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Correlation and Path Coefficient Analysis of Some Quantitative Characters in Canola Oil (*Brassica napus* L.).

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BOTH GENOTYPIC and phenotypic correlation coefficient for some quantitative characters considered of yield and quality were studied in experimental farm, Environment Studies and Research Institute, Minufiya University at Sadat city, Minufiya Governorate, Egypt, during (2009/2010) and (2010/2011). Seven accessions of (*Brassica napus* L.) were studied. The results showed that a wide range of genetic variation existed among all studied traits over all varieties in both studied years. Genotypic correlation coefficient analysis revealed that seed yield per plant were positively and highly significant. correlated with number of siliquas per plant (0.99,0.95), number of seeds per siliquas (0.95,0.95), number of secondary branches per plant (0.87,0.96) and number of primary branches per plant (0.80, 0.96) in both seasons, respectively. However negative correlation with days to 50%flowering (-0.49, -0.29) in both seasons, respectively. Also non-significantly associated with oil content and 1000 seed weight in the second year were found. The path coefficient analysis showed the major role of indirect effects for almost studied characters on seed yield traits. So number of siliquas per plant followed number of seeds per siliqua, number of secondary branches and number of primary branches are the best criteria for yield improvement in rapeseed by selection program.

Keywords: *Brassica napus*, Canola oil, Correlation coefficient, Path coefficient.

Canola (*Brassica napus* L.), is a recent growing crop in Egypt, but has a bright future and hopefully to contribute in reducing oil deficiency gap, where the degree of self sufficient ratio in edible plant oil declined from 25.6 % in 1980 to 12.3 % in 1996 (El-Tantawy & Soliman, 1999). This gap will be increase in next years mainly due to high population growth rate and increasing consumption from edible oil. To increase the yield, study of direct and indirect effects of yield components provides the basis for its successful breeding program. Hence the problem of increasing yield can be more effectively tackled on the basis of performance of yield components and selection for closely related characters (Choudhry *et al.*, 1986). Dhillon *et al.* (1990) observed that plant height had association with seed yield and secondary branches per plant. Chowdhury *et al.*

(1987) found that seed yield per plant (gm) was positively associated with number of siliquas per plant (siliquas) and protein content (gm). Singh & Singh (1995) studied the correlation between seed yield (gm) and other agronomic traits, who found that seed yield(gm) was positively correlated with 1000- seed weight (gm) and number of seeds per siliqua. Kandil *et al.* (1994) indicated that number of siliquas per plant possessed strongest association with seed yield per plant (gm) in *Brassica napus*. Lakshmamma *et al.* (1996) found that the best cultivars which gave the highest yield had carried the greatest number of siliquas per plant. Anil *et al.* (1998) reported that seed yield (gm) was positively correlated with both number of seeds per siliqua (seed) and number of siliquas per plant. Naazar *et al.* (2003) found that positive and significant correlation between seed yield (gm) and seed weigh (gm). Tunçtürk & Çiftci (2007) studied the relationships between yield and its components, they found that positive correlation between seed yield (gm), number of branches (branch), number of siliquas per plant, number of seeds per siliqua and 1000 seed weight (gm). Sajid *et al.* (2008) showed that high significant correlation between seeds per siliqua and yield per hectare (k g). Also they found low correlation among different traits, however some of the related characters like days – to – flowering, pods per plant, plant height (cm), seed yield (gm) were highly significantly and positively correlated with each other.

Generally, correlation coefficients show relationships among independent characteristics and the degree of liner relation between these characteristics (Korkut *et al.*, 1993). As we know, the seed yield of rapeseed (gm) is the results of physiological and genetically effects, in other words, the direct selection can be the main policy for the rapeseed breeding program. According to the results that was reported by Bhatt(1973), indirect selection is not sufficient enough for seed yield breeding, and for this purpose, the direct and indirect selection must be done together. Ahmad *et al.* (2003) showed the quantitative value of direct and indirect effect through path coefficient analysis for yield performance. Several researchers studied the correlation between yield and yield components via path analysis as an index for selection of rapeseed improvement.

This investigation was conducted to determine the relationships between different agronomic traits within the different accessions of *Brassica napus* L . for obtaining the best index of selection.

Materials and Methods

Experiments were conducted at the experimental farm of the Environmental Studies and Research Institute, Minufiya University, El-Sadat Branch, Minufiya Governorate, Egypt, during (2009/20010 & 2010/2011) winter seasons. Seven *Brassica napus* L., Lines; 5/09, 9/09, 21/09, 23/09, 28/09, 30/09 and 31/09. were used to investigate the relationship between yield and some yield components of rapeseed (*Brassica napus* L.) using correlation coefficient analysis. Randomize complete block design with three replication were used, each plot comprised five rows, three meters long, with 70cm width and the seedling were later thinned to one plants per hill, the distance between hills 25cm. (Canola oil practices were applied as usual for the ordinary in the new reclaimed areas). Data were recorded on ten individual guarded plants for studied traits as follows: days to 50% flowering, plant height(cm), number of primary branches, number of secondary branches, number of siliquas per plant, number of seeds per siliqua, 1000 seed weight (gm), seed yield per plant (gm), oil percentage and protein percentage (gm) .

TABLE 1. Origin and pedigree history of the used linens.

Lines	Origin	Pedigree and selection
5/09 (56/16)	DRC, Siwa NBL[#]	Cresor/Duplo 18C-121Su-4Sw-15Sw-1Sw-0Sw
9/09	DRC, Sudr NBL	C103/Sedo 2C103 9C-6Su-1Su-13Sw-2Sw-0Sw
21/09	DRC, Mar NBL	T1×L1 Sel.21Maryot2005
23/09	DRC, Mar NBL	T1×Serw-4 Sel.23Maryot2005
28/09	DRC, Mar NBL	T2×L5 Sel.28Maryot2005
30/09	DRC, Mar NBL	T1×T2 Sel.30Maryot2005
31/09	DRC, Mar NBL	T1×L5 Sel.31Maryot2005

: Newly Bred Lines selected through Desert Research Center, Canola breeding program at Siwa, Ras-Sudr and Maryout Experimental Research Station, Egypt.

Chemical analysis

Soxhlet extraction method was used to determined oil percentage as prescribed by A.O.C.S (1975). Crude protein content was estimated according to Cottenie *et al.* (1982).

Statistical analysis

Data were subjected to analysis of variance according to Steel & Torrie (1981). All possible correlation coefficients were computed following the statistical technique prescribed by Singh & Chaudhary (1979). Statistical significance of phenotypic correlation was determined by T-test as described by Steel & Torrie (1981) .

The components of variance including error variance (δ^2_e), genotypic variance (δ^2_g) and phenotypic variance (δ^2_p),were estimated, according to the following formula :

$\delta^2_e = M_e$

$\delta^2_g = (M_g - M_e)/r$

$\delta^2_p = \delta^2_g + \delta^2_e$

The phenotypic and genotypic correlation between variable x and y ($r_{(xy)p}$ and $r_{(xy)g}$), were also estimated as following formula (Kwon & Torrie, 1964):

$r_{(xy)p} = Cov_{(x,y)p} / (\delta^2_{(x)p}\ \delta^2_{(y)p})^{1/2}$

$r_{(xy)g} = Cov_{(x,y)g} / (\delta^2_{(x)g}\ \delta^2_{(y)g})^{1/2}$

where $Cov_{(x,y)p}$ and $Cov_{(x,y)g}$ are phenotypic and genotypic covariance between variable x and y, respectively. Finally the path coefficient analysis (p_{ij}) was done based on Dewey & Lu (1959):

$r_{17} = P_{17}+r_{12}P_{27}+r_{13}P_{37}+r_{14}P_{47}+r_{15}P_{57}+r_{16}P_{67}$

$r_{27}= r_{12}P_{17}+ P_{27}+r_{23}P_{37}+r_{24}P_{47}+r_{25}P_{57}+r_{26}P_{67}$
$r_{37}= r_{13}P_{17}+r_{23}P_{27}+ P_{37}+r_{34}P_{47}+r_{35}P_{57}+r_{36}P_{67}$
$r_{47}= r_{14}P_{17}+r_{24}P_{27}+r_{34}P_{37}+ P_{47}+r_{45}P_{57}+r_{46}P_{67}$
$r_{57}= r_{15}P_{17}+r_{25}P_{27}+r_{35}P_{37}+r_{45}P_{47}+ P_{57}+r_{56}P_{67}$
$r_{67}= r_{16}P_{17}+r_{26}P_{27}+r_{36}P_{37}+r_{46}P_{47}+r_{56}P_{57}+ P_{67}$

where six independed variables were(1) Plant height (cm), (2) Number of primary branches, (3) Number of secondary branches, (4) Number of siliquas per plant, (5) Number of seeds per siliqua and (6)1000 seed weight (gm) and dependent variable was seed yield (gm).

Results

Significant defferances were obtaned among all genotypes for all studied traits in both studied seasons (Table 2).

TABLE 2. Lines mean squares for all studied traits in 2009/20010 and 2010/2011.

Traits	Error mean square		Genotype mean square		Block mean square	
	Y1	Y2	Y1	Y2	Y1	Y2
Days to 50% flowering(day)	0.11	0.71	42.54**	69.66**	0.01	0.54
Plant height(cm)	2.74	8.17	82.87**	176.27**	2.33	3.62
No. of primary branches	0.11	1.07	7.65**	16.89**	0.82	0.10
No. of secondary branches	1.28	21.00	104.93**	95.34**	0.33	5.67
No. of siliquas / plant	202.47	6584.60	39827.29**	63284.83**	85.86	6142.07
No. of seeds /siliqua	0.03	0.38	3.78**	3.50**	0.04	0.47
1000 seed weight(gm)	0.01	0.03	0.19**	0.12**	0.01	0.06
Seed yield /plant(gm)	2.92	65.94	599.72**	660.45**	4.79	116.51
Oil content(gm)	0.90	0.54	7.71**	16.59**	2.41	0.17
Proteins content(gm)	0.69	0.30	3.54**	5.18**	3.93	0.20

*and ** Significant at 0.01 and 0.05 probability levels respectively.

Correlation coefficient analysis is presented in Table 3. The data showed that genotypic correlation coefficient were higher than their respective phenotypic (r_g>r_p) for most studied traits in both seasons. Concerning of days to 50% flowering there were significant negative genotypic and phenotypic correlation coefficient with plant height (cm), number of siliquas per plant, number of seeds per siliqua and seed yield per plant (gm) in the second season. Also negative correlation with allmost studied traits in both studied seasons was found. Regarding to plant height (cm) possitive correelation coefficient was found significantly with most studied traits except 1000 seed weight (gm) and oil content (gm) were found in both studied seasons. Both number of primary branches and number of secondary branches showed positive significant genotypic and phenotypic correlation coefficient with most studied traits except 1000 seed weight (gm) and oil content (gm) in both studied seasons. On other hand number of siliquas per plant had positive genotypic and phenotypic correlation coefficient with most studied traits except days to 50% flowering, 1000 seed weight (gm) in the second season and oil percentage (gm) in both studied seasons. Also it had the highest positive significant genotypic and phenotypic correlation coefficient with seed yield per plant(gm) in both studied seasons.

Possitive correelation coefficient was found significantly in number of seeds per siliqua association with plant height (cm), number of primary branches, number of secondary branches, number of siliquas per plant, seed yield per plant (gm) and protein percentage (gm) in both studied seasons. Possitive correelation coefficient was found significantly in 1000 seed weight (gm) with number of siliquas per plant, number of seeds per siliqua and seed yield per plant(gm) in the first season only. Regarding to seed yield per plant(gm) possitive correelation coefficient was found significantly with almost studied traits except days to 50% flowering and oil percentage (gm). With respect oil percentage (gm) had nonsignificant correlation coefficient with any studied traits in both studied seasons.

TABLE 3. Genotype(rg) and phenotype(rp) correlation coefficients for all studied traits in 2009/2010 and 2010/2011 seasons.

Traits	Years		Days to 50% flowering	Plant height	No. of primary branches	No. of secondary branches	No. of siliquas/ plant	No. of seeds/ siliqua	1000 seed weight	Seed yield/ plant	Oil content	Protein content
Days to 50% flowering	S_1	r_g	1.00	-0.40	-0.37	-0.35	-0.38	-0.37	-0.49*	-0.43*	0.18	0.06
		r_p	1.00	-0.38	-0.36	-0.35	-0.37	-0.36	-0.46*	-0.42*	0.15	0.05
	S_2	r_g	1.00	-0.64**	-0.52*	-0.47	-0.58*	-0.84**	-0.29	-0.58*	0.25	-0.11
		r_p	1.00	-0.60**	-0.49*	-0.37	-0.57*	-0.54**	-0.18	-0.49*	0.26	-0.08
Plant height (cm)	S_1	r_g		1.00	0.88**	0.89**	0.63*	0.74**	0.23	0.64*	0.00	0.41*
		r_p		1.00	0.82**	0.86**	0.59*	0.68**	0.19	0.59*	-0.01	0.43*
	S_2	r_g		1.00	0.82**	0.93**	0.81**	0.85**	0.12	0.89**	-0.07	0.64**
		r_p		1.00	0.65**	0.63**	0.72**	0.75**	0.11	0.71**	0.13	0.59**
No. of primary branches	S_1	r_g			1.00	0.96**	0.82**	0.91**	0.34	0.80**	-0.23	0.63**
		r_p			1.00	0.91**	0.80**	0.87**	0.31	0.78**	-0.21	0.43*
	S_2	r_g			1.00	0.99**	0.90**	0.73**	0.20	0.96**	-0.04	0.79**
		r_p			1.00	0.91**	0.98**	0.48*	0.03	0.88**	-0.15	0.74**
No. of secondary branches	S_1	r_g				1.00	0.89**	0.95**	0.44	0.87**	-0.17	0.78*
		r_p				1.00	0.87**	0.93**	0.37	0.85**	-0.19	0.60*
	S_2	r_g				1.00	0.90**	0.87**	0.07	0.96**	0.04	0.92**
		r_p				1.00	0.99**	0.39*	0.28	0.88**	-0.15	0.73**
No. of siliquas/ plant	S_1	r_g					1.00	0.96**	0.73**	0.99**	-0.11	0.79**
		r_p					1.00	0.95**	0.67**	0.99**	-0.12	0.58*
	S_2	r_g					1.00	0.80**	-0.64**	0.95**	-0.12	0.58**
		r_p					1.00	0.54**	-0.16	0.99**	-0.33	0.53**
No. of seeds/ siliqua	S_1	r_g						1.00	0.66**	0.95**	-0.12	0.89**
		r_p						1.00	0.58*	0.94**	-0.11	0.64**
	Y2	r_g						1.00	0.40*	0.95**	-0.28	0.56**
		r_p						1.00	0.11	0.63**	-0.13	0.35
1000 seed weight (gm)	S_1	r_g							1.00	0.79**	0.41	0.50
		r_p							1.00	0.67**	0.43	0.29
	S_2	r_g							1.00	-0.05	0.35	-0.45*
		r_p							1.00	0.25	-0.02	0.38
Seed yield/ plant(gm)	S_1	r_g								1.00	-0.02	0.77**
		r_p								1.00	-0.01	0.54
	S_2	r_g								1.00	-0.13	0.66**
		r_p								1.00	-0.26	0.58**
Oil content (gm)	S_1	r_g									1.00	-0.13
		r_p									1.00	0.02
	S_2	r_g									1.00	0.28
		r_p									1.00	0.31
Protein content (gm)	S_1	r_g										1.00
		r_p										1.00
	S_2	r_g										1.00
		r_p										1.00

*and ** Significant at 0.01 and 0.05 probability levels respectively.
S_1 and S_2 two studied seasons, respectively.

On other side protein percentage (gm) showed positive significant correlation with plant height(cm), number of primary branches, number of secondary branches, number of siliquas per plant, number of seeds per siliqua and seed yield per plant (gm) in both studied seasons. Path coefficient analysis of seed yield (gm) in both studied seasons are presented in Table 4, in the first season maximum direct effects on seed yield (gm) were observed in number of siliqua per plant (0.99) followed by plant height (cm) (0.21). Where both number of secondary branches and number of seeds per siliqua had negative direct effeects (-0.29, -0.06), respectivly. Concerning of indirect effects the maximum values were achieved with number of seeds per siliqua (0.95) folwed by number of secondary branches (0.88) and number of primary branches (0.81) .

On the other season the path coefficient analysis showed the major role of indirect effects for number of primary branches with number of secondary branches (2.678), number of siliqua per plant (2.41) and number of seeds per siliqua (2.329). Also high indirect effects concerning plant height (cm) (2.49) and number of primary branches (2.651) were found.

TABLE 4. Path coefficient analysis for seed yield on rapeseed in both studied seasons.

2009/2010 season									
Traits	**Direct effects**	**Indirect effects**						**Residual effect**	**Total effect**
Plant height(cm)	0.210		0.071	-0.258	0.624	-0.042	0.036	0.000	0.640
No. of primary branches	0.080	0.185		-0.278	0.813	-0.052	0.053	0.000	0.800
No. of secondary branches	-0.290	0.187	0.076		0.882	-0.053	0.068	0.000	0.870
No. of siliquas / plant	0.991	0.132	0.066	-0.258		-0.055	0.114	0.000	0.990
No. of seeds / siliqua	-0.057	0.155	0.073	-0.275	0.951		0.103	0.000	0.950
1000 seed weight(gm)	0.156	0.048	0.027	-0.127	0.723	-0.037		0.000	0.79
2010/2011 season									
Plant height(cm)	-0.840		-0.841	2.490	-0.129	0.226	-0.017	0.000	0.89
No. of primary branches	-0.690	-1.025		2.651	-0.143	0.194	-0.028	0.000	0.960
No. of secondary branches	-0.781	-1.015	2.678		-0.143	0.231	-0.010	0.000	0.96
No. of siliquas / plant	-0.681	-0.922	2.410	-0.159		0.213	0.089	0.000	0.950
No. of seeds / siliqua	-0.714	-0.748	2.329	-0.127	0.266		-0.056	0.000	0.950
1000 seed weight(gm)	-0.101	-0.205	0.187	0.102	0.106	-0.14		0.000	-0.140

Disscussion

Previous resultes reveared that the studied genotypes were different geneticly, which indicating sufficient genetic variability among these genotypes. These results were harmony with Sajid & Khalil (2008) finding who found that genotypic correlation coefficient were higher than their respective phenotypic correlation coefficient (r_g>r_p) for all most studied traits in both seasons.Thus reflex adverse environmental influence on the studied traits. These results was agreement with finding by Dhillon *et al*. (1990) and Khan *et al*. (2006). Similar finding have been reported by Chowdhury *et al*. (1987) and Lakshmamma *et al*. (1996). Positive and significant correlation of number of secondary branches was exhibited by number of siliqua per plant and protein content at genotypic level as reported by Swain (1990). Kandil *et al*. (1994) found that number of siliquas per plant possessed strongest association with seed yield per plant. This finding is also supported by Singh & Singh (1996) and Anil *et al*., (1998), Naazar *et al*. (2003) and Sajid & Khalil (2008). finding. Positive and significant correlation of number of secondary branches was exhibited by number of siliqua per plant and protein contents at genotypic level as reported by Swain (1990). Kandil *et al*. (1994) found that number of siliquas per plant possessed strongest association with seed yield per plant. This finding is also supported by Singh & Singh (1996) and Anil *et al*. (1998), Naazar *et al*. (2003) and Sajid & Khalil (2008). The higher genotipic correlation coefficient for all most traits over the respective phenotipic indicated adverse environmental influence on them. Smilar resultes were obtained by Naazar *et al*. (2003) and Sajid & Khalil (2008).

The correlation between the traits may be due to linkage or peliotropy (Adams, 1967) or, environment (Aastveit & Aastveit, 1993). Some correlation coefficients in two studied seasons were different. So it is suggested that these differences may be due to environmental variances or experimental error variance, so the appearance of traits in rapeseed, are strongly influenced by environment. Ozer *et al*. (1999) obtained different results from similar genotypes in two consecutive years. They suggeted that this difference can be partly attributed to the variation in environmental condition during the growing season.The simple correlation coefficient cannot give the clear real information from relationship between traits, so it could be divided into series of direct and indirect effects. Path coefficient analysis provides a measure of relative importance of each independent variable to predict changes in the dependent one. This previous results are in line with finding of Saini & Sharma (1995). These results agree with finding by Singh *et al*. (1988) and Khan *et al*. (2006). Singh &Singh (1995) show a negative association between oil contents and seed yield per plant. Therefor indirect effects on seed yield were greatly. Güler *et al*. (2001) **determined** relationships among yield and some yield components using path coefficient analysis in chickpea (*Cicer arietinum* L.). They found positive and significant relationships between number of seeds per pod and seed yield per plant. Our results confirm the finding of Basalma (2008) and Sadat *et al*., (2010). The promising criteria for seed yield improvement in rapeseed breeding programe was number of siliquas per plant followed number of seeds per siliqua, number of secondary branches and number of primary branches. These results were similar with those reported by Jeromela *et al*. (2007).

Conclusion

According to the previous results it could be concluded that indirect selection is not sufficient for seed yield breeding program. Therefore the direct and indirect selection must be done together and the direct selection can be the main policy for rapeseed breeding program. The direct selection for number of siliquas per plant followed number of seeds per siliqua, number of secondary branches and number of primary branches would improvement as more effective in breeding programs in canola oil.

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تحليل معامل الأرتباط ومعامل المرور لبعض الصفات الكمية فى كانولا الزيت (*Brassica napus* L.)

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تم دراسة كل من معامل الأرتباط الوراثى والمظهرى لبعض الصفات الكمية المرتبطة بالمحصول وجودته وذلك بالمزرعة التجريبية لمعهد الدراسات والبحوث البيئية التابع لجامعة المنوفية بمدينة السادات، خلال موسمين شتويين لأعوام ٢٠٠٩/ ٢٠١٠،٢٠١٠/ ٢٠١١واستخدم فى هذه الدراسة سبعة تراكيب وراثية من (*Brassica napus* L.) هى 5/09 , 9/09 , 21/09 , 23/09 , 28/09 , 30/09 , 31/09 أنتجت هذه التراكيب الوراثية بمعرفة قسم الأصول الوراثية التابع لمركز بحوث الصحراء – مركز البحوث الزراعية وأظهرت النتائج وجود مدى واسع ومعنوى من التباين الوراثى بين هذه التراكيب وذلك فى جميع الصفات المدروسة فى كلا الموسمين وأظهر تحليل الأرتباط الوراثى وجود ارتباط عالى معنوى بين صفة محصول البذور وكلا من عدد القرون للنبات (٠،٩٩ ،٠،٩٥) وعدد البذور بالقرن (٠،٩٥ ،٠،٩٥) وعدد الفروع الثانوية للنبات (٠،٩٦ ،٠،٨٧) وعدد الفروع الأولية للنبات (٠،٩٦ ،٠،٨٠) فى كلا موسمى الدراسة على التوالى بينما وجد أرتباط معنوى وسالب بين صفة محصول البذور والتبكير فى التزهير (-٠،٢٩،-٠،٤٩) فى كلا موسمى الدراسة على التوالى.

تحليل معامل المرور بين صفة محصول البذور للنبات وبعض الصفات المرتبطة بالمحصول أظهر أن التأثير الغير مباشر للصفات على بعضها البعض كان هو التأثير الرئيسى فى التأثير على صفة محصول البذور وكذلك يجب الأنتخاب لعدة صفات مجتمعة وهى عدد القرون للنبات، عدد البذور فى القرن، وعدد الأفرع الأولية للنبات وكذلك عدد الأفرع الثانوية عند التربية لتحسين محصول الحبوب عن طريق اتباع برامج الأنتخاب.