CHAPTER V
DISCUSSION

The castor is one of the most important non-edible oilseed crops of the arid and semi arid regions of the world. It yields the most useful and economically important oil. The oil is having vast and varied industrial applications as lubricants, surfactants, surface coating, cosmetics, resins, paints, pharmaceuticals, adhesives, waxes, polishes, varnishes, perfumes, flavours, textile dyes, textile furnishing agents etc. India, China and Brazil are the most important castor growing countries in the world. In India, Gujarat is pioneer in the development and release of castor hybrid on commercial scale not only in the country but also worldwide. Still there is a vast scope of improving yield potentiality of hybrid/varieties in castor by using a sound and effective breeding programme. Therefore, there is need to generate information on available genetic material for planning breeding strategies for developing high yielding varieties of castor.

The collection, evaluation and maintenance of germplasm is prerequisite for initiating any systematic breeding programme as it provide useful and valuable information about material available which can be readily used for bringing improvement in desirable attributes. Therefore, 64 genotypes of castor were evaluated for seed yield and its attributes to identify the line with desirable attributes for utilizing them in a future crop improvement programme.

The progress of any breeding programme depends on the extent of variability present in a population. Therefore, an assessment of the genetic variability in the base population should be the first step in any breeding programme. Genetic improvement in castor has been achieved mostly through selection in segregating generations of inter-varietal crosses. It is well established fact that the growth and development of the plant on which seed yield is dependent, is determined jointly by the genetic makeup of the plant and the environment in which it is grown. Thus, the first and foremost step in this direction is to select most appropriate genotypes from the available germplasm for their use in future breeding programme.
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The amount of variability present in a collected germplasm in respect of various qualitative and quantitative characters is a basic prerequisite for a plant breeder to commence with any crop improvement programme. Heritability and genetic advance would help in deciding the appropriate selection intensity, where as the genetic advance predicts the gain that is likely to be achieved through selection.

Seed yield, being a complex and polygenic character, is influenced by various components. The effectiveness of selection for high yielding genotypes depends upon magnitude and its direction of correlation between seed yield and yield contributing characters as well as association among various plant characters. The measures of direct and indirect effects of traits influencing seed yield exhibits their relative significance in selection and breeding programme can be done by path coefficient analysis.

The major factor responsible for limited success in increasing the castor yield has been the narrow genetic base in the material available. For exploiting heterosis in any crop, hybridization programme is taken up by selecting the parents on the basis of their wider adaptability, yield potentiality and other desirable characters. Such resultant crosses are expected to produce a broad spectrum of genetic variability, thereby providing a greater probability of isolation of high yielding superior segregants in advance generations. In present study, analysis of variance revealed that mean square due to genotypes was highly significant for all the traits indicating the presence of sufficient amount of genetic variability among the genotypes for all the characters studied.

5.1 Genetic Variability
5.2 Correlation coefficient
5.3 Path coefficient analysis

5.1 GENETIC VARIABILITY

Genetic variability is basic tool for crop improvement due to its wider scope for selection. Therefore, the effectiveness of selection depends upon the nature and magnitude of genetic variability present in the experimental material and the extent of its heritability. 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
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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) and Rao et al. 2009).

5.1.1 Genotypic and Phenotypic coefficient of variation

The estimate of genotypic and phenotypic coefficient of variability indicated that the values of phenotypic coefficient of variation were higher than genotypic coefficient of variation, in most of cases, indicating influence of environmental factors. The relative magnitude of difference between phenotypic coefficient of variation and genotypic coefficient of variation was low for days to 50% flowering of main raceme, days to maturity of main raceme, oil content and shelling out turn indicated that these characters were less influenced by the environments. Similar results were also reported by Dhapke et al. (1992) and Golakia et al. (2007). These indicates that selection can be effective on the basis of phenotype along with equal probability of genotypic values.

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. High genotypic and phenotypic coefficient of variation was reported in castor for seed yield per plant, plant height up to main raceme, 100-seed weight, effective branches per plant by several workers (Patel et al. 1985; Patel and Jaimini 1988; Patel et al. 1992; Mehta and Sachli 1997; Golakia et al. 2007 and Rao et al. 2009). 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. While low estimates of GCV and PCV was observed for number of nodes up to main raceme, total length of main raceme, oil content and shelling out turn indicated narrow genetic variability for these characters. Low genetic and phenotypic coefficient of variation was also reported in castor for number of nodes up
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to main raceme, total length of main raceme, oil content and shelling out turn by Patel et al. (1985), Golakia et al. (2007) and Rao et al. (2009).

5.1.2 Heritability

With help of genotypic coefficient of variation alone, it is not possible to determine the extent of variation which is heritable. Thus, the knowledge of heritability of a character help the plant breeders in predicting the genetic advance for any quantitative characters and aids in exercising necessary selection procedure. Burton (1952) suggested that genotypic coefficient of variation together with heritability estimate would give the best picture for expected selection.

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. High heritability for the characters which is controlled by polygenes might be useful to plant breeders for making effective selection. These results are akin with the finding of Patel et al. (2010), Dhapke et al. (1992), Golakia et al. (2007) and Rao et al. (2009). Low heritability level for shelling out turn and number of nodes up to main raceme suggested that environmental effects constituted a major portion of total phenotypic variation and hence direct selection for this characters would not be effective.

5.1.3 Genetic advance as per cent of mean

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), Rao et al. (2009), Patel et al. (2010), Abimiku et al. (2013), Kote et al. (2013) and Tewari and Kumar (2013) also reported the similar results. In the present study, total length of main raceme, days to 50% flowering, number of nodes up to main raceme and shelling out turn showed moderate genetic advance through selection. The value of genetic advance as per cent of mean was low (below 10%) for days to maturity of main raceme and oil
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content. Dorairaj et al. (1973), Sarwar et al. (2010) and Kote et al. (2013) also reported the similar results.

Johnson et al., (1955) suggested that the heritability estimate along with genetic advance is more useful than the heritability alone in predicting the resultant effect of selection. In the present study, the estimates of high heritability coupled with high genetic advance as per cent of mean was observed for plant height up to main raceme, number of capsules on main raceme, seed yield per plant, effective length of main raceme and 100-seed yield which may be contributed to the preponderance of additive gene action and selection pressure could be profitably applied on these characters for improving the seed yield (Panse, 1985). High heritability coupled with high to moderate genetic advance as per cent of mean was observed for length of main raceme, days to 50% flowering of main raceme and number of nodes up to main raceme which also indicated major contribution of additive gene action for these traits and hence, selection was effective. Moderate estimates of heritability coupled with low genotypic coefficient of variation and genetic gain were expressed by days to maturity of main raceme, oil content and shelling out turn. It may be inferred that these traits were regulated by non-additive gene action and presence of high genotype × environment interaction.

The heritability is being exhibited due to favorable influence of environment rather than the genotype and simple selection will not be rewarding. As such, progeny of family testing is to be practiced for amelioration of these traits. However, they can be improved by development of hybrid varieties if commercially feasible by utilization of transgressive segregants in hetrosis breeding programme. For number of effective branches per plant variation was minor and environmental leading to high heritability with moderate genetic advance and hence, little gain is expected through selection.

5.2 CORRELATION COEFFICIENT

In plant breeding programmes several yield attributing characters are often to be handled together by a breeder as most of the characters are correlated. Thus, the different components of yield very often exhibit considerable degree of association among themselves and with seed yield. Yield is a complex character and the multiplicative end product of many quantitative traits (White house et al., 1958).
Therefore, selection for yield per se will not be desirable. Searle (1965) suggested that the average merit of character in a population could be changed by means of selection programme based on phenotype of the main trait concerned. However, such improvement would be more reliable if indirect selection based on another trait, correlated with it is made. Thus, for rational improvement of yield and its components, the understanding of correlation has been very useful.

Correlation among traits may result from pleiotropy, linkage and/or physiological association among characters. The linkage is a cause of transit correlations particularly in a population derived from crosses between divergent strains. The correlation is the overall or net effect of the segregating genes. Some of the genes may increase both the characters causing the positive correlation, while the other may increase the one and decrease the other causing the negative correlation (Falconer, 1981). Thus, to accumulate optimum combination of yield contributing characters in a single genotype, it is essential to know the implication of the interrelationship among various plant characters.

In the present investigation, most of the characters paired had higher values of genotypic correlations and corresponding phenotypic correlations. Such high amount of genotypic correlations could result due to masking or modifying effect of environment on the association of characters. This indicates that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. It was also indicated that there was inherent relationship between the characters studied which is in agreement with finding of Yadav et al. (2004); Golakia et al. (2007); and Adeyanju et al. (2010). On the contrary, the phenotypic correlation coefficient of seed yield with days to 50% flowering of main raceme, number of effective branches per plant and 100-seed weight were higher than their genotypic correlation coefficients which might be due to the non-genetic causes probably environment inflated the value of phenotypic correlation.

The study of genotypic correlation coefficient indicates the extent of relationship between different variables. This relationship among yield contributing characters as well as their association with yield provides information for exercising selection pressure for bringing genetic improvement in seed yield. 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. Johanson et al. (1955) emphasized that these correlated yield attributes can serve as indicator characters for improving seed yield. They have further emphasized that such improvement depends not only on genotypic correlations but phenotypic correlations also play an important role. Such positive interrelationships between seed yield and these attributes have also been reported in castor by several researcher like Dorairaj et al. (1973); Patel and Jaimini (1988); Khorgade et al. (1994); Mehta and Vashi (1998); Ramu et al. (2005); Sarwar and Chaudhary (2008); Bhanu et al. (2010); Monpara et al. (2010) and Ramanjaneyulu and Reddy (2012). 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.

Days to 50% flowering had significant and positive association with days to maturity of main raceme, number of nodes up to main raceme and plant height up to main raceme at both genotypic as well as phenotypic level and is an important component in identifying and restricting the plant height as well as increasing the number of nodes up to main raceme. This confirms the earlier finding of Sevugaperumal et al. (2000), Yadav et al. (2004), Anjani et al. (2008) and Dedhi et al. (2010). Days to 50% flowering of main raceme exhibited significant but negative correlation with shelling out turn at genotypic level. These results are of special significance as it indicates that selection for early flowering is also likely to provide strains with higher shelling out turn.

Plant height up to main raceme had highly significant and positive association with days to 50% flowering of main raceme, days to maturity of main raceme, number of nodes up to main raceme, number of capsules on main raceme and 100-seed weight
at both genotypic as well as phenotypic levels and are of an important component in identifying and restricting the number of nodes up to main raceme. Both these traits i.e. plant height up to main raceme and number of nodes up to main raceme were also found to have positive interrelationship with days to 50% flowering of main raceme, days to maturity of main raceme, number of capsules on main raceme and 100-seed weight at genotypic as well as phenotypic level. This relationship indicated that the improvement in one will bring the improvement in another which, in turn, automatically lead to increase in seed yield per plant. These are in accordance with the findings of Patel and Jaimini (1988), Khorgade et al. (1994), Sevugaperumal et al. (2000), Yadav et al. (2004), Anjani et al. (2008) and Sarwar and Chaudhary (2008).

Total length of main raceme had highly significant and positive association with number of nodes up to main raceme, effective length of main raceme, number of capsules on main raceme and shelling out turn at both genotypic and phenotypic levels and are of an important component in identifying and increasing seed yield per plant as well as shelling out turn.

The results revealed that plant height up to main raceme, number of capsules on main raceme, effective length of main raceme, total length of main raceme and number of effective branches per plant were most important attributes which contributed towards higher yield. Therefore, more emphasis should be given to these components during selection for higher yield.

5.3 PATH COEFFICIENT ANALYSIS

A complex situation before a plant breeder is to select high yielding cultivars, which is a polygenic trait influenced by various components directly or indirectly. Consequently, path coefficient analysis could provide the more realistic picture of the interrelationship as it consider direct as well as indirect effects of the variables by partitioning the correlation coefficient.

The genotypic path coefficient analysis revealed that days to 50% flowering of main raceme, number of nodes up to main raceme, number of capsules on main raceme, 100-seed weight, oil content and shelling out turn exhibited high and positive direct effect on seed yield. All these characters turned out to be major components of seed yield. The number of effective branches per plant exerted positive but moderate direct effect towards seed yield per plant.
The phenotypic path coefficient analysis revealed that plant height up to main raceme, effective length of main raceme, number of capsules on main raceme, number of effective branches per plant and oil content exhibited high and positive direct effect on seed yield per plant. All these characters turned out to be major components of seed yield. The days to maturity of main raceme, total length of main raceme, 100-seed weight and shelling out turn exerted positive but moderate direct effect towards seed yield per plant. Such results were also reported by Dorairaj *et al.* (1973); Patel and Jaimini (1988); Sevugaperumal *et al.* (2000); Thatikunta *et al.* (2001); Yadav *et al.* (2004); Lakshmamma *et al.* (2005); Golakia *et al.* (2007); Bhanu *et al.* (2010); Monpara *et al.* (2010); Sarwar *et al.* (2010); Chaitanya *et al.* (2013) and Tewari and Mishra (2013). The residual effect was of moderate magnitude suggesting that some of the yield attributes have not been included in the path analysis that could be identified and would be used in future breeding programme in castor.

The positive direct effects of effective branches per plant and number of capsules on main raceme were further supplemented by their positive indirect effects via each other thus, giving rise to positive association of both these traits with seed yield.

Days to maturity of main raceme, plant height up to main raceme, total length of main raceme and effective length of main raceme expressed negative direct effects of low magnitude on seed yield at genotypic level. Days to 50% flowering of main raceme and number of nodes up to main raceme expressed negative direct effects of low magnitude on seed yield at phenotypic level. However, all these traits except days to 50% flowering on main raceme and days to maturity on main raceme had positive association with seed yield, because of the cumulative and minor positive indirect effects via rest of the characters at both levels. The negative direct effect of low magnitude of days to maturity of main raceme was nullified by high and positive indirect effects of days to 50% flowering of main raceme. Similarly, negative direct effects of low magnitude of plant height up to main raceme, total length of main raceme and effective length of main raceme were nullified by high and positive indirect effect of number of nodes up to main raceme and number of capsules on main raceme at genotypic level. The negative direct effect of low magnitude of days to 50% flowering of main raceme and number of nodes up to main raceme was nullified by high and positive indirect effects of plant height up to main raceme at phenotypic level.
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It was apparent from the genotypic path analysis that higher direct effect as well as appreciable indirect influences were exerted by days to 50% flowering of main raceme, number of nodes up to main raceme, total length of main raceme, and number of effective branches per plant towards seed yield per plant. All these characters except number of nodes up to main raceme exhibited significant and positive association with seed yield per plant. In Phenotypic path analysis, higher direct effect as well as appreciable indirect effect was exerted by plant height up to main raceme, total length of main raceme, effective length of main raceme and oil content. All these characters except days to 50% flowering of main raceme and days to maturity of main raceme also exhibited significant and positive association with seed yield per plant and hence, these may be considered as most important yield contributing characters and due emphasis should be placed on these components while breeding for high seed yield in castor.

It was observed that the characters which are most important for correlation studies are also important for path analysis. Thus, it can be suggested that correlation and path analysis should be considered together for rapid gain in final improvement of seed yield.