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RESEARCH ARTICLE

Stability parameters for sex expression in castor (*Ricinus communis* L.) under different environment

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Abstract

Stability parameters on 12 diverse parental genotypes of castor (*Ricinus communis* L.) including 8 pistillate lines and four male lines were estimated under three environments during *kharif* 2011. The expressions of genotypes were influenced by the varying environments. Highly significant genotype x environment interaction for all the traits studied indicated differential response of genotypes with fluctuating environmental conditions. Both linear and non-linear components of variation contributed for stability of all the traits studied. Prediction of performance under different environments could be made for sex expression (percent pistillate whorls) at primary raceme, number of pistillate whorls on secondary 1, number of pistillate whorls on secondary 2 and number of pistillate plants in primary spike. For seed yield/plant VP-1, DPC-21 and DCS-78 were found stable. It was concluded that the sex expression in castor is influenced by both genotype and environment, where in a better management improves the proportion of femaleness and stress conditions increases the proportion of maleness. The mean number of pistillate whorls on primary spike varied from 17.1 in JP-88 to 36.3 (DPC-19). In secondary spike 1 and 2 also, the number of pistillate whorls were highest in DPC-19. All the genotypes recorded least or non significant deviations from linear regression.

Key words: Castor, G x E interaction, sex expression, stability, yield component

Introduction

The development of castor hybrids gained momentum with the development of pistillate lines using S type pistillate source. The normal inflorescence in castor is a monoecious raceme which bears pistillate flowers in the upper portion and staminate flowers in the lower portion of spike. Castor is a sexually polymorphic species with different sex forms *viz*., monoecious (pistillate or female flowers at the top and staminate or male flowers at the bottom of the inflorescence), pistillate (all female flowers without any male flowers), sex revertants (pistillate plants become monoecious in later order spikes) and Interspersed staminate

flowers (ISF) (pistillate spikes with male flowers in between).

Improvement of quantitative traits and characters of economic significance i.e. seed yield or other plant product is the basic aim of the breeding programmes. However, presence of genotype x environment interaction could mitigate the progress of selection and cause hindrance in identification of stable genotypes (Comstock and Moll, 1963). To overcome this situation, the analysis of genotype x environment interaction had been considered as an effective measure in most of plant breeding programmes (Allard and Bradshaw, 1964), they also indicated that stability i.e. least phenotypic variation in response to fluctuation in environments is a genetic trait.

Sex expression in castor is highly influenced by environmental factors like high day temperature (>32^{0}C), photo period, soil fertility, age of the plant, nutrition etc. (Shifriss, 1966). Other factors like nutrition, irrigation and age of the plant were also reported to contribute to the sex tendency and sex pattern or the ratio of female and male flowers production (Shiffriss, 1966; Ramachandram and Rangarao, 1978; Solanki and Joshi, 2000; Lavanya 2002; Lavanya *et al.*, 2006). However, information on genotype x environment interaction and stability analysis is totally lacking foe sex related traits i.e. per cent pistillate whorls on primary raceme, number of pistillate whorls on secondary 1, number of pistillate whorls on secondary 2 or higher orders of racemes. Hence, present investigation was taken up to generate such information by utilizing parents with various forms of sex, pistillate and male lines.

Materials and methods

In the present experiment, 12 parental lines were used as experimental materials. Among parents, eight were pistillate lines namely Geetha, VP-1, JP-88, M-574, DPC-9, DPC-19, DPC-20 and DPC-21and four male parents namely DCS-5, DCS-9, DCS-78 and 48-1 obtained from IIOR, Hyderabad were utilized. The present study was conducted during kharif-2011 at the ICAR Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad. The experimental site is located at an altitude of 542 m MSL, 17^{o}15$^{'}$16" N latitude and 78^{o}18$^{'}$ 30" E longitude. Experiments were laid out in Randomized Block Design (RBD) with three replications for the sex expression in 3 different environments based on different doses of nitrogen as Treatment 1(40 KgN/ha), Treatment 2(60 KgN/ha), and Treatment 3 (80 kgN/ha). The nitrogen fertilizer was applied in three splits, (1) basal (2) 30 Days after sowing (3) 60 Days after sowing. Each genotype consisting two rows were space planted and seedling rate was one seed per 60 cm in rows space 90 cm apart. Recommended package for irrigated condition was adopted for raising the experiments. All plants in each plot of three replications were selected and observations were recorded for number of pistillate plants in primary spike, number of pistillate whorls on primary spike, number of pistillate whorls on secondary 1 and number of pistillate whorls on secondary 2. The number of whorls bearing male flowers and pistillate flowers were counted in each order and expressed as per cent pistillate whorls.

$$\% \text{ pistillate whorls} = \frac{\text{Number of pistillate whorls (NPW)}}{\text{Total number of flowering whorls (TFW)}} \times 100$$

Where, TFW= NPW+NMW

NPW=Number of pistillate whorls

NMW= Number of male whorls

The mean values were converted into Arcsine transformation and used for statistical analysis. The stability parameters of different genotypes were computed following Eberhart and Russell (1966).

Results and discussion

The significant differences for all the characters were observed among genotypes over all environments. Significant mean squares due to environment showed that variation in the environment greatly influenced the expression of genotypes. The highly significant genotype x environment interaction (Table1) revealed that performance of individual genotype differed considerably with the change in the environment. Both linear and non-linear components of variance genotype x environment had contributed towards stability of genotypes for all the characters. The pooled analysis of variance for traits related to sex expression like number of pistillate whorls on primary spike, secondary spike-1 and secondary spike-2 indicated highly significant differences among the 12 genotypes studied (Table1). Mean squares due to environments (linear) were significant for all the number of pistillate whorls on primary spike. Magnitude of linear component was relatively greater than nonlinear component for per cent pistillate whorls on primary raceme. The genotypes were unpredictable for characters like per cent pistillate whorls on primary raceme.

Environmental indices also varied widely for all the characters (Table 2). The environmental indices showed that, Environment-3 (N=80 kgN/ha) was the most favorable for all the three characters like number of pistillate whorls on primary, secondary spike-1 and secondary spike-2. Whereas, Environment-2 (N=60 kg/ha) was favorable for increasing the number of pistillate whorls in secondary-1 (Table 3). The two components of G x E interaction i.e. G x E (linear) and pooled deviation (non linear) were highly significant when tested against pooled error for all the three characters indicating partial predictability of genotypes.

The mean number of pistillate whorls on primary spike varied from 17.1 in JP-88 to 36.3 (DPC-19). In secondary spike 1 and 2 also, the number of pistillate whorls were highest in DPC-19. All the genotypes recorded least or non significant deviations from linear regression. Perusal of temperature observations during season suggested that high temperature (Table 4) during emergence of primer raceme in season one was mainly, responsible for high maleness. Based on present investigation it could be concluded that high day temperature favours maleness and season had pronounced effect on expression of per cent pistillate whorls. Other environmental factors also influenced the expression of per cent pistillate whorls. However, effect of factors like day and night temperature, relative humidity etc. could not be explained for want of detail study involving such parameters in present study. Detailed study under controlled/field conditions is needed to understand the effect of various factors influencing sex expression in castor. Strong male tendency is manifested intermittently during mid and late-summer, July to September, and again during winter, January to February. The number of spikes showing ISF was high up to April and later decreased in May due to high temperatures and increased in July due to the onset of monsoon. During the period of study maximum and minimum temperatures varied from 27.1°C to 43.7°C and 12.8°C to 28.4°C (Table 3). Earlier studies at Directorate of Oilseeds Research indicated that a monthly mean day temperature of 32°C to 33°C was desirable for the induction of ISF (Ankineedu and Ganga Prasada Rao, 1973) for the maintenanceof pistillate line.

In the present study, the response of the genotypes to the varying nitrogen conditions did not vary much for percentage of pistillate whorls in the pistillate lines. Similar reports were indicated in AICRP trials at SK Nagar where there was no effect of nitrogen up to 125 kg/ha and irrigation up to 1.25 IW /CPE on the percentage of ISF, pistillate plants and reversion below fourth order of spike. In contrast, both at S.K.Nagar and Junagadh, pistillate line Geeta gave higher seed yield compared to VP-1 with higher doses of nitrogen (100-125 kg N/ha) and irrigation level (IW/CPE) above one (Anonymous, 2006).

The influence of nitrogen (0, 40, 80, 120 kg N/ha) on ISF was not significant in 11 interspersed (ISF) and 5 non interspersed (NISF) breeding lines isolated from late revertant pistillate progenies of VP-1 at IIOR, Hyderabad (Anonymous, 1999). The results from the present study are in contrast to the earlier reports of the influence of nitrogen on sex expression (Shiffriss, 1960; Zimmerman and Smith, 1966; Ramachandram and Ranga Rao, 1988). The effect of nitrogen on sex expression must have been nullified due to the drought conditions prevailed during the conduct of the study. The role of environment viz., nutrition, temperature, day length, rainfall etc. on stability of sex expression needs an in depth study. Young plants with a high level of nutrition show predominance of femaleness (Zimmerman and Smith, 1966).

The stability parameters for per cent pistillate whorls at primary raceme indicated that all pistillate parents were stable for sex expression, while all male parents expressed instability at primary raceme. While at secondary pistillate except VP-1, M-574 and DPC-20 all pistillate and male parents were stable for sex expression on the basis of non-significant s2di. While at secondary 2 pistillate except VP-1, M-574, DPC-20 and DPC-21 all pistillate and male parents were stable for sex expression on the basis of non-significant s2di. The stability parameters indicated that out of 12 parental lines 9 were stable on the basis of non-significant deviation from regression for per cent pistillate whorls on primary raceme. Out of nine stable lines for sex expression at primary raceme, two parentala lines depicted b values less than unity, five parental lines recorded regression coefficient near to unity. Where as three parental lines expressed highly responsiveness. Overall consideration of stability parameters for parental lnes elucidated no definite pattern in relation to stability of pistillate or male parents involved in present study. The lines VP-1, M-574 and DPC-19 were well buffered and adapted to all the environments.

Hence, in conclusion female tendency is relatively strong in young plants, especially in primary racemes, and under conditions of moderate temperatures, moderate vegetative activity, and high level of nutrition. Furthermore, female tendency may increase most conspicuously following severe pruning of well established plants. In contrast, male tendency is relatively strong in old declining trees and under conditions of very high or fairly low temperatures, high vegetative activity, and low level of nutrition. While a combination of extremely high temperature and low level of nutrition may lead to a temporary state of complete maleness in plants of some varieties, certain cultural conditions, notably pruning, may bring about a temporary state of complete femaleness in races which ordinarily give a high pistillate-staminate ratio. Such environmentally-induced females turn quickly to monoecism and, if selfed, they invariably breed true to monoecism. Sex expression in castor is influenced by both genotype and environment, where in a better management improves the proportion of femaleness and stress conditions increases the proportion of maleness. The

development of pistillate lines in castor has played the key role in commercial exploitation of hybrids in castor bringing quantum jump in productivity. For seed production of hybrids in commercial scale, a stable pistillate line is a prerequisite.

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Table 1 Analysis of variance for number of pistillate whorls on primary, secondary 1 and secondary 2 in castor

Source of variation	Degrees of freedom	Number of Pistillate whorls on spikes		
		Primary	Secondary-1	Secondary-2
Varieties	11.00	494.24**	400.50**	283.76**
Env.+ (Var. x Env.)	24.00	10.68	19.07	16.28
Environments	2.00	23.77	27.61	4.20
Var.x Env.	22.00	9.49	18.30	17.37
Environments (Lin.)	1.00	47.54*	55.23	8.39
Var.x Env.(Lin.)	11.00	9.37	8.63	14.72
Pooled Deviation	12.00	8.81*	25.64**	18.36**
Pooled Error	66.00	3.90	6.15	3.57

*, ** Significant at 5 % and 1% level

Table 2 Stability parameters for pistillate whorls on primary spike, secondary-1 and secondary-2 in castor

Genotype	Primary pistillate			Secondary-1 pistillate			Secondary-2 pistillate		
	Mean	bi	□²di	Mean	bi	□²di	Mean	bi	□²di
Geetha	21.656	1.491	-2.167	17.311	0.734	2.309	14.200	3.811	10.137
VP-1	28.256	1.492	-3.280	17.100	-0.728	198.935	10.789	-10.918	124.923
JP-88	17.089	-0.300	1.244	1.667	0.246	9.988	0.000	0.000	-3.594
M-574	21.056	-1.016	23.084	19.089	0.642	16.033	16.322	-0.352	21.032
DPC-9	22.000	2.361	-2.995	18.056	2.983	9.892	17.389	3.389	-1.839
DPC-19	36.256	3.441	21.345	32.944	3.062	-5.956	27.489	6.305	-2.002
DPC-20	23.178	0.722	34.718	23.289	2.568	15.575	17.756	2.556	20.909
DPC-21	25.056	3.809	3.341	21.056	2.493	9.670	17.867	7.208	21.977
DCS-5	0.000	0.000	-3.807	0.000	0.000	-6.399	0.000	0.000	-3.594
DCS 9	0.000	0.000	-3.807	0.000	0.000	-6.399	0.000	0.000	-3.594
DCS 78	0.000	0.000	-3.807	0.000	0.000	-6.399	0.000	0.000	-3.594
48-1	0.000	0.000	-3.807	0.000	0.000	-6.399	0.000	0.000	-3.594

Table 4: Weather parameters in the year 2011-12

Months	Temperature		Max-Min Temp. (^{0}C)	Mean Temp. (^{0}C)	Day Length	Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum					
August	29.4	23.3	6.1	26.4	12.72	87	39.7
September	30.2	21.9	8.3	26.1	12.23	92	55.7
October	29.5	20.3	9.2	24.9	11.60	83	27.3
November	29.9	16.2	13.7	23.0	11.22	82	6.5
December	28.5	12.7	15.8	20.6	11.07	77	0.0
January	29.7	12.8	16.9	21.6	11.11	65	0.0
February	31.0	14.8	16.2	23.9	11.26	82	0.0
March	34.7	16.3	18.4	26.6	11.67	74	0.0
April	36.1	21.1	15.0	29.8	12.27	63	2.3
May	41.3	24.5	16.8	33.3	12.73	61	0.0

Table 3: Environmental indices in three different environments of fertilizer doses for primary spike pistillate, secondary spike1 pistillate and secondary spike 2 pistillate

S.No	Character		Nitrogen dose		
			N=40 kg/ha	N=60kg/ha	N=80kg/ha
1	Number pistillate whorls on primary	ij	-1.604	0.574	1.030
2	Number pistillate whorls on Secondary-1	ij	-1.618	1.391	0.227
3	Number pistillate whorls on Secondary-2	ij	-0.656	0.491	0.166

ij – environment index