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Association studies for yield components in mustard (*Brassica juncea* and *Brassica rapa)* in Gangetic alluvium zone of West Bengal

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Abstract
The present field experiment was conducted at Teaching Farm, Mondouri of Bidhan Chandra Krishi Viswavidyalaya for two consecutive years during *rabi* 2016-17 and *rabi* 2017-18 to study the correlation and path analysis among 15 genotypes of *Brassica juncea* and 7 genotypes of *Brassica rapa* for yield and yield attributing traits grown under randomized block design with three replications. The statistical analysis was done using Windostat ® ver. 8.5 software. The genotypic correlations were observed higher value than the corresponding phenotypic correlations in both *B. juncea* & *B. rapa* over the years. The number of siliqua per plant, number of seeds per siliqua and 1000 seed weight were important yield contributing characters for both *Brassica species*. The plant height, 1000 seed weight, number of primary branches and number of siliqua per plant were the most pronounced characters which have a direct contribution on yield in both *Brassica juncea* and *Brassica rapa*.

Keywords: *Brassica juncea, Brassica rapa*, correlation, path analysis, yield

Introduction

Mustard belongs to family Cruciferae (Syn. *Brassicaceae*) and genus Brassica. The origin of mustard is China and from there it was introduced to India [1, 2]. Indian mustard (*Brassica juncea*, 2n=4x=36) and yellow sarson (*Brassica rapa*, 2n=2x=20) are the important species largely grown as an oilseed crop in subtropical and tropical countries. Indian mustard also known as brown mustard is natural amphidiploid having chromosome number (2n=36). In general, this is self-pollinated with a certain amount of cross-pollination (2-15 %) due to insects and other factors. The total production of mustard seed in India is estimated to be more than 72.82 lakh tonnes. In West Bengal, rapeseed and mustard occupy a prime place amongst the oilseed crops with 4.58 lakh hectares area, 4.99 lakh tonnes of production with a productivity of 1090 kg/ha. (*Source: Department of Agriculture, Govt. of West Bengal).*

The genetic variation among the traits is of prime importance for plant breeder for selecting desirable types. Simple correlation analysis, which shows relationships among independent traits and the degree of the linear relationship between these traits, cannot provide detailed and actual knowledge in the relation between the dependent variable and predictor variables. The path analysis developed by Wright [3], clarifies relationships between traits deeply whereas, correlation coefficients are used to discuss the relationships in a simple manner [4]. Path coefficients are standardized partial regression coefficients which individually provide a measure of the direct effect of a causal factor on the effect variable. The method of analysis by path coefficients requires a cause-and-effect relationship among correlated variables [5]. The selections based only on simple correlation coefficients may mislead the breeders to find their principal breeding purposes. Path coefficient analysis measures the inter-association among yield components for their direct and indirect effects on grain yield by correlation. The investigation of direct and indirect effects of various characters on yield is of prime importance to increase the productivity of crops. Path analysis provides the basis for success in plant breeding and increases grain yield [6].

Materials and methods

The present investigation was carried out in two successive seasons i.e. during *rabi* 2016-17 and r*abi* 2017-2018 at the Teaching Farm, Mondouri of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The 15 genotypes of *Brassica juncea* and 7 genotypes of *Brassica rapa* were used in the present field experiment (Table 1). The soil of the experimental field is Gangetic alluvial and sandy loam texture having pH of 6-6.5 with the good drainage facilities. The climatic condition of this region is subtropical humid with a short and mild winter.

Table 1: List of 15 genotypes of *Brassica juncea* and 7 genotypes of *Brassica rapa*.

Sl. no	Genotypes / Varieties	Group	Type	Developing Institution	Source of Seed materials
1.	Pusa Bold	*Brassica juncea*	Indian Mustard	IARI, New Delhi	ICAR-DRMR, Bharatpur
2.	Varuna (T-59)	*Brassica juncea*	Indian Mustard	CSAUA & T, Kanpur, UP	ICAR-DRMR, Bharatpur
3.	Pusa Mustard 25 (NPJ -112)	*Brassica juncea*	Indian Mustard	IARI, New Delhi	ICAR-DRMR, Bharatpur
4.	Kranti	*Brassica juncea*	Indian Mustard	GBPUA & T, Pantnagar	ICAR-DRMR, Bharatpur
5.	NRCHB 101	*Brassica juncea*	Indian Mustard	ICAR-DRMR, Bharatpur	ICAR-DRMR, Bharatpur
6.	Sarama	*Brassica juncea*	Indian Mustard	PORS, Berhampore	PORS, Berhampore, WB
7.	Sita	*Brassica juncea*	Indian Mustard	PORS, Berhampore	PORS, Berhampore, WB
8.	Pusa Mustard 28 (Ej-124)	*Brassica juncea*	Indian Mustard	IARI, New Delhi	ICAR-DRMR, Bharatpur
9.	Pusa Mustard 27(Ej-17)	*Brassica juncea*	Indian Mustard	IARI, New Delhi	ICAR-DRMR, Bharatpur
10.	Pusa Mahak (JD 6)	*Brassica juncea*	Indian Mustard	IARI, New Delhi	ICAR-DRMR, Bharatpur
11.	Urvashi	*Brassica juncea*	Indian Mustard	CSAUA & T, Kanpur, UP	ICAR-DRMR, Bharatpur
12.	Vardan	*Brassica juncea*	Indian Mustard	CSAUA & T, Kanpur, UP	ICAR-DRMR, Bharatpur
13.	RH 406	*Brassica juncea*	Indian Mustard	CCAHAU, Hissar, Haryana	ICAR-DRMR, Bharatpur
14.	RH 749	*Brassica juncea*	Indian Mustard	CCAHAU, Hissar, Haryana	ICAR-DRMR, Bharatpur
15.	Giriraj (DRMRIJ- 31)	*Brassica juncea*	Indian Mustard	ICAR-DRMR, Bharatpur	ICAR-DRMR, Bharatpur
16.	PT 303	*Brassica rapa*	Toria	GBPUA & T, Pantnagar	ICAR-DRMR, Bharatpur
17.	Uttara (PT 2002-25)	*Brassica rapa*	Toria	GBPUA & T, Pantnagar	BHU, Varanasi, UP
18.	Tapeswari (TK 06-1)	*Brassica rapa*	Toria	CSAUA & T, Kanpur, UP	BHU, Varanasi, UP
19.	Binoy (B-9)	*Brassica rapa*	Yellow Sarson	PORS, Berhampore	PORS, Berhampore
20.	YSB 401	*Brassica rapa*	Yellow Sarson	CCAHAU, Hissar, Haryana	ICAR-DRMR, Bharatpur
21.	NRCYS 05 02	*Brassica rapa*	Yellow Sarson	ICAR-DRMR, Bharatpur	ICAR-DRMR, Bharatpur
22.	Pitambari (RYSK 05-02)	*Brassica rapa*	Yellow Sarson	CSAUA & T, Kanpur, UP	BHU, Varanasi, UP

The crop was sown in Randomized Block Design (RBD) under three replications. Under each replication, every genotype was sown in three rows of 6 m length and 1.5 m width with a spacing of 30 cm between the rows and 10 cm between the plants within rows was maintained. All the required agronomic cultural practices and plant protection measures were practiced for raising the good crop.

The observations were taken on five randomly selected plants from every plot and an average value for these five plants was used for the statistical analysis while for the days to 50% flowering and days to flowering to maturity it was taken on a plot basis. The observations were recorded for days to 50% flowering (DF), days to flowering to maturity (DFM), plant height (PH) in cm, length of the main fertility axis (LFA) in cm, primary branches per plant (PBPP), number of secondary branches (SB), number of siliqua per plant (SPP), number of seeds per siliqua (SPS), 1000-seed weight (1000 SW) in gram and yield per plant (YPP) in gram. In the present investigation, both the genotypic and phenotypic correlations and the path coefficient analysis was estimated with the help of Windostat ® ver. 8.5 software for statistical data analysis. The yield was taken as the effect while ten other characters related to yield was taken as the causal factors.

Results and discussion

The association of seed yield with other component characters is studied by correlation studies whereas the direct and indirect components are analyzed by the path coefficient analysis. In the present analysis, the correlation estimates at the phenotypic level (r_p) and at the genotypic level (r_g) had shown a close correspondence for all the characters under study. The genotypic correlations were reported to be higher than the corresponding phenotypic correlations. It indicates the inherent association among all the traits under study. This supports by the findings of Kumar *et al.*, 2013 [7], Shweta 2013 [8], Ara *et al.*, 2013 [9] and Sharma *et al.*, 2014 [10].

Phenotypic and genotypic correlation

In the first year in case of *Brassica juncea* seed yield per plant was observed to be correlated positively and significantly with the number of siliqua, 1000 seed weight, number of seeds/siliqua and number of secondary branches at both phenotypic level and genotypic level. However, for the traits like the height of the plant, the length of the main fertility axis was found significantly negatively correlated. In the second year, the seed yield per plant was observed to be correlated positively and significantly with the number of siliqua, 1000 seed weight, number of seeds per siliqua at both phenotypic level as well as genotypic level. The character number of primary branches and number of secondary branches were positively correlated to yield per plant but was non-significant for phenotypic values whereas it was significant for genotypic values. The traits like the length of the main fertility axis, plant height was found negatively correlated and significant (Table 2 and Table 3).

Similarly, for *Brassica rapa* during 2016-17, seed yield per plant was observed to be correlated positively and significantly with all the characters at both phenotypic level (Table 4) as well as the genotypic level (Table 5). Number of siliqua, number of seeds per siliqua, 1000seed weight, number of primary branches, length of the main fertility axis were found to be positively correlated and highly significant. Here, days to flowering to maturity and plant height is significant but negatively correlated. During the second year, the seed yield per plant was observed to be correlated positively and significantly with all the characters. However, the traits like days to flowering to maturity, plant height, length of the main fertility axis were negatively correlated and significant. Bind *et al.,* 2014 [11] and Basalma 2008 [12] showed that seed yield per plant correlated positively and significantly with the number of siliqua per plant. Shweta 2013 [8] and Roy *et al.,* 2011 [13] in their finding reported that 1000-seed weight had a positive but non-significant correlation with seed yield.

Table 2: Phenotypic Correlation coefficients among 10 quantitative characters of *Brassica juncea* genotypes (above the diagonal for first-year i.e. *rabi* 2016-17 and below the diagonal for the second year i.e. *rabi* 2017-18)

	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	1000SW (gm)	YPP (gm)
DF	1.0000	0.0703	0.0978	-0.2093*	0.2555*	0.4572*	0.4413*	0.0964	0.1805*	0.0645
DFM	0.3090*	1.0000	0.4418*	0.0749	0.0777	0.0765	-0.0396	0.1418	-0.1721*	-0.1135
PH(cm)	0.1446	0.1543*	1.0000	0.6614**	-0.0647	-0.3414*	-0.2342*	-0.2326*	-0.0239	-0.1236
LFA (cm)	-0.1231	-0.0764	0.6921**	1.0000	0.0583	-0.6268**	-0.5889**	-0.3169*	0.0656	-0.3161*
PBPP	0.2602**	0.5016**	0.0354	-0.0899	1.0000	0.4192*	0.1013	-0.3684*	0.2645*	-0.0614
SB	0.4122**	0.2108*	-0.3204*	-0.5642**	0.4158*	1.0000	0.5303*	0.0778	0.1286*	0.3761*
SPP	0.3081*	0.2069*	-0.2191*	-0.5917**	0.2785*	0.7119**	1.0000	-0.0045	0.4168*	0.4958*
SPS	0.1151	0.0979	-0.2120*	-0.1857*	-0.2595*	-0.0083	-0.0752	1.0000	-0.2458*	-0.0902
1000SW (gm)	0.0001	-0.0708	-0.1545*	0.0320	0.0967	0.0460	0.2675*	-0.0006	1.0000	0.4475*
YPP (gm)	-0.0136	-0.0507	-0.0351	-0.2490*	0.0672	0.1468*	0.4847*	-0.2684*	0.4093*	1.0000

*significant at the 0.05 probability level **significant at the 0.01 probability level

Table 3: Genotypic Correlation coefficients among 10 quantitative characters of *Brassica juncea* genotypes (above the diagonal for first-year i.e. *rabi* 2016-17 and below the diagonal for the second year i.e. *rabi* 2017-18)

	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	1000SW (gm)	YPP (gm)
DF	1.0000	0.8433**	0.2187*	-0.3086*	0.4522*	0.6889**	0.6714**	0.1506	0.3302*	0.1494
DFM	0.7139**	1.0000	0.5320*	0.1096	0.0979	0.0812	-0.0726	0.3346*	-0.3513*	-0.1421
PH(cm)	0.2880*	0.1256	1.0000	0.6926**	-0.0642	-0.3791*	-0.2387*	-0.3785*	-0.1407	-0.1313
LFA (cm)	-0.1738*	-0.0820	0.7580**	1.0000	0.0716	-0.6550**	-0.6094**	-0.5029*	0.0864	-0.3191*
PBPP	0.4359*	0.5543**	-0.0059	-0.0997	1.0000	0.4726*	0.1379	-0.6425**	0.3349*	-0.0427
SB	0.6052**	0.2282*	-0.3749*	-0.6050**	0.4405*	1.0000	0.5574**	0.1015	0.1831*	0.4282*
SPP	0.3663*	0.2433*	-0.2342*	-0.6225**	0.3137*	0.7460**	1.0000	-0.0557	0.5471**	0.5355*
SPS	-0.0507	0.2081*	-0.3842*	-0.3448*	-0.5629**	0.0235	-0.1531*	1.0000	-0.8096**	-0.2366*
1000SW (gm)	-0.0756	-0.0898	-0.1957*	0.0525	0.1446	0.0742	0.4118*	-0.8051**	1.0000	0.6042**
YPP (gm)	0.0513	-0.0595	-0.0521	-0.2895*	0.0431	0.1580*	0.5069**	-0.3636*	0.6653**	1.0000

*significant at the 0.05 probability level **significant at the 0.01 probability level

Table 4: Phenotypic Correlation coefficients among 9 quantitative characters of *Brassica rapa* genotypes (above the diagonal for first-year i.e. *rabi* 2016-17 and below the diagonal for the second year i.e. *rabi* 2017-18)

Character	DF	DFM	PH (cm)	LFA(cm)	NPB	SPP	SPS	SW(g)	YPP (g)
DF	1.0000	0.8829**	0.8856**	0.5834**	0.6512**	0.5842**	0.7392**	0.7110**	0.4369*
DFM	0.7924**	1.0000	0.7535**	0.6038**	0.6438**	0.2933*	0.6691**	0.7352**	0.4474*
PH(cm)	0.7373**	0.8349**	1.0000	0.6624**	0.5437**	0.5422**	0.6974**	0.6335**	0.6232**
LFA(cm)	0.3886*	0.7101**	0.5985**	1.0000	0.4117*	0.0844	0.6532**	0.5877**	0.2030*
NPB	0.4562*	0.6454**	0.5132*	0.3688*	1.0000	0.2092*	0.6484**	0.5264*	0.4580*
SPP	0.7030**	0.2930*	0.3700*	0.0806	-0.0188	1.0000	0.4217*	0.2341*	0.5454**
SPS	0.4608*	0.6873**	0.5578**	0.6861**	0.6166**	0.1025	1.0000	0.6707**	0.5768**
SW9(g)	0.1707*	0.3194*	0.4275*	0.2963*	-0.0129	0.1540*	0.3083*	1.0000	0.2105*
YPP (g)	0.6723**	0.6624**	0.6823**	0.4721**	0.6688**	0.2761*	0.7310**	0.1483	1.0000

*significant at the 0.05 probability level **significant at the 0.01 probability level

Table 5: Genotypic Correlation coefficients among 9 quantitative characters of *Brassica rapa* genotypes (above the diagonal for first-year i.e. *rabi* 2016-17 and below the diagonal for the second year i.e. *rabi* 2017-18)

Character	DF	DFM	PH (cm)	LFA(cm)	NPB	SPP	SPS	SW(g)	YPP (g)
DF	1.0000	0.3270*	0.9749**	0.8845**	0.9003**	0.3939*	0.4306*	-0.2970*	0.7344**
DFM	-0.4960**	1.0000	0.3390*	-0.4069*	-0.6252**	0.7627**	0.5795**	0.3914*	-0.0051
PH(cm)	0.8548**	-0.1751*	1.0000	0.0670	0.6562**	0.4086*	0.7944**	-0.3190*	0.8081**
LFA(cm)	0.5012*	-0.0869	0.1872*	1.0000	-0.3489*	0.9122**	0.8602**	0.8846**	0.1043*
NPB	0.3169*	-0.6196**	0.2584*	0.1734*	1.0000	-0.2340*	0.3337*	0.3870*	0.4195*
SPP	0.6861**	0.1625*	0.3323*	0.2439*	-0.4493*	1.0000	0.3833*	-0.2000*	0.4102*
SPS	0.1181	0.6909**	0.5896**	0.3650*	0.8287**	-0.5010**	1.0000	0.1440*	0.4501*
SW(g)	0.3046*	-0.2170*	0.5901**	0.2285*	-0.2024*	0.3924*	0.2499*	1.0000	-0.9596**
YPP (g)	0.6868**	-0.7345**	0.9420**	0.1342	0.8926**	0.0470	0.3292*	0.0441	1.0000

*significant at the 0.05 probability level **significant at the 0.01 probability level

Path Analysis

In the case of *B. juncea* for 2016-17, direct positive effect on yield at phenotypic level was observed for the number of secondary branches and 1000 seed weight (Table 6). The direct effects of days to 50%flowering, days to flowering to maturity, length of main fertility axis, and the number of seeds per siliqua, plant height, were found negative. All other characters such as the number of siliqua per plant, the number of primary branches had a small direct positive effect. While Indirect effect at the phenotypic level was recorded as small and nominal for many character pairs. Days to 50% flowering had a positive indirect effect via the length of the main fertility axis while it showed a negative indirect effect with the rest of the characters. Days to flowering to maturity had a positive indirect effect via the number of siliqua while it showed a negative indirect effect with the rest of the characters. Plant height had a positive indirect effect via days to 50% flowering and days to flowering to maturity while it showed a negative indirect effect with the rest of the characters. At genotypic level days to 50 %flowering, number of secondary branches, and 1000seed weight and number of siliqua, number of primary branches, were found to have a direct positive effect on yield in that order (Table 7). The direct effects of Days to flowering to maturity, length of main fertility axis, and the number of seeds per siliqua plant height were found negative. While indirect effects at the genotypic level were recorded as small and nominal for many character pairs.

In the case of *B. juncea* for the year 2017-18**,** the phenotypic effect for the number of siliqua, the number of primary branches and 1000 seed weight were found to have a direct positive effect on yield in that order (Table 8). The direct effects of days to 50 % flowering, days to flowering to maturity, length of main fertility axis, number of secondary branches, plant height, and number of seeds per siliqua were found negative. While Indirect effect at the phenotypic level was recorded as small and nominal for many character pairs.

Table 6: Direct and indirect effects of component traits on seed yield on *Brassica juncea* at the phenotypic level for *rabi* season 2016-17

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (g)
DF	-0.254	-0.018	-0.025	0.0531	-0.065	-0.116	-0.112	-0.025	-0.0458
DFM	-0.006	-0.086	-0.038	-0.0065	-0.007	-0.007	0.0034	-0.012	0.0148
PH(cm)	0.018	0.0812	0.1838	0.1216	-0.012	-0.063	-0.043	-0.043	-0.0044
LFA (cm)	0.0217	-0.008	-0.069	-0.1039	-0.006	0.0651	0.0612	0.0329	-0.0068
PBPP	-0.09	-0.027	0.0227	-0.0204	-0.351	-0.147	-0.036	0.1292	0.0927
SB	0.2294	0.0384	-0.171	-0.3145	0.2104	0.5018	0.2661	0.039	0.0645
SPP	0.0804	-0.007	-0.043	-0.1073	0.0185	0.0966	0.1822	-8E-04	0.0759
SPS	-0.011	-0.016	0.0254	0.0345	0.0402	-0.009	0.0005	-0.109	0.0268
SW (g)	0.0749	-0.071	-0.01	0.0273	0.1098	0.0534	0.173	-0.102	0.4152
YPP (gm)	0.0645	-0.114	-0.124	-0.3161	-0.061	0.3761	0.4958	-0.09	0.4475
Partial R²	-0.016	0.0098	-0.023	0.0328	0.0215	0.1887	0.0903	0.0098	0.1858

R Square = 0.4997 Residual Effect =0.5073

Table 7: Direct and indirect effects of component traits on seed yield on *Brassica juncea* at Genotypic level for *rabi* season 2016-17

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (gm)
DF	0.6272	0.5289	0.1371	-0.1936	0.2836	0.4321	0.4211	0.0945	-0.2071
DFM	-0.407	-0.483	-0.257	-0.053	-0.047	-0.039	0.0351	-0.162	-0.1697
PH(cm)	0.1176	0.2862	0.5379	0.3725	-0.035	-0.204	-0.128	-0.204	-0.0757
LFA (cm)	0.3117	-0.111	-0.699	-1.009	-0.072	0.6615	0.6154	0.5079	-0.0872
PBPP	-0.293	-0.063	0.0415	-0.0464	-0.647	-0.306	-0.089	0.4159	0.2168
SB	0.2025	0.0239	-0.111	-0.1925	0.1389	0.2939	0.1638	0.0298	0.0538
SPP	-0.645	0.0697	0.2292	0.5852	-0.132	-0.535	-0.96	0.0535	-0.5254
SPS	-0.044	-0.097	0.1095	0.1455	0.1859	-0.029	0.0161	-0.289	0.2342
SW (gm)	0.2788	-0.297	-0.119	0.073	0.2828	0.1546	0.462	-0.684	0.8445
YPP (gm)	0.1494	-0.142	-0.131	-0.3191	-0.043	0.4282	0.5355	-0.237	0.6042
Partial R²	0.0937	0.0686	-0.071	0.3223	0.0276	0.1259	-0.514	0.0685	0.5103

R Square = 0.6319 Residual Effect =0.5067

Table 8: Direct and indirect effects of component traits on seed yield on *Brassica juncea* at the phenotypic level for *rabi* season 2017-18

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (g)
DF	-0.073	-0.023	-0.011	0.009	-0.019	-0.03	-0.022	-0.008	0
DFM	-0.021	-0.066	-0.01	0.0051	-0.033	-0.014	-0.014	-0.007	-0.0047
PH(cm)	0.0447	0.0476	0.3087	0.2137	0.0109	-0.099	-0.068	-0.065	-0.0477
LFA (cm)	0.055	0.0341	-0.309	-0.4464	0.0401	0.2518	0.2641	0.0829	-0.0143
PBPP	-0.011	-0.021	-0.002	0.0038	-0.043	-0.018	-0.012	0.011	0.0041
SB	-0.098	-0.05	0.0764	0.1345	-0.099	-0.238	-0.17	0.002	-0.011
SPP	0.1188	0.0798	-0.085	-0.2281	0.1074	0.2745	0.3856	-0.029	0.1032
SPS	-0.029	-0.025	0.054	0.0473	0.0661	0.0021	0.0192	-0.255	0.0002
SW (g)	0	-0.027	-0.059	0.0121	0.0366	0.0174	0.1012	-2E-04	0.3784
YPP (g)	-0.014	-0.051	-0.035	-0.249	0.0672	0.1468	0.4847	-0.268	0.4093
Partial R²	0.001	0.0034	-0.011	0.1112	-0.003	-0.035	0.1869	0.0684	0.1549

R Square = 0.4770 Residual Effect = 0.5232

Table 9: Direct and indirect effects of component traits on seed yield on *Brassica juncea* at Genotypic level for *rabi* season 2017-18

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (g)
DF	0.4683	0.3343	0.1349	-0.0814	0.2041	0.2834	0.1715	-0.024	-0.0354
DFM	-0.09	-0.126	-0.016	0.0103	-0.07	-0.029	-0.031	-0.026	-0.0113
PH(cm)	-0.079	-0.035	-0.275	-0.2085	0.0016	0.1031	0.0644	0.1057	-0.0538
LFA (cm)	0.0337	0.0159	-0.147	-0.1941	0.0194	0.1174	0.1208	0.0669	0.0102
PBPP	-0.121	-0.154	0.0016	0.0277	-0.278	-0.123	-0.087	0.1567	-0.0402
SB	-0.422	-0.159	0.2616	0.4222	-0.307	-0.698	-0.521	-0.016	-0.0518
SPP	0.2482	0.1649	-0.159	-0.4219	0.2126	0.5056	0.6777	-0.104	0.2791

SPS	0.0221	-0.091	0.1675	0.1504	0.2455	-0.01	0.0668	-0.436	0.3511
SW (gm)	-0.008	-0.01	-0.021	0.0056	0.0155	0.008	0.0443	-0.087	0.1075
YPP (gm)	0.0513	-0.06	-0.052	-0.2895	0.0431	0.158	0.5069	-0.364	0.6653
Partial R²	0.024	0.0075	0.0143	0.0562	-0.012	-0.11	0.3435	0.1586	0.0716

R Square = 0.5534 Residual Effect = 0.4683

While direct effect at the genotypic level for days to 50% flowering, number of siliqua, number of primary branches, and 1000 seed weight were found to have a direct positive effect on yield in that order.The direct effects of days to flowering to maturity, plant height, length of main fertility axis, number of secondary branches, number of seeds per siliqua were found negative. While Indirect effects at the genotypic level were recorded as small and nominal for many character pairs (Table 9).

Similarly, in *B. rapa* during 2016-17, the direct effect at phenotypic level was observed for days to 50% flowering, days to flowering to maturity, plant height, the number of siliqua were found to have a direct positive effect on yield in that order (Table 10). The direct effects of length of main fertility axis, the number of secondary branches and 1000seed weight were found negative. Similarly, Indirect effect at the phenotypic level was recorded as small and nominal for many character pairs. For the year 2017-18 in case of *B. rapa* the direct effect at the phenotypic level for days to 50%flowering, length of main fertility axis, number of primary branches, number of seeds per siliqua were reported to be positive on yield in that order (Table 11). The direct effects of days to flowering to maturity, number of secondary branches, plant height and 1000 seed weight were found negative. The indirect effect at the phenotypic level was recorded as small and nominal for many character pairs. Days to 50% flowering had a positive indirect effect via days to flowering to maturity, plant height, length of the main fertility axis, number of primary branches, number of siliqua, number of seeds/siliqua, 1000seed weight while it showed a negative indirect effect via the number of secondary branches. Plant height had a positive indirect effect via all the characters while it showed a negative indirect effect via the number of secondary branches.

In the first year (2016-17) the direct effect at the genotypic level for days to 50% flowering, days to flowering to maturity, length of main fertility axis, number of primary branches, number of seeds per siliqua have a direct positive effect on yield in that order (Table 12). The direct effects of 1000seed weight, plant height, number of secondary branches were found negative. While indirect effects at the genotypic level were recorded as small and nominal for many character pairs.

Table 10: Direct and indirect effects of component traits on seed yield on *Brassica rapa* at the phenotypic level for *rabi* season 2016-17

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (gm)
DF	0.4223	0.3728	0.3739	0.2464	0.275	-0.362	0.2467	0.3121	0.3002
DFM	0.215	0.2435	0.1836	0.1471	0.1568	0.7923	0.0714	0.163	0.1791
PH(cm)	0.5164	0.4395	0.5831	0.3863	0.317	0.2435	0.3162	0.4067	-0.3694
LFA (cm)	-0.27	-0.279	-0.306	-0.4624	-0.19	-0.023	-0.039	-0.302	-0.2718
PBPP	0.0058	0.0058	0.0049	0.0037	0.009	-0.427	0.0019	0.0058	0.0047
SB	0.3962	0.026	0.0434	0.0322	0.4313	-0.762	-0.032	-0.601	-0.712
SPP	-0.112	-0.056	-0.104	-0.0162	-0.04	0.682	-0.192	-0.081	0.0449
SPS	0.2565	0.2322	0.242	0.2266	0.225	0.17	0.1463	0.347	0.2327
SW (gm)	-0.397	-0.411	-0.354	-0.3285	-0.294	-0.57	-0.131	-0.375	0.559
YPP (gm)	0.6369	0.5474	0.6232	0.203	0.458	0.5656	0.421	0.4768	0.2105
Partial R²	0.2689	0.1333	0.3634	-0.0938	0.0041	-0.002	-0.081	0.1655	-0.1177

R Square = 0.6430 Residual Effect = 0.4975

Table 11: Direct and indirect effects of component traits on seed yield on *Brassica rapa* at the phenotypic level for *rabi* season *rabi* 2017-18

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (g)
DF	0.8228	0.652	0.6067	0.3197	0.3754	-0.321	0.5784	0.3792	0.1404
DFM	-0.634	-0.8	-0.668	-0.5678	-0.516	-0.06	-0.234	-0.55	-0.2554
PH(cm)	0.2943	0.3332	0.3991	0.2389	0.2048	-0.034	0.1477	0.2226	-0.1706
LFA (cm)	0.0263	0.0481	0.0405	0.0677	0.025	0.512	0.0055	0.0465	-0.0201
PBPP	0.1176	0.1663	0.1323	0.095	0.2577	0.0652	-0.005	0.1589	0.0033
SB	-2.376	0.0234	0.3813	0.5212	0.236	0.162	0.4365	-0.222	-0.64
SPP	-0.185	-0.077	-0.097	-0.0212	0.0049	0.289	-0.263	-0.027	0.0404
SPS	0.2365	0.3527	0.2863	0.3521	0.3165	-0.365	0.0526	0.5132	0.1582
SW (g)	-0.007	-0.013	-0.018	-0.0124	0.0005	0.2343	-0.007	-0.013	-0.0419
YPP (g)	0.6723	0.6624	0.6823	0.4721	0.6688	0.6544	0.2761	0.731	0.1483
Partial R²	0.5531	-0.53	0.2723	0.032	0.1724	-0.177	-0.073	0.3752	-0.0062

R Square = 0.7966 Residual Effect =0.4510

Table 12: Direct and indirect effects of component traits on seed yield on *Brassica rapa* at Genotypic level for *rabi* season 2016-17

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (g)
DF	-0.756	-0.247	-0.737	-0.6684	-0.68	-0.06	-0.298	-0.325	0.2244
DFM	-0.112	-0.343	-0.116	0.4826	0.2145	-0.09	-0.262	-0.542	-0.8202
PH(cm)	1.3635	0.4741	1.3986	0.0937	0.9177	-0.001	0.5715	1.1111	-0.4462
LFA (cm)	0.0548	-0.087	0.0041	0.062	-0.022	1.421	0.0565	0.0533	-0.1168
PBPP	0.0041	-0.003	0.003	-0.0016	0.0046	0.51	-0.001	0.0061	0.0109

SB	-0.26	0.4777	0.1821	-0.056	-0.182	-0.257	-0.58	-0.207	-1.37
SPP	0.0667	0.1291	0.0692	0.1545	-0.04	0.65	0.6777	0.0649	0.1693
SPS	0.0838	0.3075	0.1547	0.1675	0.2597	1.37	0.0746	0.1947	0.2227
SW (g)	0.0293	-0.236	0.0315	-0.1858	-0.235	0.165	0.0986	-0.113	0.0986
YPP (g)	0.7344	-0.005	0.8081	0.1043	0.4195	0.4657	0.4102	0.4501	-0.9596
Partial R²	-0.555	0.0018	1.1302	0.0065	0.0019	0.0021	0.0695	0.0876	0.0946

R Square = 0.8370 Residual Effect = 0.4037

Table 13: Direct and indirect effects of component traits on seed yield on *Brassica rapa* at Genotypic level for *rabi* season 2017-18

Character	DF	DFM	PH(cm)	LFA (cm)	PBPP	SB	SPP	SPS	SW (g)
DF	1.0518	-0.522	0.8991	0.5272	0.3334	-0.04	0.7216	0.1242	0.3204
DFM	-0.2	0.4033	-0.071	-0.8416	-0.25	0.542	0.0655	0.2786	-0.0875
PH(cm)	0.3528	-0.072	0.4127	0.0773	0.1067	0.1402	0.1371	0.2434	-0.2436
LFA (cm)	0.1829	-0.761	0.0683	0.3648	0.0633	0.625	0.089	0.498	-0.0834
PBPP	-0.068	0.1321	-0.055	-0.037	-0.213	0.3	0.0958	-0.39	0.0432
SB	-0.44	0.2343	0.1462	0.0423	0.1111	-0.374	0.2841	-0.244	-0.38
SPP	-0.572	-0.136	-0.277	-0.2034	0.3747	-0.165	-0.834	0.4178	0.3272
SPS	0.0271	0.1584	0.1351	0.3128	0.4191	-0.22	-0.115	0.2292	0.0573
SW (gm)	-0.088	0.0627	-0.171	-0.066	0.0585	-0.352	-0.113	-0.072	-0.2888
YPP (g)	0.6868	-0.735	0.942	0.1342	0.8926	0.7432	0.047	1.3292	0.0441
Partial R²	0.7224	-0.296	0.3888	0.0489	-0.19	-0.136	-0.039	0.3046	-0.0127

R Square = 0.9264 Residual Effect = 0.2713

Days to 50% flowering had a positive indirect effect via plant height, length of main fertility axis, number of primary branches, number of siliqua, number of seeds/siliqua, 1000seed weight while it showed negative indirect effect via rest of the characters. Days to flowering to maturity had a positive indirect effect via the number of siliqua, number of seeds/siliqua, while it showed a negative indirect effect via the rest of the characters. Similarly, the direct and indirect effects of component traits on seed yield on *Brassica rapa* at Genotypic level for 2nd year is presented in table 13.

In the present investigation, plant height revealed negative direct effect indicating limited scope for genetic improvement of grain yield based on selection through these traits. In contrast, a positive and significant direct effect for grain yield was observed in the number of primary branches per plant, the number of siliquae per plant at the phenotypic level. This confirms the previous findings reported by Ali *et al*., 2003 [14]; Yadava *et al.,* 2011 [15], Kardam and Singh 2005 [16] and Basalama 2008 [12]. The path analysis helps in the analysis of the association of seed yield with direct and indirect components to decipher a cause and effect relationship. If the correlation between yield and a character is due to the direct effect of a character, it reveals the true relationship between them and direct selection for this trait will be effective for yield improvement. However, if the correlation coefficient is mainly due to the indirect effects of the character through another component trait, indirect selection through such trait will be effective in yield improvement. The results of this investigation agree with Doddabhimappa *et al*., 2009 [17]; Ara *et al*., 2013 [9] and Kumar *et al*., 2015 [18]. Azadgoleh *et al.,* 2009 [19] Nasim *et al.,* 2013 [20] also found similar results in *Brassica napus.*

Conclusion

On the basis of phenotypic and genotypic correlations, the number of characters such as number of secondary branches, number of siliqua per plant, number of seeds per siliqua and 1000 seed weight were identified as important yield contributing characters for *Brassica juncea* whereas number of primary branches, number of siliqua per plant, number of seeds per siliqua and 1000 seed weight were identified as important yield contributing characters in case of *Brassica rapa*. A negative correlation was observed for the character days to 50% flowering, days to flowering to maturity, plant height, length of main fertility axis in both the cases of *Brassica juncea* and *Brassica rapa.* The path analysis study in the present investigation revealed that the plant height, 1000 seed weight, number of primary branches and number of siliqua per plant are the most pronounced characters which have a direct contribution on yield in case of both *Brassica juncea* and *Brassica rapa*.

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References

1. Prain D. The mustards cultivated in Bengal. - Agr. Ledger. 1898; 5:1-80.
2. Bailey LH. The cultivated Brassicas, - Gentes Herbarum. 1992; 1:53-108.
3. Wright S. Correlation and Causation. Journal of Agricultural Research. 1921; 20:557-585.
4. Ciftci V, Toay N, Toay Y, Doan Y. Determining relationships among yield and some yield components using path coefficient analysis in chickpea (*Cicer arietinum* L.). Asian. J. Plant. Sci. 2004; 3:632-635.
5. Samonte SOPB, Wilson LT, Medley JC, Pinson SRM, McClung AM, Lales JS. Nitrogen utilization efficiency. Relationships with grain yield, grain proteins, and yield-related traits in rice. Agronomy Journal. 2006; 98:168-176.
6. Milton E, McGiffen Jr, Dan James Pantone, John B. Masiunas. Path Analysis of Tomato Yield Components in Relation to Competition with Black and Eastern Black Nightshade Journal of the American Society for Horticultural Science. 1994; 119:6-11
7. Kumar S, Chand P, Sirohi A, Kumar V, Kumar P. Studies on relationship among yield components and selection criteria for yield improvement in Indian mustard (*Brassica Juncea* L. Cezern & Coss.). Progressive Agriculture. 2013; 13(1):181-186
8. Shweta. Correlation and path coefficient analysis of yield and yield components of Indian mustard (*Brassica juncea* L.), Journal of Hill Agriculture. 2013; 4(1):44-46.

9. Ara S, Afroz S, Noman MS, Bhuiyan MSR, Zia MIK. Variability, correlation and path analysis in F2 progenies of inter-varietal crosses of *Brassica rapa*; Journal of Environmental Science & Natural Resources. 2013; 6(1):217-220.
10. Sharma RM, Kumar B, Kumar K, Chauhan MP. Character association of some quantitative traits with grain yield in Indian mustard [*Brassica juncea* (L.) Czern and Coss.]; Trends in Biosciences. 2014; 7(18):2688-2691.
11. Bind D, Singh D, Dwivedi VK. Genetic variability and character association in Indian mustard [*Brassica juncea* (L) Czerns & Coss]; Agricultural Science Digest. 2014; 34(3):183-188.
12. Basalma D. The correlation and path analysis of yield and yield components of different rapeseed (*Brassica napus* ssp *oleifera* L) cultivars. Research Journal of Agriculture and Biological Sciences. 2008; 4:120-125.
13. Roy SK, Haque S, Kale VA, Asabe DS, Dash S. Variability and character association in rapeseed-mustard (*Brassica* sp.). Journal of crop and weed. 2011; 7(2):108-112.
14. Ali N, Javidfar F, Elmira JY, Mirza MY. Relationship among yield components and selection criteria for yield improvement in winter rapeseed (*Brassica napus L*.). Pakistan Journal of Botany. 2003; 35(2):167-174.
15. Yadava DK, Giri SC, Vignesh M, Vasudev S, Yadav KA, Dass B. Genetic variability and trait association studies in Indian mustard (*Brassica juncea*). Indian Journal of Agricultural Sciences. 2011; 81:712-716.
16. Kardam DK, Singh VV. Correlation and path analysis in Indian mustard (*Brassica juncea* (L.) Czern and Coss) grown under rainfed condition. Journal of Spices and Aromatic Crops. 2005; 14(1):56-60.
17. Doddabhimappa R, Gangapur B, Prakash G, Salimath PM, Ravikumar RL, Rao MSL. Correlation and path analysis in Indian mustard (*Brassica juncea* L. Czern and Coss), Karnataka Journal of Agricultural Sciences. 2009; 22(5):971-977.
18. Kumar P, Yadav RK, Singh L. Correlation analysis and study of genetic parameters for different attributes in Indian mustard, (*Brassica juncea* L. Cezern & coss.) Environment and Ecology. 2015; 33(3A):1401-1406.
19. Azadgoleh E, Zamani MA, Yasari EM. Agronomical important traits correlation in rapeseed (*Brassica Napus* L.) Genotypes Research Journal of Agriculture and Biological Sciences. 2009; 5(5):798-802.
20. Nasim A, Farhatullah, Iqbal S, Shah S, Azam SM. Genetic variability and correlation studies for morpho-physiological traits in *Brassica napus* L. Pakistan Journal of Botany. 2013; 45(4):1229-1234.