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CORRELATION AND PATH CO-EFFICIENT ANALYSIS OF YIELD CONTRIBUTING TRAITS IN ADVANCED LINES OF *Brassica rapa* L.

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ABSTRACT

Twenty four genotypes including four check varieties of the species *Brassica rapa* L. were collected to estimating the magnitude of correlation and path co-efficient of different characters on seed yield per plant. The significant positive correlations with seed yield per plant were found in thousand seed weight, no. of siliqua per plant, no. of primary branches per plant. Path co-efficient analysis revealed that plant height, no. of primary branches per plant, no. of siliqua per plant, siliqua length, thousand seed weight showed positive direct effect with yield per plant. Days to 50% flowering, days to 80% maturity, no. of secondary branches per plant, no. of seed per siliqua showed negative direct effect on yield per plant. Beside these days to 50% flowering, days to 80% maturity, no. of secondary branches per plant, no. of seed per siliqua showed negative direct effect on yield per plant.

Key words: correlation, path co-efficient, *brassica rapa* L

INTRODUCTION

Brassica rapa L. commonly known as field mustard /turnip mustard is a plant widely cultivated as an oil seed. Rapeseed is a major oilseed crop in Bangladesh. It contributes a lion share to the total edible oil production in the country. *Brassica rapa* L. belonging to the family Brassicaceae and third most important oil crop in the world. Though the local cultivars of *Brassica juncea* and *Brassica napus* are high yielding, they are not short durable. That's why *Brassica rapa* L is grown widely in the country (Islam, 2013). Rapeseed is a crop supplying both edible oil as well as for industrial uses. It is not only a high energy food but also a carrier for fat soluble vitamins (A, D, E and K) in the body. The seeds of *Brassica rapa* L. contain 42% oil, 25% protein (Khaleque, 1985). Analysis of variability among the traits and the association of a particular character in relation to other traits contributing to yield of a crop would be of great importance in planning a successful breeding program (Mary and Gopalan, 2006). Determination of correlation coefficients is an important statistical procedure to evaluate breeding programs for high yield, as well as to examine direct and indirect contributions to yield variables (Ali *et al.,* 2003). The present study was undertaken to find out the relationship between different traits and the direct and indirect contribution of each trait towards yield in the advanced lines of *B. rapa* L.

MATERIALS AND METHODS

The present experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during November, 2013 to March, 2014. A total number of 24 (twenty four) materials were used in this experiment where four were check varieties. All the materials were collected from Department of Genetics and Pant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The materials used in the experiment is shown in Table 1. The experiment was

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laid out in Randomized Complete Block Design (RCBD) with three replications. Each replication size was 20 m × 3.5 m, and the distance between replication to replication was 1m. The spacing between line to line was 30 cm. Seeds were sown in lines in the experimental plots. The seeds were placed at about 1.5 cm depth in the soil.

Table 1. Materials used for the experiment

Sl. No.	Genotypes	Description of crosses
01	G1	SAUSR-03
02	G2	BARI-9×BARI-6(F_{12}) LINE-1
03	G3	BARI-6 ×TORI-7(F_{12}) LINE-1
04	G4	BARI-6×TORI-7 LINE-2
05	G5	BARI-9×BARRI-6 LINE-2
06	G6	SAU-1×SAU-2(F_4)
07	G7	SAU-1×BARI-15(F_4)
08	G8	SAUSR 17
09	G9	BARI-9×BARI-6(F_{12}) LINE-3
10	G10	F_6×BARI-9 LINE-1
11	G11	F_6× BARI-9 LINE-2
12	G12	BARI-6× TORI-7 (F_{12}) LINE-3
13	G13	BARI-6× TORI-7 LINE-4
14	G14	F_6× BARI-9 LINE-3
15	G15	F_6× BARI-9 LINE-4
16	G16	BARI-9× BARI-6 LINE-4
17	G17	(BARI-6×BARI-15) ×(F_1×BARI-15)
18	G18	P_5×P_{10} (F_7)
19	G19	P_7×P_{10} (F_7)
20	G20	(SAU-1×SAU-2) ×(F_1×SAU-2)
21	G21	BARI-15 (Check variety)
22	G22	BARI-6 (Check variety)
23	G23	SAU-2 (Check variety)
24	G24	TORI-7 (Check variety)

NB: SAU- Sher-e-Bangla Agricultural University, BARI- Bangladesh Agricultural Research Institute. All lines were advanced line

Data was collected on the following headlines-Days to 50% flowering, Days to 80% maturity, Plant height (cm), Number of primary branches plant^{-1}, Number of secondary branches plant^{-1}, Number of siliqua plant^{-1}, Number of seeds siliqua^{-1}, 1000 seed weight (g), Seed yield plant^{-1}(g). Genotypic and phenotypic variances were estimated according to the formula of Johnson *et al.* (1955). Genotypic and phenotypic co-efficient of variation were calculated by the formula of Burton, 1952. Data were statistically analyzed for the different component. Simple correlation co-efficient (r) was estimated with the formula of Clarke, 1973; Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Correlation

Seed yield is a complex product being influenced by several quantitative traits. Some of these traits are highly associated with seed yield. The analysis of the relationship among those traits and their association with seed yield is very much essential to establish selection criteria. Breeders always look for genetic variation among traits to select desirable type. It is evident that in most of the cases, the genotypic correlation co-efficient were higher than the corresponding phenotypic correlation co-efficient. This indicated a strong inherent association between the characters studied and suppressive effect of the environment modified the phenotypic expression of these characters by reducing phenotypic correlation values. In few cases, however, phenotypic correlation co-efficient were same or higher than their corresponding genotypic correlation co-efficient suggesting that both environmental and genotypic correlation in these cases act in the same direction and finally maximize their expression at phenotypic level.

In this experiment days to 50% flowering showed insignificant and positive correlation with days to 80% maturity ($r_g = 0.015$, $r_p = 0.013$), no. of seed per siliqua (r_g=0.190, r_p=0.194) at both genotypic and phenotypic level indicated that if days to 50% flowering increased then days to maturity also increased (Table 2). It also exhibited highly significant and positive interaction with plant height (r_g=0.550, r_p=0.544). However, it had highly significant and negative interaction with number of secondary branches per plant (r_g=- 0.390, r_p=- 0.373), number of siliqua per plant (r_g= - 0.580, r_p=- 0.492), siliqua length (r_g=- 0.421, r_p=- 0.369), thousands seed weight (r_g =- 0.413, r_p =- 0.409). It observed insignificant and negative interaction with no. of primary branches per plant (r_g =- 0.059, r_p =- 0.061). This trait had negative but highly significant interaction with yield per plant (r_g = - 0.533, r_p =- 0.491) both genotypic level and phenotypic level. This suggesting that if days to 50% flowering increased then yield plant^{-1} decreased and vice-versa. Parveen (2007) also revealed that days to 50% flowering had highly significant and negative interaction with yield per plant. Again days to 80% maturity showed significant and positive correlation with Plant height (r_g =0.308, r_p=0.311), number of secondary branches per plant at phenotypic level (r_p=0.254), number of seed per siliqua at genotypic level (r_g=0.314) but high significant and positive correlation with number of seed per siliqua at phenotypic level (r_p=0.359). It implied that yield could be improved by using above characters.

Positive insignificant association of this trait was showed with number of primary branches per plant (r_g=0.050, r_p=0.120), number of siliqua per plant (r_g=0.008, r_p=0.029), siliqua length (r_g=0.218, r_p=0.196) and no. of secondary branches per plant (r_g=0.211) at genotypic level (Table 2). Insignificant association of these traits indicated that the association between these traits was largely influenced by environmental factors. There was negative but highly significant association of this trait with thousand seed weight (r_g=- 0.480, r_p= - 0.434). Days to 80% maturity had negative significant interaction with yield plant^{-1} (r_p=- 0.299) at phenotypic level but highly significant with (r_g=- 0.342) at genotypic level. It indicates if days to 80% maturity increased then yield plant^{-1} decreased. Similar result was found by Zahan (2006) but Parveen (2007) reported insignificant and positive interaction with yield per plant for this trait. Plant height showed insignificant and positive interaction with number of primary branches per plant (r_g=0.046, r_p=0.048), number of seed per siliqua (r_g= 0.028, r_p=0.021). It implies that the variable had little role on yield per plant. It showed insignificant and negative correlation with number of siliqua per plant (r_g=-0.119, r_p=0.063). However, it had significant and positive interaction with number of secondary branches plant^{-1} (r_g=0.259, r_p=0.247). Highly significant but negative interaction of this trait with siliqua length (r_g=- 0.376) and thousand seed weight (r_g=- 0.358) at genotypic level.

It also negatively significant with siliqua length (r_p=- 0.280) and thousand seed weight (P=- 0.292) at phenotypic level. Plant height showed highly significant but negative association with yield/plant (r_g=- 0.418, r_p=- 0.379), which indicated that if plant height decreased then yield/plant increased and vice versa. Due to significant value the association between the traits is strong. Basalma (2008) reported negative correlation with seed yield for this trait. Number of primary branches per plant showed

Table 2 Genotypic and phenotypic correlation among different yield and yield contributing characters of 24 genotypes of *Brassica rapa* L.

Characters	Correlation	Day to 80% maturity	Plant height (cm)	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of siliqua Plant^{-1}	Number of Seed siliqua^{-1}	Siliqua length (cm)	1000 seed weight (g)	Yield Plant^{-1} (g)
Days to 50% flowering	r_p	0.013	0.550**	-0.061	-0.373**	-0.492**	0.194	-0.369**	-0.409**	-0.491**
	r_g	0.015	0.544**	-0.059	-0.390**	-0.580**	0.190	-0.421**	-0.413**	-0.533**
Day to 80% maturity	r_p		0.311*	0.120	0.254*	0.029	0.359**	0.196	-0.434**	-0.299*
	r_g		0.308*	0.050	0.211	0.008	0.314*	0.218	-0.480**	-0.342**
Plant height (cm)	r_p			0.048	0.247*	-0.063	0.028	-0.280*	-0.292*	-0.379**
	r_g			0.046	0.259*	-0.119	0.021	-0.376**	-0.358**	-0.418**
Number of primary branches plant^{-1}	r_p				0.471**	0.537**	-0.366**	-0.313*	0.182	0.246*
	r_g				0.427**	0.529**	-0.476**	-0.328*	0.162	0.149
Number of secondary branches plant^{-1}	r_p					0.642**	-0.500**	0.030	0.164	0.203
	r_g					0.668**	-0.544**	0.029	0.170	0.170
Number of siliqua plant^{-1}	r_p						-0.623**	-0.042	0.522**	0.474**
	r_g						-0.719**	-0.154	0.470**	0.467**
Number of seed siliqua^{-1}	r_p							0.210	-0.408**	-0.358**
	r_g							0.231	-0.434**	-0.411**
Siliqua length (cm)	r_p								-0.208	0.173
	r_g								-0.291*	0.171
1000 seed weight (g)	r_p									0.598**
	r_g									0.601**

*and** indicated significant at 5% and 1% level positive and highly significant interaction with number of secondary branches per plant (r_g= 0.427, r_p= 0.471), number of siliqua per plant (r_g =0.529, r_p=0.537), whereas negative but highly significant association with no. of seed siliqua^{-1} (r_g=- 0.476, r_p=- 0.366). It had insignificant and positive correlation with thousand seed weight (r_g= 0.162, r_p= 0.182). Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors. It had significant but negative correlation with siliqua length (r_g=- 0.328, r_p=- 0.313).This trait showed positive and significant correlation with yield/plant (r_p=0.246) at phenotypic level but insignificant at genotypic level (r_g=0.149) that indicated if number of primary branches per plant increased then yield per plant also increased (Table 2). As the value of phenotypic correlation co-efficient was greater than genotypic correlation co-efficient, it showed that the apparent association of two characters was not only due to genes but also due to favorable influence of environment. Malek *et al.* (2000) reported similar result for number of primary branches and seed yield both at genotypic and phenotypic level. Number of secondary branches per plant showed highly significant and positive interaction with number of siliqua per plant (r_g =0.668, r_p=0.642). It showed highly significant but negative correlation with number of seed per siliqua (r_g= - 0.544, r_p=- 0.500) followed by insignificant and positive correlation with thousand seed weight (r_g= 0.164, r_p= 0.170), siliqua length (r_g=0.029, r_p=0.030). The trait showed higher genotypic correlation to yield which indicated that their negative relationship was strong and due to genotypic effect and the lower phenotypic correlation was due to environment. This trait exhibited significant and positive correlation with yield per plant (r_g=0.170, r_p=0.203) which denoted if number of secondary branches per plant increased then yield plant^{-1} increased (Table 2). Naznin (2013) found positive significant relation with yield plant^{-1}. Number of siliqua per plant showed highly significant but negative correlation with number of seed per siliquae (r_g = -0.719, r_p=0.642).

However, it had insignificant and negative correlation with siliqua length (r_g=-0.154, r_p=-0.042). It showed highly significant and positive correlation with thousand seed weight (r_g =0.470, r_p= 0.522). Highly significant positive correlation with yield per plant (r_g=0.470, r_p =0.522), it indicated that for the increased no. of siliqua plant^{-1} the yield plant^{-1} must be increased (Table 2). Uddin *et al.* (2013) conducted an experiment and found that yield had high significant positive correlation with number of siliqua per plant at both phenotypically and genotypically. Number of seeds per siliqua showed highly significant and negative interaction with thousand seed weight (r_g=-0.434, r_p= -0.408), it had insignificant and positive correlation with siliqua length (r_g= 0.210, r_p= 0.231). Insignificant association of these traits indicated that the association between these traits largely influenced by environmental factors. Number of seeds per siliqua showed negative and highly significant association with yield per plant (r_g=- 0.411, r_p=- 0.358) which indicated that if number of seeds per siliqua decreased then yield plant^{-1} increased (Table 2). Naznin (2013) found negative significant correlation of the trait with yield. Siliqua length showed significant and negative interaction with thousand seed weight (r_g=- 0.291) at genotypic level but insignificant association with phenotypic level (r_p=- 0.208). It showed insignificant positive association with yield per plant (r_g=0.171, r_p=0.173) that denoted, the larger the siliqua the more yield per plant (Table 2). Due to insignificant correlation this character plays least role on yield/plant. As the value of phenotypic correlation co-efficient was greater than genotypic correlation co-efficient, it showed that the apparent association of two characters was not only due to genes but also due to favorable influence of environment. Saifullah (2010) reported positive significant correlation of the trait with yield. Thousand seed weight showed positive highly significant correlation with seed yield per plant (r_g= 0.601, r_p= 0.598), that means if thousand seed weight increased then yield per plant also increased (Table 2). Due to significant value the association between the traits is strong It indicated that yield plant^{-1} could increase by improving this trait. Alam (2007) found non significant positive correlation of the trait with yield. Akter (2010) found positive significant correlation with yield per hectare at genotypic level but negative correlation at phenotypic level while Saifullah (2010) found positive significant correlation at both level.

Path Co-efficient analysis

Correlation co-efficient determines association of characters that might not provide an exact picture of the relative importance of direct and indirect influence of each yield components on seed yield of the plant. A clear picture of the interrelationship between seed yield and others yield contributing characters, direct and indirect effects of them can be worked out by using path analysis at phenotypic level which also measures the relative importance of each component on yield. Seed yield is considered as a resultant (dependent) variable and days to first flowering, days to 50% flowering, days to 80% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of siliquae, number of seeds per silique, length of silique and thousand grain weight were usal (independent) variable. Estimation of direct and indirect effect of path co-efficient analysis for *Brassica rapa* is presented in Table 3. Residual effects of their independent

Table 3 Path co-efficient analysis showing direct and indirect effect of yield components on yield per plant in 24 genotypes of *Brassica rapaL.*

Characters	Days to 50% Flowering	Day to 80% maturity	Plant height (cm)	No. of primary branches/ Plant	No. of secondary branches/ plant	No. of siliqua/ plant	No. of seed/ siliqua	Siliqua length (cm)	1000 seed weight (g)	Yield/ plant (g)
Days to 50% flowering	-0.16	-0.001	0.002	-0.01	0.04	-0.02	-0.01	-0.12	-0.18	-0.49
Day to 80% maturity	-0.002	-0.14	0.001	0.03	-0.02	0.001	-0.03	0.06	-0.19	-0.29
Plant height(cm)	-0.09	-0.04	0.004	0.01	-0.02	-0.002	-0.002	-0.09	-0.13	-0.37
No. of primary branches/plant	0.01	-0.01	0.0002	0.27	-0.05	0.02	0.03	-0.1	0.08	0.24
No. of secondary branches/plant	0.06	-0.03	0.001	0.12	-0.11	0.02	0.04	0.01	0.07	0.2
No. of siliqua/plant	0.08	-0.004	-0.0003	0.14	-0.07	0.04	0.05	-0.01	0.23	0.47
No. of seed/siliquae	-0.03	-0.05	0.0001	-0.1	0.05	-0.02	-0.09	0.07	-0.18	-0.35
Siliqua length (cm)	0.06	-0.02	-0.001	-0.08	-0.003	-0.001	-0.01	0.34	-0.09	0.17
1000 seed weight(gm)	0.06	0.06	-0.001	0.04	-0.01	0.02	0.03	-0.07	0.4	0.59

variables, which have influenced on yield been denoted as 'R'. Path co-efficient analysis revealed that, days to 50% flowering had negative direct effect (-0.16) on yield per plant (Table 3). This trait showed indirect positive effect on plant height (0.002), number of secondary branches per plant (0.041). It had negative indirect effect on days to 80% maturity (-0.001), number of primary branches per plant (-0.01), number of siliqua per plant (-0.02), number of seeds per siliquae (-0.017), siliqua length

(-0.127), thousand seed weight (-0.18). Finally days to 50% flowering made significant negative correlation with yield plant^{-1} (-0.49). Selection based on this character would not be effective. Due to insignificant value the association between the traits is weak. Zahan (2006) reported that days to 50% flowering had negative direct effect on yield.

Path co-efficient analysis revealed that, days to 80% maturity had negative direct effect (-0.14) on yield per plant (Table 3). This trait had positive indirect effect through plant height (0.001), number of primary branches per plant (0.03), number of siliqua per plant (0.001), siliqua length (0.06). It had negative indirect effect on days to 50% flowering (-0.002), number of secondary branches per plant (-0.02), number of seeds per siliqua (-0.03), thousand seed weight (-0.19). Here, days to 80% maturity showed significant negative correlation with yield plant^{-1} (-0.29). Negative direct effects on plant yield were exhibited for days to maturity (- 0.01) observed by Ali *et al.* (2003). Plant height showed positive direct effect (0.004) on yield plant^{-1} (Table 3) and positive indirect effects through number of primary branches plant^{-1} (0.01). On the other hand, it had negative indirect effect on days to 50% flowering (-0.002), days to 80% maturity (-0.04), number of secondary branches per plant (-0.02), number of siliqua per plant (-0.002), number of seeds per siliqua (-0.002), siliqua length (-0.09), thousand seed weight (-0.13). Plant height showed significantly negative correlation (-0.37) with yield plant^{-1}.

So, yield per plant can be improved through direct selection of no. of primary branches per plant to reduce undesired indirect effect. Path analysis showed that number of primary branches plant^{-1} had positive direct effect (0.27) on yield plant^{-1} (Table 3). It showed positive significant correlation (0.24) with yield plant^{-1}. This trait had positive indirect effect on days to 50% flowering (0.01), plant height (0.0002), number of siliqua per plant (0.02), number of seeds per siliqua (0.03), thousand seed weight (0.08). It had negative indirect effect on days to 80% maturity (-0.01), number of secondary branches per plant (-0.05), siliqua length (-0.10). Number of primary branches plant^{-1} showed significant positive correlation (0.24) with yield plant^{-1}. This result suggested that yield plant^{-1} increased through direct selection of number of primary branches per plant. In this study path co-efficient analysis revealed that number of secondary branches per plant had negative direct effect (-0.11) on yield per plant (Table 3). This trait had positive indirect effect on yield via days to 50% flowering (0.06), plant height (0.001), number of primary branches plant^{-1} (0.12), number of siliqua per plant (0.02), number of seeds per siliqua (0.04), siliqua length (0.01), thousand seed weight (0.07). Finally, number of secondary branches per plant showed positive correlation (0.20) with yield plant^{-1}. Therefore yield per plant can be improved through direct selection of no. of secondary branches per plant to reduce undesired indirect effect. Rashid (2007) observed that number of secondary branches per plant had the highest direct effect on seed yield per plant. Number of siliqua plant^{-1} had positive direct effect (0.044) on yield per plant (Table 3).

On the other hand, number of siliqua plant^{-1} had positive contribution via days to 50% flowering (0.08), number of primary branches plant^{-1} (0.14), number of seeds per siliqua (0.05), thousand seed weight (0.23). Number of siliqua plant^{-1} had negative indirect effect on days to 80% maturity (-0.004), plant height (-0.0003), number of secondary branches per plant (-0.07), siliqua length (-0.01). Number of siliqua plant^{-1} had positive highly significant correlation (0.47) with yield per plant. It indicated that yield plant^{-1} can be improved through direct selection of number of siliqua plant^{-1} and selection based on this trait would be rewarded. Marjanovic-Jeromela *et al.* (2008) worked on *Brassica napus* and found positive direct effect (0.26) for this trait on yield. According to the path analysis co-efficient number of seeds per siliquae had direct negative effect (-0.09) on the yield plant^{-1} (Table 3). Positive indirect effect of the trait was found on plant height (0.0001), number of secondary branches plant^{-1} (0.05), siliqua length (0.07). This trait had negative indirect effect on days to 50% flowering (-0.03), days to 80% maturity (-0.05), number of primary branches plant^{-1} (-0.10), number of siliqua plant^{-1} (-0.02), thousand seed weight (-0.18). Finally, number of seeds per siliquae had significant negative correlation with yield plant^{-1}. Selection based on this trait would not be wise. Tusar *et al.* (2006) concluded that the number of seeds per siliquae had negative direct effect on yield. In this experiment siliqua length had direct positive effect (0.34) on yield per plant (Table 3).

In this study length of siliqua had positive indirect effect on days to 50% flowering (0.06). This trait had negative indirect effect on days to 80% maturity (-0.02), plant height (-0.00136), number of primary branches plant^{-1} (-0.08), number of secondary branches per plant (-0.003), number of siliquae plant^{-1} (-0.001), number of seeds per siliqua (-0.01), thousand seed weight (-0.18). Siliqua length showed positive correlation with yield per plant. It denoted that yield plant^{-1} will be increased through direct selection of siliqua length. Ejaz-Ul-Hasan *et al.* (2014) observed that silique length had direct positive effect (0.24) on yield. In this experiment thousand seed weight had positive direct effect on yield per plant (0.44), whereas positive indirect effect on days to 50% flowering (0.06), days to 80% maturity (0.06), number of primary branches plant^{-1} (0.04), number of siliquae plant^{-1} (0.02), number of seeds per siliqua (0.03). This trait had negative indirect effect on plant height (-0.001), number of secondary branches per plant (-0.01), siliquae length (-0.07). This trait showed positive highly significant correlation (0.59) with yield plant^{-1} (Table 3). Yield per plant will be increased through direct selection of thousand seed weight. Therefore selection based on this trait must be effective. Kakroo and Kumar (1991) found that thousand seed weight had positive direct effect (0.78) on yield.

CONCLUSION

Among the twenty advanced lines and four check varieties, wide range of variations were observed in most of the characters. Correlation co-efficients among the characters were studied to determine the association between yield and yield components. The significant positive correlation with seed yield per plant were found in thousand seed weight (r_g=0.601, r_p=0.598), no. of siliqua per plant (r_g=0.467, r_p=0.474), no. of primary branches per plant (r_g=0.246). In addition, there were non-significant positive correlation with no. of secondary branches per plant (r_g=0.203, r_p=0.170) siliqua length (r_g=0.171, r_p=0.173). Path co-efficient analysis revealed that plant height, no. of primary branches per plant, no. of siliqua per plant, siliqua length, thousand seed weight showed positive direct effect with yield per plant. Whereas days to 50% flowering, days to 80% maturity, no. of secondary branches per plant, no of seed per siliqua showed negative direct effect on yield per plant. Therefore selection based on plant height, no. of primary branches per plant, thousand seed weight, no. of siliqua per plant, siliqua length would be effective.

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