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Morphological and molecular diversity patterns in castor germplasm accessions

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ABSTRACT

Due to diversified usage and a chief raw material for numerous industrial applications and biofuel production, variability is prerequisite to develop high yielding castor (*Ricinus communis* L.) genotypes. Hence, it is necessary to document the germplasm of this high valued crop to increase its production. With this opinion, a study was conducted with 27 diverse castor inbreds to evaluate diversity using 13 morphological characters and 14 simple sequence repeat (SSR) markers. The genotypes showed presence of ample variability for most of the traits with high heritability (>67%). Genetic advance ranged from 8.06% for days to 50% flowering to 76.82% for number of capsules on main raceme. A high phenotypic than genotypic coefficients of variation was observed for 100 seed weight, shelling out turn and oil content. Seed yield per plant was significantly correlated with 100 seed weight (0.62**) and shelling out turn (0.56**) at genotypic level. The path analysis also revealed that number of nodes up to primary raceme had significant direct effect on seed yield per plant. During phenotypic based cluster analysis, Manhattan distance generated five clusters at cut-off value of 0.19. A set of 14 SSR primers detected 44 alleles with a mean of 3.14 alleles/locus. The polymorphic information content ranged from 0.16 (GB-RC-3) to 0.68 (GB-RC-2) with a mean of 0.43. The molecular marker based clustering revealed four distinct groups. A weak correlation (0.31) was recorded between the morphological and molecular matrix. The results of the present study indicated that both morphotypes and molecular markers should be deployed simultaneously to capture the actual genetic diversity of germplasm as well as to harvest greater heterosis through hybridization.

1. Introduction

Castor (*Ricinus communis* L., 2n = 2x = 20), a non-edible industrially important oilseed crop, is globally under cultivation in the arid and semi-arid regions (Govaerts et al., 2000). It appeared to be native to Ethiopian-East African region due to maximum diversity in Ethiopia (Moshkin, 1986; Foster et al., 2010). Seeds of castor contain approximately 45–55% oil which is a major source of ricinoleic acid—an unusual hydroxyl fatty acid (Jeong and Park, 2009). Other than its use as laxative, castor oil is basis for various industrial products like grease, plasticizers, lubricants, drying oil, paints, lipsticks, cosmetics, plastics, insulators, surfactants, etc (Suhail et al., 2015). As compared with other phyto-oils, the alcohol soluble castor oil exhibits high viscosity due to inter-chain hydrogen bonding consequently requires low temperature during biodiesel production. Castor has an extraordinary place in the global oilseed scenario as it holds around 19% of the total area and 9% of the total plant based oil production. Due to its high valued oil, castor crop is a commercial crop in circa 30 countries like India, Brazil, China, Russia, Thailand, Philippines, etc (Manjunath and Sannappa, 2014). Worldwide, India is dominant exporter of castor seed oil as exports 80% of its total castor oil to China followed by US, Japan, Thailand and other European countries. Although, the castor is important export commodity of agri-sector but it is grown merely on 1.5 million ha to a limited extent. Looking at the steady demand for castor oil in several industries, there is urgent need of era to greatly enhance the area, production and productivity of castor crop.

Castor is both self- and cross-pollinated (anemophily) but its monoecious nature favors out-crossing predominately (Allan et al., 2007). Though, *Ricinus* is a monospecific genus of family Euphorbiaceae but many invalid forms viz *R. macrocarpus and R. microcarpus* have reported as species (Weiss, 2000). Monotypism and rigorous selection for few specific targeted traits during the

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Table 1
Estimates of mean performance, mean square and genetic variables for 13 characters in 27 castor inbred lines evaluated at Anand during *Kharif*, 2014-15.

Characters	Mean Performance					Mean square	Genetic parameters					
	Mean ± SD	Range	S.Em.	CD (0.05)	CV (%)	Genotypes (DF = 26)	σ^2g	σ^2p	GCV	PCV	H_2 (%)	GA (%) Mean
Days to 50% flowering	49.9 ± 2.56	46.67–57.67	0.95	2.69	3.29	19.58**	2.01	4.71	4.02	4.75	67.6	8.06
Days to maturity	122.98 ± 5.7	115–134.67	0.82	2.32	1.15	97.51**	13.86	15.88	11.3	4.59	94.0	9.16
Number of nodes up to primary raceme	16.3 ± 2	12.31–20.53	0.42	1.20	4.49	12.60**	0.62	1.35	3.77	12.14	84.4	23.02
Plant height up to primary raceme (cm)	70.69 ± 14.61	47.33–102.25	4.10	11.65	10.04	638.06**	18.13	69.42	25.6	19.78	79.2	36.26
Total length of primary raceme	57.22 ± 6.11	46.04–71.12	1.76	5.00	5.33	111.84**	6.09	15.52	10.6	10.21	78.3	18.62
Effective length of primary raceme	51.4 ± 7.82	33.81–68.72	1.46	4.15	4.93	183.68**	7.73	14.13	15.0	14.96	90.2	29.27
Number of capsules on main raceme	58.75 ± 23.38	32.9–141.3	4.27	12.10	12.55	1639.29**	26.51	80.09	45.1	39.13	90.8	76.82
Number of effective racemes	6.29 ± 0.81	4.17–7.33	0.45	1.29	12.49	2.20**	0.05	0.96	0.76	10.16	31.8	11.80
Seed yield per plant (g)	135.95 ± 50.4	93.33–246.33	10.35	29.36	13.14	7621.78**	129.56	459.59	95.3	36.26	88.0	70.10
100 seed weight (g)	29.32 ± 4.85	14.77–37.16	0.64	1.82	3.78	70.55**	2.83	4.05	9.65	16.39	95.0	32.91
Oil content (%)	47.74 ± 3.32	32.19–50.81	0.75	2.12	2.71	33.06**	2.95	4.62	6.19	6.78	86.2	12.97
Shelling out turn (%)	62.1 ± 6.46	43.89–73.93	3.05	8.65	8.51	125.01**	5.26	34.03	8.47	9.12	52.7	13.64
Length/Breadth (LB) ratio of seed	1.49 ± 0.11	1.29–1.72	0.02	0.07	2.77	0.0347**	0.0030	0.0048	0.20	7.02	85.8	13.42

** significant at 1% level.
SD: Standard deviation; S.Em: Standard error of mean; CD: Critical difference; CV: Coefficient of variation; σ^2g: genotypic variance, σ^2p: phenotypic variance, GCV: genotypic coefficient of variation, DF: Degree of freedom; PCV: phenotypic coefficient of variation, H_2: Broad sense heritability and GA: genetic advance.

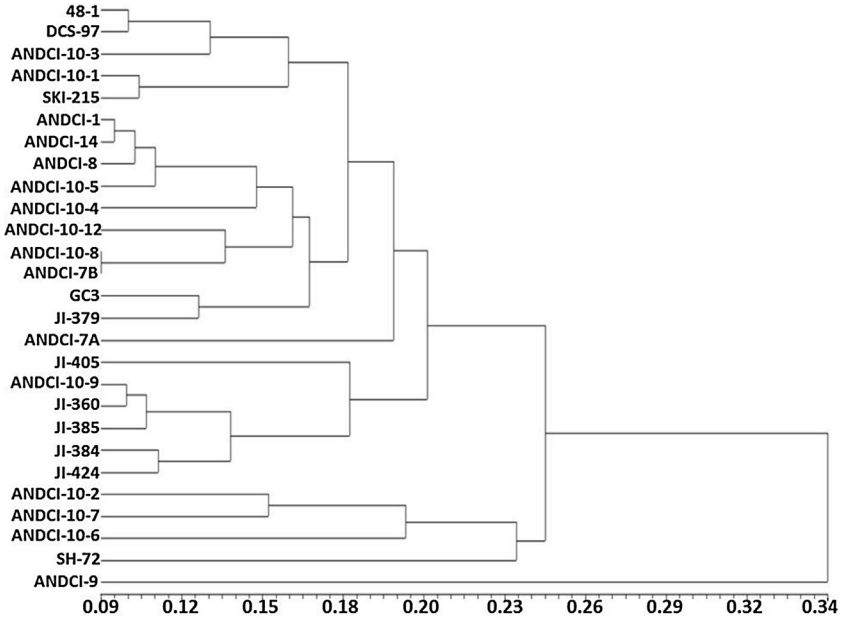

Fig. 1. Classification of 27 castor inbreds based on 13 morphological traits.

course of domestication promoted reduction in variability and erosion of genetic diversity. Due to cross-pollination nature, the cultivation of hybrids are preferred over varieties in India as hybrids fetch higher yield. Information of genetic diversity present in gene pool prior to hybrid development is of paramount important to capture higher heterosis and genetically superior hybrids. Further, there is also need for selection of important traits which are associated with phenotypic and genotypic variations and also contribute for genetic advance (GA). Though, agro-morphological characteristics are strong determinants of variability but due to overlapping variations in germplasm it is difficult to distinguish genotypes from each other (Ahsyee, 2013).

The information on variability using various morphological and biochemical traits in castor has been generated by various workers. Genetic relationship and diversity assessment in a reliable manner needs adequate number of polymorphic markers including morphological, biochemical/isozymes and molecular markers. Traditionally, morphological/biochemical phenotyping is deployed in castor due to easy and quick scoring but Morpho-biochemical traits are substantially influenced by the environment. Therefore, dissecting the variation present in gene pool into genotypic and phenotypic nature is an efficient way to know the extent of environmental effects on trait(s) of interest (Rao et al., 2008). Despite high variability at morphological level, DNA marker variability assessment in castor germplasm especially inbreds is not fully investigated. Though, a range of DNA markers like RAPD, ISSR (Gajera et al., 2010), AFLP (Allan et al., 2008) and SSR (Bajay et al., 2009) has been deployed in castor but up to limited extent consequently the pace of castor breeding is slow than other oilseed crops like soybean, sunflower, Brassicas. Moreover, very few attempts have been made to dissect the genetic variation employing both microsatellite markers and morphometric data simultaneously.

2. Materials and methods

2.1. Plant materials and field evaluation

Present investigation was carried out in well drained sandy loam soil at Regional Research Stations, A.A.U., Anand during *kharif* season of 2014-15. The experimental material comprised of 27 diverse