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GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN ADVANCED LINES OF RAPESEED (*BRASSICA NAPUS* L.) FOR YIELD COMPONENTS

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ABSTRACT. The present research was carried out to determine the best selection criteria for yield improvement in rapeseed (*Brassica napus* L.). Nine genotypes of *Brassica napus* were sown at Oilseeds Research Institute, Faisalabad, during the years 2011- 2012, to evaluate the means and components of variability (genotypic and phenotypic), heritability ($h^2_{B.S}$), correlation (genotypic and phenotypic) and path analysis for yield and various yield components. At phenotypic and genotypic level, seed yield/plant had significant positive correlation with plant height, seeds/plant and siliqua/plant. A positive and highly significant genetic relationship was found between plant height and seeds/plant, siliqua length and seeds/siliqua, days to maturity and 1000 seed weight, days to flowering and seeds/plant, days to maturity and seeds/plant. Path coefficient revealed that the seeds/siliqua, 1000 seed weight, days to flowering, days to maturity and seeds/plant had direct positive contribution towards seed yield per plant. For rapeseed breeding seed per plant was the variable with maximum potential of selection for seed yield improvement because this trait possessed high $h^2_{B.S}$, highly significant positive correlation and maximum positive direct effects with yield.

Key words: Genotypes; Siliqua; Heritability; Variance; Hybridization.

INTRODUCTION

Rapeseed (*Brassica napus* L.) is an amphidiploid (AACC genome, 2n=38) and is believed to have arisen by inter-specific hybridization between diploid *Brassica rapa* L. (AA genome, 2n=20) and *Brassica oleracea* L. (CC genome, 2n=18) (Prakash and Hinata, 1980). *Brassica napus* is second most important oilseed crop in the international oilseed market after soybean and important source of vegetable oil (Hasan *et al.,* 2006).

Pakistan is producing 186.0 thousand tones of rapeseed and mustard from an area of 213.0 thousand hectares. The edible oil

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consumption was 2.103 million tons of which 0.636 million tons (30%) came from local resources and 1.467 million tons (70%) were imported (Anonymous, 2012). The production in Pakistan is not sufficient to meet the consumption requirement. Consequently, a huge amount of hard earned foreign exchange is spent every year on its import. It is necessary to take important measures to improve the yield potential of *Brassica* (Shah *et al*., 2000).

The yield is complex character and is dependent on many other morphological traits which are mostly inherited quantitatively. It is important to examine the contribution of each of the trait in order to give more attention to those having the greatest influence on seed yield (Tuncturk and Ciftci, 2007). Importance of genotypic and phenotypic variability, heritability and character association have proved by many scientists (Ali *et al.,* 2002; Lekh *et al*., 1998; Saini and Sharma, 1995) for further genetic improvement. Gosh and Gulati (2001) also showed that the traits showing high heritability are under the control of additive genes and can be successfully utilized for plant selection on the basis of phenotypic performance.

A positive and highly significant genotypic character association between silique per plant and yield per plant was also found by Tuncturk and Ciftci, 2007; Sandhu and Gupta, 1996; found positive and significant correlations of seed yield with plant height, branches and silique per plant. Khubli and Pant (1999) indicated positive correlation of seed yield with silique per plant, 1000 seed weight in Indian mustard. The simple correlation analysis could not fully explain the relationship among the characters. Therefore, path coefficient analysis is suggested to exploit for more and complete determination of impact of independent variable on dependent one (Korkut *et al*., 1993). It helps the breeders to explain direct and indirect effects and had extensively been used in breeding work in different crop species by various researchers. Khayat *et al.* (2012); Shalini *et al*. (2000) found positive direct effect of 1000 seed weight, days to flowering, and days to maturity on yield. Sinha *et al*. (2001) reported that days to flowering, siliqua length had positive direct effect while plant height had negative direct effect on yield per plant. The present investigations were planned to estimate heritability, association and selection criteria for yield components in rapeseed (*Brassica napus*).

MATERIAL AND METHOD

The experiment was conducted in the research area of Oilseeds Research Institute, Faisalabad, Pakistan, during the years 2011-‘12. Nine varieties/strain (KN-256, KN-257, RBN-04016, RBN-04047, RBN-04077, HC-17, 8CBN021, Hyola-401 and Punjab Sarson) of *Brassica napus* yield trial with different genetic background were selected for this study. These genotypes were sown in a randomized complete block design

(RCBD), with three replicates. Each plot consisted of 5 meter long and three rows for each entry. Seeds were planted with the help of a seed drill and the distance between rows was kept 45 cm. Normal agronomic and cultural practices were applied to the experiment throughout the growing season. Randomly selected plants were tagged to record data for days to flowering, days to maturity, plant height (cm), branches per plant, siliqua length (cm), seeds per siliqua, 1000 seed weight (g), silique per plant, seeds per plant and yield per plant (g). The analysis of variance was performed on each measured trait as proposed by Steel and Torrie (1980). The heritability of a population is the proportion of observable differences between individuals that is due to genetic differences. Factors including genetic, environmental and random chance can all contribute to the variation between individuals in their observable characteristics. Thus heritability estimates were determined by the formula given by Falconer (1989). Genotypic (rg) and phenotypic (rp) correlation coefficients were determined as described by Kwon and Torrie (1964) whereas path coefficients analysis was made according to Dewey and Lu, 1959. In path coefficient analysis relationship between variables in multivariable system is considered. Therefore, in the present investigation, path coefficient analysis was carried out by taking seed yield per plant (g) as dependent variable and other observed traits as independent variables.

RESULTS AND DISCUSSION

The presence of variability is the prerequisite for any breeding program. The data (*Table1*) showed that genotypic mean square for each trait was highly significant except 1000 seed weight and days to maturity for which it was only significant. The wide range of phenotypic variability estimated for all the traits showed that these traits can be utilized for developing new high yielding rapeseeds varieties. Genotype KN-258 took maximum days to flowering (91), days to maturity (166), yield per plant (26.64 g) and plant height (232.40 cm).

Heritability in broad sense ($h^2_{B.S}$) was also calculated for various trait (*Table 2*) showed that plant height, seed yield per plant and days to flowering have high values i.e.0.906, 0.90 and 0.976, respectively. High heritability was also calculated for these traits by Yadava *et al.* (2011). Maximum genotypic and phenotypic variance was found for seeds per plant (7235.12 & 8185.68) and maximum genotypic and phenotypic coefficient of variance (21.626 and 23.50%), respectively. Ali *et al.* (2002) also confirmed similar result.

Correlation studies were also great interest for plant breeders in determining the traits which are correlated with main breeding objectives. The genotypic and phenotypic correlations between the ten characters are also summarized (*Table 3*) at 1% and 5% significant level. A positive and highly significant genotypic character association was found between plant height and yield per plant (0.8883), plant height and seeds per plant (0.9220), seeds per siliqua and siliqua length (0.9079), days to maturity and yield per plant (0.5831), seeds per plant and yield per plant (0.8189), silique per plant and yield per plant (0.4832), days to maturity and 1000 seed weight (0.2627), days to flowering and seeds per plant (0.5536), days of maturity and seeds per plant (0.4687), silique per plant and seeds per plant (0.9294).

A positive and highly significant genotypic character association between silique per plant and yield per plant was also found by Tuncturk and Ciftci (2007). Highly positive correlation found between plant height and yield per plant, silique per plant and yield per plant by Khayat *et al.* (2012).

A positive and highly significant phenotypic correlation was found between plant height and seeds per plant (0.8178). Positive association for yield per plant also found in seeds per plant (0.7292) and silique per plant (0.3985) at phenotypic level. The correlation studies revealed that the most important traits in selection for yield are plant height, days to maturity, seeds per plant and silique per plant. Moreover, in analysis most of the correlated pair of characters, genotypic and phenotypic association were in the same direction. The genotypic estimates were higher than phenotypic estimates indicating that an inherited association occurred between traits. Almost similar results are given by Rameeh (2011), while these results are also partial agreement with the earlier findings of Dar *et al.* (2010); Tahira *et al.* (2012).

Path coefficient analysis splits the correlation coefficient into direct and indirect effects. It reveals whether the association of the traits with yield is due to their direct effect or is a consequence of their indirect effect via other traits. The data (*Table 4*) revealed that highest positive direct effect of seeds per plant on yield (1.729) and this character was followed by days to maturity (0.697), days to flowering (0.484), seeds per siliqua (0.315), siliqua length (0.241) and 1000 seed weight (0.019). The total indirect effect of branches per plant (0.438), plant height (0.595), siliqua length (0.231) and seeds per siliqua (0.596), 1000 seed weight (0.132), days to flowering (0.030) and silique per plant (1.721) was positive on yield per plant. However, days to maturity (-0.112) and seeds per plant (-0.911) contributed negative total indirect effect with yield per plant Khayat *et al*. (2012) also found positive direct effect of 1000 seed weight, days to flowering, and days to maturity on yield. Sinha *et al*. (2001) reported that days to flowering, siliqua length had positive direct effect while plant height had negative direct effect on yield per plant. It is observed that branches per plant, plant height and silique per plant exerted negative direct effects. Basalma (2011) confirmed that direct effects of plant height and branches per plant on yield were negative.

Table 1 - Mean values for different yield related traits of *Brassica napus* genotypes during Rabi 2011-'12

Genotypes	Branches /plant	Plant height (cm)	Siliqua length (cm)	Seeds/ silique	Yield/ Plant (g)	1000 seed weight (g)	Days to flowering	Days to maturity	Seeds/ plant	Silique/ plant
KN-256	8.0	232.40	6.07	23.00	26.64	3.57	91	166	7557.00	315.33
KN-257	7.3	222.33	5.68	18.67	23.15	3.02	88	164	7687.33	418.00
RBN-04016	8.0	197.67	7.51	25.00	20.03	2.87	86	162	6199.67	273.67
RBN-04047	9.3	212.33	7.45	24.33	23.51	4.22	87	162	6338.33	233.33
RBN-04077	5.3	196.4	7.08	24.67	20.52	4.07	80	163	5107.67	215.67
HC-17	8.3	209.87	6.98	23.33	21.38	3.46	79	162	6205.67	264.00
8CBN021	8.3	209.53	7.46	27.67	19.95	3.37	90	157	5983.33	268.67
Hyola-401	8.0	200.87	7.37	24.00	21.78	3.69	86	161	5883.67	246.33
Punjab Sarson	6.3	203.00	7.40	23.67	19.23	3.65	57	165	5386.33	235.33
Mean square (Genotypes)	4.25**	422.11**	1.34**	16.76**	16.20**	0.57*	346.5**	20.34*	2265.25**	112.8**

*=significant ($P<0.05$), **=highly significant ($P<0.01$)

Table 2 - Genetic parameters for different yield related traits of *Brassica napus* genotypes during Rabi 2011-'12

Genetic parameters	Branches /plant	Plant height (cm)	Siliqua length (cm)	Seeds/ siliqua	Yield/ plant (g)	1000 seed weight (g)	Days to flowering	Days to maturity	Seeds/ plant	Silique / plant
Genotypic variance	1.282	135.97	0.369	5.111	5.205	0.138	114.56	4.145	7235.12	3523.62
Phenotypic variance	1.685	150.15	0.605	6.537	5.786	0.296	117.38	12.047	8185.68	4160.74
Genotypic coefficient of variation (%)	14.771	5.569	8.675	9.493	10.46	10.456	12.895	1.253	13.586	21.626
Phenotypic coefficient of variation (%)	16.932	5.852	11.112	10.736	11.03	15.322	13.054	2.137	14.451	23.500
Heritability in broad sense ($h^2_{B.S}$)	0.761	0.906	0.609	0.782	0.90	0.467	0.976	0.344	0.884	0.847

Table 3 - Genotypic (r_g) and phenotypic (r_p) correlation coefficients for different yield related traits

		Branches /plant	Plant height (cm)	Siliqua length (cm)	Seeds/ silique	Yield/ plant (g)	1000 seed weight (g)	Days to flowering	Days to maturity	Seeds/ plant
Plant height (cm)	r_g	0.3989								
	r_p	0.2984								
Siliqua length (cm)	r_g	0.1628	-0.8713**							
	r_p	0.0539	-0.6695*							
Seeds/silique	r_g	0.1664	-0.5333	0.9079**						
	r_p	0.1074	-0.4087	0.6751*						
Yield/plant (g)	r_g	0.4043	0.8883**	-0.7629*	-0.4623*					
	r_p	0.3297	0.7805*	-0.5550	-0.4290*					
1000 seed weight (g)	r_g	-0.0375	-0.1332	0.4045	0.3135	0.1506				
	r_p	-0.1796	-0.1185	0.1757	0.1765	0.1360				
Days to flowering	r_g	0.5649	0.4080	-0.3172	0.0776	0.5152	-0.2030			
	r_p	0.5016	0.3754	-0.2017	0.0765	0.4844	-0.1768			
Days to maturity	r_g	-0.5111	0.4772	-0.8663**	-0.9853**	0.5831**	0.2627**	-0.5294**		
	r_p	-0.2538	0.2927	-0.2826	-0.3553	0.3559	0.2352*	-0.3040		
Seeds/plant	r_g	0.4748	0.9220**	-0.9183**	-0.6398**	0.8189**	-0.5421**	0.5536**	0.4687**	
	r_p	0.3624	0.8178**	-0.6728*	-0.6217*	0.7292*	-0.3140*	0.5073*	0.2024*	
Silique/plant	r_g	0.1279	0.7153*	-0.9771**	-0.8058**	0.4832**	-0.7523*	0.3872*	0.3333*	0.9294**
	r_p	0.0908	0.6138	-0.6837*	-0.6471*	0.3985*	-0.5348*	0.3536*	0.1953*	0.7655*

*=significant (P<0.05), **=highly significant (P<0.01)

Table 4 - Direct and indirect effect in path coefficient analysis

	Direct effects	Indirect effects									Total indirect effect	Total effect
		1	2	3	4	5	6	7	8	9		
1. Branches /plant	-0.039		-0.149	-0.039	0.052	-0.007	0.274	-0.356	0.821	-0.158	0.438	0.399
2. Plant height (cm)	-0.374	-0.016		0.209	-0.168	-0.003	0.198	-0.333	1.594	-0.886	0.595	0.221
3. Siliqua length (cm)	0.241	-0.008	0.326		0.286	0.008	-0.154	-0.604	1.588	-1.211	0.231	0.472
4. Seeds/ siliqua	0.315	-0.007	0.199	-0.219		0.006	0.038	0.687	-1.106	0.998	0.596	0.911
5. 1000 seeds weight (g)	0.019	0.002	0.049	-0.097	0.099		-0.099	0.183	-0.937	0.932	0.132	0.151
6. Days to flowering	0.484	-0.022	-0.153	0.076	0.024	-0.004		-0.369	0.957	-0.479	0.030	0.514
7. Days to maturity	0.697	0.02	-0.178	0.209	-0.310	0.005	-0.256		0.811	-0.413	-0.112	0.585
8. Seeds/plant	1.729	-0.018	-0.345	0.221	-0.202	-0.010	0.268	0.327		-1.152	-0.911	0.818
9. Silique /plant	-1.239	-0.005	-0.268	0.235	-0.254	-0.014	0.188	0.232	1.607		1.721	0.482

CONCLUSION

Seed per plant was the variable with maximum potential of selection for seed yield improvement because this trait possessed high $h^2_{B.S}$, highly significant positive correlation and maximum positive direct effects with yield.

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