REVIEW OF LITERATURE
II. REVIEW OF LITERATURE

The literature pertaining to the objectives of the present investigation has been reviewed and presented under the following headings.

2.1 Stability of sex expression in pistillate lines

2.2 Combining ability of parents and hybrids for seed yield and its contributing traits

2.3 Heterosis for seed yield and its contributing traits

2.4 Stability of hybrids for seed yield and its contributing traits

2.1 Stability of sex expression in pistillate lines

A critical analysis of genetic and non-genetic factors influencing sexual polymorphism in castor has helped in identification of three types of pistillateness N, S and NES. N type pistillateness is controlled by single recessive gene in homogenous condition (ff), while, S type of pistillateness originating from sex reversal variations is governed by polygenic complex with environmental sensitive genes for interspersed staminate flowers (ISF) expressing under high temperature (>32°C). Use of ‘N’ pistillate lines (conventional) in hybrid seed production programme leads to great deal of roguing resulting in less hybrid seed production and large scale rejection of hybrid seed plots due to sex instability and reversion to monoecism in any sequential order spikes. Among the three systems, ‘S’ system (modified) appears to be the best because of its predictable sex behaviour resulting in less roguing, more hybrid seed production/ unit area and high rate of success of hybrid seed plots besides easiness in development and maintenance of such types of pistillate lines in castor (Patel et al., 2010f).

Solanki and Joshi (2000) based on their studies concluded that high day temperature favours the maleness and seasons had pronounced effects on sex expression. All pistillate and male parent RG-184 were considered as stable for sex expression. However, NES type pistillate line 240 usually contributed to instability at higher orders in various cross combinations. Superior genotypes/ inbreds could be developed by handling the segregating generation of prominent stable crosses.
Kenchanagoudar et al. (2010) evaluated seven pistillate lines to study the stability of pistillate lines over seasons as well as the combining ability in the rainy and winter/summer seasons for three years. They revealed that the pistillate lines VP-1(NR), NES-19 and LRES-17 were not stable and showed reversion. These lines are therefore, required to be improved for femaleness and stability through selection.

Balakishan and Prabakaran (2010) made studies on DPC 9, the female parent of the castor hybrid DCH -177, for production of breeder and foundation seed of the pistillate line and for production of certified hybrid seeds of DCH 177 at various locations for both summer and winter season during 2007-08, 2008-09 and 2009-10. Observations on sex expressions were recorded at suitable intervals to rogue out the off-types. The results showed that though the pistillate character is influenced by weather parameters, high level of nutrition and regular irrigation could help to avoid stress and maintain pistillateness in the female lines. Even under unfavorable weather situation, it would be possible to produce seeds with adequate genetic purity. The various implications of sex reversal in pistillate lines in seed production plots on the purity of seed produced is discussed.

Prabakaran and Balakishan (2010) conducted a study to understand the pattern of variation among segregating materials of the pre breeding programme in terms of sex expression. Crosses were attempted between three pistillate lines and six staminate plants. The hybrid plants in each combination showed differential sex expression varying from complete male (staminate), interspersed staminate flower (ISF), interspersed pistillate flower (IPF), pistillate, monoecious and monoecious with ISF etc. They observed that the sex expression in castor is influenced by environment, and is highly variable.

Lavanya (2010) attempted to understand the breeding behaviour of completely male plants. She revealed that castor is a sexually polymorphic species. Genetic quality of foundation seed of the varieties or male lines of released hybrids is affected by completely male plants with 10% male flowers in all spike orders.

Patel et al. (2010b) used 20 pistillate lines with two dates of sowing to understand the influence of date of sowing on pistillate expression. Recovery of pistillate and monoecious plants was not influenced by date of sowing while number of interspersed staminate flower were influenced.
Parimala et al. (2010) conducted field experiment during winter season of 2009-10 to evaluate the effect of sowing dates, spacings and growth regulators on hybrid seed production of castor hybrid, PCH-111. The parental lines of DPC -9 (female) and CS -1 (male) were sown in 4:1 ratio with three sowing dates and three different spacings. Growth regulators (Ethrel @ 0.1, 0.05 and 0.01%) were sprayed at 27 days after sowing (DAS) and 47 days after sowing on seed parent to determine their influence on sex expression. Highest seed yield was recorded from September and October sowings with a spacing of 90 cm x 90 cm and 120 cm x 60 cm. Ethrel@0.1% enhanced the seed quality compared to GA3 treatment and cool. Maximum genetic purity (92.7 – 95.1%) was recorded in September and October sowings with Ethrel @0.1% spray was very effective for obtaining better quality seed by suppression of interspersed staminate flowers (ISF) in the seed parent.

Kalarani et al. (2010) conducted field experiments during rainy season of 2008 and 2009 to study the effect of exogenous application of chemicals on pistillate production efficiency, seed setting per cent and seed yield using castor varieties viz., TMV- 5 and TMV- 6 and hybrids viz., TMVCH1 and YRCH 1. Growth regulators viz., gibberlic acid (GA3) (100 mg/l), Naphthal acetic acid (NAA) (40 mg/l), Salicylic acid (100 mg/l), Ethrel (50 mg/l), Brassinisterod (0.1 mg/l) and plant growth regulator (PGR) consortia (100 mg/l) were sprayed eight days before initiation of flowering. Among the chemicals tried, irrespective of the genotypes, PGR consortia induced earliness (7 to 13 days), increased number of pistillate flowers (7 to 45 flowers) and developed compact raceme with 92% of seed set. Among the hybrids, YRCH 1 recorded the highest seed yield (1744 kg/ha) followed by TMVCH 1 (1388 kg/ha) in PGR consortia sprayed plot. Among varieties, TMV 6 recorded the highest yield (1215 kg/ha) followed by TMV 5 (1128 kg/ha) in PGR consortia treatment.

2.2 Combining ability of parents and hybrids for seed yield and its contributing traits:

Mehta (2000) evaluated ten castor bean genotypes and crosses in half-diallel fashion and reported that magnitude of mean sources for all traits was higher in GCA than SCA effects indicating the predominance of the additive gene action in the expression of these traits.
Joshi et al. (2001) tested four pistillate and 28 male lines and their crosses in four environments. They reported that the best general combiners for early flowering and maturity were the parents RCG-5, EC-103745, Bhagya for dwarf plant height. JI-77, Hazari-1, JH-16 and SH-66 for low number of nodes up to main spike. SH-21, SH-16 and combination for days to flowering and maturity. VP₁ x SA₂ for plant height and SKI-93 x SKI-12 for number of nodes up to main spike.

Kavani et al. (2001) studied the combining ability for nine attributes using Line x Tester mating design involving 5 lines and 7 testers in castor (Ricinus communis. L). The estimated components of gca and sca variances showed the preponderance of non additive gene action for all the characters. The female JP-81 was good general combiner for seed yield per plant and some other important yield attributing characters. Among males, DCS-47, JL-251 were found to be good general combiners for yield per plant and other related attributes. The highest sca effect was exhibited by the cross combination JP-81 x DCS-47 for seed yield per plant. The cross combination JP-82 x DCS-47 showed highest sca effect for number of capsules on primary raceme. The highest sca effect for number of effective spikes per plant was recorded by the cross JP-83 x DCS-47. He concluded that the parents with high gca and crosses with high sca effects should be exploited for further breeding programmes. The crosses with high sca effects for yield per plant and other important yield attributing characters should be exploited for heterosis breeding.

Lavanya and Chandramohan (2003) reported that components of gca and sca variances showed predominance of non additive gene action for days to 50 per cent flowering, number of nodes to primary raceme, plant height and seed yield in first, second and third picking and total seed yield. Additive gene action was predominant for effective spikes per plant, hundred seed weight and oil content. The female line, M 619 for plant height, 100-seed weight, seed yield in all three pickings and total seed yield, while M 584 for effective spikes per plant height, 100-seed weight, seed yield in all the three pickings and total seed yield, while M 584 for effective spikes per plant, yield at first picking and oil content were good general combiners. Among the males, JI 240 for seed yield in all the three pickings, total seed yield and oil content, JI 220 for seed yield in second and third pickings, SKI 233 for effective spikes per plant and SKI 229 and JI 225 for 100 seed weight were good general combiners.

Solanki et al. (2004) studied combining ability of new pistillate line MCP-1-1 along with the most popular line VP-1 crossed with 16 testers (male combiners) in line x
tester design. The analysis of variance indicated genetic differences among genotypes. The estimated variance of gca ad sca indicated preponderance of non additive gene action for seed yield, days to 50% maturity of primary raceme and effective length of primary raceme and additive gene action for 100 seed weight, number of nodes up to primary raceme and plant height up to primary raceme. The new pistillate line MCP-1-1 was a good general combiner for seed yield and 100-seed weight. It differed from VP-1 with respect to seed yield, 100 seed weight and effective length of primary raceme. Amongst testers MP-17-01 was identified as a good general combiner for seed yield, effective length of primary raceme and number of primary branches per plant. MCP-1-1 × MP-17-01 was identified as the best cross combination for seed yield, it can be directly used as F₁ hybrid. Selection in segregating generation of MCP-1-1 × MP-17-01, MCP-1-1 × MP 6-01 and MCP-1-1 x MP-7-01 would be effective for development of superior varieties / inbreds.

Three pistillate lines (DPC-9, DPC-10 and DPC-13) and 9 wilt resistant testers (PCS-1, PCS-121, JI-220, JI-225, JI-240, JI-260, SKI-229, SKI-323 and SKI-233) were crossed in a line x tester design. Two crosses namely DPC-10 × J-1225 and DPC-13 × PCS-1 were found to have high specific combining ability for seed yield (Ramana et al., 2005).

Fifteen castor hybrids were obtained by crossing three pistillate lines with five testers in a line x tester mating design and evaluated for character association and path analysis along with parents. The traits like total number of spikes per plant, total number of capsules on main spike and seed yield per plant had significant positive association with oil yield. Path analysis indicated the importance of seed yield per plant, total number of spikes per plant and oil content (Ramu et al., 2005).

Gadhesariya et al. (2006) carried out line x tester analysis to determine the nature of combing ability of four lines and 9 testers and their crosses. They observed non-additive type of gene action for days to 50 per cent flowering, effective length of main spike, number of capsules on main spike, total number of branches per plant and seed yield per plant. They found that female parent JP-65 and SKP-23 and male parents 63-M0 and JE-84 were good general combiners for effective length of main spike, number of capsules on main spike and 100 seed weight. Three crosses namely SKP-93 × SH-16, JP-65 × JI-95 and SKP-93 × 48-1 were found to be best specific combiners for seed yield per plant.
Chandra Mohan et al., (2006) studied combining ability for 10 characters using line × tester mating design involving 4 females and 9 males in castor. Analysis of combining ability revealed the existence of significant variation among lines, testers and line x testers for all the characters studied barring oil content in testers. The components of gca and sca variances indicated the predominance of additive gene action for days to 50 per cent flowering, days to maturity, number of nodes, plant height, effective spike length, seed yield/plant and oil content. The three lines, DCS-5, DCS-27 and SH-72 and two testers, VP-1 and DPC-9 were identified as good combiners for seed yield per plant. However, the three lines, DCS-5, DCS-9 and DCS-85 and one tester, LRES-17 were found to be best combiners for earliness and associated traits apart from oil content. The per se performance of crosses is not correlated with the sca effects of crosses resulted from the parents with either high × high or high × low or low × low gca effects for yield and yield component traits.

Lavanya et al. (2006) studied twenty five castor hybrids generated in a line × tester (5 pistillate lines × 5 male parents) design along with parents for heterosis and combining ability of seed yield and yield components. Estimates of variance due to GCA and SCA indicated predominant additive gene action for number of nodes to secondary raceme (S1), hundred seed weight and seed yield while, non additive gene action was predominant for number of nodes to primary raceme, plant height, total spike length, effective spike length, effective spikes/plant and number of capsules. Among female parents, DPC 9 and DPC 10 were good general combiners for number of nodes to primary raceme, secondary racemes (S1, S2) and hundred seed weight. DPC 10 and M 584 were good combiners for seed yield. Among male parents RG 47, RG 297 and RG 2445 were good combiners for number of nodes to primary, secondary S1 and S2 racemes. The parent RG 47 was also a good combiner for hundred seed weight. Standard heterosis for seed yield ranged from -31.9% to 105.5% over the standard checks DCH -32 and GCH -4. Seven hybrids which exhibited >50% standard heterosis can be used for commercial purpose. Two hybrids viz., DPC 10 x RG 297 and DPC 10 x RG 2178 were both heterotic and wilt resistant are suitable for wilt endemic areas.

Padhar et al. (2010) carried out the combining ability analysis in line x tester design and revealed that both gca and sca variances were important in build up variability in parents and crosses. The non-additive genetic variance appeared to contribute an overwhelming component in the total genetic variance as the $\sigma^2_{gca} / \sigma^2_{sca}$ ratios were less than unity for all the characters studied. The assessment of gca effects of females and
males revealed that JP-102 (female) and JI-376 (male) were observed to be the good general combiners for seed yield and some of yield contributing traits. Some of the crosses were also indentified with very high sca effects for various characters. Crosses such as JP-102 × JI-372 and JP-96 × JI-368 for seed yield, JP-101 × SKI-291, JP-102 × JI-368 and JP-101 × SKI-215 for oil content, JP-102 × SKI-291 and JP-102 × SKI-215 for 100 seed weight, JP-102 × JI-372 for number of effective raceme per plant and JP-96 × SKI-215 for effective length of primary raceme and number of capsules on primary raceme were identified for the respective traits. The composition of a population comprising these parents was suggested with scope of improvement through recurrent selection.

Patel et al. (2010c) carried out Line x tester analysis using four females and 10 males to estimate combining ability and nature of gene action in castor (Ricinus communis L.) for 10 different characters during rainy season of 2004. The analysis of variance for combining ability and the estimates of variance ratio ($\sigma^2_{gca}/\sigma^2_{sca}$) revealed that the non-additive gene action was predominantly involved in expression of all the traits. The hybrids SKP-106 × PCS 124, SKP-106 × SKI 294, Geeta × SKI-192, SKP-106 × SKI-299 and SKP-106 × SH-41 exhibited higher specific combining ability effects in desired direction for seed yield/plant and its attributes. The estimates of gca effects indicated that the female parent, SKP-106 was good combiner for seed yield and also other important traits. Whereas, Geeta was a good combiner for seed yield, number of effective spikes and oil content.

Patel et al. (2010e) carried out Line x tester analysis using seven females and eight males to estimate combining ability and nature of gene action in castor (Ricinus communis L.) for eight different characters during rainy season of 2008. The analysis of variance for combining ability and the estimates of variance ratio ($\sigma^2_{gca}/\sigma^2_{sca}$) revealed that the non-additive gene action was predominantly involved in expression of most of the traits. The hybrids SKP-106 × SKI-166, Geeta × SKI-330, SKP-117 × SKI-192, Geeta × JI-368 and JP-90 × SKI-192 exhibited higher specific combining ability effects in desired direction for seed yield/plant and its attributes. The estimates of gca effects indicated that the female parent SKP 120 was good combiner for seed yield and also other important traits. The SKI 329 was good general combiner for length of main raceme and number of capsule on primary raceme with significant positive gca for total seed yield.

Rao et al. (2010) reported that seven elite lines consisting of released varieties (Haritha, Kranthi, Kiran), advanced breeding lines (PCS-17, PCS-171) and pistillate lines
(VP-1 and DPC -9) were crossed in diallel method excluding reciprocals. The resultant 21 hybrids were evaluated along with their parents in a randomized block design, replicated thrice. The analysis of variance for combining ability revealed significant differences among the genotypes, indicating wide diversity in the material studied. The mean squares due to general and specific combining ability (gca ad sca) were highly significant for all traits indicating that both additive and non-additive types of gene action were involved in the inheritance of these traits. The gca effects of the parents revealed that three parents Harihta, Kranthi and VP -1 were promising general combiners for seed yield and other yield contributing traits. Based on the sca effects and per se performance, four hybrids viz., Haritha × DPC -9, Haritha × VP-1, Haritha × Kiran and Haritha × PCS -170 were identified as promising for seed yield/plant and other characters.

Kavani et al. (2010) conducted a line × Tester analysis, using three female (line) and eight male (tester) parents and made observations on seed yield and some component traits in castor (Ricinus communis L). They revealed that mean sum of squares due to general and specific combining ability were significant, suggesting the importance of both additive and non-additive components of genetic variance. Among the females, SKP 84 and males, J 368 and SKP 215 were good general combiners exhibiting high gca effects for seed yield and some of its component traits. The crosses SKP 84 × JI 355, JP 103 × SKI 291 and JP 103 × JI 273 had high sca effects for seed yield/plant. SKP 84 x JI 355 expressed the highest sca effect for seed yield/plant along with the highest per se performance in F1. The hybrid SKP 84 x JI 342 expressed the highest heterotic values over mid (50.7%) and better parent (42.6%) for seed yield/plant.

### 2.3 Heterosis for seed yield and its contributing traits

Heterosis or hybrid vigour indicates the superiority of hybrid over its parents. Koelreuter (1766) noted that vigour in crosses increased with the increase in dissimilarity of parents. The term ‘heterosis’ as is now widely used, was coined by Shull (1908). It refers to the phenomenon in which the F1 hybrid obtained by crossing two genetically dissimilar individuals shows the increased or decreased vigour over the better or mid-parent value. Later on Fonseca and Patterson (1968) used the new term ‘heterobeltiosis’ to describe improvement of a heterozygotes in relation to better parent. This phenomenon in castor is due to the availability of 100 per cent pistillate lines which has opened a way for increasing castor yield by the development of hybrids in castor for commercial
purposes as suggested by Gopani et al. (1968). White (1918) observed that the F₁ castor hybrids produced a large amount of seeds than either of the parents.

Golakia et al. (2008) studied forty four castor hybrids developed by line x tester mating design (four pistillate lines × 11 male parents) along with parents and a standard check for heterosis of yield determinant characters. Significant desired heterobeltiosis ranged from 18.7 to 39.6% and standard heterosis ranged from 17 to 32.8% for seed yield/plant. Other characters also showed considerable heterosis over better parent and standard check. However, magnitude of heterosis was found to vary substantially from cross to cross and character to character. Five superior hybrids sorted out on the basis of seed yield/plant per se showed no indication of yield heterosis arising from yield components. However, effective branches/ plant found to be major contributor towards seed yield so far standard heterosis is concerned. The JP 88 x DCS 89, JP 65 x DCS 89, JP 88 x PCS 124, JP 88 x JI 274, P 65 x DCS 89, JP 88 x PCS 124, JP 88 x JI 274 and JP 65 x JI 309 were the promising hybrids over standard check (GCH 6), need to be tested in different agro climatic zones to prove their yield superiority over the environments.

Patel, et al. (2010a) evaluated forty eight hybrids and their parents (4 pistillate lines and 12 monoecious lines) to study the extent of heterosis and standard heterosis for seed yield and other important characters over three environments within crop duration. They observed that parents and hybrids responded differently to environments for their per se performance for most of the characters studied. The estimates and magnitude of various heterotic effects varied with crosses irrespective of characters. Inconsistent performance of most of the hybrids across the environments for all the characters under study revealed that parental genes, and their combinations were susceptible to environmental variation, which is general feature of polygenic inheritance. About two thirds of hybrids registered significant and positive heterobeltiosis for seed yield. The hybrids viz., SKP 24 x SKI 270 (108.02%), VP 1 x DCS 47 (102.19%), Geeta × SKI 147 (94.30%), Geeta × SPS 44-1 (75.5%), SKP 84 × DCS 47 (75.35%) and SKP 24 × SKI 270 (40.9%) registered significant standard heterosis. The heterotic effects for seed yield might have resulted from direct effect of number of capsules/ plant, shelling outturn and test weight of 100 seeds. Accordingly, heterotic effects for seed yield could be outcome of indirect effect of effective length of primary spike, number of capsules on primary spike, number of secondary spikes/plant and number of tertiary spikes/plant. The magnitude of heterobeltiosis was negative for development of characters leading to earliness. It was also negative for growth attributes related to plant stature, for seed yield and yield component
characters it was positive and for seed quality characters, seed size and oil content, magnitude of heterobeltiosis was negative. The pistillate lines VP 1 and SKP 84 and monoecious lines DCS 47 and SKI 270 may yield promising cross combinations with other genotypes/parents.

Najan et al. (2010) evaluated fifteen genotypes of castor (Ricinus communis L.) for variability parameters like seed yield and its related characters during rainy season of 2009. They observed significant variation for seed yield and its components. High heritability with high genetic advance and genotypic coefficient of variation were observed for plant height, days to maturity and seed yield, indicating direct selection of these traits were effective. High heritability with moderate genetic advances was observed in number of capsules to primary spike and effective primary spike length. Studies showed that selection of these traits were effective.

Gouri Shankar et al. (2010) used seven elite lines consisting of released varieties (Haritha, Kranthi, Kiran), advanced breeding lines (PCS- 170, PCS-171) and pistillate lines (VP-1 and DPC -9) for diallel method of crossing excluding reciprocals. The resultant 21 hybrids were evaluated along with their parents and a standard check GCH 4 in a randomized block design, replicated thrice. Observations were recorded on days to 50% flowering, plant height, number of nodes up to primary spike, primary spike length, number of effective spikes/plant, 100 seed weight and seed yield/plant. Data obtained was subjected to heterosis analysis to estimate heterosis, heterobeltiosis and standard heterosis. They identified four hybrids viz., Haritha x DPC -9, Haritha x VP -1, Haritha x Kranthi and Hartha x Kiran as promising for seed yield and most of the desirable characters.

Vaithiyalingam et al. (2010) used a set of 15 castor accessions to study the correlation coefficient and direct and indirect effects of path coefficients to study the effect of characters for improvement in yield. They observed that genotypic correlation coefficients were higher than the phenotypic correlation coefficients. Seed yield exhibited significant positive association with number of nodes to primary spike, number of spikes/plant and 100 seed weight. Path analysis revealed that 100 seed weight recorded maximum direct effect on seed yield followed by number of spikes/plant and number of nodes on seed yield.

Ramesh et al. (2010) have undertaken investigation with an objective to study genotypic correlations and path coefficient analysis in 62 castor genotypes including two
checks, Kiran and 48-1 during the rainy season of 2007. Character associations revealed strong positive association of seed yield with total and effective length of primary (main)spike, number of capsules on main spike, number of effective spikes/plant and oil content. However, path coefficient analysis revealed maximum direct effect of number of capsules on main spike, number of effective spikes/plant and oil content on seed yield. Moreover, the indirect effects through total and effective length of primary spike were appreciable.

Gondaliya et al. (2001) investigated the genetic architecture of seed yield and related traits through generation mean analysis for three crosses in six generations. Additive and non additive gene effects for seed yield and majority of the traits were significant. However, magnitude of dominance and epistasis components were higher than additive components. None of traits was under the control of the epistasis. Higher magnitude of dominance and dominance x dominance gene effects were observed for seed yield per plant. Thus heterosis breeding, synthetic variety and population improvement adopting inter se mating among promising divergent genotypes and effecting simultaneous selection for seed yield, oil content and other components of yield is an ideal breeding approach for castor improvement.

Solanki et al. (2003) obtained estimates of gene effects based on analysis of generation mean for eight characters in five crosses of castor. They observed the presence of additive, dominance and epistatic gene effects. Among non-allelic interaction dominance x dominance (I) interactions was of greater magnitude than main gene effects for almost all the characters, indicating the importance of heterosis breeding to utilize non-additive gene effects. The additive gene effects (d) also contributed significantly for different traits like, capsules on primary, capsules on S1T1 raceme and effective length of primary raceme in VP1 x RG 299 and RG184 x RG 299 crosses, for capsules on S1T1 raceme and effective length of S1T1 raceme in cross MCP 2 x RG 125. Selection in segregating generations of these crosses will be effective for development of inbreds possessing longer spikes and higher number of capsules on primary and S1T1 raceme. However to exploit additive as well as non-additive gene effects reciprocal recurrent selection procedure may be adopted.

Thatikunta et al. (2000) an attempt was made with a view to develop early maturing varieties and hybrids suitable for Andhra Pradesh, they tried to estimate heterotic potential of elite parents through (8x8) line x tester mating design. The lines as well as
testers exhibited good gca effects for seed yield. The data indicated that for realization of heterosis, at least one parent must have higher gca for yield components. High heterosis for crosses made between poor parents was also observed. These results suggest that, additive as well as non-additive components can be exploited for the development of potential varieties and hybrids.

2.4 Stability of hybrids for seed yield and its contributing traits

Solanki and Joshi (2000) studied the phenotypic stability of castor (28 hybrids and 8 parents), grown in six environments over two seasons for seed yield and other traits. Both linear and non-linear components of G x E Interaction were found important for stability of seed yield and its components. Pistillate line, MCP 2 for seed yield and capsules/spike, the male parent, RG 184 for capsules on primary raceme, RG 299 for spikes/plant, and RG 125 for 100 seed weight were found to be stable. The hybrids MCP2 x RG 184 and VP1 x RG 125 were identified as stable for seed and some component traits.

Manivel and Hussain (2001) reported the phenotypic stability of 79 genotypes of castor grown over four environments and studied for oil content, seed yield and other related traits. They observed that the traits like number of nodes up to primary raceme, 100 seed weight and oil content were less affected by the changing environments on the other hand, substantial fluctuations due to change of environments were reported for plant height, length of primary raceme, number of capsules and seed yield per plant.

Joshi et al. (2002) evaluated thirty-two castor cultivars under 4 environments for seed yield and yield components and reported that the cultivars EC-97700 and SA-2 recorded wider adoptability and stability in terms of seed yield per plant over four environmental conditions.

Kumara et al. (2003) reported that among the three different environments studied, early sowing (15th July) was the most suitable environments for crop as the majority of the genotypes recorded high seed as well as oil yield.

Madariya et al. (2010) studied the phenotypic stability of 54 genotypes of castor (40 hybrids resulted from Line x Tester mating design along with 4 lines and 10 testers) grown in four environments (two dates of sowing and two locations) for seed yield and its attributes. They observed that only linear component of G X E interaction was significant.
for number of effective branches/plant and oil content, while both linear and non-linear components were significant for number of capsules on main raceme, 100 seed weight and shelling outturn with preponderance of linear component, which indicated that prediction of performance would be easy for these traits. For length of main raceme and seed yield/plant, prediction of performance would be difficult as only non-linear component of GxE interaction was significant. Among parents, JI-306 was found to be stable for seed yield/plant, number of capsules on main raceme and 100 seed weight. Eleven hybrids were found to be moderately stable with high seed yield/plant, while three hybrids with high seed yield/plant were responsive to unfavorable/poor environmental conditions, while three hybrids with high seed yield/plant were responsive to unfavorable/poor environmental conditions (bi<1, S^2d > 0). Three hybrids viz., JP-84 × JI-285, JP-84 × SKI-226 and JP-88 × SKI-226 were the best hybrids for stability and could be thoroughly tested over space and time before their exploitation for commercial cultivation.

Thakkar et al. (2010) carried out stability analysis for castor hybrids along with their parents over the seasons to know the existence of genotype x environmental (GXE) interactions and stability for yield and its attributes. Analysis of variance revealed significant differences among parents and their hybrids for all the characters indicating diversity in the material. Presence of significant G X E interactions was noticed for all the characters under study. Significance of G × E (linear) and pooled deviation for various traits suggested importance of both linear and non linear components of G × E interaction with respect of all the characters. Parent VP-1 and SKP-4 were found to be responsive to poor environments for seed yield per plant. SH 72 inbred found stable for the node number, where as TMV-5 was stable for plant height and number of capsules on main spike. SKP-5 as pistillate line and SH 72 as male were found stable for effective branches/plant. SKI-119 was responsive to better environments for capsules per plant of the five high yielding hybrids but, none was found stable for seed yield/plant. However, Geeta × SKI 147 showed stability for some yield attributes and recorded responsiveness in better production environments for seed yield. On the basis of per se performance and stability, Geeta × SKI 147, SKP 49 × SPS 43-3 were found to be promising hybrids for yield attributing characters offering good scope for commercial exploitation.

Patel et al. (2010d) studied stability parameters with 16 parents (4 pistillate and 12 monoecious lines) and their 48 hybrids using three created environments during crop season of the year 2007-08. Mean square due to genotypes and environments (linear) were significant for all the characters under study. The values of mean square due to genotypes
x environments interaction were significant for plant height up to primary spike, shelling outturn and oil content. Accordingly, linear component of $G \times E$ interaction was significant for above stated characters, and it was of greater magnitude than $G \times E$ (non-linear) component, which suggested that performance of genotypes would be predictable in different environments. None of the crosses was stable for all the characters, however VP 1 × DCS 47 was well adapted to poor environment for plant height and to better environment for number of tertiary spikes/plant as well as shelling outturn. However, for seed yield/plant, stability parameters were not computed as genotypes x environments interaction had non significant value of mean square; therefore, estimates of stability parameters for other characters had less importance.