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Study of Path Analysis for Seed yield and its Associated Characters in Indian Mustard [*Brassica juncea* (L) Czern and Coss]

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Abstract :-In *rabi* season 2018-19, 22 strains/cultivars including Varuna of Indian mustard were raised in a randomized block design with three replications for the study of correlation coefficient and path analysis regarding yield and its contributing characters. Analysis of variance (ANOVA) exhibited significant among genotypes for all 12 characters. Number of siliquae per plant, biological yield and harvest-index had a significant positive associationship with yield. Contrary, days to flower and siliqua-length exhibited negative correlation coefficient at genotypic level with the yield. Path analysis revealed direct, indirect and residual effects as the causation of associationship among various attributes. The residual effect (R) was estimated 1.086. Biological yield, number of siliquae/plant and harvest index had also positive direct effects for the yield, respectively. Negative correlation coefficients between yield and two characters *viz*. days to flower and siliqua-length were noted but their direct effects were positive

Key words: Indian mustard, Brassica juncea, Correlation coefficient and Path analysis.

Introduction:-

Indian mustard, the most important member of rapeseed mustard group, especially for north Indian population because of liking the oil due to its bitter pungency preferred by them for their kitchen preparations. Indian mustard (*Brassica juncea* L.) which is commonly called *Rai, Raya or Laha* is an allotetraploid belongs to family *Brassicacea* 2n=AABB=36. Two basic species were involved in natural hybridization and chromosome doubling *i.e*. *B. compestris* (2n=AA=20) X *B. nigra* (2n=BB=16) for its evolution. Indian mustard was originated in Middle East due to interspecific hybridization (Prakash, 1980). Hemingway (1976) believed China is secondary centre of origin of Indian mustard from where it reached into India.

Among the rapeseed mustard group, Indian mustard had a lion share (more than 75%) in area and production (Singh, 1993). Due to a high demand of edible oil, India imported 15 million tonnes of edible oil worth approximately 7300 crores INR in 2019 and increased edible oil consumption 19.5 kg/head/year from 15.8 kg in 2012-13 (Jha *et al*., 2021). The price of 1 litre refined mustard oil varied between 180 - 200 INR in 2021. It is not only today's problem but India has been paying second highest import cost after crude oil and natural gas. Yellow revolution was initiated by GOI in 1986-87 to enhance the area, production and productivity of rapeseed-mustard and sesame for self reliance with other seven edible oil production. The average mustard oil recovery varies 36-44% with high palatability. Mustard cake has good protein content, 93-115 iodine number and approximately 1.5% essential oil (used in perfume industry). Therewhy, the suitable genotypes' variability, adaptability and suitability for stresses and yield quality are required to screen out them.

The need of energy from visible and non-visible fats is reversible proportionate to the age of the human being. It is highest in infants and least in adults. Now-a-days, the GOI maintains the consumption at 19 kg fat/capita/annum since last three years which is approximately one-third of consumption rate in European Union. The high yielding varieties may be evolved to reduce the gap between demand and supply. To assess the associationship between yield and its components and its partition into direct, indirect and residual effects would provide knowledge for choosing of beneficial characters (genes) through suitable breeding programmes.

Materials and Methods:-

All 23 genotypes/cultivars of Indian mustard were sown at *Nidharia* agricultural farm of SMM Town PG College, Ballia, UP, India in a randomized block design (RBD) with three replications in *rabi* season, 2018-
19. The plot spacing was two rows of 2.4 m X 0.40 m X 0.3 m. There was once little rain and no frost during the cropping period with temperature ranging from 7° C to 30.28 °C and relative humidity varying 48.14% to77.8%. The data were collected on randomly selected five plants per plot per replication for 12 characters namely days to 50% flowering, plant height (cm), number of primary branches per plant, number ofsecondary branches per plant, number of siliquae per plant, siliquae length, number of seeds per siliquae, days to maturity, biological yield (g), 100 seed weight/test weight (g), harvest index and seed yield per plant. Days to flower and maturity were counted from the day of sowing to almost 50% blossom and pale yellow color of per plot. Rest attributes' data were averaged for estimation of analysis of variance (ANOVA) as per method suggested by Panse and Sukhatme (1961). Correlation coefficient and path analysis were estimated as per procedure of Wright (1921) and Dewey and Lu (1959), respectively.

Result and Discussion:-

Analysis of variance for all characters was found significant, exhibiting an appropriate variation among genotypes. A high heritability (broad sense) was noted for all characters except primary branches.

The genotypic (r_g) and phenotypic (r_p) correlation coefficients for 11 characters are given in Table-1. A positive significant associationship was found between yield and biological yield; number of siliquae per plant and harvest index at genotypic level. Contrary to these, days to flower and siliqua length exhibited negative correlation coefficient with seed yield per plant at genotypic level. Harvest index vs yield had positive and significant correlation at phenotypic level also.

A high positive significant correlation coefficients at both genotypic and phenotypic levels between some important attributes were recorded *viz*. between days to flower and number of primary branches, plant height, days to maturity, seeds per siliqua, biological yield and test weight. But, on the other hand, it had negative magnitudes for secondary branches, harvest index as well as seed yield. Similarly, primary branches were positively correlated with height, siliquae number and length, maturity and biological yield but negative for harvest index.

A very high magnitude of associationship was found between plant height and days to maturity, biological yield and test weight. Similarly, longer siliquae had more seeds (0.789 and 0.702, respectively) at genotypic and phenotypic level. Longer maturity period gave positive associationship value with biological yield but negative to harvest-index. A higher test weight had reciprocal magnitudes of harvest-index but proportionalto biological yield.

Insight of all above correlations, it might be concluded that a taller plant had taken more flowering and maturity period, more primary branches but poor secondary branches and siliqua number , high biological yield but poor harvest index. A breeder can increase the yield if he chooses genotypes which are taller alon with early flowering but late maturity period. Biological yield and harvest-index will exhibit their importance in combination with above mentioned attributes at the time of selection of parents. Mather and Jinks (1982) also opined that complex character yield was the result of many sub-characters governed by separate genes and simple inheritance pattern of sub-characters. Magnitudes of correlation coefficients were predominantly result of either pleiotropic effect or linkage (coupling and repulsion) based on loci of two or more genes onto one chromosome or their corresponding homologues respectively. Similar results were also reported by Gangapur *et al*. 2009, Shekhawat *et al.* 2014 and Ali *et al*. 2017; while negative results were given by Singh *et al.* 2011 and Tiwari *et al.* 2017.

The results of path analysis are depicted in Table No-2. The yield *per se* and variable character which were recorded positive significance with yield as well as negative significance at genotypic level were really important. Their magnitudes partitioned along with direction into direct and indirect effects. The negative magnitude of associationship with seed yield (-0.246) and days to flower indicate that not only early flowering would be responsible for high yield in genotypes but also having a high (+ve) magnitude of directeffect (0.553). The negative correlation between both characters was due to high (-ve) indirect effects of primary branches number (-0.929), harvest index (-0.560), siliquae number/plant (-0.319), seeds per siliqua (-0.161), test weight (-0.156), etc. Almost similar negative correlation coefficient between seed yield and siliqua length (-0.240) along with other positive direct and indirect effects *viz*., biological yield (0.468),

flower days (0.319). Other important attributes like primary branches/plant, number of seeds/siliqua, siliquaenumber had shown indirect negative effect onto it. As stated earlier, harvest index, number of siliquae/plant and biological yield had exhibited a positive and meaningful relationship with seed yield per plant. These characters had a very high positive direct effect along with few other indirect effects. However, few characters also gave negative indirect effects at the time of partitioning of correlation values.

A high magnitude of residual effect (R=1.0863) depicts the importance of some more valuable character which could affect the accuracy and precision of results had left out. The value of residual effect may changethe real cause and effect of attributes. Similar findings were also found by Gangapur *et al*. 2009, Prasad and Patil 2018 and Pal *et al*. 2019. Antagonistic results were reported by Singh *et al.* 2013, Tantuway *et al*. 2018and Singh *et al.* 2018.

On the basis of such findings it would be suggested that the gene types had really diverse genes and suitable for selection of parents on the basis of early flowering but late maturity period attributes along with smaller siliqua length but high siliquae number coupled with high harvest index. This results would be more realisticif attributes had high heritability.

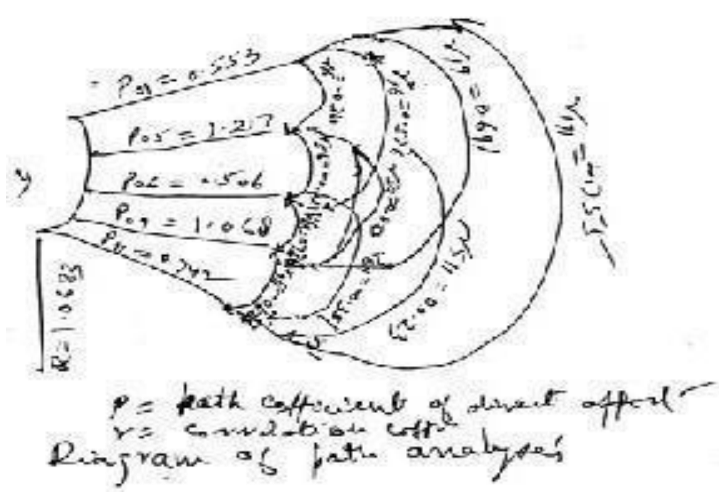

Table-1 Genotypic and Phenotypic Correlation Coefficients among 12 characters in Indian Mustard

Characters	Days to 50% flowering	Number of primary branches	Number of secondary branches	Plant height (cm)	Number of siliquae per plant	Siliqua length (cm)	Days to maturity	Seeds per siliqua	Biological yield(g)	Test weight(g)	Harvest index (%)	Seed yield per plant(g)
Days to 50% flowering	r(g) r(p)	0.550** 0.360**	-0.539** -0.525**	0.784** 0.736**	0.262* -0.258**	0.576** 0.549**	0.725** 0.714**	0.428** 0.365**	0.691** 0.681**	0.351** 0.311**	-0.755** -0.737**	-0.246* -0.233
Number of primary branches		r(g) r(p)	-0.146 -0.075	0.335** 0.213	0.545** 0.325**	0.444** 0.273*	0.629** 0.395**	0.213 0.650	0.594** 0.381**	0.062 0.041	-0.45.** -0.256**	-0.033 0.026
Number of secondary branches			r(g) r(p)	-0.382** -0.361**	0.559** 0.550**	-0.668** -0.637**	-0.315** -0.305*	0.668** 0.578**	-0.292** -0.280**	0.197 0.177	0.336** 0.332**	0.197 0.203
Plant height(cm)				r(g) r(p)	-0.112 -0.104	0.290* 0.258*	0.707** 0.691**	0.300* 0.249*	0.628** 0.620**	0.524** 0.480**	-0.575** -0.561**	-0.039 -0.042
Number of siliquae per plant					r(g) r(p)	-0.224 -0.211	0.111 0.106	-0.337** -0.261*	0.023 0.025	0.023 0.014	0.216 0.216	0.307* 0.302*
Siliqua length (cm)						r(g) r(p)	0.383** 0.371**	0.789** 0.702**	0.288* 0.275*	-0082 -0076	-0.35.** -0.339**	-0.240* -0.235
Days to maturity							r(g) r(p)	0.255* 0.209	0.728** 0.710**	0.349** 0.333**	0.604** -0.593**	0.035 0.024
Seeds per siliqua								r(g) r(p)	0311** 0.622**	-0157 -0126	-0.378** -0.310	-0.200 -0.181
Biological yield(g)									r(g) r(p)	0.456** 0.424**	-0.618** -0.619**	0.295* 0.289*
Test weight (g)										r(g) r(p)	-0.376** -0.319	0.052 0.049
Harvest index (%)											r(g) r(p)	0.537** 0.550

r_p= Phenotypic Correlation Coefficient ** P=0.01

r_g = Genotypic Correlation Coefficient * P=0.05

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Table-2 Direct and Indirect Effects of 11 characters on Seed Yield in Indian Mustard

Characters	Days to 50% flowering	No. of primary branches	No.of secondary branches	Plant height (cm)	No. of siliquae per plant	Siliqua length (cm)	Days to maturity	Seeds per siliqua	Biological yield (g)	Test weight (g)	Harvest index (%)	Seed yield per plant (g)
Days to 50% flowering	**0.553**	-0.929	0.057	-0.121	0.319	0.292	-0.028	-0.161	1.125	-0.156	-0.560	-0.246*
No. of primary branches	0.301	**1.588**	0.016	0.054	0.664	0.225	0.024	0.080	0.967	0.027	0.335	0.033
No. of secondary branches	-0.298	0.247	**-0.106**	0.062	0.681	-0.338	0.012	0.251	-0.475	-0.087	0.250	0.197
Plant height (cm)	0.414	-0.566	0.041	**-0.162**	-0.136	0.147	-0.027	-0.113	1.022	-0.232	-0.427	-0.039
No. of siliquae per plant	-0.145	-0.920	0.060	0.018	**1.217**	-0.114	-0.004	0.126	0.038	-0.010	0.160	0.307*
Siliqua length (cm)	0.319	-0.750	0.071	-0.047	-0.273	**0.506**	-0.015	-0.296	0.468	0.036	-0.261	-0.240*
Days to maturity	0.402	-1.062	0.034	-0.114	0.136	0.196	**-0.038**	-0.096	1.181	-0.155	-0.449	0.035
Seeds per siliqua	0.237	-0.360	0.071	-0.049	-0.410	0.400	-0.010	**-0.375**	0.507	0.070	-0.261	-0.200
Biological yield (g)	0.382	-1.002	0.031	-0.102	0.028	0.146	-0.028	-0.117	**1.628**	-0.206	-0.466	0.295*
Test weight (g)	0.194	0.105	-0.021	-0.085	0.028	-0.042	-0.013	0.059	0.758	**-0.443**	-0.279	0.052
Harvest index (%)	-0.418	0.761	-0.093	0.093	0.263	-0.178	-0.023	0.142	-1.022	0.167	**0.742**	0.537**

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