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Estimation of combining ability and gene action for agro-morphological characters of rapeseed (*Brassica napus* L.) using line×tester mating design

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ABSTRACT

Combining ability effects were estimated for different agronomic characters in line × tester crossing program comprising 21 hybrids produced by crossing 7 lines and 3 testers. Parents and hybrids differed significantly for general combining ability (GCA) and specific combining ability (SCA) effects, respectively. The variance due to GCA and SCA showed that gene action was predominantly additive for number of branches. This characters may further be improved through simple selection method in early generation, whereas predominance of non-additive gene action was discovered for plant height, pod per plant and seed yield which are desirable for heterosis breeding and may be exploited in hybrid seed production. Both additive and non-additive genetic constitution were important for seed per pod and thousand kernel weight. Among the 7 female lines, RGS003 revealed maximum GCA effects for seed yield, thousand kernel weight, seed per pod and number of branches. Among the testers, Option500 was desirable as it manifested higher estimates of GCA effects for seed yield and thousand kernel weight. Three cross-combiners Magent × Opera, Elect × Option500 and Shiralee × Opera were found to be the best specific crosses for seed yield.

Key words: Canola,Genetic analysis, Gene action, Heterosis.

INTRODUCTION

Oil seeds are the second source of world food after cereals and according to FAO statistics, rapeseed is the third source of vegetable oil after soybean and palm (FAO, 2010). The oilseed *Brassica* species especially rapeseed (*B. napus* L.) have important role in oilseed production because of their wide adaptation to different diverse climatic conditions (Downey and Rimer, 1993). Seed yield of canola is a quantitative trait, which is largely influenced by the different environmental effects and hence in most of the cases it has low heritability (Rameeh, 2010). The success of any plant breeding program largely deponds on selection of desirable parental genotypes. Knowledge of different types of gene action, their relative contribution in the genetic variance and estimation of general and specific combining ability effects (GCA and SCA) are important parameters for the improvement of rapeseed crop. This important information could provide an essential tool for the rapeseed breeders in the selection of better parental combination for further improvement (Sher Aslam Khan *et al*, 2009; Panhwar *et al*, 2008). One of the most important mating designs that have been used for the genetic analysis and estimation of GCA and

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SCA is the line × tester design (Mather and Jinks, 1982; Singh and Narayanan, 1993). The line × tester analysis was developed by Kempthorne in 1957. It is a modified form of top cross scheme. In case of top cross only one tester is used, while in case of line × tester cross, several tester are used. This design divides the variation among male parents, variation among female parents and variation due to interaction of male and female parents (Singh and Narayanan, 1993). By using this scheme, and other genetic designs like diallel analysis significant GCA and SCA effects of phenological traits, seed yield and other yield associated traits were reported in rapeseed (Wang *et al*, 2007). Various breeders have used line × tester analysis for the genetic analysis of agro-morphological traits, estimation of GCA and SCA, evaluation of gene action and heterosis in cotton (Panhwar *et al*, 2008), Sunflower (Asalm Khan et al,2009), Sorghum (Mohanraj *et al*, 2006), wheat (Saeed *et al*, 2001), pea (Ceyhan *et al*, 2008) and in in *B. napus* (Leon, 1991; Thakur and Sagwal, 1997; Rameeh, 2010). The objectives of the present study were (i) to identify general and specific combining abilities and (ii) to determine type of gene action controlling agro-morphological characters of Rapeseed.

MATERIALS AND METHODS

Seven lines of Rapeseed namely; RGS003, Dunkeled, Magent, Ryder, Shiralee, Elect, Ceres (female parents) and three testers namely; Option500, Opera, Parade (male parents) were crossed in Feb- March, 2009. Necessary precautions were taken to avoid the contamination of genetic material at the time of crossing. Ten genotypes and 21 F1 hybrids were grown in a randomized complete block design with two replications in 2009-2010. Each plots contained two rows of 4 m length at planting. The distance between and within the rows spacing were 60 cm and 30 cm, respectively. The experimental population was kept under normal agronomic care from sowing to maturity. All the inputs like irrigation and fertilizer were applied as per recommendations when ever needed. At maturity, 5 plants from each plot were taken randomly and data were recorded on the traits: plant height, pod per plant, seed per pod, thousand kernel weight, seed yield and number of branches**.** Analysis of variance and combining ability analysis were done using line × tester analysis as described by Kempthrone (1957). If significance differences among the genotypes including crosses and parents were found, then line × tester analysis is done.

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance (Table 1) indicated that the mean squares of genotypes for all characters investigated were significantly different ($p<0.01$), indicating the presence of variability among hybrids and their parents, hence later analysis of line × tester for combining ability was possible. Sum of squares of genotypes for yield and yield components were further portioned into parents, parents vs crosses and crosses which revealed highly significant differences among themselves. The sum of squares calculated for rapeseed crosses were further portioned into lines, testers and line × tester components. Female parents (lines) revealed significant differences for all the characters studied whereas, male parents (testers) exhibited significant differences for seed yield only. Interaction of line × tester was highly significant for all the traits except seed per pod.

Combining ability analysis

Variation in general combining ability (GCA) effects was estimated among lines and testers for 6 traits to identify the best parent for subsequent hybrid development programs. The results of the general combining ability effects of lines and testers are presented in Table 2. Significance of GCA (variances due to lines and testers) and SCA (variances due to lines × testers) implied that both additive and non-additive types of gen actions were available for these characters. Seed yield, being the ultimate objective, is very important to rapeseed breeders. Positive GCA effects for yield and yield components are desirable. Female lines RGS003 (421.26**) and Magent (293.78**) showed maximum and Ryder (-324.44**), Shiralee (-307**) and Ceres (-147.35*) showed minimum GCA effects for seed yield. Among the testers, Option500 (30.12) was desirable as it manifested higher estimates of GCA effects for seed yield and thousand kernel weight (Table 2). The GCA effects of parents (Table 2) suggested that among the female lines, Magent exhibited positive and significant GCA effect, while among the testers male pollinators, Option500 displayed high GCA effect implying that if both the parents are used in the hybridization program, the promising progenies could be developed and selected to improve thousand kernel weight. It is generally assumed that these parents exhibit better SCA effects together. Such assumption held true in our studies because hybrid Magent × Option500 showed the highest SCA effect for thousand kernel weight (Table 3). The estimates of specific combining ability (SCA) effects of 6 hybrids are presented in Table 3. The specific combining ability, which represents the predominance of non-additive gene action, is a major component that may be utilized in heterosis breeding. Heterosis in the cross involving low × high combiners might be due to dominant × additive type of interaction, which is partially fixable and the crosses involving both the poor combining parents reveals high SCA effects (Sivagama Sundari et al., 1992). The cross Shiralee × Opera showed significant high SCA effect for seed yield. But both the parents displayed negative significant GCA effect. The cross combinations Magent × Opera, ElectxOption500 and Shiralee × Opera revealed positive and highly significant SCA effect for seed yield. This is in agreement with the results obtained by Panhwar et al. (2008) in cotton, Singh & Kumar (2004) in rice and Weerasekara et al. (2008) in Okra. The crosses Dunkeled × Opera for number of branches per plant, Shiralee × Parade for plant height and pod per plant, Dunkeled × Opera for seed per pod, were found to be the best specific combinations (SCA effects) for the characters mentioned. More productive seed per pod and increased thousand kernel weight are also desirable traits of rapeseed hybrids with increased seed yield. The cross combinations Dunkeled × Opera and Magent × Option500 possess the highest positive SCA effects for productive seed per pod and significant positive SCA effects for thousand kernel weight. These results are in agreement with the reports of Sachan and Singh **(**1988) and Ramsay et al. (1994).

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Table 1: Analysis of variance for combining ability of different characters in rapeseed

Source	df	Plant height	Number of branches	Pod per plant	Seed per pod	Thousand kernel weight	Seed yield
Replication	1	41.16	1.41	600.79*	32.66*	0.01	15554.99
Genotypes	30	331**	5.34**	669.07**	30.21**	0.05**	157628.20**
Parents (P)	9	542.08**	6.90**	528.56**	24.77**	0.04**	157893.19**
P vs C	1	508.79**	0.33	2741.06**	22.18	0.01	510.77
Crosses (C)	20	227.13**	4.89**	628.70**	33.05**	0.05**	165364.82**
Lines(GCA)	6	664.89**	11.62**	1230.19**	89.98**	0.15**	503610.34**
Testers(GCA)	2	48.40	0.81	37.25	2.57	0.01	170959.8*
L × T(SCA)	12	38.04*	2.21*	426.54**	9.68	0.01*	221976.2*
Error	30	18.24	0.89	122.78	5.68	0.01	14666.06

*; **Significant at 5% and 1% level of probability, respectively

Table 2: Estimates of GCA for yield and yield component in Rapeseed

Parents	Plant height	Number of branches	Pod per plant	Seed per pod	Thousand kernel weight	Seed yield
Lines						
Rgs003	10.66**	1.94**	12.97**	6.24**	0.21**	421.26**
Magent	2.77	1.77**	11.47*	1.69	0.12**	293.78**
Elect	-5.61**	-0.72	-16.69**	-3.53**	-0.08*	-59.20
Ryder	11.66**	-0.78	1.75	-1.48	-0.14**	-324.44**
Shiralee	-5.84**	-1.28*	-7.41	-1.70	-0.05	-307.00**
Dunkled	4.32*	0.39	16.14**	3.24*	0.14**	122.95
Ceres	-17.98**	-1.33*	-18.25**	-4.48**	-0.21**	-147.35*
S.E.gi	1.48	0.39	3.87	0.92	0.03	51.48
Testers						
option500	0.10	0.28	-1.36	0.20	0.004	30.12
opera	-1.91	-0.15	1.81	0.29	0.007	-4.94
Parade	1.81	-0.13	-0.45	-0.49	-0.010	-25.18
S.E.gi	0.97	0.26	2.53	0.60	0.020	33.70

*; **Significant at 5% and 1% level of probability, respectively

Table 3: SCA effect for hybrids (crosses) for different characters in Rapeseed.

Crosses	Plant height	Number of branches	Pod per plant	Seed per pod	Thousand kernel weight	Seed yield
RGS003xOption500	0.23	0.39	2.52	-1.37	0.05	21.89
RGS003xOpera	1.41	-0.68	0.36	-0.46	0.04	2.02
RGS003xParade	-1.64	0.29	-2.88	1.83	-0.09	-23.91
MagentxOption500	3.12	-0.94	4.52	1.69	0.12*	-174.57
MagentxOpera	-2.04	0.48	0.36	-2.40	-0.07	244.66**
MagentxParade	-1.08	0.46	-4.88	0.71	-0.06	29.90
ElectxOption500	-2.66	-0.94	20.19**	-2.09	-0.10	210.80*
ElectxOpera	1.19	-0.52	-18.31*	1.82	0.04	-99.85
ElectxParade	1.47	1.46	-1.88	0.27	0.06	-14.95
RyderxOption500	4.56	0.61	4.25	0.52	0.05	20.33
RyderxOpera	1.24	-0.46	7.41	-1.74	-0.06	-39.28
RyderxParade	-5.81*	-0.15	-11.66	1.21	0.01	18.96
ShiraleexOption500	-1.27	0.28	-19.92**	2.08	-0.04	25.55
ShiraleexOpera	-4.59	-0.79	-4.59	0.98	0.07	198.10*
ShiraleexParade	5.86*	0.52	24.50**	-3.06	-0.03	-127.65
DunkeledxOption500	-5.60	0.44	-1.14	-1.70	0.01	51.27
DunkeledxOpera	6.08	1.3*	-3.31	3.04	-0.09	-53.67
DunkeledxParade	-0.47	-1.82*	4.45	-1.34	0.08	2.40
CeresxOption500	1.62	0.17	-10.42	0.86	-0.09	-59.27
CeresxOpera	-3.29	0.60	18.07*	-1.24	0.06	-55.98
CeresxParade	1.67	-0.76	-7.66	0.38	0.03	115.25
S.E.gi	**2.57**	**0.68**	**6.70**	**1.59**	**0.06**	**89.17**

*; **Significant at 5% and 1% level of probability, respectively.