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Virendra Bahadur
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Ankaj Tiwari
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Shivam Dubey
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Lal Ji Bharti
Department of plant breeding and genetics, Dr. RPCAU, Pusa, Bihar, India

Avanish Kumar
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

KN Maurya
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Virendra Bahadur
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Analysis of character association and cause-effect on relationship of yellow mustard for yield and its components

Virendra Bahadur, Ankaj Tiwari, Shivam Dubey, Lal Ji Bharti, Avanish Kumar and KN Maurya

Abstract
The experiment was conducted for study of correlation and path analysis at Research Farm of Department of Genetics & Plant Breeding, ANDUAT, Kumarganj, Ayodhya (U.P.) during *rabi*, 2018 with 26 yellow mustard genotypes. The character association of the yield contributing traits, seed yield per plant (g) exhibited positive significant correlation with primary branches per plant, Silique on main raceme, length of main raceme, number of seed per silique and oil content (%). The selection based on these characters may be useful for yield improvement. The characters primary branches per plant, days to maturity, oil content (%), number of seeds per silique and length of main raceme positive direct effect was exhibited on seed yield per plant (g). The primary branches per plant, oil content (%), number of seed per silique, and length of main raceme have both positive significant and positive direct effect on seed yield per plant (g), that’s reason selection based on these characters can improve yield and yield contributing traits.

Keywords: Path coefficient, phenotypic correlation, correlation coefficient

Introduction
Field mustard (*Brassica rapa* L.) are originated near the Mediterranean Sea rather than from the Mediterranean coastal areas and it is also known as Bird rape/Yellow sarson/Turnip rape/Keblock/Colza. Oilseed Brassica are the world's third most important sources of vegetable edible oil. Rapeseed-Mustard crops are cultivated in 53 countries spreading over the six continents across the globe covered area. It comprises of several economically important species which yield edible roots, stems, leaves, buds, flowers and seed condiment. Yellow sarson is the major *Rabi*, oilseed crop, which is sown during October-November and the harvesting begins from February onwards. The seeds of field mustard contain 42-48% oil and 25% protein. It is self-compatible and largely self-pollinated crop (85-90%) (Shekhawat *et al.* 2014) [14]. India has area 6.23 million hector, production 9.34 million tons, and productivity 1499 kg/hector and also Uttar Pradesh has area 0.75 million hector, production 1.12 million tons and productivity 1483 kg/hector (2018-19). The *Brassica rapa* var. yellow *sarson* is major *Rabi* crop growing state are Rajasthan, Gujarat, M.P., Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Assam. India occupies third position in rapeseed-mustard production in the world after China and Canada.

India is the largest agrarian subcontinent supporting 26% world’s agricultural population on 12% arable land. India is also the fifth largest vegetable oil economy accounting 7.4% oil seeds, 5.8% oils and 6.1% oil meal production, and 9.3% of edible oil consumption in the world. The Indian mustard have nutritional value *viz.*, carbohydrates 4.51g, sugar 1.41g, dietary fiber 2g, fat 0.47g and protein 2.56g per 100g. Indian cultivars have high glucosinolate (18-120 µ moles (g) in seed meal) and contains adequate amount of two essential fatty acids, linoleic and linolenic. The oil of mustard possesses a sizable amount of erucic acid (38-57%), together with linolenic acid (4.7 to 13.0%). The protein content in rapeseed and mustard normally ranges between 24-30% on the basis of whole seed basis and between 35-40% on meal basis. But the presence of toxic glucosinolates in the mustard cake renders it unsuitable as a source of human protein.

The correlation coefficient which provides symmetrical measurement of degree of association between two variables or characters helps us in understanding the nature and magnitude of association among yield and yield components.

Path coefficient has been used to estimate the magnitude and direction of direct and indirect effects of various yield sand its contributing characters. Correlation coefficients along with path coefficients together provide more reliable information which can be effectively predicted in crop improvement programmed. If the correlation between yield and a character is due to direct effect of a character, it reveals true relationship between them and direct selection for this trait will be rewarding for yield improvement.

Material and Methods

The present investigation was conducted at Research Farm of Department of Genetics & Plant Breeding, Narendra Deva University of agriculture an Technology, Narendra Nagar, Ayodhya (U.P.) during *rabi*, 2017-18 with experimental materials 28 yellow mustard genotypes (Table 1) in Randomized Block Design. These lines were growing in three replications and single row length 3 meter spaced at 30cm apart. The distance between plant to plant 15cm was maintained by thinning. All the recommended dose of fertilizers and cultural practices were done. Geographical, this place is located at 26.56 ^{0}N latitude, and 81.83 ^{0}E longitudes and at an altitude of 113 m above from mean sea level in the gangetic plains of eastern U.P. this area falls in sub-tropical climatic zone. All the observations are recorded on five competitive plants from each plot were randomly selected except day to 50% flowering and days to maturity which were recorded on plot basis.

Table 1: List of field mustard genotypes and their source

S. No.	Genotype	Sources
1	NDYS08-1	NDUA &T, Kumarganj, Ayodhya
2	NDYS08-4	NDUA &T, Kumarganj, Ayodhya
3	NDYS-125	NDUA &T, Kumarganj, Ayodhya
4	NDYS11-3	NDUA &T, Kumarganj, Ayodhya
5	NDYS116-1	NDUA &T, Kumarganj, Ayodhya
6	NDYS-128	NDUA &T, Kumarganj, Ayodhya
7	NDYS11-2	NDUA &T, Kumarganj, Ayodhya
8	NDYS116-1	NDUA &T, Kumarganj, Ayodhya
9	NDYS16-12	NDUA &T, Kumarganj, Ayodhya
10	NDYS16-1	NDUA &T, Kumarganj, Ayodhya
11	NDYS16-7	NDUA &T, Kumarganj, Ayodhya
12	NDYS16-9	NDUA &T, Kumarganj, Ayodhya
13	NDYS16-10	NDUA &T, Kumarganj, Ayodhya
14	NDYS16-4	NDUA &T, Kumarganj, Ayodhya
15	NDYS16-8	NDUA &T, Kumarganj, Ayodhya
16	NDYS16-8	NDUA &T, Kumarganj, Ayodhya
17	NDYS16-5	NDUA &T, Kumarganj, Ayodhya
18	NDYS16-6	NDUA &T, Kumarganj, Ayodhya
19	YSCN16-1	DRMR Bharatpur, Rajasthan
20	YSCN16-2	DRMR Bharatpur, Rajasthan
21	YSCN16-3	DRMR Bharatpur, Rajasthan
22	YSCN16-4	DRMR Bharatpur, Rajasthan
23	YSCN16-5	DRMR Bharatpur, Rajasthan
24	YSCN16-6	DRMR Bharatpur, Rajasthan
25	Jagriti	NDUA &T, Kumarganj, Ayodhya
26	NDYS-2	NDUA &T, Kumarganj, Ayodhya

Association among different characters at genotypic and phenotypic levels. The simple correlation between different characters at genotypic and Phenotypic levels between characters was worked out as suggested by Al-jibouri *et al*., (1958). Path coefficient analysis was carried out according to Dewey and Lu (1959). Seed yield per plant was assumed to be dependent variable (effect) which is influenced by all the eight characters, the independent variable (cause), directly as well as indirectly through other characters.

Results and Discussions

Correlation coefficient

The phenotypic correlation coefficients computed between the nine characters under study are presented in Table-2. The genotypic correlation coefficients are more than the phenotypic correlation coefficients. The character seed yield per plant (g) exhibited positive significant correlation with primary branches per plant (0.661), Silique on main raceme (0.505), length of main raceme (0.414), number of seed per silique (0.563) and oil content (%) (0.576). However, seed yield per plant are found non-significant positive correlation with days to maturity (0.340) and plant height (cm) (0.178), and non-significant negative correlation with days to 50% flowering (-0.004).

Days to 50% flowering exhibited significant and positive phenotypic correlation with days to maturity (0.427). Days to maturity showed non-significant positive phenotypic correlation with all other characters. Plant height exhibited highly significant positive phenotypic correlation with length of main raceme (0.529) and non-significant for other characters. Primary branches per plant exhibited positive highly significant phenotypic correlation with seed yield per plant (g) (0.661), silique on main raceme (0.544), and number of seed per siliqua (0.534), significant and positive phenotypic correlation with oil content (%) (0.433) and length of main raceme (0.384). Silique on main raceme exhibited positive highly significant phenotypic correlation with length of main raceme (0.667), and seed yield per plant (g) (0.505), positive significant phenotypic correlation with oil content (%) (0.421) and number of seed per siliqua (0.398). Length of main raceme (cm) exhibited significant and positive phenotypic correlation with number of seed per siliqua (0.439), seed yield per plant (g) (0.414) and oil content (%) (0.387). Number of seed per siliqua exhibited highly significant and positive phenotypic correlation with oil content (%) (0.569) and seed yield per plant (g) (0.563). Oil content (%) showed highly significant and positive phenotypic correlation with seed yield per plant (g) (0.576)

The seed yield per plant are considered as super character which results from multiplicative interaction of several other characters that are termed as yield components. Therefore, identification of important yield components and information about their association with yield and also with each other is very useful for developing efficient breeding strategy for evolving high yielding varieties. In this respect, the correlation coefficient which provides symmetrical measurement of degree of association between two variables or characters helps us in understanding the nature and magnitude of association among yield and yield components. Seed yield per plant (g) exhibited positive significant correlation with primary branches per plant, silique on main raceme, lengh of main raceme, number of seed per silique and oil content (%), that's selection based on these characters may be useful for yield improvement and similar results were observed by Lodhi *et al.* (2013) [9], Mekonnen *et al.* (2014) [10], Naznin *et al.* (2015) [12], Joya *et al.* (2016) [7], Devi (2018) [5], Raliya *et al.* (2018) [13].

Path coefficient

The present results of phenotypic path coefficient of yield and yield contributing characters discussed here under which were presented in Table 3 and diagram 1. The primary branches per plant (0.431), days to maturity (0.221), oil content (%) (0.218), number of seed per silique (0.147), and length of main raceme (0.140) positive direct effect on seed yield per plant. The day to flowering 50% (-0.062), plant height (cm) (-0.102), and silique on main raceme (-0.025) negative direct effect on seed yield per plant. Day to flowering 50% had positive indirect effects via days to maturity (0.094) and silique on main raceme (0.002). Positive indirect effects of days to maturity were recorded via seed yield per plant (g) (0.340), primary branches per plant (0.072), oil content (%) (0.063), number of seed per siliqua (0.022) and length of main raceme (0.016). Plant height exhibited positive indirect contribution through seed yield per plant (g) (0.178), primary branches per plant (0.091), length of main raceme (0.074), oil content (%) (0.050), days to maturity (0.038) and number of seed per silique (0.036). Primary branches per plant had positive indirect effects via seed yield per plant (g) (0.661), oil content (%) (0.094), number of seed per siliqua (0.079), length of main raceme (0.054), days to maturity (0.037), and day to 50% flowering (0.001). Silique on main raceme exhibited positive indirect effect via seed yield per plant (g) (0.505), primary branches per plant (0.235), length of main raceme (0.093), oil content (%) (0.092), days to maturity (0.077), number of seed per siliqua (0.059) and day to 50% flowering (0.005). Length of main raceme exhibited positive indirect effects through seed yield per plant (g) (0.414), primary branches per plant (0.166), oil content (%) (0.084), number of seed per siliqua (0.065), days to maturity (0.025) and day to 50% flowering (0.006). Number of seed per silique exhibited positive indirect effects through yield per plant (g) (0.563), primary branches per plant (0.230), oil content (%) (0.124), length of main raceme (0.061), days to maturity (0.032), and day to 50% flowering (0.002). Positive indirect effects of seeds oil content (%) were recorded via seed yield per plant (g) (0.576), primary branches per plant (0.187), number of seed per siliqua (0.084), days to maturity (0.064), length of main raceme (0.054) and day to 50% flowering (0.003).

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of seed yield components on seed yield to provide clear picture of character association for formulating efficient selection strategy. Path analysis differs from simple correlations is that it point out the cause and their relative importance, whereas, the later measures simply the mutual association ignoring the causation. Path coefficient analysis of different characters contributing positive direct effect towards seed yield per plant revealed that primary branches per plant, days to maturity, oil content (%), number of seed per silique, and length of main raceme at phenotypic effect. Positive direct effects of various characters on seed yield per plant observed in the present study are in according to the finding of by Raliya *et al.* (2018) [13], Kumar *et al.* (2018) [8, 13], Devi (2018) [5], Mohan *et al.* (2017) [11], Joya *et al*. (2016) [7], Akabari and niranjana (2015) [2], Naznin *et al.* (2015) [12], Mekonnen *et al.* (2014) [10], Bind *et al.* (2013) [4], and Lodhi *et al*. (2013) [9].

Table 2: Phenotypic correlation coefficients

Character	Day to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Silique on main raceme	Length of main raceme	Number of seed per silique	Oil content (%)
Day to 50% flowering	1.000							
Days to maturity	0.427*	1.000						
Plant height (cm)	0.011	0.173	1.000					
Primary branch per plant	-0.016	0.167	0.211	1.000				
Silique on main raceme	-0.079	0.347	0.292	0.544**	1.000			
Length of main Race	-0.091	0.112	0.529**	0.384*	0.667**	1.000		
Number of seed per silique	-0.037	0.147	0.242	0.534**	0.398*	0.439*	1.000	
Oil content (%)	-0.056	0.288	0.227	0.433*	0.421*	0.387*	0.569**	1.000
Seed yield per plant (gm)	-0.004	0.340	0.178	0.661**	0.505**	0.414*	0.563**	0.576**

*, **: significant at 5%, and at 1% respectively.

Table 3: Phenotypic path coefficient

Character	Day to 50% flowering	Days to maturity	Plant height (cm)	Primary branches per plant	Silique on main raceme	Length of main raceme	Number of seed per silique	Oil content (%)
Day to 50% flowering	-0.062	-0.027	-0.001	0.001	0.005	0.006	0.002	0.003
Days to maturity	0.094	0.221	0.038	0.037	0.077	0.025	0.032	0.064
Plant height (cm)	-0.001	-0.018	-0.102	-0.022	-0.030	-0.054	-0.025	-0.023
Primary branch per plant	-0.007	0.072	0.091	0.431	0.235	0.166	0.230	0.187
Silique on main raceme	0.002	-0.009	-0.007	-0.013	-0.025	-0.016	-0.010	-0.010
Length of main Race	-0.013	0.016	0.074	0.054	0.093	0.140	0.061	0.054
Number of seed per silique	-0.005	0.022	0.036	0.079	0.059	0.065	0.147	0.084
Oil content (%)	-0.012	0.063	0.050	0.094	0.092	0.084	0.124	0.218
Seed yield per plant (gm)	-0.004	0.340	0.178	0.661**	0.505**	0.414*	0.563**	0.576**
Partial R^2	0.000	0.075	-0.018	0.285	-0.012	0.058	0.083	0.126

*, **: Significant at 5%, and at 1% respectively, R Square = 0.5959 Residual effect = 0.6357

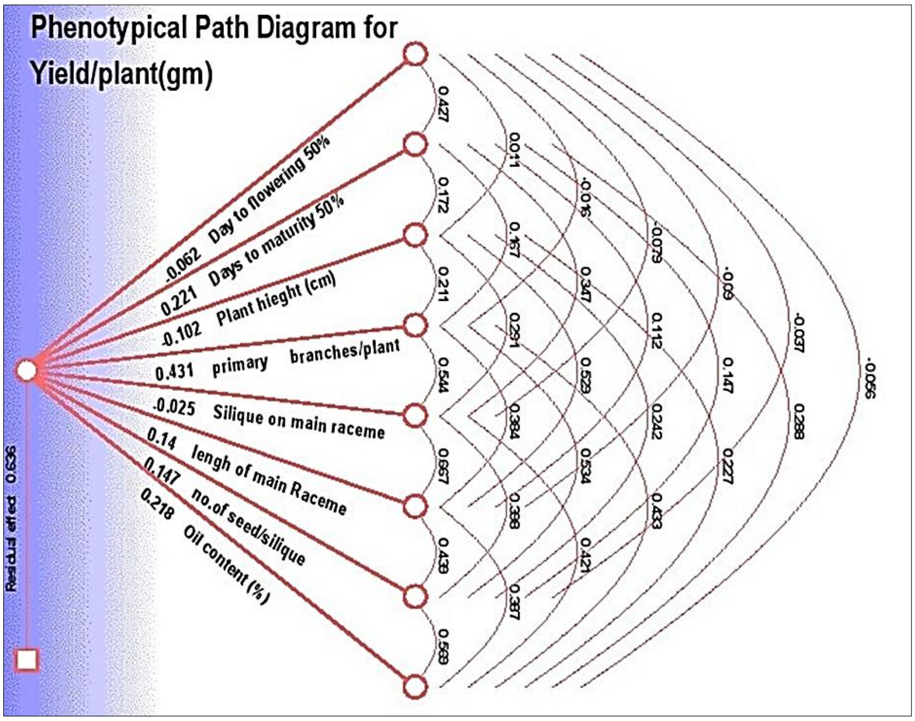

Fig 1: Phenotypic diagram for yield and yield contribute traits

Conclusion

Primary branches per plant, Silique on main raceme, length of main raceme, number of seed per silique and oil content (%) exhibited positive significant correlation with seed yield per plant (g). Primary branches per plant exhibited positive highly significant phenotypic correlation with seed yield per plant (g), silique on main raceme, and number of seed per siliqua, significant positive phenotypic correlation with oil content (%) and length of main raceme. Silique on main raceme exhibited positive highly significant phenotypic correlation with length of main raceme, and seed yield per plant (g), positive significant phenotypic correlation with oil content (%) and number of seed per siliqua. Length of main raceme exhibited highly significant and positive correlation with plant height (cm), primary branches per plant and silique on main raceme. Number of seed per silique exhibited highly significant and positive correlation with primary branches per plant, length of main raceme and silique on main raceme. The primary branches per plant, days to maturity, oil content (%), number of seed per silique, and length of main raceme positive direct effect on seed yield per plant. The primary branches per plant, length of main raceme, number of seed per silique and oil content (%) exhibited positive significant correlation and positive direct effect with seed yield per plant (g) that's selection based on these characters more useful for yield improvement.

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