GENE EFFECTS FOR OIL CONTENT IN CASTOR (*Ricinus communis* L.)

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ABSTRACT

The present investigation was undertaken with a view to generate genetic information on gene effects for oil content in castor (Ricinus communis L.). The experimental materials consisted of twelve generations, namely P_1, P_2, F_1, F_2, B_1, B_2, B_{11}, B_{12}, B_{21}, B_{22}, B_1s and B_2s of three crosses of castor viz., JP 96 x JI 368 (cross 1), JP 96 x JI 372 (cross 2) and JP 101 x SKI 215 (cross 3). Special scaling tests such as X and Y were significant in all the three crosses besides significance of B_1s in cross 1; A, B_{11}, B_{21}, B_{22}, B_1s and B_2s in cross 2; and B_{11} and B_1s in cross 3 showing the presence of epistasis. In ten-parameter model, 'm', [d], [j], [w] were significant in cross 1 and cross 2 apart from significance of [y] and [z] in cross 2, while 'm', [j] and [y] were significant in cross 3. The $\chi^2_{(3)}$ value at two degrees of freedom was non-significant in cross 1 proving trigenic interaction model as the best fit model. While the $\chi^2_{(3)}$ value at two degrees of freedom for the remaining two crosses (cross 2 and cross 3) were significant showing the presence of higher order epistasis and /or linkage.

KEY WORDS: CASTOR, Ricinus communis L.)

INTRODUCTION

Castor (*Ricinus communis* L.) is a non-edible industrial oilseed crop of the world. Its seeds contain about 45 to 58 per cent oil. The castor oil is tremendously used in petrochemicals, pharmaceuticals, cosmetics, textile, soap, leather, paint, varnish, ink, nylon, and plastic industries. This oil is traditionally associated with medical and veterinary uses, for example in obstetrics and dermatology, and also as purgative and laxative. Its current use as bio-fuel production has magnified its importance. Moreover, castor oil does not freeze at high altitude. Due to this particular property, it is used in aero planes, helicopters and other vehicles operating at high altitudes or in low temperature zones. Further, it is the best lubricant for jet engines. The shell of castorbean is used in organic termite control in soil, and its seed cake is used as manure. The information on the nature of gene action could be helpful in predicting the effectiveness of selection in a population. A distinct knowledge of the type of gene action, its magnitude and composition of genetic variance are of fundamental importance to a plant breeder which helps in formulating an effective and sound breeding programme. The assessment of the magnitude of gene action for oil content in castor is helpful in deciding the appropriate breeding procedures. Hence, experiment was planned to study the gene effects in castor with 12 generations.

MATERIAL AND METHODS

The basic set of twelve generations *viz.*, P_1, P_2, F_1, F_2, B_1 (F_1x P_1), B_2 (F_1x P_2),

B_{1S} (B_1selfed), B_{11} (B_1x P_1), B_{12} (B_1x P_2), B_{2S} (B_2 selfed), B_{21} (B_2 x P_1) and B_{22} (B_2 x P_2), derived from three castor crosses namely JP 96 x JI 368 (cross 1), JP 96 x JI 372 (cross 2) and JP 101 x SKI 215 (cross 3) were sown in compact family block design with three replications during *Kharif* 2011. The plots of various generations contained different number of rows i.e., parents and F_1 in single row; B_1 and B_2 in two rows and F_2, B_{1S}, B_{11}, B_{12}, B_{2S}, B_{21} and B_{22} in four rows. Each row was of 7.2 m in length with 90 cm and 60 cm inter and intra row spacing, respectively. All the recommended agronomical practices and necessary plant protection measures were followed timely to raise good crop of castor. The observations were recorded on individual plant basis in each replication on randomly selected five plants from P_1, P_2 and F_1; ten plants from first backcross (B_1 and B_2) and twenty plants of F_2, B_{1S}, B_{11}, B_{12}, B_{2S}, B_{21}, B_{22} generations for oil content. The oil content was estimated by Nuclear Magnetic Resonance (NMR) technique. The inheritance of oil content was computed through generation mean analysis methods (Mather, 1949; Hayman and Mather, 1955; Hayman, 1958 and Hill, 1966). The $\chi^2_{(1)}$ of joint scaling test under three-parameter model gives idea about fitness of additive-dominance model. In addition to six generations and six-parameter model given by Hayman (1958), the data were subjected to ten-parameter model given by Hill (1966). He proposed estimation of first order and second order epistasis utilizing twelve generations including double backcross generations. The $\chi^2_{(2)}$ and $\chi^2_{(3)}$ values were estimated under six-parameter model at six degrees of freedom and for ten-parameter model at two degrees of freedom, respectively. This is an additional advantage of using twelve generations and ten-parameter model as it provides sufficient degree of freedom for testing validity and goodness of fit for different models. The results of models given by Hayman (1958) and Hill (1966) were compared whenever six-parameter model was satisfactory for inheritance of the trait.

RESULTS AND DISCUSSION

The data was initially subjected to simple scaling tests A, B, C and D. Significant estimates of any one or more of these tests indicated the presence of digenic interactions. Further, simple scaling tests B_{11}, B_{12}, B_{21}, B_{22}, B_1s and B_2s (Hill, 1966) and X and Y (Van Der Veen, 1959) were also computed. Significant estimates of the test(s) given by Hill (1966) showed contribution of particular generation to higher order epistasis which is indirectly indicating presence of epistasis. If any of the Van Der Veen's tests significantly deviates from zero, it also indicates presence of trigenic or higher order epistasis. The results of simple scaling tests were further confirmed by joint scaling test (Cavalli, 1952), which effectively combines the whole set of simple scaling tests. Thus, it offers a more general, convenient, adoptable and informative approach for estimating gene effects and also for testing adequacy of additive-dominance model. The [$\chi^2_{(1)}$] test with nine degrees of freedom; [$\chi^2_{(2)}$] at six degrees of freedom and [$\chi^2_{(3)}$] at two degrees of freedom was applied to test the fitness of three-parameter model, six-parameter model and ten-parameter model, respectively. The ten-parameter model was used to estimate higher order epistasis (Hill, 1966). To draw inference on adequacy of ten-parameter model, chi-square test [$\chi^2_{(3)}$] at two degrees of freedom was applied. The character and cross-wise results of oil content is presented in Table 1.

Out of all the scaling tests *viz.*, A, B, C, D, B_{11}, B_{12}, B_{21}, B_{22}, B_1s and B_2s, only B_1s and special scaling tests (X and Y) were significant in cross 1 and B_{11}, B_1s, X and Y in cross 3 showing the presence of epistasis, while the scaling tests A, B_{11}, B_{21}, B_{22}, B_1s, B_2s, X and Y were found

significant in cross 2 showing digenic and trigenic gene interaction. All the three parameters i.e., 'm', additive (d) and dominance (h) of three-parameter model were significant except dominance (h) in cross 1 and cross 2. The $\chi^2_{(1)}$ values with nine degrees of freedom of joint scalingtest was significant in all the three crosses resulting to the failure of additive-dominance model which indirectly pointed out the presence of epistasis. Cockerham (1959) postulated that the epistatic gene action is common in the inheritance of quantitative traits and there is no sound biological reason why this type of gene action should be less common for these traits.

When the simple additive-dominance model failed to explain the variation among generation means, a six-parameter perfect fit model involving three digenic interactions ([i], [j] and [l]) proposed by Hayman (1958) was applied. This model utilized only six basic generations *viz*., P_1, P_2, F_1, F_2, B_1 and B_2. On the other hand, based on weighted least square technique, digenic interaction model of Hill (1966) was also tested which had provision of testing the adequacy of model with six degrees of freedom besides being utilizing means of all the twelve generations. The goodness of fit for six-parameter model of Hayman (1958) could not, however, be tested in the present study owing to no degrees of freedom left for testing chi-square estimates for oil content. Hence, the present study was planned and executed with means of twelve generations and model of Hill (1966) was tested in which six degrees of freedom left for testing the adequacy of six-parameter model of Hill (1966). According to the six-parameter model of Hayman, only 'm' and additive [d] were found significant in all the three crosses. On the other hand, according to the six-parameter model of Hill, all the parameters i.e., 'm', additive [d], dominance [h], digenic [i, j and l] were found significant in cross 2; only 'm' and additive [d] were found significant in cross 1 and 'm', additive [d], dominance [h] and digenic [j] in cross 3 were found significant. The $\chi^2_{(2)}$ value at six degrees of freedom were found in all the three crosses supporting the presence of higher order epistasis.

In ten-parameter model, 'm', additive x dominance [j] were found significant in all the three crosses for oil content besides significance of additive [d] and additive x additive x additive [w] in cross 1 and cross 2; additive x dominance x dominance [y] in cross 2 and cross 3 and dominance x dominance x dominance [z] only in cross 2. The $\chi^2_{(3)}$ value was non-significant at two degrees of freedom in cross 1 proving the ten-parameter model as the best fit model.The $\chi^2_{(3)}$ value was significant at two degrees of freedom in cross 2 and cross 3 indicating the presence of higher order epistasis and /or linkage.

These findings were further confirmed from the investigations done by several researchers who worked on different kind of gene effects in castor. Bhapkar and D' cruz (1967) reported that epistasis played a major role in castor beans with high oil content. The opposite signs of either two or all the three gene effects *viz*., dominance [h], dominance x dominance [l] and dominance x dominance x dominance [z] gene effects suggests the presence of duplicate type of epistasis. In present study, duplicate epistasis was observed in all the crosses for oil content.

CONCLUSION

It can be concluded from the present study that oil content recorded in three castor crosses were governed by additive, dominance and digenic and/or trigenic epistasis gene effects along with duplicate type of gene action. When additive as well as non-additive effects are involved, a breeding scheme efficient in exploiting both types of gene effects should be employed. Reciprocal recurrent selection could be followed which would

facilitate exploitation of both additive and non-additive gene effects simultaneously.

REFERENCES

Bhapkar, D. G. and D'cruz, R. (1967). Inheritance of oil content in *Ricinus communis*. *Indian J. Genet.*, **27**:152-153.

Cavalli, L. L. (1952). An Analysis of Linkage in Quantitative Inheritance. In: Rev, E.C.R. and Waddington, C. H. (Eds.). Quantitative Inheritance, HMSO, London. pp. 135-144.

Cockerham, C. C. (1959). Partition of hereditary variance for various genetic models, *Genetics*, **44**: 1141-1148

Hayman, B. I. (1958). The separation of epistatic from additive and dominance variation in generation. *Heredity*, **12**:371-90.

Hayman, B. I. and Mather, K. (1955). The description of genetic interactions in continuous variation. *Biometrics*, **11**:69-82.

Hill, J. (1966). Recurrent backcrossing in study of quantitative inheritance. *Heredity*, **21**:85-120.

Mather, K. (1949). Biometrical Genetics. Methuen and Co. Ltd., London.

Van Der Veen, J. H. (1959). Tests of non-allelic interaction and linkage for quantitative characters in generations derived from two diploid pure lines. *Genetica*, **30**:201-232.

Table 1: Scaling tests and estimation of gene effects for oil content in three crosses of Castor

Scaling Tests / Gene Effects	JP 96 x JI 368 (Cross 1)	JP 96 x JI 372 (Cross 2)	JP 101 x SKI 215 (Cross 3)
A	0.95 ± 1.53	-4.22** ± 1.52	2.63 ± 1.42
B	-1.09 ± 1.82	-0.70 ± 1.35	0.85 ± 1.95
C	-2.16 ± 2.76	-4.33 ± 2.29	6.16 ± 3.21
D	-0.056 ± 1.16	0.30 ± 1.28	1.33 ± 1.70
B_{11}	-0.02 ± 2.15	4.26* ± 1.65	-18.11** ± 2.83
B_{12}	-1.55 ± 3.40	-0.53 ± 2.61	-5.17 ± 2.98
B_{21}	-0.26 ± 3.37	22.82** ± 2.23	-1.57 ± 2.97
B_{22}	-4.41 ± 3.56	-7.11* ± 3.17	3.37 ± 2.12
B_{1S}	12.35** ± 4.20	9.61** ± 3.71	-24.34** ± 5.48
B_{2S}	-12.01 ± 6.18	-29.79** ± 4.94	3.82 ± 4.01
X	201.55** ± 0.95	196.72** ± 1.03	198.29** ± 0.98
Y	98.44** ± 1.36	101.07** ± 1.12	94.11** ± 1.22
Three Parameter Model			
m	49.42** ± 0.22	48.63** ± 0.25	47.73** ± 0.24
(d)	1.89** ± 0.21	1.36** ± 0.25	-0.93** ± 0.23
(h)	-0.03 ± 0.49	0.65 ± 0.49	4.56** ± 0.53
$\chi^2_{(1)}$ (9 df)	28.24**	161.98**	62.77**
Six Parameter Model (Hayman)			
m	48.77** ± 0.41	48.37** ± 0.47	50.53** ± 0.68
(d)	2.83** ± 0.82	2.01* ± 0.87	-2.13* ± 1.01
(h)	0.93 ± 2.58	3.51 ± 2.65	3.08 ± 3.51
(i)	0.11 ± 2.33	-0.60 ± 2.56	-2.67 ± 3.40
(j)	0.070 ± 0.98	-1.75 ± 1.00	0.88 ± 1.09
(l)	1.93 ± 4.29	5.54 ± 4.18	-0.82 ± 5.16
Digenic and Trigenic Interactions (Hill)			
m	48.89** ± 1.07	54.20** ± 1.09	46.63** ± 1.18
(d)	1.74** ± 0.38	3.62** ± 0.41	-1.41** ± 0.35
(h)	-0.51 ± 3.37	-16.35** ± 3.18	8.89** ± 3.39
(i)	0.95 ± 1.05	-5.33** ± 1.12	0.65 ± 1.17
(j)	-0.24 ± 1.32	-9.78* ± 1.46	2.02 ± 1.33
(l)	1.72 ± 2.87	12.61** ± 2.37	-3.90** ± 2.67
$\chi^2_{(2)}$ (6 df)	23.60**	83.71**	58.35**
m	49.38** ± 2.79	51.35** ± 3.06	43.32** ± 3.69
(d)	-5.23* ± 2.10	-8.11** ± 2.26	-1.96 ± 2.32
(h)	-3.74 ± 14.85	2.51 ± 16.23	29.98 ± 20.29
(i)	-0.22 ± 2.80	-3.95 ± 3.07	2.90 ± 3.70
(j)	13.34* ± 6.20	23.24** ± 6.75	18.77** ± 6.44
(l)	5.34 ± 23.88	-31.47 ± 25.37	-41.28 ± 31.38
(w)	7.73** ± 2.05	11.63** ± 2.23	-0.84 ± 2.29
(x)	5.82 ± 8.36	3.26 ± 9.12	-7.65 ± 12.30
(y)	-5.02 ± 6.04	-28.11** ± 6.89	-32.48** ± 6.35
(z)	-0.66 ± 12.52	29.13* ± 12.44	20.23 ± 15.17
$\chi^2_{(3)}$ (2 df)	5.01	13.99**	8.91*
Type of Epistasis	Duplicate	Duplicate	Duplicate

****, ** Significant at 5 per cent and 1 per cent levels of significance, respectively***

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