

Variability analysis of the seeds and oil yields of several accessions *Citrullus colocynthis* (L.) collected in Morocco

BENMOUMOU Abdelhamid, EL MADIDI Saïd

Biometrics and Bio Resources Laboratory Biotechnologies and Natural Resources Development (LBVRN) Faculty of Sciences, University Ibn Zohr, Agadir, Morocco.

How to cite this paper: Abdelhamid, B., Saïd, E. M. (2019) Variability analysis of the seeds and oil yields of several accessions *Citrullus colocynthis* (L.) collected in Morocco. *International Journal of Food Science and Agriculture*, 3(4), 287-291.

DOI: 10.26855/ijfsa.2019.12.004

*Corresponding author: EL MADIDI Saïd, Biometrics and Bio Resources Laboratory Biotechnologies and Natural Resources Development (LBVRN) Faculty of Sciences, University Ibn Zohr, Agadir, Morocco.

Email: s.elmadidi@uiz.ac.ma

Abstract

The ripe fruits of *Citrullus colocynthis* (L.) Schrad were collected in 12 different localities in Morocco to evaluate the variability of seed and oil yields. The measured traits are: seed weight (SW), seed number (SN), weight of 100 seeds (W 100), seed oil content (OC), seeds yield (SY) and oil yield (OY). The seed oil content ranging between 17 and 24 % of seed weight. The extrapolated seed yield among the accessions ranged from 156 to 816 Kg ha⁻¹, with an overall mean of 413 Kg ha⁻¹. The oil yield varied between 35 to 172 Kg ha⁻¹. The oil extracted from the seed revealed high levels of unsaturated fatty acids (74%) with C 18: 2 (60.06 %) and C 18: 1 (11.14%). The results of anova (GLM) show significant and very highly significant effect according to the characters measured.

Significant variability was observed for seed and oil yields. This variability could be exploited for the selection of accessions with high oil yields.

Keywords

Citrullus colocynthis, accessions, seed yield, oil yield, Morocco

1. Introduction

Citrullus colocynthis is a perennial herbaceous species in the Cucurbitaceae family widely distributed in the Sahara-Arabian desert in Africa and the Mediterranean region [1,2]. This plant has a natural adaptation to drought and several studies have reported that this plant has a great potential for adaptation to drought with a tolerance to water deficit [3-5]. Some authors suggest that it has a number of genes involved in the process of adaptation to abiotic stresses [6]. It has been pointed out by several authors that extracts of different parts of *C. colocynthis*, including seeds, fruits, roots and stems, have different pharmacological activities and bioactive compounds that have been used for a long time in the treatment of several diseases in traditional medicine [7-9]. The plant was also shown to be rich in nutritional value with high protein contents and important minerals as well as edible quality of seed oil [10]. The oil was found to contain high levels of unsaturated fatty acids, especially C18:2 (linoleic acid) and C18:1 (oleic acid) [11,12]. *C. colocynthis* has been garnering interest in recent times as a potential biodiesel feed stock crop due to its high seed oil content [13,14].

2. Materials and Methods

12 accessions of *C. colocynthis* collected from different regions from Morocco. The trial was carried out for 2 years during growing seasons 2015-16 and 2016-17 at the experimental farm of Sidi Bibi (30° 15' 00" N, 9° 30' 36" W), following a randomized block experimental design with 3 replicates. For each trial, the seeds were planted at 75 cm between the plants and 150 cm spacing between the lines. Each plot received a limited amount of water equivalent to 100 mm of irrigation water. The measured traits are: seeds weight (SW), seeds number (SN), weight of 100 seeds, seed oil content (OC), oil yield and seeds yield. For the extraction of the lipid components, the seeds were crushed and the

next racted with n-hexane (200 ml) at 40-60 ° C in a soxhlet apparatus. The total extraction time is 6 hours for each repetition. The composition of the oil in fatty acids is determined by Chroma to graphy coupled with Mass Spectrometry.

Data were analyzed by the GLM procedure of SAS with the following statistical model: $Y_{ijk} = m + A_i + B_j + C_k + D_{i \times j} + E_{ijk}$, A_i : Effects of accessions, B_j : Effects of trials, C_k : Effects of blocks, $D_{i \times j}$: interaction (Accx Tr) and E_{ijk} : random residual error. The comparison of means was done by the Duncan test and all statistic analyzes were performed using SAS version 9.3 software [15].

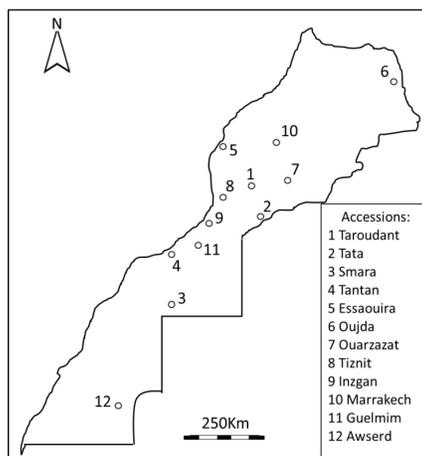


Figure 1. Origin of accessions de *citrullus colocynthis* (L.) Schrad collected in several localities in Morocco



Figure 2. photos of seeds of different accessions

3. Results and discussion

Analysis of the data of both trials shows a high degree of variability with the coefficient of variation (CV) ranged from 7.65 % to 44 %. The seeds weight has the highest CV and the values are ranged from 2.96 to 41.52 grams per plant, while for the seeds number the values vary from 53 to 682 seeds per plant. The seed yields ranging between 155.78 and 815.76 kg per hectare and the oil yield varies between 35.27 and 171.71 kg / hectare while the seed oil content (OC) shows the lowest CV and the minimum and maximum are respectively 17.1 and 24.3% (table 1).

Table 1. Descriptive statistics for the measured characters

	Mean	Min	Max	CV	SE
SN	254,84	53,00	682,00	40,03	2,19
SW	14,18	2,96	41,52	43,92	0,13
W100	5,54	3,01	9,63	14,44	0,02
SY	419,88	155,78	815,76	38,09	18,85
OY	89,84	35,27	171,71	38,96	4,12
OC	21,41	17,10	24,29	7,65	0,19

SN: seeds number, SW: seeds weight, W100: weight of 100 seeds, SY: Seed yield/ha (kg/ha) , OY: Oil yield/ ha (kg/ha) and OC: seed oil content. Min: Minimum, Max: Maximum, CV: coefficient of variation and SE: standard error

The fatty acid profiles of the seed oil showed an unsaturated fatty acid content of 74.10 % with the predominant fatty acid was linoleic acid (C18.2) in 60.06 %, followed by oleic acid (C18.1) (14.4%), palmitic acid (C16.0) (11.14%), and stearic acid (C18.0) (8.36%). The oil content and fatty acid compositions of the seed oil found in this study are in agreement with the results observed in other studies that show a predominance of unsaturated fatty acids [7,13,14].

The analysis of variance (ANOVA) indicated high statistically significant differences among the 12 accessions for all the characters analyzed (table 2). The interaction accessions x trials was highly significant for SN, SW and significant for W100 and OC.

Table 2. Results of GLM Anova (Fisher-Snedecor values and significant levels)

SV	ddl	SN	SW	W100	OC	SY	OY
Accessions	11	22.19 ***	19.97 ***	13.68 ***	9.52 ***	9.37 ***	6.69 ***
Trials	1	34.11 ***	30.13 ***	28.78 ***	13.55 **	14.21 **	8.45 **
Acc x Tr	11	3.24 **	4.60 **	12.32 *	2.64 *	0,58 ^{NS}	0.66 ^{NS}
Blocs	2	2.32 ^{NS}	2.94 *	3.25*	1.25 ^{NS}	1,49 ^{NS}	1,75 ^{NS}

SN: seeds number, SW: seeds weight, W100: weight of 100 seeds, OC: seed oil content, SY: seeds yield and OY: oil yield *** , ** , * : was significant at 0,001, 0.01 and 0,05 level respectively

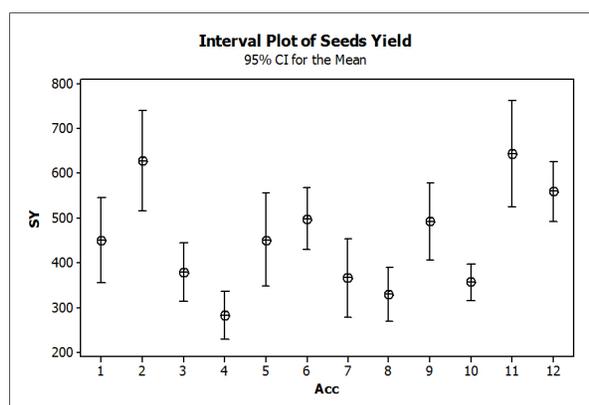


Figure 3. Variation of seeds yield for the differents accessions

The comparison of accessions means show edhighly significant differences (table 3). For seed yield, average values are grouped into 5 homogeneous groups and range from 289 kg/ha (accession 4) to 641 kg/ha (accession 11). For oil yield, the average values are arranged also in 5 homogeneous groups and vary between 61 kg/ha (accession 10) and 147 kg/ha (accession 11).

Table 3. Comparison of means of accessions (Duncan test)

Accessions	Seeds yield (Kg/ha)	Oil yield(Kg)
	Mean	Mean
4	289,06 a	63,43 ab
8	304,28 ab	65,99 ab
10	306,89 ab	61,21 a
3	346,91 ab	80,43 ab
7	369,09 ab	73,97 ab
5	375,69 ab	78,19 ab
1	405,10 abc	84,87 abc
9	418,76 abc	96,25 bcd
6	451,48 bcd	87,56 abc
12	543,91 cde	116,11 cde
2	586,68 de	123,10 de
11	640,69 e	146,97 e

a, b, c, d: Means with incolumns with different super script are significantly different ($p < 0,01$)

The yield values obtained in this study under limited irrigation conditions, without any fertilization and with a sowing density equal to one plant per m² are lower than those reported by other authors. The cultivation of plants in condition of no water limitation has given 4400 kg of seed and 1000 to 1175 L/ha of oil [22]. At a sowing density of 4 plants per m², the seed yield of *C. colocynthis* accessions ranged from 0.47 to 14.95 tonnes/ha, with an overall average of 5.17 tonnes/ha [19]. In the Pakistan desert, some accessions that have an extensive root system even under limited irrigation conditions can produce up to 1 to 1.5 t of seeds [23].

This plant is a naturally drought tolerant species as it is one of the few spontaneous species of plants to grow in arid conditions in the southern Mediterranean and Middle East countries [17,7]. In addition to these widely documented traditional medical uses, numerous studies have shown that this plant can be used in the production of biodiesel feedstock [17-19].

Several authors have studied the nutritional properties and the composition of the seeds in fatty acids and in proteins. The results of these studies concluded that the seeds of this plant can also be used as a food source for animals and humans [20,21,10]. The growing demand for energy and the problem of food security in the context of climate change have motivated for many years the interest of the research of new species of plants that can produce the biodiesel feedstock. *C. colocynthis* natural distribution suggests that it may be more appropriate for cultivation on marginal lands and in areas with arid and semi-arid environments generally unfavorable for producing conventional crops. This plant could potentially be grown in a very economical and sustainable way knowing that the seeds of fruits can also be used as food for animals and humans.

4. Conclusion

These results show that this plant has the potential to be used for grain production for oil extraction, especially under difficult conditions on arid and semi-arid lands. The large variability in grain and oil yield suggests that better yields can be obtained by analyzing the best growing conditions and selecting the best accessions for yield with good tolerance to different abiotic stresses.

Acknowledgements

This work has received financial support from Ibn Zohr University and the valuable assistance of the management and technicians of the Sidi Bibi experimental center for the installation and monitoring of the field experience.

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