

Original Research Article

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Screening of Castor Genotypes for Ricinoleic Acid Content

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Fourteen castor genotypes including two checks GC 3 and GCH 7 were grown in irrigated condition with recommended agronomic practices. The seeds were harvested at stage of their physiological maturity. The soil properties, seed quality parameters, fatty acid profile, ricinoleic acid were analysed as per standard methods. The highest value of 100 seed wt 39.0 g was determined in genotype RG 380 and the highest seed yield was found in RG 63 (4987 kg/ha). The highest seed oil content was determined in RG 311, RG 330 genotypes which was 50.7 % and 50.6%, respectively. Ricinoleic acid, the predominant monounsaturated fatty acid varied among castor genotypes from 85.10 (RG 311) to 89.83 (RG 357). In the present study, the ricinoleic acid content was significantly negatively correlated with palmitic acid ($r = -0.869^{**}$); stearic acid ($r = -0.877^{**}$); oleic acid ($r = -0.967^{**}$); linoleic acid ($r = -0.978^{**}$) and with linolenic acid ($r = -0.676^{**}$). The Oleic (MUFA) / Ricinoleic acid ratio among the all 14 genotypes varied from 0.037 (RG 357) to 0.057 (RG 311). The present study is vital for selecting male parent for developing castor hybrids for high ricinoleic acid.

Introduction

Castor (*Ricinus communis* L.) is an important non-edible oilseed crop of *Euphorbiaceae* family. Castor has enormous significance in the country as it plays an important role in the agricultural economies because it enables them to earn substantial foreign exchange through export of castor beans and oils. It is believed that castor is indigenous to the south-eastern Mediterranean Basin, Eastern Africa and India. Castor is grown throughout the tropical, warm temperate and subtropical regions between latitudes 40° South and 52° North in the world, but the commercial cultivation of castor is carried out in about 30 countries especially in arid and semi-arid region. About 90 per cent of the world's total

castor is grown in India, China and Brazil. India with almost 65 per cent share in castor and its derivatives production enjoys an almost monopolistic situation in world. Gujarat, Rajasthan and Andhra Pradesh are the major castor growing states in India.

Castor seed is the source of castor oil which varies from 45% to 51%. Apart from castor oil the de-oiled cake (DOC)/meal serves primarily as an organic fertilizer. The presence of a unique fatty acid *i.e.* ricinoleic acid (12-hydroxy, 9-octadecenoic acid) makes castor oil suitable for many industrial usages. Ricinoleic acid has three functional groups- hydroxyl, carboxylate and carbon-carbon

double bond (alkene) (Mutlu *et al.*, 2010). It is the only source of an 18-carbon hydroxylated fatty acid with one double bond in each of the fatty acid chain and ricinoleic acid make up about 89% of the fatty acid composition. The other fatty acids found in the castor oil are oleic, stearic, palmitic, linoleic, dihydroxystearic acid, linolenic acid and eicosanoic acid. Castor oil is used to make soap, detergent and other forms of the oil are important for the treatment of leather, industrial lubricants, and other industrial uses (Isah *et al.*, 2006). The dehydrated oil is an excellent drying agent which compares favourably with tung oil and is used in paints and varnishes and hydrogenated oil is used in the manufacture of waxes, plastics, carbon paper, candles and crayons. In food processing industry it is used as an additive for flavouring and also as a mould inhibitor. Castor is used even in anti-cancer therapy and in the treatment of skin ulcers. Castor oil is also regarded as one of the most valuable laxatives in medicine. In modern-day medicine, castor oil is also used as a drug delivery vehicle. An example is Cremophor EL. It is also often used as a drug delivery vehicle for very non-polar drugs such as the anticancer drugs paclitaxel and docetaxel. Other novel uses of castor oil and its derivatives include nylon-6, 10 from sebacic acid, nylon-11 from 11-aminoundecanoic acid. Castor oil is neither becomes stiff with cold nor thin with heat therefore is used for lubricant in jet and racing cars engines. Castor oil properties indicate a very low pour and cloud points which make suitable as bio fuel (Shah *et al.*, 2014).

Materials and Methods

Fourteen castor genotypes including two checks GC 3 and GCH 7 were grown in irrigated condition at Castor-Mustard Research station, S.D.A.U., Sardarkrushinagar, Gujarat (India). Standard

agronomic practices were practiced for the crop production. The seeds were harvested at stage of their physiological maturity. The soil samples were collected from 0-15 cm depth before sowing of the crop and after the harvesting of crop. In the present study the soil profile parameters like pH, EC, O.C (%), Avail. N (Kg/ha), Avail. P₂O₅ (Kg/ha), Avail. K₂O (Kg/ha), Avail. S (ppm) was determined (Table 1).

Quality parameters of seed

100 seed weight (g), seed oil content (%), seed yield (kg/ha), fatty acids (Palmitic, Stearic, Oleic, Linoleic, Linolenic and Ricinoleic acid) composition (%) were determined as per standard methods.

Seed oil content (%)

The Seed oil content of castor seeds were calculated on Nuclear Magnetic Resonance Spectroscopy (NMR) instrument (MQC model, Oxford instruments) as per method described by Yadav and Murthy (2016).

Seed yield (kg/ha)

The seeds were harvested manually in each experimental plot at maturity and weighed in g/plot with the help of a weighing balance and then convert into kg/ha.

Fatty acid composition

Fatty acid profile of oil of different genotypes of castor performed on Thermo Gas chromatography (GC-FID, Trace GC Ultra) using Fatty Acid Methyl Esters (FAMES) of castor oil as described by FSSAI, 2015.

Oil stability index

Oleic and Linoleic acid (O/L) ratio were computed, as oil stability index.

Results and Discussion

Soil quality parameter

The soils of experimental site were neutral in soil reaction, low in electrical conductance. Nutrient content of experimental site was as follows: Available N was low; Available P₂O₅ was medium; Available K₂O was low and Available S was medium (Table 2).

Seed quality parameters

The seed quality parameters are the most important quality parameter which determines the price of seeds at the time of sale. In the present study among the all genotypes analysed, the highest value of 100 seed wt 39.0 g was determined in genotype RG 380 and lowest value of 17.0 g was determined in genotype RG 2451 (Table 3). Seed weight is an important characteristic for milling. The highest seed yield was found in RG 63 (4987 kg/ha), RG 311 (4408 kg/ha) and RG 358 (4373 kg/ha) genotypes with compared to that of the hybrid varieties GCH 7 (4275 kg/ha) and GC 3 (2205 g/net plot) which was kept as control. The highest value of seed oil content was determined in RG 311, RG 330 genotypes which was 50.7 % and 50.6% respectively and lowest value 47.8 % of seed oil content was determined in RG 2685 genotype with compared to that of checks. The better oil yield makes industrial practice of oil recovery a profitable venture (Abitogun *et al.*, 2009).

Fatty acid profile

Saturated fatty acid, palmitic and stearic acids were in the range of 1.02-1.64% and 1.18-1.93%, respectively (Table 4). Significant positive correlation was observed between palmitic acid and stearic acid ($r = 0.702^{**}$). Mono unsaturated fatty acid (MUFA) - oleic acid varied from 3.28% (RG 357) to 4.88 %

(RG 311). Higher value of oleic acid is a desirable trait for high oxidative stability, hence suitability of castor oil for industrial usage (Rojas *et al.*, 2004). The oleic acid showed significantly positive correlation with palmitic acid ($r = 0.786^{**}$) and stearic acid ($r = 0.832^{**}$). These results were resembled with the findings of Shah *et al.*, (2014).

The Poly unsaturated fatty acid (PUFA) – linoleic and linolenic fatty acid were in range of 4.17% to 5.96% and 0.45% to 0.73%, respectively. The linoleic acid has significantly positive correlation with palmitic acid ($r=0.865^{**}$), stearic acid ($r = 0.793^{**}$) and oleic acid ($r = 0.918^{**}$). However, the linolenic acid has positive correlation with stearic acid ($r = 0.570^*$), oleic acid ($r = 0.647^{**}$) and linoleic acid ($r = 0.664^{**}$) (Table 7). Ricinoleic acid, the predominant monounsaturated fatty acid varied among castor genotypes from 85.10 (RG 311) to 89.83 (RG 357). Ricinoleic acid was higher (85.1% - 89.8%) than other fatty acids in the castor oil and compares well with literature. In the present study, the ricinoleic acid content was significantly negatively correlated with palmitic acid ($r = -0.869^{**}$); stearic acid ($r = -0.877^{**}$); oleic acid ($r = -0.967^{**}$); linoleic acid ($r = -0.978^{**}$) and with linolenic acid ($r = -0.676^{**}$). The hydroxyl functionality of ricinoleic acid (RA) makes the castor oil a natural polyol providing oxidative stability to the oil, and a relatively high shelf life compared to other oils by preventing peroxide formation. Castor oil can be stored for long periods without appreciable deterioration for periods up to two years. The functional group causes ricinoleic acid to be usually polar and also allows chemical derivatization that is not practically possible with most other vegetable oils. Results of present study of fatty acid profile resembled with the findings of Lakshminarayana *et al.*, (1984).

Table.1 Methods used for determination of soil properties

Parameter	Method
pH (1:2.5)	1:2.5 soil water suspension- (Jackson, 1967)
EC (1:2.5)	1:2.5 soil water suspension- (Piper,1950)
O.C (%)	Walkley and Black (1947)
Avail. N (Kg/ha)	Subbiah and Asija (1956)
Avail. P ₂ O ₅ (Kg/ha)	Olsen's method (Jackson, 1967)
Avail. K ₂ O (Kg/ha)	Ammonium acetate method using flame photometer (Chapman and Pratt, 1961)
Avail. S (ppm)	Turbidimetric method (Chesnin and Yien, 1950)

Table.2 Soil properties of experimental site

Parameter	Value
pH (1:2.5)	7.4
EC (1:2.5)	0.03
O.C. %	0.25
Avail. N (kg/ha)	104
Avail P ₂ O ₅ (kg/ha)	52
Avail K ₂ O (kg/ha)	169
Avail S (ppm)	11.2

Table.3 Determination of seed quality characteristics of castor genotypes

Genotype	Oil content (%)	100 Seed weight (g)	Seed yield (kg/ha)
RG 2685	47.8	38	3270
RG 226	49.0	34	4043
RG 2451	47.9	17	1608
RG 311	50.7	34	4408
RG 329	50.0	34	2962
RG 330	50.6	38	3370
RG 3445	48.8	35	1044
RG 3451	49.2	32	1434
RG 3467	49.7	34	3694
RG 357	49.1	35	3685
RG 358	49.3	31	4373
RG 370	49.6	25	3036
RG 380	48.7	39	2865
RG 63	49.3	33	4987
GC 3 (C)	50.2	32	3351
GCH 7 (C)	49.7	33	4275

Table.4 Fatty acid composition of castor genotypes

Genotype	SFA		MUFA	PUFA		RA
	Palmitic	Stearic	Oleic	Linoleic	Linolenic	Ricinoleic
	16:0	18:0	18:1	18:2	18:3	18:1 (OH)
RG 2685	1.25	1.56	4.10	5.05	0.65	87.39
RG 226	1.31	1.76	4.78	5.34	0.73	86.08
RG 2451	1.21	1.84	4.04	4.66	0.57	87.68
RG 311	1.56	1.93	4.88	5.96	0.57	85.10
RG 329	1.57	1.89	4.78	5.90	0.71	85.15
RG 330	1.64	1.78	4.64	5.60	0.63	85.71
RG 3445	1.36	1.46	4.30	5.50	0.66	86.72
RG 3451	1.17	1.51	4.44	5.18	0.68	87.02
RG 3467	1.10	1.24	3.89	4.29	0.52	88.96
RG 357	1.05	1.18	3.28	4.17	0.49	89.83
RG 358	1.02	1.33	3.57	4.42	0.53	89.13
RG 370	1.46	1.34	4.03	4.91	0.51	87.75
RG 380	1.10	1.38	3.97	4.67	0.54	88.34
RG 63	1.35	1.64	4.37	5.11	0.59	86.94
GC 3 (C)	1.32	1.67	4.44	5.17	0.55	86.85
GCH 7 (C)	1.27	1.43	4.18	4.78	0.45	87.89

Table.5 Comparison of Saturated Fatty Acid (SFA) and Unsaturated Fatty Acid (UFA) in different castor genotypes

Genotype	SFA	MUFA	PUFA	RA	UFA
RG 2685	2.80	4.10	5.70	87.40	97.20
RG 226	3.07	4.78	6.07	86.08	96.93
RG 2451	3.05	4.04	5.23	87.68	96.95
RG 311	3.49	4.88	6.53	85.10	96.51
RG 329	3.46	4.78	6.61	85.15	96.54
RG 330	3.40	4.64	6.27	85.71	96.60
RG 3445	2.82	4.30	6.16	86.72	97.18
RG 3451	2.67	4.44	5.85	87.04	97.33
RG 3467	2.34	3.89	4.80	88.96	97.66
RG 357	2.23	3.28	4.66	89.83	97.77
RG 358	2.35	3.57	4.95	89.13	97.65
RG 370	2.79	4.03	5.42	87.76	97.21
RG 380	2.48	3.97	5.20	88.35	97.52
RG 63	2.99	4.37	5.70	86.94	97.01
GC 3 (C)	2.99	4.44	5.72	86.85	97.01
GCH 7 (C)	2.70	4.18	5.23	87.89	97.30

Table.6 Computation of different ratios among fatty acids of castor genotypes

Oleic/Linoleic (O/L)	MUFA/PUFA	MUFA/RA
0.81	0.72	0.047
0.89	0.79	0.055
0.87	0.77	0.046
0.82	0.75	0.057
0.81	0.72	0.056
0.82	0.74	0.054
0.78	0.70	0.050
0.86	0.76	0.051
0.91	0.81	0.044
0.79	0.70	0.037
0.81	0.72	0.040
0.82	0.74	0.046
0.85	0.76	0.045
0.85	0.77	0.050
0.86	0.78	0.051
0.87	0.80	0.048

Table.7 Correlation coefficient among different fatty acids

Fatty acid	Stearic	Oleic	Linoleic	Linolenic	Ricinoleic
Palmitic	0.702**	0.786**	0.865**	0.384	- 0.869**
Stearic		0.832**	0.793**	0.570*	- 0.877**
Oleic			0.918**	0.647**	- 0.967**
Linoleic				0.664**	- 0.978**
Linolenic					- 0.676**

The presence of the hydroxyl group in ricinoleic acid and ricinoleic acid derivatives provides a functional group location for performing a variety of chemical reactions including halogenations, dehydration, alkoxylation, esterification, and sulfation.

This functionality allows the castor oil to be used in industrial applications such as paints, coatings, inks, and lubricants (Dunford, 2012).

The of GC-FID revealed that the unsaturated fatty acids (UFA) composition was between 96.5% and 99.77% and saturated fatty acid (SFA) ranged between 2.23% and 3.49% (Table 5).

Oleic (MUFA) / Ricinoleic acid (O/R) ratio

The Oleic (MUFA) / Ricinoleic acid ratio among the all 14 genotypes varied from 0.037 (RG 357) to 0.057 (RG 311) (Table 6). High oleic and low ricinoleic acid content in castor oil could have industrial uses requiring high oxidative stability such as bio fuel applications requiring lower ricinoleic acid percentages than the standard castor oil (Rajos *et al.*, 2004).

Oil stability index

In the present study all the genotypes studied have Oleic/Linoleic ratio in range of 0.78%

(RG 3445) to 0.91% (RG 3467). High O/L ratio indicated higher oil stability of genotype (Shah *et al.*, 2014). The presence of antioxidants is higher in cold extracted oils than solvent extracted or pure methyl esters.

In conclusion, on the basis of present study it can be concluded that among the inbreds studied, the maximum weight of 100 seed was 39 g in RG 380, while maximum oil content was 50.7 and 50.6 in RG 311 and RG 330 respectively. The highest seed yield was 4987 kg/ha in RG 63, 4408 kg/ha in RG 311 and 4373 kg/ha in RG 358. The maximum value of ricinoleic acid was 89.83 % recorded in RG 357 inbred. The present study is of vital importance for the selection of male parents for high ricinoleic acid castor hybrid.

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