
Total	2846	0.65	0.03091	0.53	0.85

209

210 Mean values per plant oscillate between 0.53 and 0.85 and the range of variation in a single
211 plant oscillates between 0,05 and 0,23 (not shown).

212 Differences between plants were found in all populations except in GHO (not shown).

213 Per populations, the minimum roundness corresponds to MAT (0.62) and maximum to GHO
214 and KEB (0.68; Table 4).

215 Differences were found between climatic regions with highest values in the Saharan region,
216 lowest in the upper and inferior arid region and intermediate values in the other two regions
217 (table 2A).

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221 3.3. J index

222 A summary of the results for J index is presented in tables 2 and 5. The mean value of J
223 index in all seeds is of 0.87 and the values oscillate between 0.77 and 0.93 (table 5).

224

225 **Table 5: J index per images of seeds in 13 populations.**

Population	Number of plants	Mean	Standard deviation	Min	Max
NEF	100	0.86 ^{a,b,c}	.0205	.81	.90
AGH	126	0.88 ^{d,e}	.0170	.83	.91
MOR	175	0.87 ^{b,c,d,e}	.0197	.81	.91
BAL	75	0.88 ^e	.0134	.85	.91
SWA	150	0.86 ^{a,b,c}	.0178	.81	.89
BTH	175	0.88 ^{d,e}	.0199	.78	.93
GAB	150	0.87 ^{c,d,e}	.0178	.82	.90
MAT	25	0.86 ^{a,b,c}	.0213	.82	.91
KSJ	25	0.86 ^{a,b,c}	.0290	.77	.92
MED	150	0.87 ^{a,b,c,d}	.0154	.82	.90
GHO	125	0.85 ^{a,b}	.0234	.77	.90
KEB	150	0.85 ^a	.0269	.78	.91
Total	1426	0.87	.0219	.77	.93

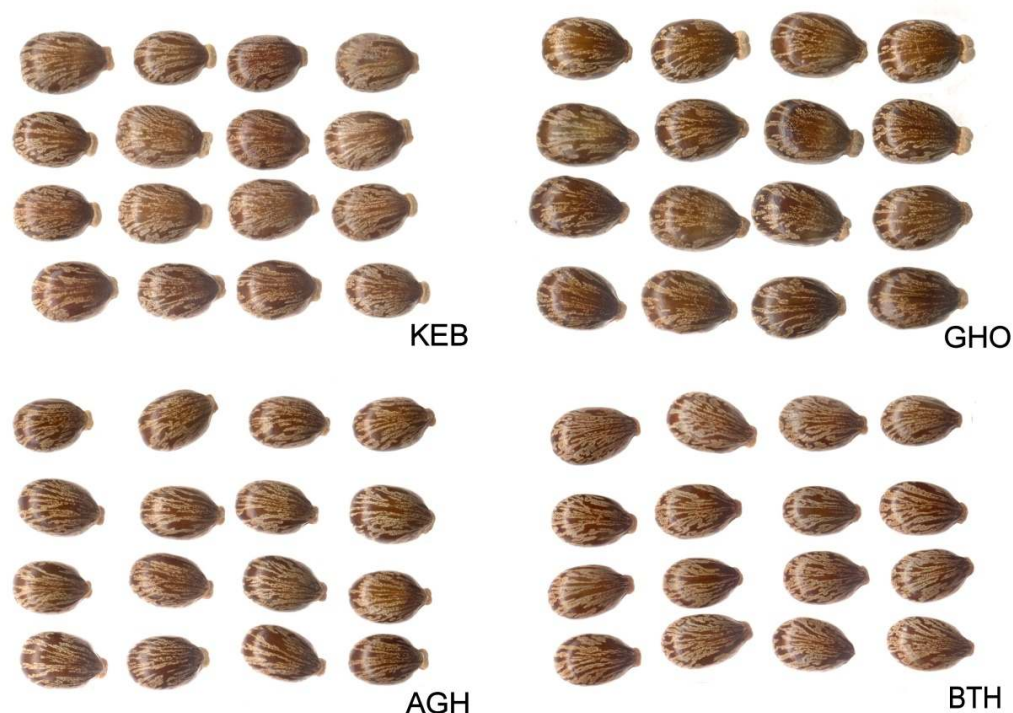
226 The mean values per plant oscillate between 0.84 and 0.89. The standard deviation per
227 plant was 0.022 for all plants and oscillated between 0.010 and 0.029 (not shown).

228 Differences between plants were found in all populations except in NEF, BAL and MED (not
229 shown).

230 Differences were found between populations with KEB and GHO having the lowest J index
231 values (0.85) and AGH, BTH and BAL, the highest (0.88; table 5; figure 4).

232 J index is smaller in the Sahara than in the other three climatic regions (Table 2B).

233



234

235 **Figure 4:** Seeds of KEB, GHO, AGH and BTH. KEB have the lowest J index values and
 236 AGH and BTH, the highest. GHO have larger seeds of higher circularity index and lower J
 237 index, whereas plants in AGH and BTH have smaller seeds.

238

239 3.4. Gray values

240 A summary of the results for gray values is presented in tables 2, and 6. Table 6 contains
 241 data of gray values for the upper side (6a) and the lower side (6b) of the seeds. Higher gray
 242 values correspond to less coloured seeds.

243 Mean gray value in the upper side is 112 (table 6a) and the values oscillate between 79.4
 244 and 135.7.

245 Mean gray value in the lower side is 101.4 (table 6b) and the values oscillate between 72.9
 246 and 135.9.

247 In the upper side of seeds, the mean values in populations (table 6a) oscillate between 94.9
 248 (MED, 10) and 134.1 (BAL, 4).

249 In the lower side of seeds, the mean values in populations (table 6b) oscillate between 72.9
 250 (MOR) and 135.9 (KEB).

251

252 **Table 6a: Mean grey values for seeds corresponding to plants in 10 populations**
 253 **(upper side).**

Population	Number of plants	Mean	Standard deviation	Min	Max
NEF	4	110.8 ^{a,b,c}	2.199	108.3	113.2
AGH	5	113.1 ^{b,c}	3.454	107.7	116.5
MOR	7	102.6 ^{a,b}	11.158	79.4	114.0
BAL	3	134.1 ^d	1.980	131.9	135.7
SWA	6	106.9 ^{a,b}	9.860	88.8	115.9
BTH	7	117.4 ^{b,c,d}	4.808	107.1	121.4
GAB	6	110.8 ^{a,b,c}	5.675	102.3	116.5
MED	6	94.9 ^a	7.423	80.1	100.8
GHO	5	113.1 ^{b,c}	2.726	109.2	116.9
KEB	6	128.4 ^{c,d}	4.930	121.5	135.5
Total	55	112.0	12.080	79.4	135.7

254

255

256 **Table 6b: Mean grey values for seeds corresponding to plants in 10 populations**
 257 **(lower side).**

Population	Number of plants	Mean	Standard deviation	Min	Max
NEF	4	100.2 ^{a,b}	2.769	98.4	104.3
AGH	5	103.1 ^{a,b}	4.598	96.4	107.9
MOR	7	93.9 ^a	10.827	72.9	104.9
BAL	3	114.5 ^{b,c}	4.252	110.1	118.6
SWA	6	94.6 ^a	10.795	74.3	104.7
BTH	7	106.7 ^{a,b}	2.626	103.8	111.2
GAB	6	90.8 ^a	4.821	84.8	96.1
MED	6	88.7 ^a	7.579	74.9	96.8
GHO	5	100.5 ^{a,b}	2.798	96.6	104.0
KEB	6	127.7 ^c	5.731	120.8	135.9
Total	55	101.4	13.087	72.9	135.9

258

259 Differences were found between populations, both in the upper as in the lower side, with
260 MED having the lowest gray values and BAL and KEB, the highest. Figure 5 shows seeds of
261 MED (figure 5a) and BAL (figure 5b).

262
263 Differences in gray values were found between climatic regions with highest values in the
264 Saharan region, and lower in the other regions (table 2C).

265

266

267 3.5. Discussion

268 Size, shape and colour are important characteristics in the description of seeds [18,19, 26].
269 Our estimation of size is based in the area of seed images. Shape is evaluated using two
270 magnitudes: roundness and J index. For colour, grey and RGB values are obtained with
271 Photoshop from the analysis of 50 seeds. Thus, the analysis of colour does not involve
272 comparison between plants in each population (there is only one data available for each
273 plant). In the other instances (area, roundness and J index), the study involves a comparison
274 between plants in a population, the comparison between populations, and finally between
275 climatic regions.

276 A large amount of the total variation observed for size and shape is concentrated at the level
277 of a single plant. For example, area values expand a total of 0.87 units and the area values
278 for the seeds of a single plant expand 0.60 units in the case of MOR; 3-4. For the J index,
279 variation total expands 0.16 units, and variation in a single plant reaches 0.10 units in GH0;
280 11-1.

281 The shape of *R. communis* seeds adjust better to an ellipse than to a circle. Values obtained
282 are higher for J index than for roundness, thus J index is a magnitude more appropriate to
283 study seed shape variations in this species than roundness.

284 In general there is no correlation between size and shape, or between roundness and J
285 index. Nevertheless a combination of these magnitudes may give an idea of particular
286 variations between plants or populations. For example, the seeds of Souassi (SWA, 5) and
287 Ghomrassen (GH0; 11) are larger than in the other locations, and seeds in GH0 have
288 higher roundness than in SWA. The populations in BTH and AGH had highest J index
289 values, with small seed size; and KEB and GH0, lowest J index values with the larger seed
290 size in the case of GH0. This is in contrast with the results of our recent study in *Jatropha*
291 *curcas* (Euphorbiaceae), where lower J index values were associated with reduced seed
292 size, lower weight and reduced productivity [23].

293

294 In this study, highest J index values correspond with populations having smaller area values
295 (BTH and AGH). The difference with the results obtained with *Jatropha curcas* may be
296 explained because in *Jatropha*, we were comparing seed yield in culture between cultivars of
297 different provenances, and low yield involves difficult growth conditions with higher
298 proportion of aborted seeds, smaller seeds and alterations in shape, resulting in lower J
299 index values. In contrast, the *Ricinus communis* seeds of this study were obtained from
300 plants growing in the field, where smaller seeds with higher J index may represent special
301 adaptations to particular environments.

302 Seed colour is a distinctive characteristic of *Ricinus* seeds, and it may present characteristic
303 variations useful to distinguish between subspecies or varieties [1, 27]. Among the

populations used in this study, seeds are darker in MED and lighter in KEB and BAL. The analysis of both, the upper and the lower side yielded similar results in all populations.

The comparison of size, shape and colour among climatic regions revealed interesting peculiarities. As expected, seeds grown in the dessert are small, due to lack of water and nutrients. But the seeds grown in the dessert have also lower values of J index and higher values of roundness. In addition, they are darker (have larger grey values) as an adaptation for protection against high irradiation. Studies with other plant species reveal an increased production of total antioxidants, and of total phenolics in the arid conditions of the dessert [28, 29].

Among the magnitudes considered, there is large variation in seed size or colour than in those concerning seed shape. Among the latter, J index describes better the shape of the seed, because the seed images resemble more an ellipse than a circle. Consequently there is more variation in the values of circularity index than in those of J index.

4. CONCLUSION

Ricinus communis is adapted to Tunisian climatic conditions; it is present in the spontaneous state in the different regions and bioclimates throughout the country. Castor bean oil has a great interest in international market. Our results show a large variability of seed parameters, including shape, size and colour. Size and colour present higher diversity than shape. Bioclimatic conditions affect all three magnitudes, and plants from the dessert have smaller seeds with reduced values of J index but increased circularity and colour intensity. These parameters are high interest to any work of selection and initiation of castor bean culture in Tunisia. Previous studies on the correlation between these parameters and castor bean oil yield seem promising.

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