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Aagronomical Important Traits Correation in Rapeseed (*Brassica Napus* L.) Genotypes

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Abstract: In order to investigate the relationships between traits in rapeseed (*Brassica napus* L.), twenty–seven genotypes were studied based on randomized complete block design with four replication. Field experiments were conducted on a clay soil with pH 8 in the Agriculture Research Station of Biekola in Mazandaran province (northern Iran) with average precipitation 650 to 700 mm during two consecutive cropping seasons: 2006–2007 and 2007-2008. The result of variance revealed significant differences among genotypes for phonological and morphological traits, seed yield and yield components. The maximum seed yield (3851 $Kg.h^{-1}$) was recorded for the genotype Hyola 401 corresponding to the maximum number of pods per sub-branches (126.5), higher number of pods per plant (169.8), maximum number of seeds per pod (24.4) and highest 1000-seed weight (4.3 g) which was coincided with the highest flowering duration (45 days). Seed yield was significantly and positive correlated with number of pod per plant (r = 0.66), number of pods in sub branches (r = 0.74) and number of seeds per pod (r = 0.55), so any changing of these traits based on agronomic treatments or plant breeding methods can be effective on seed yield. Path coefficient analysis identified number of pods in sub branches, number of seeds per pod and number of pods per plant as having the greatest effect on seed yield, respectively.

Key words: *Rapeseed, seed yield, yield component, oil percentage*

INTRODUCTION

The oilseed *Brassica* species (*B. napus, B. rapa, B. campestris and B. jancea*) are now the third most important source of edible oil in the world after palm and soybean oil[15]. Yield potential of a crop is a theoretical assessment of the maximum yield that can be generated when high yielding biological material is grown in an optimum physico–chemical environment[4]. Optimizing yield is one of the most important goals for most rape growers. Seed yield is a complex character that can be determined by several components reflecting positive or negative effects upon this trait, whereas it is important to examine the contribution of each of the various components in order to give more attention to those having the greatest influence on seed yield. Therefore, information on the association of plant characters with seed yield is of great importance to a breeder in selecting a desirable genotype[8].

In many cases the reported correlations are highly dependent on the environment and on the material[5]. Basing decisions solely on correlation coefficients may not always be effective because they provide only limited information, disregarding interrelations among traits. Thus, many breeders were involved in analyzing the path coefficient, usefulness of information obtained from correlation coefficient can be enhanced by partitioning them into direct and indirect effects for a set of a priori cause and effect interrelationship. The path coefficient analysis helps the breeder(s) to explain direct and indirect effects and hence has extensively been used in breeding work in different crop species by various researchers[10,1]. Zang & Zhou[15] reported that number of pod per plant, seeds per pod and 1000–seed weight were positively correlated with seed yield. On the other hand, length of Pods was negatively correlated with seed yield. Singh & Singh[12] reported greatest positive direct effect of pods per plant, seeds per plant and seed weight on seed yield. The objective of the study was to determine the interrelationships between some phonological, morphological yield components, yield and quality characters.

MATERIAL AND METHODS

Three cultivars Hyola 401, RGS–300 and PF704/91 (control) and twenty–four breeding lines (CA_1–CA_{24}) were used in this study. Field experiments were conducted on a clay soil with pH 8 in the Agriculture

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Research Station of Biekola in Mazandaran province (northern Iran) with average precipitation 650 to 700 mm during two consecutive cropping seasons: 2006–2007 and 2007-2008. The experiments were arranged in a randomized complete block design with 4 replications. Four rows of five meter length and 30 cm apart were planted for each genotype in each replication. The two center rows of each plot were harvested for yield and yield components measurement. Data for 12 different characters, including flowering duration (Fd), days to maturity (M), plant height (H), number of pod per plant (NPP), number of pods in main raceme (NPMR), number of pods in sub branches(NPSB), number of sub branches in plant (NSBP) length of Pod (PL), seeds per pod (NSP), 1000–seed weight (TSW), oil percentage (Oil) and seed yield per plant (Y) were recorded from 10 randomly selected plants. Oil content was determined by NMR. The correlation coefficients and the path coefficient analysis was conducted following the procedure developed by Wright[14] and applied by Dewey & Lu[3]. Yield per plant was kept as resultant variable and all other component characters as causal variables. Data were analyzed following the analysis of variance technique (ANOVA) and the mean differences were adjudged by Duncan's multiple range test[7].

RESULT AND DISCUSSION

Results of Yield and Yield Attributing Characteristics: Among the studied genotypes, minimum seed yield (2475 $Kg.h^{-1}$), the two years averaged data, was obtained from the genotype CA3 (Table 1) which could be attributed to the less number of pods per plant (131). The results showed that although the maximum number of pods per plant (178.87) obtained from genotype CA24, but it was not conducive enough to produce the maximum seed yield. The maximum seed yield (3851.1 $Kg.h^{-1}$), however was recorded for the genotype Hyola 401 corresponding to the maximum number of pods per sub-branches (126.5), higher number of pods per plant (169.8), maximum number of seeds per pod (24.4) and highest 1000-seed weight (4.3 g) which was coincided with the highest flowering duration (45 days). The superiority of the genotype Hyola 401 to the other genotypes was also observed by Zhang and Zhou[15].

Results of Correlation: The results of correlation coefficient between the traits studied are shown in table 2. Positive values were obtained between seed yield and the characters: flowering duration, number of pods per plant, number of pods in sub branches, number of seeds per pod, 1000–seed weight, and oil percentage, whereas negative values were obtained between seed yield and days to maturity, plant height and number of pods in main raceme. Positive relationships have frequently been cited between the seed yield and the number of pods per plant, as well as the number of seeds per pod[2,15]. In this study, seed yield was significantly and positive correlated with only number of pod per plant (r = 0.66), number of pods in sub branches (r = 0.74) and number of seeds per pod (r = 0.55).

The maximum significant and positive correlation coefficient was estimated for number of pods per plant and number of pods in sub branches (r = 0.88). The greatest of significant and negative correlation coefficient existed between flowering duration and days to maturity (r = -0.65). A significantly negative correlation was observed between plant height and number of pods in sub branches, but plant height had significantly and positively correlated with number of pods in main raceme, and their coefficients were -0.49 and 0.52, respectively. These results are in agreement with the results of Zang & Zhou[15].

Number of seeds per pod had significantly correlated only with seed yield. Non-significant positive correlation was detected between 1000–seed weight and seed yield. 1000–seed weight had significantly correlated with plant height (r = 0.57) and number of pods in main raceme (r = -0.41). These results disagreed the findings of Gabriele *et al.*,[5] and Zang & Zhou[15]. Weight of seeds per area unit was changed under the influence of genetic factor[13]. This subject can be considered as the agent of difference for two experiments. A significant positive correlation was observed between number of pods per plant and number of sub branches in plant (similar to number of pods per plant and number of pods in sub branches), and its coefficient was 0.43. These results confirm the findings of Ali *et al.*,[2]. Length of pod and oil percentage were not significantly correlated with all agronomic characters.

Results of Path Analysis: Since the simple correlation coefficients did not give clear information about the interrelationship between the causal and resultant variables, the correlation coefficient estimates were partitioned into direct and indirect effects to establish the intensity of effects of independent variables on dependent one. Correlation study revealed that the association among number of pod per plant, number of pods in sub branches and number of seeds per pod and seed yield showed positive and significant consistent trend. Path analysis indicated number of pods in sub branches and number of seeds per pod had positively associated with seed yield (Fig 1).

Table 1: Mean comparison of the traits related to 27 studied genotypes (The Data presented are average of two cropping seasons 2006-2007 and 2007-2008)

Genotype	Days to Flower initiation	Flowering period	Days till maturity	Total number of pods per plant	number of see per pod	1000-seed weight (g)	number of pods in main stem	number of pods in sub-branches	Seed oil percentage	Seed yield $Kg.ha^{-1}$
CA1	152.5 ef	32.25 ef	225.75 ab	157.69 ac	23.6 ac	3.75 g-j	43.54 g	114.15 ab	46.1 a-c	3428.ac
CA2	147.75 j	34.25 de	222.25 f-j	135.75 bc	19.8 d-g	3.70 h-j	61.31 ab	74.44 e-h	45.78 a-g	275 f-I
CA 3	152 e-g	29.75 g-i	221.5 f-j	131.9 cd	20.58 b-g	3.75 g-j	58.29 a-f	73.66 e-h	47.5 d-b	2475 h-I
CA 4	150.25 hi	31.75 fg	222.75 f-j	147.65 ac	21.66 a-g	3.95 c-g	49.1 d-g	98.55 b-d	44.01 f-h	2804.2 e-I
CA 5	150.25 hi	31.25 f-h	222.25 f-j	164.12 ac	21.87 a-g	4 c-g	52.33 b-f	111.79 ab	45.90 a-g	3162.5 b-g
CA 6	152 eg	32.5 ef	224.25 b-f	137.03 bc	20.65 a-g	3.75 g-j	59.87 a-e	77.16 e-g	43.89 f-h	2450 I
CA 7	148.5 j	32.75 ef	221.25 f-j	156.03 a-c	22.95 a-d	4 c-g	57.27 b-f	98.76 b-d	45.77 a-g	3479.2 a-c
CA 8	157.5 c	27.75 ij	225.5 a-c	152.36 a-c	24.05 ab	3.55 j-k	55.68 b-g	96.68 b-e	47.60 a	3377.5 a-d
CA 9	151 f-h	27.5 ij	220 kl	142.25 a-c	21.22 a-g	3.95 c-h	64.06 a-c	78.19 e-g	44.28 e-h	2883.3 d-i
CA10	159 b	29.5 g-i	225.75 ab	102.08 d	21.37 a-g	3.8 f-j	46.12 fg	55.96 i	46.85 a-c	2675 g-I
CA11	155 d	29.25 hi	223.25 d-h	159.42 a-c	21.97 a-f	3.9 c-h	57.27 b-f	102.15 b-g	46.13 a-c	3337.5 a-e
CA12	148 j	32.25 ef	222.25 f-j	155.44 a-c	22.59 a-d	4.3 ab	48.68 d-g	106.75 bc	47.30 ab	3457.5 a-c
CA13	161 a	25.75 jk	225.75 ab	150.92 a-c	20.25 c-g	4.15 a-d	53.5 b-g	97.42 b-d	47.25 ab	3158.3 b-g
CA14	157 c	26 jk	225.25 ab	152.69 a-c	24.40 a	4.1 a-c	45.52 fg	107.17 bc	43.83 f-h	3537.5 ab
CA15	152 e-g	30.25 f-h	225.5 a-c	149.09 a-c	19.93 c-g	4.2 a-c	50.52 d-g	98.57 b-d	44.14 e-h	3012 b-h
CA16	153 e	25 k	230.5 jk	159.98 a-c	20.35 b-g	4.3 ab	51.33 c-g	108.65 bc	41.09 i	2940 b-h
CA17	145.25 k	37 c	220.5 jk	167.39 a-c	21.14 a-g	4.05 c-g	70.47 a	96.91 b-e	44.72 d-h	3229.2 b-f
CA18	151.2 f-h	30.25 f-h	223.5 c-g	136.31 b-c	18.44 fg	4.1 a-c	45.62 fg	90.69 c-f	45.48 b-h	2829.2 c-I
CA19	150.7 g-j	31.25 f-h	223.25 d-h	142.31 a-c	21.22 a-g	3.65 i-k	64.66 ab	77.65 e-g	44.92 c-h	2508.3 hi
CA20	149.25 ij	30.25 f-h	221 j-k	148.65 a-c	17.94 g	3.85 f-j	50.16 b-g	94.48 b-e	45.65 a-g	2933 b-h
CA 21	160 ab	22.75 l	224.75 a-c	150.78 a-c	21.63 a-g	4.35 a	47.35 efg	103.5 b-d	43.10 h	3125 b-g
CA22	144 k	35.25 cd	219.5 kl	152.06 a-c	18.79 e-g	4.3 ba	48.56 defg	103.43 b-d	46.65 a-h	2654.2 h-j
CA23	156 cd	29 hi	225.75 ab	150.72 a-c	22.42 a-c	3.8 f-j	56.1 b-g	94.6 b-e	44.44 e-h	2488.3 hi
CA 24	159.7 ab	24.5 kl	226.75 a	178.87 a	19.41 d-g	3.4 k	65.58 ab	113.29 ab	44.70 d-h	3466.7 a-c
Hyola 401	122 n	45.25 ab	213.5 m	169.83 ab	24.40 a	4.3 ab	43.37 g	126.46 a	47.15 ab	3851.2 a
Sarigol	137 l	43.75 b	223 d-h	156.63 a-c	22.84 a-d	3.7 h-j	50.31 d-g	106.31 bc	43.77 gh	3095.8 b-g
RGS-003	129 m	47 a	218.25 l	155.75 a-c	22.73 a-d	3.65 i-k	44.87 fg	111.88 ab	46.77 a-c	3465.8 a-c

Table 2: Correlation coefficients between characters calculated from twenty–seven rapeseed which were grown under Biekola ecological conditions in 2006.

	FD	M	H	NPP	NPMR	NPSB	NSB	LP	NSP	TSW	Oil	Y
FD	1											
M	-0.65**	1										
H	-0.43**	0.58**	1									
NPP	0.16	-0.23	-0.26	1								
NPMR	-0.20	0.09	0.52**	0.09	1							
NPSB	0.25	-0.26	-0.49**	0.88**	-0.38*	1						
NSB	0.55**	-0.43*	0.01	0.43*	0.06	0.36	1					
LP	0.21	0.36	0.35	0.09	-0.15	0.15	-0.05	1				
NSP	0.27	-0.07	-0.10	0.23	-0.28	0.35	0.21	0.30	1			
TSW	0.08	-0.33	0.57**	0.11	-0.41*	0.30	-0.14	0.19	-0.03	1		
Oil	0.28	-0.16	-0.14	-0.14	-0.07	0.30	-0.13	-0.11	0.13	-0.16	1	
Y	0.22	-0.21	-0.34	0.66**	-0.28	0.74**	0.36	0.16	0.55**	0.16	0.20	1.00

* : Significant at $P = 0.05$, ** : Significant at $P = 0.01$. {flowering duration (FD), days to maturity (M), plant height (H), number of pod per plant (NPP), number of pods in main raceme (NPMR), number of pods in sub branches(NPSB), number of pods in sub branches (NSB), length of Pod (LP), number of seeds per pod (NSP), 1000–seed weight (TSW), oil percentage (Oil) and seed yield (Y).}

The number of pods in sub branches have the greatest direct effect on seed yield (0.567) and it´s indirect effects by all yield components except the length of pod were positive. The greatest indirect effect of the trait was related to number of seeds per pod (0.116), whereas between number of pods in sub branches and number of pods per plant was greatest of significant and positive correlation coefficient, but it had non-significantly correlated with and number of pods per plant.

The data further indicated that the total positive effect of number of seeds per pod (0.387) on yield per plant was the result of positive and indirect effect of number of pods in sub branches (0.170) and number of pods per plant (0.017). Ghoshi & Mukhopadhyay(1994) also reported the same results in *Brassica rapa*. The indirect effect of this trait by way of 1000–seed weight on seed yield was -0.001. These results disagree the findings of Ali *et al*.,[2] and Masood *et al*.,[9], because they found significant and positive correlation between number of seeds per pod and 1000–seed weight.

The direct effect of pods per plant followed by number of pods in sub branches was (0.499) and number of seeds per pod (0.092), respectively on plant yield. These results confirm the findings of Singh & Singh[12] and Sheikh *et al*.,[11]. The indirect effect of number of seeds per pod on yield through its association with 1000-seed weight was zero. Path coefficient analysis showed that the indirect effect of 1000–seed weight were negligible and inconsistent. The direct effects of length of Pod were all negative and of least importance.

Conclusion: The averaged data obtained from two years of experiments showed that number of pods per plant, number of pods in sub branches and number of seeds per pod had highly significant correlation with plant yield. By partitioning the mutual relationship among the independent variables into direct and indirect effects on yield, it came into account that number of pods in sub branches and number of seeds per pod were the only characteristics that exhibited the

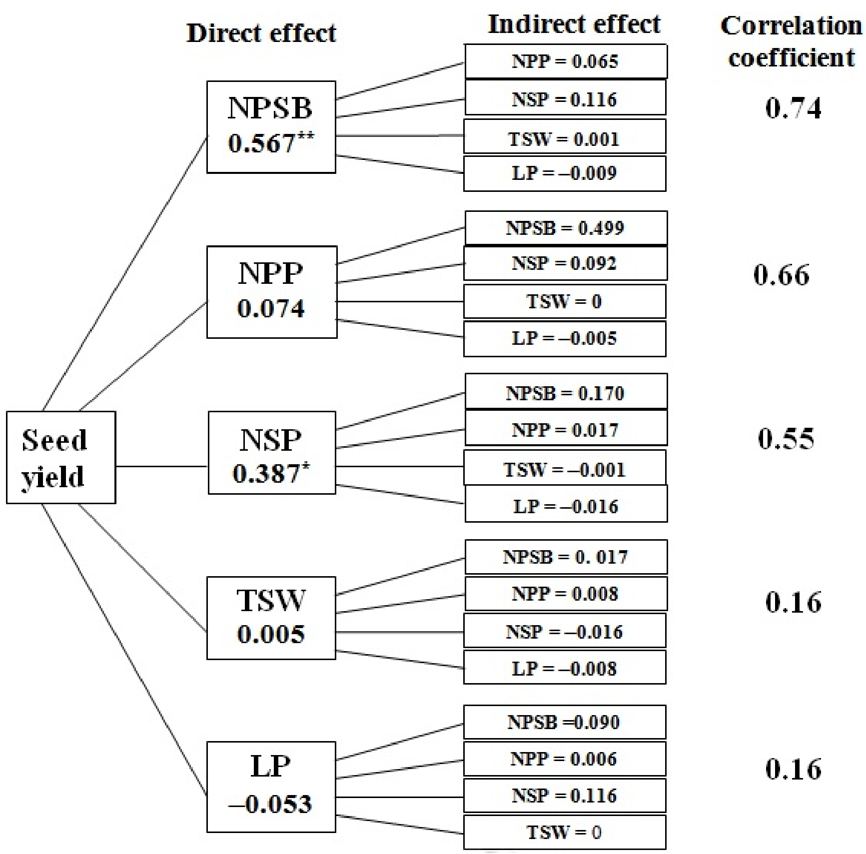

Fig. 1: Path-coefficient values estimated for seed yield and other five characters
* : Significant at P = 0.05, ** : Significant at P = 0.01. number of pod per plant (NPP), number of pods in sub branches(NPSB), number of pods per Plant (NSP), length of Pod (LP), number of seeds per pod (NSP), 1000-seed weight (TSW).

highest direct effect on yield per plant. These results revealed the importance of the number of pods in sub branches and number of seeds per pod as a criterion for oilseed rape yield improvement. Therefore, selection for increasing seed yield through these traits might be more successful.

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