Combining ability in *Brassica* oilseed crops

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Abstract

Estimation of combining ability effects is a prerequisite for any successful hybrid breeding program. Combining ability of three *Brassica napus*, one *Brassica rapa* and four *Brassica juncea* cultivars were studied using line×tester crosses at main station of Dryland Agricultural Research Institute (DARI). The effects of general combining ability (gca) for different characters showed that Rainbow have positive and highly significant gca effects for grain yield, pods per plant and grains per pod. The parents Landrace and Westar had significant positive gca effect for grains per pod. However, The Westar cultivar, had significant negative gca effects on pods per plant and thousand kernel weight. The cross 'Rainbow×Cutlass' showed best performance for grain yield with highly significant specific combining ability (sca) effects. In general, crosses with high sca usually involved a high general combiner as one of the parents. On the base of the results, Rainbow and Landrace are good materials for transferring male sterility systems and beginning hybrid production program.

Keywords: GCA, Line × Tester, SCA.

Introduction

For breeding of hybrid cultivars, there must be a sufficient amount of heterosis and a system for large-scale production of hybrid seed must be available along with an efficient method to identify hybrids with high combining ability. Many studies have shown that there is a considerable heterosis for yield in the oilseed *Brassica* species (Becker, 1987; Leon, 1991; Macvetty, 1995). These reports indicate that breeding methods of rapeseed and mustard are being used to the production and development of hybrid cultivars. In addition, it is necessary to test the combining ability of genetic materials before any work. In fact, combining ability of different cultivars is prerequisite for hybrid production in plants. Combining ability of some common cultivars have been studied using diallel cross method in different conditions (Becker, 1999), but there is a few reports on combining of different species of oilseed *Brassica* genus (Shiga, 1970; Morinaga, 1984). In this research, combining ability of 4 rapeseed and 4 mustard cultivars which had desirable characteristics in previous researches (Alizadeh and Abdolrahmani, 2000; Alizadeh, 2001) were studied in the field condition of Dryland Agricultural Research Institute (DARI).

Materials and Methods

In the present study, combining ability of eight spring oilseed *Brassica* cultivars have been investigated. Plant materials including three Brassica napus (Westar, Echo and Torch), one Brassica rapa (Rainbow) and four spring type mustard cultivars (Cutlass, Landrace, Bard-1 and UCD) were planted in the research station of DARI in Maragheh in the spring of 2001.

All required crosses were made by hand pollination in flowering stage as a line×tester crosses (Landrace and Westar were as tester). Related offspring were harvested separately and were planted among with parents in spring of 2002. A randomized complete block design with 3 replications was used. Subsequent analysis were done according to Kempthorn method (1957) for line×tester crosses. The general combining ability (gca) effects were calculated by deviation of line-mean from average/mean of hybrids. Specific combining ability (sca) effects were deviation of each cross mean from all hybrid mean adjusted for corresponding gca effects of parents. Variances of gca and sca were estimated using covariance of half-sib and full- sib famillies as follow:

$$\sigma^2_{gca} = \text{Cov (HS)}$$

$$\sigma^2_{sca} = \text{Cov (FS)} - 2\text{Cov (HS)}$$

Results and Discussion

Analysis of variance for grain yield (GY), pods per plant (P/P) and thousand kernel weight (TKW) of parents and hybrids is presented in Table-1. The former partitioned into lines (females), testers (males) and females vs. males, components. Since the mean squares due to hybrids was significant (Table-1), hybrid analysis is carried out by partitioning the hybrid sum of squares into its three components namely: Females in hybrids (F/H), Males in hybrids (M/H.) and 'female×male' in hybrids (Fh×Mh); which were significant for pods per plant. For other traits ie. GR and TKW, only Fh×Mh was significant (Table 1).

The comparison of parents *vs*. hybrids which indicates average heterosis, was significant for pods per plant (Table 1). Thus considerable amount of average heterosis was reflected in the hybrids. Significant differences among hybrids (Table 1), however, means varying performance of cross-combinations. The effects of gca for different characters (Table 2) showed that Rainbow have positive and highly significant gca effects for grain yield, pods per plant and grains per pod. The parrents

Landrace and Westar, had significant possitive gca effect for grains/pod. However, The cultivar Westar, had significant negative gca effects for pods/plant and TKW. Most researchers concerning hybrid vigor in rapeseed have reported high heterosis in yield compared to mid-parent or better parent levels (Becker, 1987; Leon, 1991; Macvetty, 1995). This is more evident in the crosses of different geographical origins and pedigrees (Brandle and Mcvetty, 1990). Grant and Beversdrof (1985) reported of highest specific combinations for seed yield heterosis between Canadian and European cultivars and Lefort-Buson *et a*l. (1987) found similar results in hybrids between European and Asiatic selfed lines. In this investigation, only present breeding stocks were included which, met suitable requirement for cold dry lands of Iran (Alizadeh, 2001). This narrows the genetic basis of the material and makes it difficult to definitely outline the best competitive varieties. So, on the base of this research, only recognizing of the best parent(s) from exist materials in order to transferring male sterility systems is reasonable which are Rainbow and Landrace refer to Table-2.

Table 1. Analysis of variance for some traits in a line×tester trial in rapeseed and mustard.

S.O.V.	Df	MS			EMS
		GY	P/P	TKW	
Replication	2	2.56	12.07	0.0491	-
Entries	19	5.62**	39.47**	0.1246*	-
Parents(P)	7	3.69	36.68**	0.0968	-
Females(F)	5	3.41	37.27**	0.1146	-
Males(M)	1	2.97	29.68*	0.0442	-
F vs. M	1	5.81	40.73*	0.0604	-
Hybrids(H)	11	6.74**	41.24**	0.1471*	-
F/H	5	5.87*	49.26**	0.1635*	σ^2_e+3Cov$_{FS}$-2Cov$_{HS}$ +6Cov$_{HS}$
M/H	1	3.69	34.51*	0.0486	σ^2_e+3Cov$_{FS}$-2Cov$_{HS}$ +18Cov$_{HS}$
Fh × Mh	5	8.22**	34.57**	0.1504*	σ^2_e +3Cov$_{FS}$-2Cov$_{HS}$
P vs. H	1	6.81	39.53*	0.0717	-
Error	38	1.89	6.07	0.0549	σ^2_e
Total	59	-	-	-	-

* and **: significant at 0.05 and 0.01 probability level, respectively.

Table 2. Estimated effects of general combining ability in some crosses of *Brassica* oilseed.

Parent	Grain yield	Pods/plant	Grains/pod	TKW
Landrace	1.10	7.07	3.72**	0.05
Rainbow	4.71**	14.93**	4.32**	-0.08**
Bard-1	-0.47	2.05	-1.65**	0.07*
Cutlass	-0.06	-4.02	0.04	0.05
UCD	0.77	7.41	-0.85*	0.04
Echo	-0.20	-9.02	-1.14**	-0.05
Westar	1.01	-18.89**	6.16**	-0.10**
Torch	-3.75**	0.78	-1.53**	0.02

* and **: significant at 0.05 and 0.01 probability level, respectively.

Mean values of F_1 hybrids and sca effects of 8 crosses showing significant effects for one or more characters are presented in Table-3. The cross 'Rainbow×Cutlass' showed best performance for grain yield with highly significant sca effects. This cross also had highest number of pods per plant. 'Echo×Landrace' was another promising combination, giving significant sca effects for grain yield and pods/plant. Other crosses giving significant sca effects were; 'Echo×Westar' for pods/plant; 'Cutlass ×UCD' and 'UCD×Landrace' for TKW. In general, crosses with high sca usually involved a high general combiner as one of the parents.

Table 3. Mean Performance of F_1 and estimated specific combining ability effects for yield and its components in some crosses of *Brassica* oilseed.

Cross	GY		Pods/Plant		Grains/Pod		TKW	
	Mean (gr/plot)	sca effects	Mean	Sca effects	Mean	sca effects	Mean (gr)	Sca effects
Rainbow×Cutlass	33.44	11.52**	181.60	74.90	22.26	-0.67	2.91	-0.04
Rainbow×UCD	28.94	6.19	77.83	42.40	24.45	2.41*	2.82	-0.13
Bard1×Echo	21.30	4.71	88.33	28.34	17.68	1.90	2.94	-0.07
Cutlass ×UCD	20.50	2.51	-7.58	-12.97	17.21	-0.54	3.28	0.21*
UCD×Landrace	15.75	-1.93	-5.42	-15.94	17.15	1.04	3.24	0.21*
Echo×Westar	24.50	6.42	100.17	47.81**	23.38	-0.02	2.75	-0.08
Echo×Landrace	24.94	8.77*	113.82	49.68**	16.22	0.42	2.96	0.01
Landrace×Torch	19.33	6.70	11.31	2.31	15.67	0.26	3.09	0.08

* and **: significant at 0.05 and 0.01 probability level, respectively.

The general and specific combining ability are the main criteria of rapid genetic assaying of test genotypes under L×T analysis (Diers *et a*l. 1996). In the test of general and specific combining ability in this investigation, there are different results according to different characteristics in the same cultivar or cross. For instance, the parent Westar had significant positive gca effect for grains per pod and in the same time, had significant negative gca effects for pods per plant and TKW. It may be inferred from the negative correlation between yield components, especially grains per pod and TKW in rapeseed (Gabriele and Becker, 1993).

References

1. Alizadeh, Kh (2004). Oilseed research results 2000/2001. Dryland Agricultural Research Institute.
2. Becker, HC (1999). Breeding of oilseed rape, An overview. In: Gomez-Campo (ed.), Biology of *Brassica* Coenospeecies. Elsevier Science B. V. pp. 413-460.
3. Brandle, JE and McVetty, PBE (1990). Geographical diversity, parental selection and heterosis in oilseed rape. Canadian Journal of Plant Science 70, 935-940.
4. Gabriele, ME and Becker, HC (1993). Correlation studies for agronomic characters in segregating families of spring oilseed rape. Hereditas 118, 211-216.
5. Morinaga, T (1984). Interspecific hybridization in *Brassica*. The cytology of F_1 hybrids of *B. juncea* and *B. nigra*. Cytologia 6(1), 62-67.
6. Ringdahl, E, McVetty, PBE and Sernyk, JL (1987). Intergeneric hybridization of Diplotaxis spp. to *Brassica* napus as a means of developing new cytoplasmic male sterility systems. Canadian Journal of Plant Science 67, 239-243.
7. Shiga, T (1970). Rape breeding by interspecific crossing between *Brassica napus* and *Brassica campestris* in Japan. Japan Agronomy Research 5, 5-10.