Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 1474-1477
Received: 17-01-2018
Accepted: 18-02-2018

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Study of variability and correlation for seed yield and its attributes in castor (*Ricinus communis* L.)

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Abstract
A trial was conducted to assess variability and correlation for seed yield and its attributes with a set of 64 genotypes of castor (*Ricinus communis* L.). The characters studied were 12 quantitative characters *viz*., days to 50% flowering of main raceme, days to maturity of main raceme, number of nodes up to main raceme, plant height up to main raceme, total length of main raceme, effective length of main raceme, number of capsules on main raceme, number of effective branches per plant, seed yield per plant, 100-seed weight, oil content and shelling out turn. The analysis of variance revealed highly significant differences among the mean square due to genotypes for all characters. High GCV and PCV, high heritability coupled with high genetic advance as per cent of mean was observed for all the characters except number of nodes up to main raceme and number of effective branches per plant. Seed yield per plant had significant and positive correlation with total length of main raceme, effective length of main raceme, number of capsules on main raceme and oil content.

Keywords: variability, correlation, seed yield and castor

Introduction
Castor (*Ricinus communis* L., 2n = 2x = 20) belongs to family euphorbiaceae is an industrially important non-edible oilseed crop widely cultivated in the arid and semi-arid regions of the world (Govaerts *et al.*, 2000) [6]. Its monoecious nature favours cross-pollination and it is up to the extent of 50 per cent. It is essentially a semi-tropical, intermediate perennial plant, but it has naturalized as annual / seasonal crop plant throughout the world in frost free zones. The seed of castor contains more than 45 per cent oil, this oil is rich (80-90%) in an unusual hydroxyl fatty acid, ricinoleic acid. Castor oil is the only oil soluble in alcohol, presenting high viscosity and requiring less heating than other oils during the production of biodiesel. Presently, it is one of the most important indispensable industrial raw materials. Castor cake is also a good source of nitrogen and widely used as manure, but it is unfit for cattle feed due to presence of ricin the highly poisonous substance. Castor leaves are generally used as rearing of silk worms. Study of genetic variability of seed yield and its components characters among different genotypes provides a strong basis for selection of desirable genotypes for augmentation of yield and other agronomic characters. Heritability and genetic advance are also important selection parameters. It will help the plant breeder in selecting the elite genotype from diverse population. To assess the magnitude of correlations for various characters with yield would be immense help in the indirect selection for the improvement of yield. Seed yield is influenced by its various components directly and/or indirectly via other traits that create a complex situation before a breeder for making desirable selection.

Material and Methods
The present investigation was conducted at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh during *Kharif* 2016-17. The experimental material consisted of 64 genotypes of castor (*Ricinus communis* L.) The pure seeds of these genotypes were obtained from the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh. Sixty four genotypes of castor were sown in a randomized block design with three replication. Each line was sown in a single row plot of 6.0 m length with a spacing of 120x60cm. The genotypes were randomly allotted to the plots in each replication.

Experimental Result and Discussion
1. Analysis of variance
The analysis of variance for all the twelve characters under study is presented in table 1. The analysis of variance revealed that mean square due to genotypes was highly significant

for all the characters indicating the presence of sufficient amount of variability in the experimental material used. The present experimental material showed wide range of phenotypic variation for number of effective branches per plant, plant height up to main raceme, effective length of main raceme, seed yield per plant, number of capsules on main raceme, 100-seed weight and number of nodes up to main raceme as revealed by high values of coefficient of range. Shelling out turn, total length of main raceme and days to 50% flowering of main raceme were noted moderate phenotypic range of variation. There was narrow range of variation for days to maturity and oil content. Similar results were also reported by Golakia *et al*. (2007) [5] and Rao *et al*. (2009) [18].

2. Genetic variability

The genotype RG-3794 had the highest seed yield per plant (322.33 g) which was statistically at par with SH-10, SKI-215, DCS-85, JP-90 and JP-65. The genotypes JI-365 and JI-386 were the earliest in days to flowering (44 days). The genotypes JI-258 and SKI-291 were the earliest in days to maturity (108.33 days) and RG-3946 had a minimum plant height (47.67 cm).The genotypes RG-3831, SKP-42, SKI-257, RG-3850, SKI-215 and SKI-291 had maximum number of nodes up to main raceme, total length of main raceme, effective length of main raceme, number of capsules on main raceme, number of effective branches per plant and shelling out turn, respectively. The genotypes JI-347, RG-3070, JI-372 and JI-355 had high oil content.

Table 1: Analysis of Variance for 12 Characters in 64 Genotypes in Castor

		Mean Squares											
Source	**d.f**	**Days to 50% flowering of main raceme**	**Days to maturity of main raceme**	**No. of nodes up to main raceme**	**Plant height up to main raceme (cm)**	**Total length of main raceme (cm)**	**Effective length of main raceme (cm)**	**No. of capsules on main raceme**	**No. of effective branches per plant**	**Seed yield per plant (g)**	**100-seed weight (g)**	**Oil content (%)**	**Shelling out turn (%)**
Replications	2	52.75**	129.81**	47.39**	330.69**	122.06**	152.35**	246.85**	10.63**	2635.4**	29.53**	5.47**	80.34**
Genotypes	63	144.04**	153.09**	20.93**	3247.64**	380.52**	421.95**	413.87**	13.83**	8202.75**	134.97**	2.49**	123.93**
Error	126	7.08	18.25	2.72	33.67	35.81	21.78	21.58	0.45	539.97	7.30	0.31	18.25

*, ** Significant at 5 % and 1 % levels, respectively

2.1 Genotypic Coefficient of Variation and Phenotypic Coefficient of Variation

The highest genotypic coefficient of variation and phenotypic coefficient of variation was observed for plant height up to main raceme followed by effective branches per plant, seed yield per plant, number of capsules per plant, 100-seed weight and effective length of main raceme. The high genotypic coefficient of variation indicated the presence of wide variation for the characters under study to allow selection for individual traits. Similar result was observed by several worker Patel *et al*. (1985) [15]; Patel and Jaimini (1988) [13]; Patel *et al*. (1992) [13]; Mehta and Vashi (1997) [9]; Golakia *et al.* (2007) [5] and Rao *et al*. (2009) [18]. In present study, moderate estimates of genotypic coefficient of variation and phenotypic coefficient of variation was observed for effective length of main raceme, total length of main raceme and number of nodes up to main raceme.

2.2 Heritability

High Heritability estimates was found for plant height up to main raceme (97.0 %) followed by number of effective branches per plant (90.8 %), days to 50 % flowering of main raceme (86.6 %), effective length of main raceme (86.0 %), number of capsules on main raceme (85.8 %), 100-seed weight (85.4 %) and seed yield per plant (82.5 %).Maximum heritability was observed for number of effective branches per plant and plant height up to main raceme. All other characters except shelling out turn and number of nodes up to main raceme showed high heritability estimates. These results are akin with the finding of Patel *et al.* (2010) [9], Dhapke *et al*. (1992), Golakia *et al*. (2007) [5] and Rao *et al*. (2009) [18].

2.3 Genetic advance expressed as per cent of mean

Genetic advance expressed as per cent of mean was maximum for plant height up to main raceme (71.53 %) followed by number of effective branches per plant (59.59 %), seed yield per plant (45.74 %), number of capsules on main raceme (44.71 %), 100-seed weight (42.18 %) and effective length of main raceme (40.96 %). Maximum genetic advance as per cent of mean was observed for plant height up to main raceme followed by number of effective branches per plant, seed yield per plant, number of capsules on main raceme, 100-seed weight and effective length of main raceme which illustrated that they could be improved to a large extent. Bhatt and Reddy (1981), Dhapke *et al*. (1992), Golakia *et al.* (2007) [5], Rao *et al*. (2009) [18], Patel *et al*. (2010) [9], Abimiku *et al*. (2013), Kote *et al*. (2013) [8] and Tewari and Kumar (2013) [20] also reported the similar results.

Table 2: Phenotypic range, coefficient of range, phenotypic and genotypic coefficient of variation, heritability, genetic advance and genetic advance expressed as per cent of mean for various characters in castor

Characters	Phenotypic range of variation	Coefficient of range (%)	Mean ± S.E	PCV (%)	GCV (%)	H^2 broad sence (%)	Genetic advance	Genetic advance (%)
Days to 50% flowering of main raceme	44.00-70.33	23.02	53.42± 1.53	13.59	12.64	86.6	12.95	24.24
Days to maturity of main raceme	108.33-139.67	12.63	118.90± 2.46	6.68	5.63	71.1	11.64	9.79
No. of nodes up to main raceme	9.00-22.67	43.16	15 ± 0.95	19.76	16.42	69.0	4.21	28.10
Plant height up to main raceme (cm)	47.67-196.67	60.98	92.80 ± 3.35	35.81	35.26	97.0	66.39	71.53
Total length of main raceme (cm)	38.33-85.67	38.17	60.60 ± 3.45	20.25	17.68	76.2	19.28	31.81
Effective length of main raceme (cm)	23.33-86.67	57.58	53.84 ± 2.69	23.13	21.45	86.0	22.05	40.96
No. of capsules on main raceme	27.00-82.33	50.60	48.81± 2.68	25.28	23.42	85.8	21.82	44.71
No. of effective branches per plant	2.33-15.33	73.61	6.95 ± 0.38	31.85	30.35	90.8	4.14	59.59
Seed yield per plant (g)	103.33-322.33	51.44	206.79±13.41	26.89	24.44	82.5	94.59	45.74
100-seed weight (g)	19.03-54.50	48.21	29.43 ± 1.55	23.98	22.16	85.4	12.41	42.18
Oil content (%)	45.61-50.14	4.73	48.48 ± 0.32	2.10	1.75	69.5	1.46	3.01
Shelling out turn (%)	26.94-62.82	39.97	55.62 ± 2.46	13.14	10.67	65.9	9.92	17.84

Table 3. Genotypic (r_g) and Phenotypic (r_p) correlation coefficients among 12 characters in castor

Characters		Days to 50% flowering of main raceme	Days to maturity of main raceme	No. of nodes up to main raceme	Plant height up to main raceme (cm)	Total length of main raceme (cm)	Effective length of main raceme (cm)	No. of capsules on main raceme	No. of effective branches per plant	100-seed weight (g)	Oil content (%)	Shelling out turn (%)
Seed yield per plant (g)	R_G	-0.2314	-0.2724*	0.1898	0.1640	0.5015**	0.5202**	0.4599**	0.2341	0.0108	0.3062*	0.2373
	R_P	-0.2379	-0.2041	0.1648	0.1546	0.4558**	0.4885**	0.4268**	0.2463	0.0170	0.2415	0.1985
Days to 50% flowering of main raceme	R_G		0.9539**	0.6046**	0.5555**	-0.0008	0.0068	0.0779	-0.1401	0.3100*	-0.0269	-0.2742*
	R_P		0.7707**	0.4609**	0.4986**	-0.0058	-0.0183	0.0603	-0.1506	0.2405	-0.0262	-0.2243
Days tomaturity of main raceme	R_G			0.6948**	0.6415**	-0.0325	-0.0661	0.0905	-0.3178*	0.4352**	-0.0807	-0.2618*
	R_P			0.4425**	0.5238**	-0.0558	-0.0900	0.0828	-0.2633*	0.3425**	-0.0578	-0.2607*
No. of nodes up to main raceme	R_G				0.8942**	0.4433**	0.4303**	0.5254**	-0.1951	0.4835**	-0.0053	-0.0465
	R_P				0.7574**	0.3843**	0.3798**	0.4056**	-0.1474	0.4013**	0.0129	-0.0185
Plant height up to main raceme (cm)	R_G					0.2496	0.2466	0.4090**	-0.2031	0.5933**	0.0163	-0.1013
	R_P					0.2326	0.2372	0.3678**	-0.1819	0.5457**	0.0270	-0.0718
Total length of main raceme(cm)	R_G						0.9415**	0.7396**	-0.2650	0.0523	0.1415	0.3813**
	R_P						0.8920**	0.6524**	-0.1975	0.0250	0.0963	0.2875*
Effective lengthof main raceme (cm)	R_G							0.7691**	-0.2055	0.1027	0.0549	0.2803*
	R_P							0.7021**	-0.1634	0.0809	0.0323	0.2377
No. of capsules on main raceme	R_G								-0.2801	0.2152	-0.0712	0.0502
	R_P								-0.2311	0.1711	-0.0684	0.0321
No. of effective branches perplant	R_G									-0.3457**	0.3125*	-0.0023
	R_P									-0.2937*	0.2338	-0.0011
100-seed weight (g)	R_G										-0.1075	-0.2437
	R_P										-0.0571	-0.1870
Oil content (%)	R_G											-0.0448
	R_P											0.0167

*, ** Significant at 5% and 1% levels, respectively

3. Correlation Coefficient

The correlation coefficients were estimated among 12 characters to find out association of seed yield per plant and its component at genotypic (r_g) and phenotypic (r_p) levels given at table 3. Seed yield per plant had highly significant and positive correlations both at genotypic and phenotypic levels with total length of main raceme (r_g= 0.501, r_p=0.455), effective length of main raceme (r_g= 0.520, r_p =0.488) and number of capsules on main raceme (r_g= 0.459, r_p = 0.426). Oil content (r_g= 0.306, r_p = 0.241) had also showed positive and significant correlation with seed yield per plant at genotypic level but non- significant at phenotypic level. In present study, seed yield per plant was found to be highly significantly and positively correlated with total length of main raceme, effective length of main raceme and number of capsules on main raceme at both genotypic and phenotypic levels, while oil content and days to maturity of main raceme had significant and desirable correlation with seed yield per plant at genotypic level, indicating that these attributes were influencing more on seed yield in castor and therefore important for bringing improvement in seed yield. Dorairaj *et al*. (1973) [4]; Patel and Jaimini (1988) [13]; Khorgade *et al*. (1994) [7]; Mehta and Vashi (1998) [10]; Ramu *et al*. (2005) [16]; Sarwar and Chaudhary (2008) [19]; Bhanu *et al*. (2010) [2]; Monpara *et al*. (2010) [11] and Ramanjaneyulu and Reddy (2012) [17]. Number of nodes up to main raceme, plant height up to main raceme, number of effective branches per plant, 100-seed weight and shelling out turn had positive but non-significant association with seed yield per plant at both levels, while days to maturity and oil content had desirable but non-significant association with seed yield per plant at phenotypic level only. Days to 50% flowering of main raceme had negative but non-significant association with seed yield per plant at both levels.

Conclusion

It can be concluded from the present finding that additive gene action was operating for seed yield per plant, total length of main raceme, effective length of main raceme, number of capsules on main raceme, number of nodes up to main raceme, plant height up to main raceme, oil content, number of effective branches per plant and shelling out turn. Correlation analysis also revealed the importance of these traits. Therefore, due to weightage should be given to these traits for genetic improvement in castor. Hence, pedigree selection followed by transgressive segregant may give fruitful result for genetic improvement of these traits in castor.

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