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Combining ability analysis of rapeseed genotypes under restricted nitrogen application

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Abstract

Half diallel crosses of rapeseed (*Brassica napus* L.) varieties along with their parents were evaluated for siliquae per main shoot, siliquae per plant, seeds per siliqua, 1000-seed weight and seed yield without application of nitrogen. Analysis of variance based on Griffing's method revealed significant mean squares of general combining ability (GCA) and specific combining ability (SCA) for all the traits. Significant ratio of GCA to SCA mean square and high narrow-sense heritability estimate observed for 1000-seed weight indicated the prime importance of additive genetic effects for controlling this trait. Significant positive correlation was exhibited between the GCA effects of siliquae per main shoot and seed yield, but for SCA effects, siliquae per plant had important role for seed yield. The parent PF7045/91 having significant positive GCA effects for yield components along with seed yield may be considered as good combiner. However, most of the crosses with significant positive SCA effects for seed yield had at least one parent with significant positive GCA effect for yield components.

Keywords : additive, diallel, GCA, SCA, yield components

Introduction

Rapeseed (*Brassica napus* L.) is an important oil seed crop of the world and due to its autumn cultivation in Iran it need low irrigation, therefore, it has major role in producing self sufficiency in edible oil. Hence, it is necessary to develop the new ideotypes of rapeseed with high seed yield having efficient nitrogen use under Iran ecosystems as lot variation in rapeseed germplasm has been reported (Holmes, 1980) for NUE. However, information regarding this aspect is lacking and to achieve this goal either screening or generation elite germplasm is most urgent. Among the different methodologies, combining ability of a particular parent for desired trait is very useful to know the genetic constitution and to adopt breeding strategies to get effective genetic gains in any crop breeding. To estimate nature and magnitude of general combining ability (additive gene actions) and specific combining ability (non-additive gene actions), two approaches are very common i.e. top-crosses and diallel crosses for conducting a successful breeding program (Amiri-Oghan *et al*., 2009). Estimation of genetic constitution of parents for seed yield and its components can be important for indirect selection for high seed yield in rapeseed (Downeyand Rimer, 1993; Nassimi *et al*., 2006; Singh *et al*., 2010; Teklewold and Becker, 2005; Yadav *et al*., 2005). Although combining ability studies in oilseed *Brassica* are scanty, most of these studies emphasized the preponderance effect of GCA for yield and its components indicating the importance of additive gene action (Brandle and McVetty, 1989; McGee and Brown, 1995; Wos *et al*., 1999). On the other hand, Pandey *et al*. (1999) reviewed evidences for the presence of significant SCA effects for yield and yield components. Ramsay *et al*., (1994) reported that variation for both GCA and SCA were responsible for dry matter yield and other quantitative traits in *B. napus*. Significant GCA and SCA effects were reported for siliquae per main shoot, siliquae per plant, siliqua length, number of seeds per siliqua, 1000-seed weight and seed yield in *B. napus* (Leon, 1991; Singh and Murty, 1980; Thakur and Sagwal, 1997), but in other study (Singh *et al*., 1995) the importance of additive genetic effects for siliquae per plant and 1000-seed weight was emphasized. Singh and Yadav (1980) and Thakur and Sagwal (1997) while examining the genetic control of seed yield in oilseed rape found both additive and non-additive gene effects to be involved.

Generally diallel analysis are used in rapeseed breeding to assess general combining abilities for seed yield and its component traits under optimum growing condition but under low input condition nature and magnitude of gene action is scanty. The objective of this study was therefore to evaluate whether F_2 rapeseed generations can utilize nitrogen more efficiently than parental cultivars at low N level.

Materials and methods

Six cultivars of rapeseed including RGS-003, Option-500, RW-008911, RAS-3/99, 19-H and PF7045/91 were crossed in diallel fashion excluding reciprocal crosses during 2004-05. In order to produce F_2 seeds, fifteen F_1 populations from a 6 × 6 diallel cross were selfed at Biekol Agriculture Research Station, located in Neka, Iran (13Ú, 53² E longitude and 43Ú 36² N latitude, 15 m above sea level) during winter 2005-06. Fifteen F_2 progenies along with 6 parents were grown in a randomized complete block design with four replications during 2006-07. The plots consisted of four rows 5 m long and 40 cm apart and the distance between plants on each row was 5 cm. The soil was classified as a deep loam soil (Typic Xerofluents, USDA classification) contained an average of 280 g clay kg^{-1}, 560 g silt kg^{-1}, 160 g sand kg^{-1}, and 22.4 g organic matter kg^{-1} with a pH of 7.3. Soil samples were found to have 45 kg ha^{-1} of mineral nitrogen (N) in the upper 30-cm profile. Field experiment received 50 kg ha^{-1} P, 75 kg ha^{-1} K and any N fertilizer, so totally nitrogen accessible for plant growth was based on soil samples s(45 kg ha^{-1}). All the plant protection measures were adopted to make the crop free from insects. Seed yield (adjusted to kg/ha) was recorded based two middle rows of each plot while yield components were measured based on 10 randomly selected plants in each plot.

The combining ability analysis was performed using mean values their F_2 generation along with parents by using Griffing's method 2 with mixed –B model (Griffing, 1956). The statistical t-student test was applied to examine the effects of general combining ability (GCA) and specific combining ability (SCA). All the analyses were performed using MS-Excel and SAS softwares.

Results and discussion

Analysis of variance for siliquae on main shoot, siliquae per plant, number of seeds per siliquae, 1000-seed weight and seed yield revealed significant mean squares of GCA and SCA for all the traits indicating the importance of additive and dominance genetic effects. But significant ratio of GCA to SCA mean square coupled with high narrow-sense heritability estimates for 1000-seed weight indicated the prime importance of additive genetic effects for this trait. Significant GCA and SCA effects were reported for siliquae on main shoot, siliquae per plant, siliqua length, number of seeds per siliqua, 1000-seed weight and seed yield in *B. napus* (Leon, J. 1991; Singh and Murty, 1980; Thakur and Sagwal, 1997), but in other study (Singh *et al*., 1995) the importance of additive genetic effects for siliquae per plant and 1000-seed weight was emphasized.

On the basis of GCA estimation effects it be concluded that for each yield component different parents were considered as good general combiners indicating genetic diversity. RAS-3/99, RW008911 and PF7045/91 with significant positive GCA effects were good combiners for siliquae on main shoot (table 2). Significant positive correlation was detected between GCA effect of siliquae on main shoot and seed yield (Table 4), thus correlated response based on siliquae on main shoot can be considered as indirect selection for seed yield improvement as well. Due to high significant positive GCA effects of PF7045/91 and RGS003, these varieties were good combiners for siliquae per plant. None of parents had significant GCA effects

Table 1: Analysis of variance for seed yield and its components in rapeseed varieties based on Griffing's method II under non applications of nitrogen

S.O.V	df	M. S.				
		Siliqua on main shoot	Siliqua per Plant	Seeds per Siliquae	1000-seed Weight	Seed Yield
Replication	3	43.73*	119.46**	14.30*	0.16*	257213.33*
Cross	20	296.28**	1382.23**	12.29**	0.59**	1031295.49**
GCA	5	428.58**	700.13**	8.90*	1.54**	988737.67**
SCA	15	252.18**	1609.59**	13.42**	0.27**	1045877.83**
Error	60	6.06	16.89	3.02	0.05	81013.68
MS(GCA)/MS(SCA)		1.69	0.43	0.66	5.7**	0.94
Narrow-sense heritability		0.12	0.07	0.11	0.53	0.14

*, ** Significant at p=0.05 and 0.01, respectively

for seeds per siliqua; therefore the parents had lowest genetic variation for this trait. The parent 19H with significant positive GCA effect for 1000-seed weight was the best combiner for this trait. Significant positive GCA effect of seed yield was exhibited for PF7045/91 and this parent also had significant positive GCA effect for siliquae per main shoot and siliquae per plant. In previous studies reported significant GCA effects for number of primary branches per plant, 1000-seed weight and number of siliquae per main shoot in rapeseed in *B. napus* (Nassimi, *et al*., 2006) and *B. juncea* (Singh *et al*., 2010; Yadav *et al*., 2005).

Data presented in table 3 for SCA effects of the crosses showed that out of 15 crosses, 7 crosses

Table 2: Estimates of GCA effects for yield components and seed yield in six parents of *B. napus* under non application (low) of nitrogen

Parents	Siliquae on main shoot	Siliquae perPlant	Seeds per Siliqua	1000-Seed Weight	Seed Yield
RAS-3/99	2.56**	-7.41**	-0.69	0.05	70.85
RW008911	2.78**	1.28	0.16	0.03	-76.77
19H	-4.06**	0.38	-0.09	0.36**	-46.83
RGS 003	-0.53	3.09**	-0.50	0.02	-38.11
Option 500	-4.59**	-3.13**	0.59	-0.18**	-215.15**
PF7045/91	3.84**	5.78**	0.53	-0.28**	306.01**
S.E(gi)	0.39	0.66	0.28	0.03	45.93
S.E(gi-gj)	0.62	1.03	0.43	0.05	71.16

*, ** Significant at $p<0.05$ and 0.01, respectively

exhibited significant positive SCA effects for siliquae per main shoot and the combinations including RGS003 x Option 500, RAS-3/99 x PF7045/91 and RW008911x 19H had high significant positive SCA effects for this trait. Most of the crosses with significant positive SCA effects for siliquae per main shoot had at least one parent with significant positive GCA effect for this trait. Out of 15 crosses, 8 crosses had significant positive SCA effects for siliquae per plant and most of the crosses with significant positive SCA effects for siliquae per main shoot had significant positive SCA effects for this trait. Among crosses only two combinations had significant positive SCA effects for seeds per siliqua. In compare to the parents, the crosses had more genetic variation for seeds per siliqua, so some of SCA effects of crosses were significant but none of the parents had significant GCA effects for seeds per siliqua. Significant positive correlation was observed between SCA effects of 1000-seed weight and siliquae per plant; therefore all of the crosses with significant positive SCA effects for 1000-seed had significant positive SCA effects for siliquae per plant (table 4). The crosses including RAS-3/99 ×19H, RW008911×19H, RGS003 x Option 500 and Option 500×PF7045/91 had significant positive SCA effects for 1000-seed and siliquae per plant. Out of 15 crosses, 8 crosses had significant positive SCA effects for seed yield. Due to positive correlation between SCA effects of seed yield and siliquae per plant, most of the crosses with significant positive SCA effects for seed yield had significant positive SCA of seed yield indicating the involvement of non-additive gene effects for low nitrogen input in rapeseed. Singh and Yadav (1980) and Thakur and Sagwal (1997) while examining the genetic control of seed yield in oilseed rape found both additive and non additive gene effects to be involved.

In general siliquae per plant were more heritable than other yield components. For GCA effects of the parents, siliquae per main shoot was more correlated to seed yield but for SCA effects of the crosses, siliquae per plant was more correlated to seed yield. In restricted nitrogen application condition, SCA effects of the crosses were more

Table 3: Estimates of SCA effects for yields components and seed in the half diallel crosses of six parents of *B. napus* under non application of nitrogen

Crosses	Siliquae on main shoot	Siliquae per plant	Seeds per siliqua	1000-Seed weight	Seed yield
RAS-3/99 x RW008911	-5.27**	29.13**	-3.36**	-0.02	591.68**
RAS-3/99 x 19H	5.57**	13.78**	1.89*	0.44**	21.74
RAS-3/99 x RGS 003	-1.21	-3.94*	0.30	0.07	649.27**
RAS-3/99 x Option 500	4.10**	-20.97**	-2.05*	-0.18	-79.95
RAS-3/99 x PF7045/91	12.42**	-1.12	0.26	-0.18	29.15
RW008911 x 19H	7.86**	22.10**	-1.21	0.38**	294.37*
RW008911 x RGS 003	2.57*	-7.13**	1.20	-0.06	375.65**
RW008911 x Option 500	-1.62	17.09**	0.61	-0.01	-269.82*
RW008911 x PF7045/91	4.45**	5.44**	-2.33*	-0.18	189.02
19H x RGS 003	-0.09	-11.47**	1.20	-0.14	-651.79**
19H x Option 500	-3.02*	-3.25*	-0.90	-0.52**	485.24**
19H x PF7045/91	2.29	16.85**	-0.58	-0.29**	481.58**
RGS 003 x Option 500	16.20**	18.28**	-2.24*	0.29**	365.02*
RGS 003 x PF7045/91	-2.24	1.63	0.83	-0.06	-102.13
Option 500 x PF7045/91	1.82	23.35**	1.73*	0.22*	524.90**
S.E(sij)	1.09	1.82	0.77	0.09	126.14

*, ** Significant at p<0.05 and 0.01, respectively

Table 4: Correlation among GCA effects of parents and SCA effects of crosses

Yields components		Siliquae on main shoot	Siliquae per plant	Seeds per siliqua	1000-Seed weight	Seed yield
Siliquae on main shoot	GCA	1				
	SCA	1				
Siliquae per plant	GCA	0.21	1			
	SCA	0.06	1			
Seeds per siliqua	GCA	-0.13	0.40	1		
	SCA	-0.11	-0.16	1		
1000-Seed weight	GCA	-0.37	-0.22	-0.53	1	
	SCA	0.39	0.51*	0.20	1	
Seed yield	GCA	0.73*	0.41	0.02	-0.31	1
	SCA	-0.02	0.041	-0.31	0.06	1

* Significant at $p<0.05$

significant than the GCA effects of the parents reveals that hybrid(s) can give more sustainability in production under these ecosystems than pure lines.

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