GENE ACTION OF SOME PHYSIOLOGICAL ATTRIBUTES IN INDIAN MUSTARD (BRASSICA JUNCEA L. CZERN & COSS).

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ABSTRACT

Genetic analysis of the physiological attributes related to seed yield in two crosses of Indian mustard revealed involvement of epistatic effects alongwith main effects (d) and (h) for most of the characters. Important physiological parameters such as net assimilation rate (NAR), leaf area duration (LAD) and leaf weight ratio (LWR) were found to be predominantly under the control of additive gene effects, whereas other characters like leaf area ratio (LAR), crop growth rate (CGR) and leaf area index (LAI) were largely controlled by dominant gene effects. The important finding of this study was that the genetic control of these important physiological attributes at the vegetative phase did differ from the genetic system operative at the reproductive phase. This investigation revealed the prospects for these physiological attributes as an aid for further improvement of seed yield in Indian mustard.

INTRODUCTION

The physiology of oleiferous Brassicae is different from that of other crops. The plant having excessive foliage at the vegetative phase reflects different physiological indices than at its reproductive phase. At the later phase, green siliquae and branches contribute significantly to photosynthesis and the role of leaves is minimized (Allen et al. 1971 and Pandya 1975). The genetic control systems of these two different phases also appear to be different. No concerted efforts have been made so far to understand these physiological indices in respect of their genotypic variability and gene action which may, however, supplement to a larger extent the traditional breeding methods employed with this crop.

The present investigation was, therefore, planned to gain insight into the nature and magnitude of gene effects involved in various physiological attributes in the two important crosses of Indian mustard.

MATERIALS AND METHODS

The experimental material for the present study comprised a set of basic six generations (P1, P2, F1, F2, B1, B2) in respect of two crosses, namely, RH30xRC781 and PrakashxRC1425. The experiment was conducted in a randomized block design with three replications. Each entry was represented in a plot of 11 rows each of 6 m length and 30 cm apart in each replications. A spacing of 15 cm from plant to plant within row was also maintained for each genotype in all the replications. Five competitive plants from alternate rows for each of the parents and F_1s, 15 from the respective back crosses and 45 plants from each of the F_2s were sampled at random. The observations viz; 21, 42, 63, 84 and 126 days after sowing. This period was divided into two phases, i.e. upto 63 days of sowing as the vegetative phase and the rest as the reproductive phase. To find out various physiological attributes, observations were recorded on drymatter production and leaf area in respect six generations of both the crosses. The growth parameters such as net assimilation rate (NAR), crop growth rate (CGR), leaf area ratio (LAR), leaf area index (LAI), leaf area duration (LAD) and leaf weight ratio (LWR) were obtained according to the methods suggested by Blackman (1919), Gregory (1917), Briggs et al (1920) and Radford (1967). Canopy temperature was recorded with the help of an infrared thermometer from BARNS (U.S.A.) at the time of flowering.

The estimates of gene effects were derived from generation mean analysis of Hayman (1958) following the scaling tests of Cavalli (1952) and Hayman and Mather (1955).

RESULTS AND DISCUSSION

On the three-parameter model the weighted least square estimates of mean(m), additive (d) and dominance (h) components were obtained. Prior to this, data were subjected to both individual as well as joint scaling tests. The significant values of x^2 as well as at least one of the individual scales i.e. A, B, C and D indicated the inadequacy of the simple additive-dominance model (the three-parameter model) for all the physiological attributes in RH30xRC781 and for most of the characters except LAR at the reproductive phase and canopy temperature at flowering in PrakashxRC1425, where this model was adequate. This accounted for the genetic variation in these attributes not being wholly attributed to the additive (d) and dominance (h) gene effects. The failure of this model was attributed mainly to the presence of epistasis. The assumption of no epistasis on the three-parameter model has already been reported to be biologically unrealistic for polygenic traits (Cockerham 1959). The reason for the adequacy of the model in cross PrakashxRC1425 for the above mentioned two attributes could be due to the absence of epistasis and lesser variation among the parents for LAR and Canopy temperature (Table 1). Additive as well as dominance gene effects were responsible for the genetic variation in these traits. The magnitude of the dominance effect was higher than the additive effect. Preponderance of the dominance gene effect for leaf area was also observed by Yap and Harvey (1972) in barley and Marinkovic (1980) in sunflower.

The attributes for which simple additive-dominance model showed its inadequacy were subjected to a digenic epistatic model (the six-parameter model) of Hayman (1958) to work out the various gene effects. These results have also been compiled in Table 1. CGR at vegetative phase is advantageous to build up photosynthate for sink. Its expression is dependent on NAR and LAI. The variation for this character was attributable to dominance gene effects in both the crosses at the vegetative phase; however, at the reproductive phase additive gene effects were more important. NAR at the vegetative phase, where the contribution of leaves is at a maximum, was found to be controlled by both additive and dominance gene effects and epistatic effect of (i) type in both the crosses. Thus, the preponderance of the additive effects was more important for this attribute at this phase. However, gene effects altered at the reproductive phase because at this phase, instead of leaves, green siliquae contributed maximum towards the photosynthates. These results corroborate the findings of Crosbie et al. (1978) in maize.

Preponderance of additive gene effects was revealed for LAD which is an important physiological parameter as it provides a prolonged photosynthetically active leaf area. LAI plays a significant role in this crop prior to the seed filling stage when macroscopic green siliquae and branches contribute significantly towards photosynthesis (Allen et al. 1971, Allen and Morgan 1972, Scott et al. 1973 and Pandya 1975). Similar to CGR, LAI at the vegetative phase exhibited significant dominance gene effects in both the crosses. At the reproductive phase, in RH30xRC781, even digenic epistatic model failed to detect the non-allelic interactions, indicating thereby the prevalence of genotype-environment interaction or trigenic or higher order interactions or linkage of the interacting genes. However, for cross PrakashxRC1425, LAI at the reproductive phase was found to be under the control of additive gene effects and epistatic effects of (i) and (j) type. Contrary to this, Johnson (1973) in his study on maize reported that LAI was controlled by non-additive gene effects.

LWR, which is a ratio of leaf dry weight to total dry weight, was judged to be governed by a predominantly additive type of gene effects. Studies on gene effects of canopy temperature in both the crosses suggested its fixable nature, since additive components were more important for the expression of this trait.

The results on physiological attributes based on the present study indicated a sizeable impact of the additive gene effects involved in their expression. These characters, therefore, are more amenable for further improvement by simple selection procedures. Untill efficient and realiable techniques for screening large segregating material for these physiological parameters are available, the selection of the parents based on physiological indices reported in present study would be of additional value to the breeders for supplemeting the hybridization programme in this crop.

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Table 1. Estimates of gene effects on three as well as on six parameter for various physiological attributes.

Character	Cross	Estimates of gene effects					
		m	(d)	(h)	(I)	(J)	(L)
A. <u>Thre-parameter</u>	+						
1. LAR(R.)++	2	0.186 ±0.003	0.067** ±0.005	-0.128** ±0.004	-	-	-
2. Canopy Temp. (R.P.)	2	15.36 ±0.09	0.834 ±0.085	2.019** ±0.161	-	-	-
B. <u>Six-parameter</u>							
1. NAR(V.P.)	1	0.043 ±0.001	0.008** ±0.002	-2.553** ±0.005	-1.113** ±0.005	-1.067** ±0.003	-0.007 ±0.008
"	2	0.057 ±0.002	0.018** ±0.002	-0.024** ±0.008	-0.034** ±0.008	-0.003 ±0.002	0.070** ±0.010
2. NAR(R.P.)	1	0.031 ±0.002	0.005 ±0.003	-1.783** ±0.088	0.004 ±0.009	0.001 ±0.003	-0.036* ±0.014
"	2	0.030 ±0.001	0.006** ±0.002	-0.026** ±0.006	-0.017* ±0.006	0.011** ±0.002	0.009 ±0.008
3. CGR(V.P.)	1	10.85 ±0.54	0.010 ±1.015	10.53** ±2.98	-4.301 ±2.974	-2.769* ±1.022	4.440 ±4.632
"	2	11.33 ±0.48	0.820 ±1.147	17.02** ±3.003	11.87** ±2.992	0.392 ±1.160	-9.861 ±4.999
4. CGR (R.P.)	1	8.114 ±0.300	1.642** ±0.357	-0.062 ±1.409	0.881 ±1.398	-0.542 ±0.373	-6.380 ±1.898
"	2	8.082 ±0.249	1.254** ±0.429	-7.160** ±0.322	-2.877* ±1.317	-2.269** ±0.444	±1.826 ±2.002
5. LAD (V.P.)	1.	120.6 ±6.28	40.38** ±13.13	260.2** ±86.82	107.4** ±86.33	-16.30 ±13.23	130.01** ±59.42
"	2	88.99 ±4.05	23.07** ±6.73	7.660 ±21.12	27.59 ±21.06	-3.767 ±6.885	-69.34** ±8.158

6.	LAD(R.P.)	1	115.1 ±5.91	51.47** ±12.74	253.9** ±85.25	108.1** ±84.77	-27.12* ±12.81	88.85 ±57.36
	"	2	76.65 ±3.78	28.33** ±7.105	8.353 ±20.79	41.50* ±20.77	-4.757 ±7.145	-67.55 ±82.28
7.	LAR(V.P)	1	3.165 ±0.067	0.256** ±0.030	-6.032 ±0.299	-0.403 ±0.298	0.353* ±0.148	0.302* ±0.383
	"	2	3.019 ±0.067	0.470** ±0.091	-2.446** ±0.325	-2.024** ±0.324	-0.041 ±0.095	3.207** ±0.456
8.	LAR(R.P.)	1	0.944 ±0.027	0.328** ±0.039	0.588** ±0.135	0.323* ±0.134	0.057 ±0.041	0.279 ±0.194
9.	LAI(V.P.)	1	1.101 ±0.071	0.019 ±0.137	2.341** ±0.396	8.092** ±0.395	0.390* ±0.139	2.037** ±0.619
	"	2	1.245 ±0.062	0.083 ±0.085	0.740* ±0.302	0.535 ±0.302	0.231* ±0.086	-3.081** ±0.423
10.	LAI(R.P.)	1	5.017 ±0.305	1.737** ±0.497	6.655** ±1.576	2.102 ±1.573	-0.884 ±0.501	4.285 ±2.342
	"	2	5.697 ±0.248	1.418** ±0.423	0.636 ±1.311	2.363 ±1.306	-0.347* ±0.424	-3.432 ±1.979
11.	LWR(R.P.)	1	0.347 ±0.009	0.039 ±0.021	0.138* ±0.05	0.143* ±0.056	0.107** ±0.022	0.071 ±0.095
	"	2	0.334 ±0.013	0.081* ±0.021	-0.029 ±0.066	0.131* ±0.066	-0.056** ±0.022	-0.176 ±0.100
12.	Canopy Temp. (R.P.)	1	15.37 ±0.143	1.367** ±0.094	-0.833 ±0.773	0.667 ±0.757	1.567** ±0.266	0.333 ±1.189

\+ 1. RB30xRC781; 2. PrakashxRC1425.
++ V.P. = Vegetative phase. R.P = Reproductive phase.
* Significant at 5 percent level.
** Significant at 1 percent level.