Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 8 [4] March 2019 : 110-115

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Genetic variation of oil content and quality in castor (*Ricinus communis* L.) under moisture deficit stress conditions

Sowmya P*.,Vanaja M., P.Raghuram Reddy, Sunita V., Razzaq SK.
CRIDA-Central Research Institute for Dryland Agriculture

ABSTRACT

A field study was conducted on two CRIDA castor genotypes along with the national check 48-1 during kharif-2014under moisture deficit stress conditions to assess their variability for yield and oil quality through genetic analysis. Results revealed significant variability.CRC-2 recorded not only higher seed yield but also higher ricinoleic acid content under moisture deficit stress conditions while CRC-9 was on par with the national check 48-1. High genetic advance with high heritability was recorded for oil yield and ricinoleic acid respectively indicating the predominance of additive gene action in inheritance of these characters. Hence, these traits can be taken into consideration for the improvement of castor productivity of oil content and quality while these two CRIDA castor genotypes have potential to be released as cultivars.

Keywords: CRC-9, CRC-2, Ricinus communis

Received 02.12.2018 Revised 19.12.2018 Accepted 30.01.2019

INTRODUCTION

Castor bean (*Ricinus communis* L.) is a tropical non-edible oil yielding plant of high commercial importance. Castor bean is a monotypic species belonging to the family Euphorbiaceae and has a wide range distribution in both tropical and sub-tropical regions [6]. The major production of castor bean comes from India, China and Brazil, which adds more than 90% of global production. The productivity of the country in 2011-12 was 1417 kg ha-1 with a world average of 850 kg ha-1 [2]. Gujarat is the leading castor growing state in India and contributes about 70% of the production from about 47% of the area [6].

Castor seed contains 40% to 60% of oil and among all the vegetable oils it is the world's most useful and economically important natural oil as it is very distinct with its high level (85%) of fatty acid known as ricinoleic acid in which global demand is increasing [16]. Castor plants have great levels of drought tolerance, but seed yields are condensed under limited water supply [20]. Breeders have given great attention for development of new varieties in castor (Sujatha *et al*., 2008). Success in Castor is based on looking for genetic distinctions for increased seed yield, high oil content and resistance to various biotic and abiotic stresses [24].

MATERIALS AND METHODS

During Kharif-2014, a field study was conducted with two CRIDA castor genotypes, viz.,CRC-2, CRC-9and a check 48-1 at Hayathnagar Research Farm, Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. The trial was sown on July 26th, 2014 in RBD with three replications each for irrigated conditions and for moisture stress conditions. The irrigated plots were maintained stress free by not withholding irrigation at initiation of primaries moisture deficit stress treatment was imposed bywithholding irrigation till wilting symptoms appeared and then the stress was relieved. Five plants from each treatment were randomly selected in each replication in all the genotypes. Three replications were maintained in the field for each treatment.Each genotype was sown in 5m length of three rows with plant to plant spacing of 30cm and 1m between rows.

The crop received 249 mm rainfall spreading in 19 rainy days (>2.5 mm) during the crop growth period, the crop experienced rainless period of more than 10 days during vegetative stage, 31 days during initiation to maturation of primaries and initiation of secondaries and 97 days during maturation of secondaries and initiation to maturation of tertiaries. During the crop growth period, the average temperature was 30.3°C with minimum and maximum of 4.5°C and 35.6°C respectively.

Seed quality: The oil content of seed was determined by soxhlet-extraction method.

Fatty acid profile: Fatty acids were analyzed in Department of Biochemistry, Directorate of Oilseed Research, Hyderabad by Autosystem XL Gas Chromatography (Perkin Elmer, USA) equipped with capillary column. The oil extraction was dried in argon current and reconstituted in 1:50 volumes of chloroform [12]. Appropriate fatty acid standards from Sigma Aldrich (USA) were used and the fatty acid peaks were identified by integrating them with the standards' profiles. The area under the peak was expressed as percentage fatty acid content.

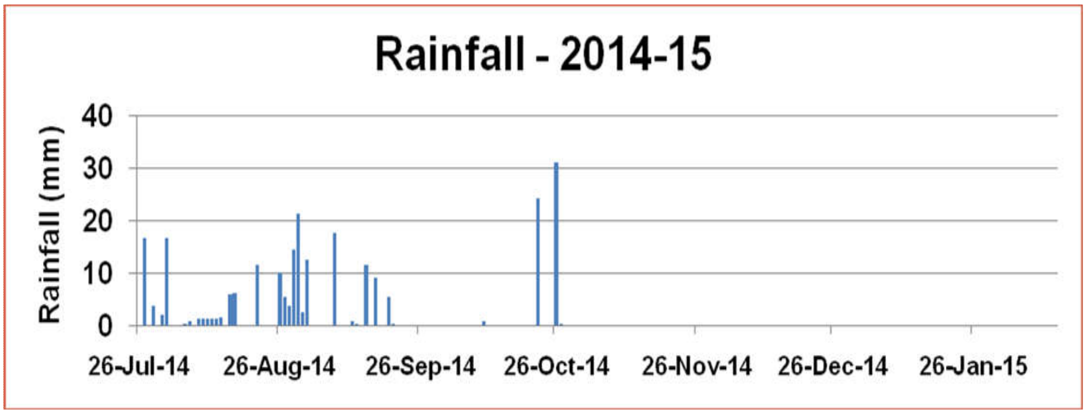
Genetic Analysis:

- Heritability in broad sense (H^2or h^2) *[7]*
- Phenotypic and genotypic correlations
- Genotypic (σ^2g) and Phenotypic variances (σ^2ph) *[5].*
- Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) [21].
- *Statistical analysis* - Analysis of variance (ANOVA)-*STAR* (Statistical Tools For Agricultural Research).

Table-1: Weather data during crop growth period-Kharif-2014

	Temp		RH	
	Max. (°C)	**Min. (°C)**	**Max (%)**	**Min (%)**
Average	30.3	14.4	84. 8	49.7
Minimum	21.3	4.5	42	24.0
Maximum	35.6	31	100.0	49.7

Total Rainfall = 249 mm **Number of rainy days (>2.5 mm) = 19 days**



RESULTS

Seed yield (g/pl) : Under irrigated conditions, the seed yield was highest for CRC-2 (41.45g/pl) than CRC-9 (29.18 g/pl) and check 48-1 (36.45g/pl). Under moisture deficit stress condition also CRC-2 (27.68g/pl) was highest for seed yield than CRC-9 (22.21 g/pl) and 48-1 (22.57 g/pl).

Oil content (%): Under irrigated conditions,the oil content was low for both the genotypes CRC-2 (30.5%) and CRC-9(42.5%) than 48-1 (43.41%). Under, moisture deficit stress, it was higher for CRC-9 (50.16 %) than CRC-2 (38.61 %) and 48-1 (36.67%).

Oil yield (g/pl): Under irrigated conditions oil yield was higher for check 48-1 (15.82 g/pl) followed by CRC-2 (12.64 g/pl) and CRC-9 (12.41g/pl).Under moisture deficit stress, oil yield was higher for CRC-9 (11.14 g/pl) than CRC-2 (10.69 g/pl) and 48-1(8.28g/pl).

Ricinoelic acid (%): Under irrigated conditions ricinoelic acid were highest for check 48-1 (87.1%) followed by CRC-9 (84.47%) and CRC-2 (83.7%).Under moisture deficit stress, ricinoelic acid was higher for CRC-2 (85.86%) than CRC-9 (83.56%) and 48-1(80.4%).

Table-2: Mean performance of castor genotypes for oil and its yield underirrigated and moisture deficit stress conditionsduring Kharif-2014

Genotype	Seed yield (g/pl)		Oil content (%)		Oil yield (g/pl)		Ricinoleic acid (%)	
	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress
CRC-2	41.45	27.68	30.50	38.61	12.64	10.69	83.7	85.86
CRC-9	29.18	22.21	42.50	50.16	12.41	11.14	84.47	83.56
48-1	36.45	22.57	43.41	36.67	15.82	8.28	87.1	80.4
Average	**35.7**	**24.16**	**38.80**	**41.81**	**13.62**	**10.04**	**85.09**	**83.27**

The ANOVA for oil content (%) showed significant variability among the genotypes, moisture levels and interaction of genotypes and moisture levels (Table-3).

Table-3: Analysis of variance for oil parameters in castor genotypes during Kharif-2014

		Mean sum of squares			
Source	**DF**	**Oil content**	**Oil Yield**	**Seed yield**	**Ricinoleic acid**
Replication	2	0.020	11.288	62.203	1.579
Genotypes	2	208.240**	0.240	118.676**	1.712
Moisture levels	1	40.861**	57.878**	599.118**	14.833**
G x ML	1	107.096**	17.783*	23.437	30.338**
Error	2	0.008	2.935	12.874	0.854
CV(%)		0.22	14.48	11.99	1.10

**Significance at p<0.05 and **Significance at p <0.01*

Oil quality: Under irrigated condition, both CRC-2 and CRC-9 were superior for all the six fatty acids composition studied except for ricinoleic acid. Under moisture stress conditions, CRC-2 and CRC-9 were better than the check (Table-4).

Table -4: Oil quality of two castor genotypes along with check 48-1 during Kharif-2014

Genotype	Palmitic acid		Linolenic acid		DHSA		Linoleic acid		Stearic acid		Ricinoleic acid (%)	
	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress
CRC-2	1.80	1.60	7.06	6.64	0.57	0.63	4.9	3.51	1.97	1.76	83.7	85.86
CRC-9	1.72	1.89	7.44	8.32	0.68	0.66	3.9	3.65	1.79	1.91	84.47	83.56
48-1	1.55	2.37	6.03	9.87	0.59	0.64	3.18	4.47	1.56	2.25	87.1	80.4

The ANOVA for oil quality showed significant differences among the genotypes for palmitic acid and linoleic acid (Table-5).

Table-5: Analysis of variance for oil quality parameters in castor genotypes during Kharif-2014

		Mean sum of squares					
Source	**DF**	**Palmitic acid**	**Linolenic acid**	**Linoleic acid**	**Stearic acid**	**DHSA**	**Ricinoleic acid**
Replication	2	0.002	12.604	0.003	0.00	0.001	1.579
Genotypes	2	0.107**	2.504	0.337**	0.005	0.008	1.712
Moisture levels	1	0.312**	44.588*	0.061*	0.178**	0.004	14.833**
G x ML	1	0.397**	6.218	2.729**	0.306**	0.003	30.338**
Error	2	0.001	2.79	0.370	0.001	0.002	0.854
CV(%)		1.89	24.95	2.32	1.85	7.00	1.10

Correlations: The genotypic (r_G) and phenotypic correlations(r_P) for all the oil parameters under both irrigated and moisture stress conditions are presented in Table-6.

Table-6:Genotypic and phenotypic correlations for oil quality of castor genotypesunder irrigated and moisture deficit stress conditions during Kharif-2014

		Oil content		Oil yield		Ricinoleic acid		Seed yield	
		Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress
Oil content	r_G	1.00	1.00	0.546	**0.995****	0.772	0.223	-0.804	-0.822
	r_P	1.00	1.00	0.437	0.465	0.654	0.220	-0.712	-0.276
Oil yield	r_G			1.00	1.00	**0.998****	**0.998****	0.062	**-0.997****
	r_P			1.00	1.00	0.897	0.579	0.318	0.715
Ricinoleic acid	r_G					1.00	1.00	-0.197	**0.997****
	r_P					1.00	1.00	-0.001	0.540
Seed Yield	r_G							1.00	1.00
	r_P							1.00	1.00

**Significance at p<0.05 and **Significance at p <0.01*

Genotypic and phenotypic variability,heritability and genetic advance as percent of mean (GAM %): The variances, coefficient of variations, heritability and genetic advance as percent of mean (GAM) were presented in Table-7.Under irrigated conditions,high heritability with high GAM was recorded for seed yield and oil yield, whereas, high heritability with low GAM was recorded for ricinoleic acid and low heritability with high GAM was found for oil content. Under moisture deficit stress, high heritability with high GAM was recorded for oil content, whereas, high heritability with low GAM was observed for oil yield and ricinoleic acid and moderate heritability with low GAM was observed for seed yield.

Table-7: Co-efficient of variation, variances,heritability and GAM for oil Parameters under irrigated and moisture deficit stress conditions during Kharif-2014

	Genotypic Variance		Phenotypic Variance		GCV		PCV		Heritability		GAM (%)	
	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress	Irri	Stress
Oil content	51.93	53.17	51.93	53.19	18.57	17.43	18.87	17.44	0.100	0.951	38.26	35.92
Oil yield	3.06	0.68	4.81	5.72	12.84	8.25	16.10	23.83	0.637	0.900	21.12	5.89
Ricinoleic acid	2.63	7.45	3.68	7.61	1.90	3.27	2.156	3.31	0.714	0.979	3.32	6.68
Seed yield	34.84	2.638	44.36	22.78	16.53	6.72	18.65	19.75	0.785	0.553	30.19	4.71

DISCUSSION

Among the three genotypes studied, the *per se* oil content was highest in 48-1(43.41%) under irrigated condition. However, with15.5% reduction in oil content with moisture deficit stress it was lowest among the genotypes revealing the susceptibility of this genotype to moisture deficit stressfor this trait.

The high yielding genotype CRC-2, recorded lowest oil content under irrigated among the three genotypes and moderate with moisture deficit stress. It is interesting to note that the low yielding genotype CRC-9 recorded highest oil content under moisture deficit stress. This trend reflected in performance of oil yield of these genotypes.

Under moisture deficit stress, oil yield was highest for low yielding genotype CRC-9 as it recorded highest *per se* oil content than high yielding CRC-2 revealing the importance of *per se*oil content than quantum of seed yield.

The impact of moisture deficit stress was lower in CRC-2 for oil content and ricinoleic acid whereas for oil yield in CRC-9. Among the genotypes, moisture deficit stress impact was higher for 48-1 as the reduction for oil content, oil yield and ricinoleic acid was more revealing its susceptibility for these quality traits.

Climatic conditions could be considered as a determining factor for oil percentage and yield and the reduction of these may be due to unfavorable conditions like moisture deficit stress and high temperature in flaxseed [13].

Salimon *et al.* [19] reported ricinoleic acid content of 84% of the total fatty acid composition and with the total of 10% of linoleic, palmitic, stearic and linolenic acids in Malaysian castor bean varieties. Earlier reports of Wang *et al.* [23] of fatty acid analysis revealed about 84.51% ricinoleic acid and among 1033 castor accessions collected from 48 countries worldwide in the USDA germplasmand found significant variability in fatty acid composition among the accessions. Reports of Omari *et al.* [14] in Tanzanian varieties of castor revealed fatty acid compositions of ricinoleic acid (83.5%-92.3%).Variations in percentage composition of fatty acids occur where there are differences in species or varieties, geographical origin, climatic conditions, soil types etc. [11]. Ramos *et al*. [17] found that different varieties have different ricinoleic acid content ranging from 83.65% to 90.00%. Rojas-Barros *et al*. [18] reported considerable variation for ricinoleic acids in the analysis of fatty acid composition of individual F2 castor seeds.

Ramos *et al.* [17] observed non-significant simple correlation for oil content with ricinoleic acid and non-significant correlations for oil content with fatty acid percentage in castor. Patel *et al.* [15] observed non-significant $r_G$and r_P correlation for seed yield with oil content in castor. Huang *et al.* [8] observed non-significant simple correlations with seed yield and ricinoleic acid in castor. Bharadwaj *et al.* [4] found non-significant relationship with oil content and ricinoleic acid in castor.

Khan *et al.* [9] reported high heritability with high GAM for seed yield and oil yield in sunflower. Awas *et al.*[3] observed high heritability with high GAM for oil content in Ethiopian coriander. Singh *et al.*[21] found high heritability with low GAM for oil yield in Jatropa. Khan *et al.* [9] observed medium heritability with low GAM for seed yield in maize.

Oil yield and seed yield recorded high heritability with high GAM under irrigated conditions while under drought oil content recorded high heritability with high GAM indicating the additive gene action and are their selection is important for the crop improvement under both the conditions.

CONCLUSION

From the per se values and genetic observations, it can be concluded that among the genotypes, CRC-2 was superior and CRC-9 was on par with check 48-1 for the traits studied viz., seed yield, oil content,oil yield and ricinoleic acid content. Hence these traits can be taken into consideration for the improvement of castor productivity and these two CRIDA castor genotypes can be progressed further to release as varieties mainly for rain-fed tracts of semi-arid regions.

ACKNOWLEDGEMENTS

We acknowledge the Director, CRIDA and Head, Division of Crop Sciences for providing both field and lab facilities to conduct experiments.

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CITATION OF THIS ARTICLE

Sowmya P.,Vanaja M., P.Raghuram Reddy, Sunita V., Razzaq SK.. Genetic variation of oil content and quality in castor (*Ricinus communis* L.) under moisture deficit stress conditions. Bull. Env. Pharmacol. Life Sci., Vol 8 [4] March 2019 : 110-115