

## Study of morpho-agronomic diversity and oil content in desert gourd (*Citrullus colocynthis* (L.) Schrad.)

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### Abstract

*Citrullus colocynthis* (L.) Schrad., also known as desert gourd, is a xerophytic perennial creeper. In a field trial conducted on sandy soil and under arid conditions in the United Emirates (UAE), 27 germplasm accessions were studied for their potential as feedstock for biodiesel production. All accessions were evaluated for two qualitative and eleven quantitative morpho-agronomic traits over a period of one year (November 2013- December 2014) in a field trial laid out in a randomized complete block design with three replicates. Analysis of the data revealed high variability among the accessions, with seed yields ranging between 12 and 374 grams per plant and seed oil content from 7.8 to 43.8% of seed weight. When the data were statistically analyzed using principal components analysis, traits of economic importance such as seed yield, oil content and number of fruits per plant grouped together, while others such as number of branches and branch length grouped separately. Agglomerative hierarchical clustering grouped the accessions into three main clusters. The extrapolated annual oil yield in several accessions exceeded 1 ton ha<sup>-1</sup> (the highest being 3.44 tons ha<sup>-1</sup>) – showing the desert gourd to be a highly attractive biodiesel feedstock species for cultivation on marginal lands. The oil from most accessions had a free fatty acid content of less than 0.5% which is within suitable limits for biodiesel production. The observed variability in saponification values suggests that the oil is prone to oxidation upon storage. The wide range of variation found in this study for seed yield, oil quantity and oil quality provides the opportunity for genetic improvement to develop desert gourd into an economically-viable, non-edible, alternative biodiesel feedstock crop.

**Keywords:** Biodiesel feedstock; *Citrullus colocynthis*; Morpho-agronomic diversity; Oil content.

**Abbreviations:** ASTM\_American Society for Testing and Materials; ECPGR\_European Cooperative Programme for Plant Genetic Resources; FYM\_Farmyard Manure; ICBA\_International Center for Biosaline Agriculture; NIH\_National Institutes of Health; NPK\_Nitrogen: Phosphorous: Potassium; PCA\_Principle Components Analysis; RCBD\_Randomized Complete Block Design; UAE\_United Arab Emirates; USDA\_United States Department of Agriculture.

### Introduction

*Citrullus colocynthis* (L.) Schrad., also known as desert gourd (*Handhal* and *Thumba* in Arabic) is a member of the Cucurbitaceae family known for its high seed oil content (Achu et al., 2005). It bears yellow-green inedible fruits (Bande et al., 2012). It is a highly xerophytic perennial creeper native to the Mediterranean basin, the Middle East and South Asia. In the Arabian Peninsula, the plant often grows in the wild in sandy soils covering large areas and surviving under hyper-arid desert conditions with less than 50 mm annual precipitation. This plant also grows in coastal areas with salty or brackish waters (Qasim et al., 2011). The desert gourd was chosen for this study because of its perceived potential as a non-food biodiesel feedstock crop and the possibility for its cultivation in both arid and biophysically-marginal arid lands because it occurs naturally in such habitats.

The two main biodiesel feedstock crops cultivated worldwide are soybean and rapeseed, which are also two of the most widely consumed edible oils in the world. These crops require arable land for cultivation, thus not only increasing the price of edible oil, but also encroaching on land that can be used for the production of food crops. When

blended with petroleum, biodiesel from the desert gourd is known to exhibit performance parameters similar to that of *Jatropha* (*Jatropha curcas*) – another non-food biodiesel crop (Mathur et al., 2012). The blends also have lower smoke opacity. The natural distribution of desert gourd suggests that compared to *Jatropha*, it could be more suitable for growing on lands generally inhospitable to produce crops of any kind or otherwise yield a profit. Additionally, the oil from desert gourd reportedly has lower viscosity (Pal et al., 2010), which could be of great advantage in terms of its potential as a biodiesel feedstock.

The desert gourd has been used in traditional Arabic medicine for centuries. Studies show that its root and callus extracts have anti-microbial (Gurudeeban et al., 2010), anti-inflammatory (Rajamanickam et al., 2010), anti-diabetic (Gurudeeban and Ramanathan, 2010) and anti-oxidant (Gurudeeban et al., 2010) properties. Also being studied over several decades now, are its anti-cancer properties. A study as early as 1958 showed that the toxic and potent resinous constituents of the fruit caused damage to tumors in mice (Faust et al., 1958). Besides the known medicinal value, if its use in biodiesel production could be established, the desert

gourd could potentially be cultivated in an economically feasible and sustainable manner on marginal lands and in regions with arid to hyper-arid environments.

In this paper, the morpho-agronomic characteristics and seed oil content of 27 desert gourd accessions are presented in order to assess the potential of this crop for large-scale cultivation and use as biodiesel feedstock. To the authors' knowledge, this is the first comprehensive study of desert gourd involving field trials.

## Results

In the field trial, 27 accessions survived through the year of study (November 2013-December 2014) with a sufficient number of plants for observations. The remaining 10 accessions which were initially planted, either did not germination or died out within weeks after germination. While the mean daily temperatures during the growing period ranged between 20°C (January) and 36°C (July), the average maximum temperatures were between 28°C (January) and 46°C (July). The rainfall received during the study period amounted to 66.5 mm.

### Morpho-agronomic evaluation

The data recorded for morphological and agronomic characteristics showed considerable variability among the accessions (Table 1). The number of fruits per plant varied between 2 to 36, seed yield from 11 to 373 grams per plant, and seed oil content from 7.8 to 43.8% of seed weight. Leaf water content which is a useful indicator of plant water balance and is intimately related to several physiological variables, such as leaf turgor, stomatal conductance, transpiration, photosynthesis and respiration, did not differ significantly and ranged from 76% to 85%, with a standard deviation of 2.67 among the accessions. The fresh and dry weights of leaves, from which the moisture content was calculated, also showed no significant variations among the accessions (data not presented).

The correlation matrix (Table 2) showed positive correlation between growth-related characteristics such as number of branches, vine length and leaf size. Interestingly, the number of primary branches and vine length were negatively correlated with number of fruits and yield per plant ( $r < 0.00$ ). The yield per plant did not correlate positively with any parameter other than the number of fruits ( $r = 0.481$ ). The number of fruits also correlated positively with seed oil content ( $r = 0.134$ ) (Table 2).

Based on the screen plot from the principal components analysis, the first two components, contributing to 46.49 and 15.29 % of the variation respectively were used to generate a biplot (Fig 1). From the results of analysis presented in the latent vector loading table (Table 3), it is shown that traits of economic interest such as yield per plant, number of fruits, and oil content, all loaded more significantly on the second component. This meant that these traits were associated more strongly with each other than with traits associated with vegetative growth. The dendrogram from the agglomerative hierarchical clustering of all accessions based on the collected agronomic data is presented in Fig 2.

### Yield

With the spacing of four plants per  $m^2$  used in this study, the extrapolated annual seed yield among the accessions ranged from 0.47 to 14.95 tons  $ha^{-1}$ , with an overall mean of 5.17 tons  $ha^{-1}$ . The yield was highest in KMK 1 (14.95 tons  $ha^{-1}$ ),

followed by RMS 227 (12.37 tons  $ha^{-1}$ ) and RMS 244 (11.63 tons  $ha^{-1}$ ). The oil yield extrapolated from the data varied between 0.07 and 3.44 tons  $ha^{-1}$  with an overall mean of 0.98 ton  $ha^{-1}$ . While several accessions had oil yield exceeding 1 ton  $ha^{-1}$ , it was highest in RMS 228 (3.44 tons  $ha^{-1}$ ), followed by RMS 244 (2.28 tons  $ha^{-1}$ ).

### Oil characteristics

The oil extracted from the seeds, like many other characteristics varied in composition among the accessions (Table 4). The saponification value, which is an indicator of the average molecular weight, ranged from 203.8 to 211.4 in this study. Oil from nine accessions (RMS 246, RMS 254, RMS 234, RMS 231, RMS 257, RMS 228, RMS 256, RMS 250 and RMS 240) had a free fatty acid content higher than 0.5% and the average kinematic viscosity at 40°C was determined to be 33.26  $mm^2 s^{-1}$ .

## Discussion

This study on the desert gourd was carried out over a period of one year under growing conditions representative of the harsh desert environment with main purpose to evaluate the potential of the species for use in biodiesel production and identifying accessions with high seed and oil yields. The results indeed showed that desert gourd is an attractive candidate for development as a biodiesel feedstock crop, with yields comparable to other oilseed crops such as soybean and rapeseed. The correlation matrix showed that higher yielding varieties generally have lower values of vine length and other growth factors. From a large-scale cultivation point of view, this means a higher density of plants can be achieved per hectare, increasing the yield per hectare (Diepenbrock, 2000). The principal components analysis showed that characteristics of agricultural and economic interest such as yield per plant, oil content and number of fruits, group together and load more significantly on the first component, indicating the scope to further improve the species through selection and breeding.

If the accessions are ranked on the basis of important characteristics such as oilseed yield, oil yield and number of fruits per plant, accessions KMK1, RMS 227, RMS 228 and RMS 244 are the best performing among the 27 accessions studied. If oil quality, mainly fatty acid content of  $< 0.5\%$  is also taken into consideration, RMS 227 appears to be the most promising accession in this study. From the hierarchical clustering and the biplot of principal components analysis, it can be seen that the accessions grouped into two large clusters, with the exceptions of accessions PI 388770 and PI 525082. Accessions PI 388770 and PI 525082 were low yielding and similar to each other in their highly branched growth habit and greater vegetative growth in terms of vine length and leaf size compared to other accessions. Accessions RMS 228 and RMS 239, though loaded separately in the PCA biplot along the second component because of their high yield, grouped together with accessions RMS 246, RMS 257, RMS 255, RMS 220, RMS 245, RMS 244, RMS 258, RMS 247, RMS 237, RMS 240, RMS 249, RMS 215 and KMK1 in the dendrogram from cluster analysis, to form one large group composed of the higher yielding accessions.

Based on the plant density used in present studies, the extrapolated mean annual oil yield of 0.98 ton  $ha^{-1}$  is greater than that of soybean and rapeseed oil yields of 0.5-0.6 ton  $ha^{-1}$  (Clemente and Cahoon, 2009; Rondanini et al., 2012). The saponification value range of desert gourd corresponded with an average C16-C18 fatty acid chain length (Sanford et al.,

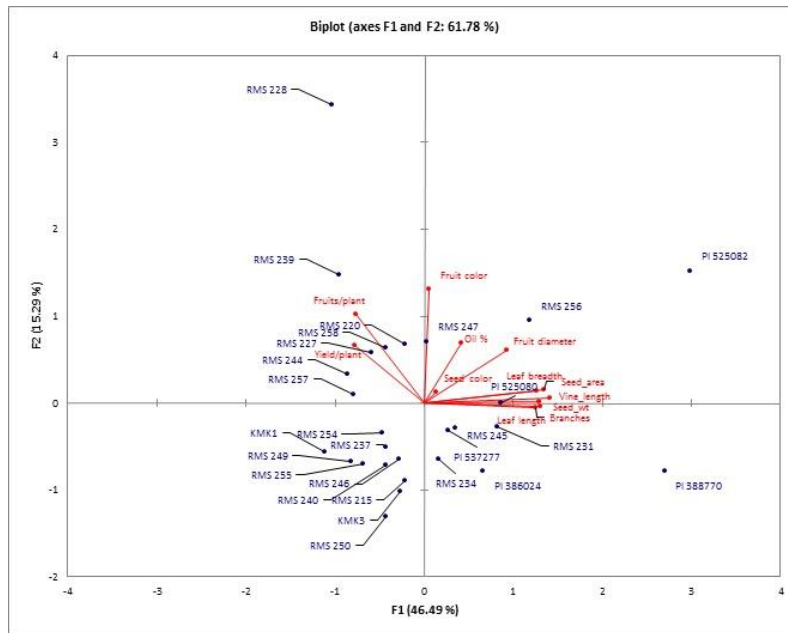
**Table 1.** Mean values of morpho-agronomic data for desert gourd accessions. Standard deviations for each quantitative characteristic across accessions is provided as an indicator of variability.

Identity	Origin	No. of primary branches	Vine length (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf moisture (%)	No. of fruits per plant	Fruit diameter (cm)	Seed oil content (%)	Seed yield per plant (g)	1000 seed weight (g)	Seed Size/ Surface area (cm <sup>2</sup> )	Seed color*	Fruit color*
RMS 215	UAE	3.20	65	6.55	3.80	82.38	5.20	6.78	12.0	108.94	18	0.19	1	1
RMS 220	UAE	7.00	68	6.90	4.25	81.00	23.00	4.65	13.2	119.20	22	0.16	2	2
RMS 227	UAE	4.00	65	7.16	3.58	84.02	24.89	7.40	13.6	309.40	22	0.14	1	1
RMS 228	UAE	1.25	27	5.20	3.65	79.21	36.00	8.10	30.4	282.73	18	0.11	1	3
RMS 231	UAE	2.29	142	9.77	6.13	76.40	11.14	6.29	22.8	80.60	36	0.23	1	1
RMS 234	UAE	3.13	124	6.36	3.29	76.05	10.63	5.45	14.4	95.86	36	0.25	2	1
RMS 237	UAE	4.25	47	7.86	3.15	83.49	14.13	5.39	16.0	142.70	20	0.15	1	1
RMS 239	UAE	1.67	32	5.44	3.18	79.15	29.83	6.43	16.0	208.24	18	0.15	2	2
RMS 240	UAE	4.00	37	6.00	3.23	79.75	9.00	5.20	19.4	92.40	26	0.14	2	1
RMS 244	UAE	2.86	55	4.24	2.18	79.80	14.29	8.40	19.6	290.85	22	0.14	1	1
RMS 245	UAE	3.23	91	8.17	4.54	76.15	3.15	7.20	27.0	135.91	30	0.19	2	1
RMS 246	UAE	3.77	61	5.67	3.98	78.34	11.31	6.80	12.2	83.75	24	0.15	2	1
RMS 247	UAE	2.13	89	7.26	5.30	84.61	18.38	6.21	43.8	97.83	20	0.15	2	1
RMS 249	UAE	1.67	23	4.15	2.85	80.04	9.33	6.53	15.0	122.27	24	0.14	1	1
RMS 250	UAE	2.29	30	5.43	3.17	82.67	2.71	7.30	10.0	24.63	24	0.15	1	1
RMS 254	UAE	1.44	49	4.68	3.15	84.59	9.67	7.13	28.2	50.10	24	0.14	1	1
RMS 255	UAE	3.17	47	5.32	3.15	80.06	14.83	4.30	18.0	77.40	24	0.13	1	1
RMS 256	UAE	4.77	185	9.25	5.99	81.25	8.62	7.60	19.6	160.56	38	0.28	3	2
RMS 257	UAE	1.80	21	5.26	3.29	77.80	22.20	5.38	22.6	139.95	32	0.11	2	1
RMS 258	UAE	2.14	55	5.98	3.29	79.42	10.71	8.92	17.6	116.44	18	0.14	1	2
KMK1	UAE	2.50	23	4.57	3.14	80.55	3.50	5.28	9.4	373.86	18	0.13	1	1
KMK3	UAE	5.30	102	6.67	3.20	83.90	8.80	5.40	13.0	81.12	22	0.11	1	1
PI 386024	Iran	4.93	81	8.13	4.62	83.65	2.53	6.47	26.2	38.81	54	0.16	1	1
PI 388770	Morocco	14.00	250	13.15	7.99	84.40	2.44	8.20	16.2	11.90	48	0.28	1	1
PI 525080	Egypt	5.38	135	7.32	3.67	84.23	6.63	8.36	27.6	123.76	52	0.25	2	1
PI 525082	Egypt	12.00	220	9.45	5.73	79.45	2.33	15.29	31.0	47.56	72	0.41	1	2
PI 537277	Pakistan	2.67	72	7.24	3.85	78.36	9.33	8.90	13.0	74.60	28	0.24	4	1
Mean		3.96	81.3	6.78	3.98	80.77	12.02	7.01	19.55	129.31	29.3	0.18	NA	NA
Standard deviation (+/-)		2.91	58.95	1.97	1.25	2.67	8.57	2.06	7.82	88.61	13.12	0.07	NA	NA

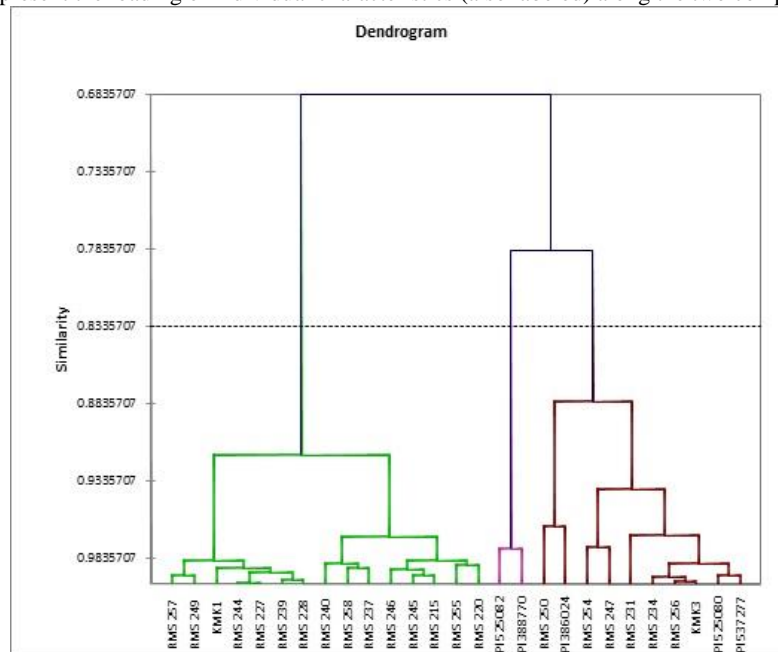
\*The numbers indicated for seed and fruit colors are nominal. Seed color represented by 1- Dark brown, 2- Medium brown, 3- chestnut brown, 4- Olive green/brown. Fruit color represented by 1- Dark green with light green striations, 2- Dark green with yellow striations, 3- Dark green with orange tinged striations.

**Table 2.** Correlation matrix of morpho-agronomic characteristics. Positive correlations are indicated by r values >0, negative correlations by r<0. Values in bold are different from 0 with a significance level alpha=0.05.

Trait	No. of branches	Vine length (cm)	Average leaf length (cm)	Average leaf breadth (cm)	No. of fruit per plant	Fruit diameter (cm)	Seed Oil content (%)	Seed yield per plant (g)	1000 seed weight (g)	Seed size (cm <sup>2</sup> )	Seed color	Fruit color
No. of branches	1	0.797	0.751	0.668	-0.367	0.458	0.013	-0.35	0.683	0.668	-0.099	0.059
Vine length (cm)	0.797	1	0.869	0.835	-0.415	0.51	0.223	-0.387	0.754	0.856	0.09	0.054
Average Leaf length (cm)	0.751	0.869	1	0.911	-0.335	0.323	0.177	-0.406	0.621	0.685	0.092	-0.002
Average leaf breadth (cm)	0.668	0.835	0.911	1	-0.266	0.325	0.304	-0.383	0.574	0.646	0.105	0.11
No. of fruits per plant	-0.367	-0.415	-0.335	-0.266	1	-0.234	0.134	0.481	-0.469	-0.436	0.065	0.522
Fruit diameter (cm)	0.458	0.51	0.323	0.325	-0.234	1	0.307	-0.108	0.592	0.695	-0.015	0.349
Oil content (%)	0.013	0.223	0.177	0.304	0.134	0.307	1	-0.127	0.34	0.17	0.005	0.196
YPP (g)	-0.35	-0.387	-0.406	-0.383	0.481	-0.108	-0.127	1	-0.43	-0.354	-0.095	0.253
1000 seed weight (g)	0.683	0.754	0.621	0.574	-0.469	0.592	0.34	-0.43	1	0.795	0.04	-0.004
Seed Size (cm <sup>2</sup> )	0.668	0.856	0.685	0.646	-0.436	0.695	0.17	-0.354	0.795	1	0.243	0.114
Seed color	-0.099	0.09	0.092	0.105	0.065	-0.015	0.005	-0.095	0.04	0.243	1	0.036
Fruit color	0.059	0.054	-0.002	0.11	0.522	0.349	0.196	0.253	-0.004	0.114	0.036	1



**Fig 1.** Biplot of distribution of desert gourd accessions based on two principal components. Component 1 from the loading vector table is represented by the X-axis and component 2 by the Y-axis. Individual points represent accessions, as identified by the labels, and the central vectors represent the loading of individual characteristics (also labeled) along the two components.



**Fig 2.** Dendrogram generated from agglomerative hierarchical clustering based on unweighted pair-group average of 27 desert gourd accessions.

2009), which is within the acceptable limits for biodiesel production. While Pal et al. (2010) already reported that seed oil from desert gourd can be used as an alternative fuel with better performance and lower emissions compared with diesel, Giwa et al. (2010) also found that oil from Egusi melon, a close relative of desert gourd has 60% linoleic acid – a polyunsaturated omega-6 C18 fatty acid with low viscosity, which make it well-suited for biodiesel production due to improved fuel flow characteristics compared to other biodiesel feedstocks.

The free fatty acid content in biodiesel feedstock oil is an important parameter because an excess of it can cause the formation of emulsion during transesterification, which makes the separation of biodiesel difficult besides resulting in

yield loss. According to ASTM standards, free fatty acid content should be less than 0.5% by weight in biodiesel feedstock oil (Atadashi et al., 2012). High free fatty acid content makes the oil prone to rancidity due to hydrolysis by enzymes or oxidation upon storage. Considering that the majority of the accessions studied have free fatty acid content lower than 0.5% and that large variability exists between accessions for seed and oil yields, it should be possible to improve the desert gourd through selection and hybridization for low free fatty acid content combined with high oil yield potential and thus develop it into an economically-important non-edible biodiesel feedstock crop.

**Table 3.** Latent Vector Loadings for two principal components for the various traits in 27 desert guard accessions.

Trait	Component	
	1	2
1000 seed weight (g)	0.860	0.009
Average leaf length (cm)	0.872	-0.027
Average leaf breadth (cm)	0.839	0.095
Branch length (cm)	0.946	0.038
Fruit color	0.036	0.872
Fruit diameter (cm)	0.615	0.405
No. of branches	0.830	-0.031
No. of fruits per plant	-0.510	0.686
Oil content (%)	0.277	0.459
Seed surface area (cm <sup>2</sup> )	0.894	0.101
Seed color	0.094	0.082
Seed yield per plant (g)	-0.516	0.446

**Table 4.** Free fatty acid content, Saponification Value and Kinematic viscosity at 26 °C in 27 desert gourd accessions.

Identity	FFA (wt %)	Saponification value (mg KOH/g)	Kinematic viscosity (mm <sup>2</sup> /s)
RMS 215	0.23	205.40	25.51
RMS 220	0.02	208.90	27.43
RMS 227	0.04	210.60	25.75
RMS 228	1.13	209.80	25.75
RMS 231	2.89	203.90	23.47
RMS 234	1.27	205.40	28.57
RMS 239	0.04	204.70	26.87
RMS 240	1.43	205.30	33.14
RMS 244	0.23	204.30	32.65
RMS 245	0.08	207.60	27.99
RMS 246	1.09	205.60	25.14
RMS 247	0.02	203.80	35.71
RMS 249	0.46	210.57	26.87
RMS 250	0.70	207.80	31.34
RMS 254	1.67	204.30	24.63
RMS 255	0.03	210.30	23.47
RMS 256	1.01	205.90	35.43
RMS 257	1.21	208.60	25.14
RMS 258	0.02	208.90	25.14
KMK1	0.04	211.10	26.29
KMK3	0.08	210.17	28.57
PI 386024	0.03	208.13	26.53
PI 388770	0.05	207.35	28.57
PI 525080	0.04	206.10	24.63
PI 525082	0.23	205.89	30.86
PI 537277	0.56	211.40	23.51
Mean	0.56	207.38	27.65
Standard Deviation (+/-)	0.7	2.42	3.47

## Materials and Methods

### Plant materials

Thirty accessions of desert gourd collected from different locations within the UAE (Shahid and Rao, 2014) and seven accessions, originating from arid environments obtained from the United States Department of Agriculture (USDA) were used in this study. The geographical coordinates of the local collection sites are listed in Supplementary Table 1 and a schematic map of the collection sites is presented in Supplementary Fig 1. The details of accessions obtained from the USDA are provided in Supplementary Table 2.

### Experimental design

The accessions were sown in mid-November 2013 using a randomized complete block design (RCBD) with three replicates at the International Center for Biosaline

Agriculture (ICBA) research station (25.09°N, 55.38°E) on the outskirts of Dubai, UAE. The soils at the research station were sandy in texture (sand 98%, silt 1%, and clay 1%), calcareous (50–60% CaCO<sub>3</sub> equivalents), porous (45% porosity) and moderately alkaline (pH 8.22), being very low in organic matter (<1%). Prior to planting, the soil fertility of the experimental site was improved by incorporating farmyard manure (FYM) at the rate of 40 tons ha<sup>-1</sup>. The seeds were planted to a depth of 2-3 cm in field plots each of four rows of 2 m and with a spacing of 1 m between two plots. The distance between rows as well as between the plants within the row was 50 cm. The plants were irrigated twice a day by drip irrigation with low-quality municipal water that had an electrical conductivity of 0.3-0.5 dS m<sup>-1</sup>. Urea (46%) was applied one month after planting followed by NPK (20-20-20) at 30 kg ha<sup>-1</sup>, 60 days after planting. Prior to sowing, the seeds were scarified with sand paper, soaked for 48 hrs and incubated at 30°C for 24 hrs to overcome dormancy observed in the freshly-harvested seeds (Menon et al., 2014).

## Morpho-agronomic characterization

The accessions were characterized for two exclusively qualitative (fruit and seed color) and 11 quantitative traits (such as branching, vine length, leaf, fruit and seed characteristics, and oil content (see Table 1), largely based on the Descriptors for *Citrullus* (ECPGR, 2008). Measurements such as the vine length, leaf length and breadth, and number of branches were recorded at the end of the study period in December 2014. The total number of mature fruits was recorded after harvesting them periodically throughout the year, as most accessions flowered more than twice a year under irrigated conditions. Data were collected from five randomly selected plants in each plot and the averages were calculated. Leaf length and breadth were noted for approximation of leaf size, with the fifth leaf on a primary branch set as the standard. Twenty leaves were collected at random from each plot for fresh and dry weight measurements as an indicator of plant biomass and vegetative growth. Leaf moisture content was calculated from the data as an estimate of plant water balance in different accessions using the formula (Afzal et al., 2010):

### Leaf moisture content

$$= \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Seed weight (per 1000 seeds) was determined using a seed counter Contador. Seed size (surface area of the large, flat phase) was calculated from images using the ImageJ Image processing and the analysis software provided as freeware by the National Institutes of Health (NIH), USA, which is a benchmark tool for image analysis and area measurements (Bylesjö et al., 2008; Johnson et al., 2009). The average per plant seed yield was extrapolated to tons ha<sup>-1</sup>, assuming a plant density of 6.25 plants per m<sup>2</sup>.

### Seed oil content

Fifty grams of seed from each plot, in triplicates for each accession was used to extract oil following the conventional method of solvent extraction (n-hexane) with a Soxhlet apparatus (Cravotto et al., 2011). Hexane was removed from extracted oil using a rotary evaporator.

### Oil characterization

Saponification value and free fatty acid (calculated from Acid Number) were determined using standard American Society for Testing and Materials (ASTM) test methods (D5558, D664) (Wang et al., 2014; Shao and Agblevor, 2015). Dynamic viscosity was calculated using a digital viscometer (model LT-730 from Labtronics).

### Statistical analysis

Variations in quantitative traits were explained by using descriptive statistics such as means, ranges and standard deviation. Principal component analysis (PCA) was performed on the correlation matrix of the variables and represented graphically using a biplot display. Agglomerative hierarchical cluster analysis was carried out based on the unweighted pair-group method with arithmetic averages of the traits that differed significantly. All calculations and analyses were conducted using XLSTAT (version 2015.4) with MSEXcel (© Addinsoft).

## Conclusion

The desert gourd, a xerophytic perennial creeper has multiple uses for its oil and medicinal compounds. In the field trial involving of 27 accessions – most of them collected from the wild in the UAE, significant differences were observed for morpho-agronomic traits as well as oil quantity and quality. The extrapolated oil yield in some accessions was found to be higher than in most other oil-yielding crops – especially soybean and corn, the two main globally cultivated biodiesel feedstock crops. Most of the accessions of the desert gourd were also found to be higher yielding than *Jatropha* – a non-edible biodiesel crop with the reported oil yields of about 1.5 to 2 tons ha<sup>-1</sup> (Sujatha et al., 2008). *Jatropha* yields are however, highly dependent on climate and soil conditions (Tikkoo et al., 2013). In current studies, the maximum oil yields obtained in desert gourd were similar to the yield reported in *Calophyllum inophyllum* (4.68 tons ha<sup>-1</sup>) but lower than that of palm oil (5.95 tons ha<sup>-1</sup>) (Atabani et al., 2012). Nevertheless, compared to other biodiesel feedstock crops, desert gourd is more likely to be tolerance to marginal growing conditions with lower water requirements because of its natural adaptation to desert environments. This however, needs confirmation through well-designed field trials. Oil from the desert gourd appears to have properties suitable for biodiesel production, but may be prone to oxidation and could require addition of antioxidants for storage. The low viscosity of desert gourd oil has especial advantage because it doesn't need blending with petroleum fuels before use, unlike the highly viscous oils. In addition to its potential as a biodiesel feed stock crop, the medicinal properties of desert gourd merit further investigation as extracts are rich in a number of bioactive phytochemicals and purification and isolation of the bioactive compounds and cell cytotoxicity assays could lead to the identification of novel drugs.

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