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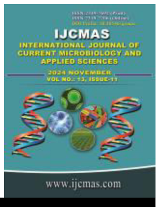

Original Research Article

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Studies on Genetic Variability in Castor (*Ricinus communis* L.)

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ABSTRACT

The current research was conducted at the Main Agricultural Research Station in Raichur during the late *Rabi* season of 2020 to evaluate the variability in yield and its components among 18 castor genotypes preserved at the College of Agriculture in Bheemarayanagudi. ANOVA indicated a significant difference for all analysed characteristics. Plant height, effective length of the main spike, number of capsules on the primary spike, 100-seed weight, and seed production per plant demonstrated high phenotypic and genetic coefficients of variation. Significant heritability with genetic gain percentage was noted for plant height, effective length of the main spike, number of capsules on the primary spike, 100-seed weight, and seed output per plant.

Introduction

Castor (*Ricinus communis* L.), a monospecific crop, is classified under the Euphorbiaceae family and has a chromosomal number of 2n=20. This non-edible oilseed crop, of significant economic importance, is extensively farmed in arid and semi-arid locations globally (Govaerts *et al.,* 2000). It is native to Eastern Africa, perhaps originating in Ethiopia. The genus Ricinus is monotypic, with *Ricinus communis* as its only species, exhibiting the highest degree of polymorphism. Multiple types were classified as species (*R. communis*, *R. macrocarpus, R. microcarpus*) (Weiss, 2000). Castor is a cross-pollinated species exhibiting a typical monoecious state, characterised by racemes that contain female flowers at the top section and male flowers at the bottom section, with the fruit manifesting as a spherical capsule. In castor, two distinct female genotypes have been identified: a stable, monogenic recessive and the other termed sex reversals, which possess a gene for intermittent staminate blooming. This gene is expressed under male-promoting environmental circumstances.

Castor need a somewhat elevated temperature range of 20 to 27˚C and low humidity throughout the growth season. It thrives optimally in regions characterised by clear, warm, and sunlit days. Castor is farmed on a commercial basis in around 30 countries, with India, Brazil, China, Russia, Thailand, and the Philippines being the most significant producers. India is the global leader in castor production, yielding 12.2 lakh tonnes from 7.62 lakh hectares, with an average yield of 1.6 tonnes per hectare (ICAR-IIOR 2020). In India, the principal castor-producing states are Gujarat, Andhra

Pradesh, Tamil Nadu, Odisha, and Karnataka, with Gujarat leading in terms of area, output, and productivity.

Heritable variation is obscured by non-heritable variance, complicating the current selection process. Therefore, it is crucial to partition total variance into heritable and non-heritable components, which may assist breeders in devising a subsequent breeding program.

Direct selection based on crop yields presents a contradiction in breeding programs, since yield is a complex trait inherited polygenically and influenced by its constituent characteristics.

The principal aim of rice breeding programs is yielding increase, necessitating an understanding of the nature and extent of genetic variation governing the transmission of quantitative traits such as yield and its components for successful genetic improvement. An exhaustive examination of genetic variability parameters, specifically genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability, and genetic advance for significant economically relevant traits is essential for any plant breeder engaged in crop improvement initiatives.

Materials and Methods

The experiment was conducted during the *Rabi* season of 2020 at the Main Research in Agriculture Station in Raichur. The experimental material comprises 18 castor genotypes, including inbred lines and two control varieties (48-1, DCS-9), cultivated in a Randomised Block Design with a spacing of 90 × 60 cm at the College of Agriculture, Bheemarayanagudi. Conventional agronomic techniques and phytosanitary treatments were used to ensure optimal crop development.

Data were collected from five randomly selected plants regarding the following traits: days to 50% flowering, days to maturity, plant height (cm), the number of nodes up to the primary spike, primary spike length (cm), number of capsules on the primary spike, number of effective spikes per plant, the actual length of the main spike (cm), 100 seed weight (g), oil content (%), and seed yield per plant (g). The data analysed using INDOSTAT software to calculate the genetic coefficients of variance (%), phenotype coefficient of variation (%), heritability (%) (broad sense), and genetic progress as a percentage of the mean.

Results and Discussion

Analysis of variance

The examination of variance confirmed an important distinction for all the examined variables. This indicated a substantial degree of diversity across genotypes for all yield-related traits examined (Table 1).

Mean performance

The average values of 16 inbred lines, coupled with the checks 48-1 and DCS-9 of castor, for 11 traits are shown in Table 2. The oil content fluctuation ranged from 39.78% to 44.57%. The inbred lines RI-6, RI-2, and RI-32 exhibited dramatically enhanced oil content and seed output per plant. The genotype with the greatest seed yield was RI-6 (125.96 g), whilst the lowest seed yield (65.31 g) was recorded in RI-9. The quality criteria of seeds are the primary qualities that influence their market price, and the 100-seed weight indicates seed boldness; so, superior mean performance is preferred. The maximum value of 100-seed weight was established at 30.69 g. The selection of better varieties or populations is feasible only when sufficient variety is present in the gene pool. Thus, understanding the extent of heterogeneity within the gene pool of a crop species is crucial for plant breeding programs. The quantity of capsules on the initial spike varied from 52.50 (RI-34) to 91.30 (RI-1). RI-9 had a markedly greater effective primary spike length of 51.40 cm. The days to maturity vary from 94.50 (RI-24) to 107.50 (RI-11).

Genotypic and phenotypic coefficient of variance

Table 3 presents the estimations of mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad-sense heritability (h2), and predicted genetic advance as a percentage of the mean (GAM). The PCV values exceeded the GCV values, indicating a diminished environmental impact on trait expression. The GCV and PCV values were elevated for the following traits: plant height (20.15% and 23.91%), effective length of the main spike (27.67% and 24.78%), number of capsules on the primary spike (23.63% and 25.91%), 100 seed weight (20.72% and 22.40%), and seed yield per plant (20.47% and 21.16%).

The elevated PCV and GCV estimations for these features indicate a heightened likelihood of yield enhancement via the selection of these traits. The GCV and PCV values for the features of the number of nodes up to the main spike (15.31% and 16.02%), primary spike length (14.41% and 17.19%), and number of effective spikes per plant (12.04% and 14.92%) were determined to be moderate. Minimal GCV and PCV were recorded for days to 50% blooming (7.89% and 8.64%) and days to maturity (5.61% and 5.89%). Figure 1 illustrates the graphical depiction of PCV and GCV for yield-related characteristics. Comparable findings were noted in the studies conducted by Sadaiah *et al.,* (2021); Nagarajan *et al.,* (2019a); Sowmya *et al.,* (2019); Movaliya *et al.,* (2018); Patel *et al.,* (2018); Alemaw *et al.,* (2014) and Patel *et al.,* (2010).

Heritability and genetic advance

High heritability (broad sense) estimates (>60%) was observed for most of the traits studied *viz*., days to 50% flowering (77.45%), days to maturity (93.94%), number of nodes upto primary spike (73.70%), plant height (89.40%), primary spike length (77.60%), effective length of main spike (88.90%), number of capsules on primary spike (83.50%), 100 seed weight (74.80%), oil content (82.30%), and seed yield per plant (93.50%). High heritability indicates the presence of additive gene effects; hence the selection may be effective for these traits helps in improving yield. However, number of effective spikes per plant showed Low heritability (47.20%). Genetic advance per cent mean was observed high for number of nodes upto primary spike (20.06), plant height (25.61%), effective length of main spike (29.08%), number of capsules on primary spike (25.64%), 100 seed weight (39.11%) and seed yield per plant (40.77%). Graphical representation on h^2 with GAM for yield related traits is given in Fig. 2. Similar results were scrutinized by Sadaiah *et al.,* (2021); Sowmya *et al.,* (2019); Patel *et al.,* (2018); Nagarajan *et al.,* (2019); Movaliya *et al.,* (2018); Patel *et al.,* (2010) and Alemaw *et al.,* (2014); Sarwar and Chaudhary (2008); Patel *et al.,* (2018); Ramesh *et al.,* (2012); Abimiku *et al.,* (2012) and Patel and Patel (2014).

Out of 16 genotypes, RI-6, RI-11, RI-2, RI-32 and RI-22 were found to perform superior when compared to the checks 48-1 and DCS-9 in terms of seed yield which could be utilized for selection and further breeding programmes.

The overall result indicated sufficient heterogeneity among the examined genotypes. This variety might be efficiently harnessed via suitable breeding procedures and programs to cultivate enhanced variants. Elevated GCV and PCV were noted for the majority of the characteristics examined, indicating a substantial degree of variability across the genotypes, which is essential for selection. A significant estimate of heritability and genetic progress was noted in the majority of characteristics, suggesting the dominance of additive gene action and the feasibility of direct selection for yield enhancement via these qualities.

Table.1 Analysis of variance for 11 characters in castor genotypes

Source of variation	***d.f***	**Mean sum of sqaures**										
		Days to 50% flowering	**Days to maturity**	**No of nodes upto primary spike**	**Plant height (cm)**	**Primary spike length (cm)**	**Effective length of main spike (cm)**	**No of capsules on primary spike**	**No of effective spikes per plant**	**100 Seed weight (g)**	**Oil content (%)**	**Seed yield per plant (g)**
Replication	1	9.00	4.00	4.00	3588.07	1.284	0.016	393.34	0.49	7.71	0.38	1.55
Genotypes	18	13.41**	20.47**	2.11**	300.57**	33.60**	6.546**	219.94**	0.137**	18.59**	3.63**	715.08**
Error	17	9.11	11.11	0.47	31.89	20.98	6.85	36.38	0.114	4.68	2.70	46.2

Note: **Significant at 1% level

Table.2 Mean performance of castor inbred lines for yield and its attributing traits

S.No	Inbred lines	Days to 50% flowering	Days to maturity	Number of nodes upto primary spike	Plant height (cm)	Primary spike length (cm)	Effective length of main spike (cm)	Number of capsules on primary spike (no)	Number of effective spikes per plant (no)	100 seed weight (g)	Oil content (%)	Seed yield per plant (g)
1	RI-1	56.50	96.00	15.50	95.50	56.80	47.00	91.30	5.70	20.45	43.52	88.35
2	RI-2	61.50	103.50	17.50	101.50	53.10	46.90	67.10	5.20	26.25	44.57	108.42
3	RI-5	53.00	96.00	17.00	80.70	50.80	45.20	62.50	5.20	24.58	39.78	97.47
4	RI-6	57.50	101.00	18.00	97.60	60.40	49.40	86.80	5.70	21.46	43.53	125.96
5	RI-9	57.50	98.50	17.00	98.90	56.40	51.40	71.10	5.80	24.66	40.24	65.31
6	RI-11	61.50	107.50	17.00	87.00	52.90	47.90	83.80	5.60	21.26	41.88	120.09
7	RI-12	53.50	97.50	16.00	109.30	57.90	44.70	66.60	5.50	30.69	43.94	71.43
8	RI-15	56.50	101.00	17.50	99.80	51.10	46.60	77.10	4.80	25.11	40.66	70.59
9	RI-16	54.50	99.50	18.50	80.30	54.60	46.70	75.30	5.30	23.08	43.48	66.09
10	RI-22	54.50	101.00	18.00	80.60	56.10	45.70	67.60	5.30	29.52	42.19	100.22
11	RI-24	56.00	94.50	18.00	108.30	52.90	45.00	62.60	5.30	27.74	43.63	70.02
12	RI-31	55.00	103.50	17.50	89.20	48.90	47.50	74.80	5.20	21.87	43.45	98.72
13	RI-32	57.00	101.00	16.50	74.50	55.70	45.00	59.50	5.20	25.16	42.51	105.68
14	RI-33	55.00	100.50	16.00	79.20	52.40	46.40	56.10	5.30	21.90	42.57	66.45
15	RI-34	53.50	100.50	19.00	83.30	51.30	46.50	52.50	5.30	27.21	41.42	91.10
16	RI-35	58.50	103.50	16.00	69.50	43.70	44.30	66.00	5.00	22.72	41.18	77.16
17	48-1(check)	59.50	103.00	16.50	77.60	53.40	46.30	78.30	5.30	21.58	42.25	96.32
18	DCS-9(check)	59.00	101.00	15.50	73.90	46.20	44.30	66.70	5.00	27.57	42.07	88.86
	MEAN	56.67	100.50	17.06	88.15	53.03	46.49	70.32	5.32	24.60	42.38	89.35
	MINIMUM	53.00	94.50	15.50	69.50	43.70	44.30	52.50	4.80	20.45	39.78	65.31
	MAXIMUM	61.50	107.50	19.00	109.30	60.40	51.40	91.30	5.80	30.69	44.57	125.96
	SE (m)	2.13	2.35	0.48	3.99	3.24	1.85	4.26	0.23	1.53	1.17	4.81
	C.D. 5%	6.35	7.01	1.43	11.9	9.66	5.52	12.71	0.68	4.56	3.49	14.35
	C.V (%)	5.32	3.31	4.02	6.41	8.64	5.63	8.57	6.33	8.79	3.91	7.62

Table.3 Genetic variability parameters for different characters in castor inbred lines

Character	**Range**		**Mean**	**Coefficient of variation**			**h^2 (Broad sense)**	**GAM (%)**
	Minimum	**Maximum**		**GCV**	**PCV**	**ECV**		
Days to 50% flowering	53.00	61.50	56.67	7.89	8.64	5.32	77.45	14.79
Days to maturity	94.50	107.50	100.50	5.61	5.89	3.31	93.94	8.94
Number of nodes upto primary spike	15.50	19.00	17.06	15.31	16.02	3.31	73.70	20.06
Plant height	69.50	109.30	88.15	20.15	23.91	6.40	89.40	25.61
Primary spike length (cm)	43.70	60.40	53.03	14.41	17.19	8.03	77.60	15.56
Effective length of main spike (cm)	44.30	51.40	46.49	24.78	27.67	5.63	88.90	29.08
Number of capsules on primary spike	52.50	91.30	70.32	23.63	25.91	8.57	83.50	25.64
Number of effective spikes per plant	4.80	5.80	5.32	12.04	14.92	6.33	47.20	17.14
100-seed weight (g)	20.45	30.69	24.60	20.72	22.40	8.79	74.80	39.11
Oil content (%)	39.78	44.57	42.38	5.57	6.18	3.91	82.30	11.59
Seed yield per plant (g)	65.31	125.96	89.35	20.47	21.16	7.62	93.50	40.77

Note: GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation and ECV= Environmental coefficient of variation, GAM- Genetic advance as per cent of mean

Figure.1 Phenotypic and genotypic coefficient of variation for different yield and yield related traits in castor

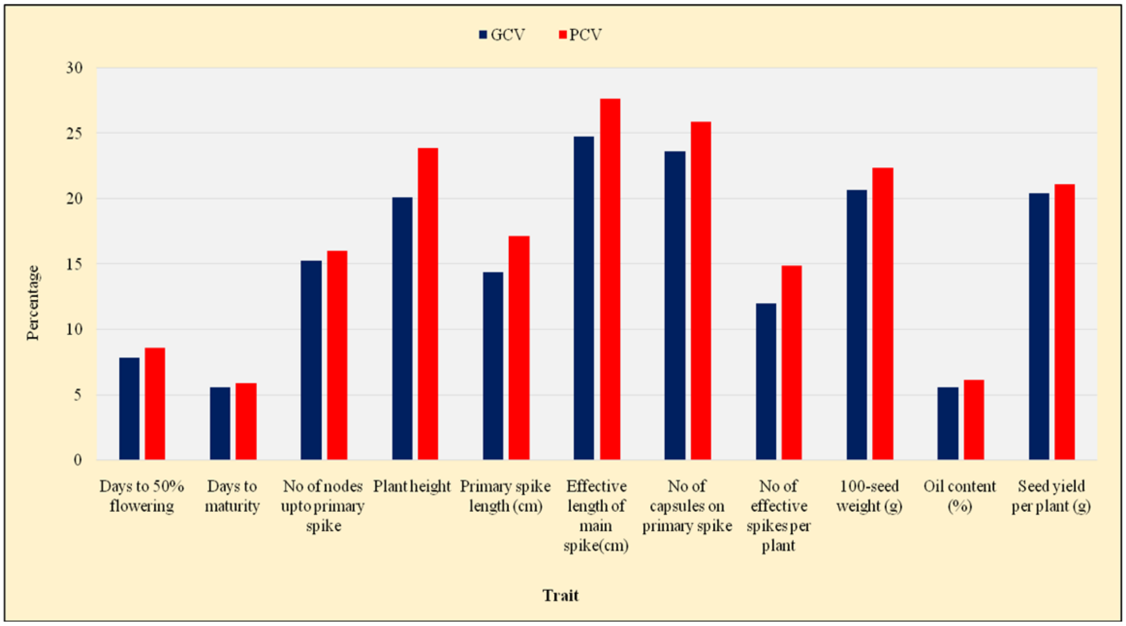
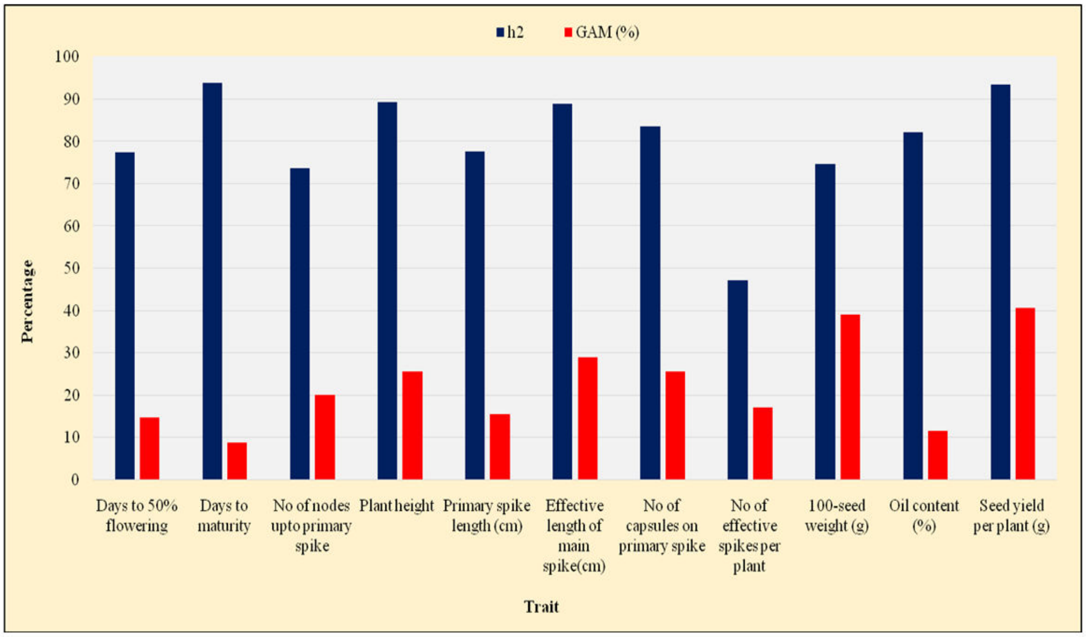


Figure.2 Heritability and genetic advance as per cent of mean for different yield and yield related traits in castor



Author Contributions

M. Karuna Sri: Investigation, formal analysis, writing—original draft. G. C. Shekar: Validation, methodology, writing—reviewing. S. Bharati:—Formal analysis, writing—review and editing. B. V. Tembhurne: Investigation, writing—reviewing. B. Arunkumar: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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