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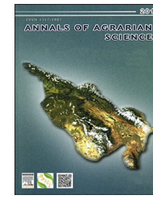

Genetic variability, character association and genetic divergence studies in castor (*Ricinus communis* L.)

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A B S T R A C T

Castor (*Ricinus communis* L.) is an important inedible oilseed crop which, has a great value in industry, pharmaceutical and agricultural sectors. The present study aimed to estimate the nature and magnitude of variability present in castor genotypes with respect to yield and its contributing traits. A study with 15 genotypes on variability, correlation, path and genetic divergence was carried out for thirteen characters. The variability in oil content ranged from 46.75% to 51.71%. The genotypic and phenotypic coefficients of variation were high for number of capsules on main raceme. Positive association of number of nodes up to primary raceme and total length of primary raceme was observed with seed yield per plant hence, these traits may be directly attributed for the improvement of seed yield. The path coefficient analysis demonstrated that utmost positive direct effect on seed yield per plant was exerted by total length of primary raceme (0.62). Mahalanobis D^2 statistic grouped the 15 genotypes into seven clusters. Number of capsules on main raceme contributed much to the total genetic divergence. Selection of genotypes from diverse clusters like cluster II and V, and cluster II and VII for hybridization programme would help in achieving novel recombinants. In conclusion, for the improvement of seed yield the main emphasis should be given on total length of primary raceme and number of nodes up to primary raceme. However, shelling out turn should also be taken into account to improve oil percentage.

Introduction

Castor (*Ricinus communis* L.) is a monotypic species belonging to the Euphorbiaceae family and favours cross-pollination up to the extent of 50% due to its monoecious nature [1]. It is an important oilseed crop and although its oil is inedible, it has great value in industry, pharmaceutical and agricultural sectors. Castor is believed to have most probably originated in Ethiopian-East African region [2,3]. There are four centres of diversity for castor, *viz.*, Ethiopian-Eastern African, North-West, South-West Asia and Arabian Peninsula, Sub-continent of India and China. Seeds of castor contain approximately 45–55% oil which is a major source of ricinoleic acid an unusual hydroxyl fatty acid [4]. Castor oil is the only oil soluble in alcohol, presenting high viscosity and requiring less heating than other oils during the production of biodiesel [5]. The castor oil and its products have numerous industrial uses including biofuel; hence, the demand for castor oil is ever increasing globally. Castor is grown in tropical, sub-tropical and temperate regions of the world. It is cultivated in about 30 countries on commercial scale. Among those, India, Brazil, China, Russia, Thailand and Philippines are the principal castor growing countries. Total world production of castor seed was 18.55 lakh tone during the year 2013–14, from an area of 15.02 lakh ha with 1234 kg/ha productivity [6].

Total area under castor crop in India for the year 2014–15 is 1.10 million hectares with production 1.73 lakh million and average yield is 1568 kg/ha [7]. The major castor growing states in India are Gujarat, Andhra Pradesh, Rajasthan, Tamilnadu, Karnataka and Orissa. Gujarat is the leading castor growing state, where the crop was grown in around 0.683 million ha with 1.3 million tonne production and productivity of 2061 kg/ha during the year 2014–15 [7]. Being the largest producer, India is also the largest exporter of castor seed oil and exports 80% of its total castor oil to China, which is the world's largest importer of castor oil, followed by US, Japan, Thailand and European countries. With the availability of short stature and early hybrids, cultivation of castor in middle Gujarat

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region of India is increasing year by year. The crop ecological condition of middle Gujarat is different in comparison to semi-arid regions, where soils are fertile with good rainfall, and assured irrigation facilities. Due to diversified usage and a chief raw material for numerous industrial applications and biofuel production, diversity among parents is of utmost importance, for a successful breeding programme and to develop high yielding castor. India is one of the centres of diversity, where great diversity exists across the country in varied ecosystems [8]. For a successful breeding programme, the diversity among parents is of utmost importance, since the crosses made between the parents with maximum genetic divergence would more likely to yield desirable recombinants in the progenies. In breeding programme, progenies derived from diverse crosses which are selected based on genetic divergence analysis are expected to show a broad spectrum of genetic variability, providing a greater scope for isolating transgressive seggregants in advance generation and high heterosis. The present study aimed to estimate the nature and magnitude of variability present in castor genotypes with respect to yield and its contributing traits.

Materials and methods

Experimental details

The experiment was carried out at Regional Research Stations, Anand Agricultural University, Anand during *kharif* season (an Indian term for monsoon season) 2014–15 with the objectives to obtain information on variability, correlation, path analysis and genetic divergence (using D^2 statistic) of yield and its components characters in castor. The observations were recorded in fifteen genotypes of castor for 13 quantitative characters (Table 1).

Statistical analysis of morphological data

Analysis of variance technique described by Panse and Sukhatme [9] was followed to test the differences among the genotypes for all the characters. The statistical analysis was performed as per randomized block design (RBD). The genotypic and phenotypic components of variance, coefficients of variability, broad sense heritability and genetic advance were estimated as detailed in Boghara et al. [10]. Pearson correlations were performed by SAS 9.2 to determine trait association. As correlation alone is not enough to elucidate associations among the characters, path coefficient was also analysed [11]. Genetic divergence was calculated using Mahalanobis's D^2 statistic [12]. Grouping of the genotypes in different clusters was done by using Tocher's method [13].

Result and discussion

Variance components

The analysis of variance revealed that the mean sum of squares due to genotypes was found significant for all the thirteen characters indicating the presence of considerable variability in the genotypes (Table 2). The wide range of variation provides ample scope for selection of superior and desired genotypes by the plant breeder for further crop improvement.

The wide morphological variability for different traits of castor has been previously reported by many researchers [14–16]. The mean values of 15 genotypes of castor for 13 characters along with the standard error of mean (S.Em.) and coefficient of variation (CV %) are given in Table 2. The variability in oil content ranged from 46.75% to 51.71%. The result of oil content was incongruence with Shah et al. [17] who observed 46.6%–51.3% of oil content in castor. DCS-105, SKI324 and SKI-380 were significantly superior for oil

Table 1
Mean values for 13 agro-morphological traits in 15 castor genotypes.

Genotypes[a]	Days to 50% flowering	Days to maturity	Number of nodes up to primary raceme	Plant height up to primary raceme (cm)	Total length of primary raceme (cm)	Effective length of primary raceme (cm)	Number of capsules on main raceme	Number of effective racemes	Seed yield per plant (g)	100-seed weight (g)	Oil content (%)	Shelling out turn (%)	L/B ratio of seed
ANDCI 10-1[b]	49	117	17	88.85	58.63	42.80	47	6	218.00	32.76	48.20	65.36	1.42
ANDCI-10-6[b]	50	119	18	89.17	55.88	52.27	141	6	107.33	33.16	47.81	53.86	1.69
DCS-105[c]	49	118	17	52.43	50.11	39.55	42	5	207.00	28.81	51.70	75.47	1.60
DCS-84[c]	47	125	16	105.63	54.23	49.60	88	7	91.33	45.23	46.75	60.42	1.50
DCS-85[c]	49	119	17	83.82	59.92	44.25	49	6	198.67	25.29	47.25	60.32	1.50
DCS-95[c]	49	128	15	60.17	41.50	34.65	43	7	100.67	17.16	48.96	60.31	1.50
JC-12	50	131	17	55.10	48.03	39.67	29	4	98.67	21.63	49.10	69.56	1.50
JI-413[d]	49	119	14	65.00	51.50	47.17	56	5	135.00	37.96	48.47	69.15	1.28
JI-422[d]	49	119	15	68.10	55.07	51.98	131	5	101.67	41.13	47.58	61.99	1.31
JI-423[d]	48	119	15	52.75	63.92	53.80	57	8	102.67	36.25	50.37	66.87	1.40
SH-72[e]	48	117	18	102.25	71.12	68.72	88	7	194.67	32.06	50.81	60.59	1.36
SKI-215[e]	51	116	18	89.44	50.93	45.89	57	7	196.00	27.86	48.60	65.49	1.35
SKI-324[e]	51	118	16	46.34	60.13	54.85	144	5	140.00	28.75	51.47	54.78	1.50
SKI-380[e]	51	118	18	75.66	54.58	44.00	55	5	183.67	30.89	51.47	70.59	1.57
SKI-385[e]	51	116	17	73.08	62.70	56.60	112	7	207.67	33.12	47.06	60.85	1.39
Mean	49	120	17	72.78	55.69	48.79	78	6	147.50	31.38	49.10	63.59	1.46
Minimum	47	116	14	46.34	41.5	34.65	29	04	91.33	17.16	46.75	53.86	1.28
Maximum	51	131	18	105.63	71.12	68.72	144	08	218	45.23	51.7	75.47	1.69
S. Em.	1.44	1.07	0.77	5.08	2.53	2.24	5.36	1	13.99	1.02	0.83	3.8	0.029
CV%	3.57	1.09	5.6	8.4	5.55	5.66	8.67	16	11.27	3.99	2.07	7.32	2.50

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