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Variation, correlation, regression and path analyses in *Eruca sativa* Mill.

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In the present study variation, correlation, regression and path coefficients in *Eruca sativa* Mill. were analyzed. Great variations were observed with agronomic and oil quality traits in *Eruca*. Partial correlation, stepwise regression and path analyses indicated that the contributions of siliqua number per plant (X_7), seeds per siliqua (X_8), 1000-seed weight (X_9) and siliqua number of main raceme (X_6) to seed yield per plant (Y) were highly significant and positive ($P<0.01$), and those of number of secondary branches (X_4) and plant height (X_1) were also significant and positive ($P<0.05$), while that of branching height (X_2) was significant and negative ($P<0.05$). The regression formula of these agronomic traits to seed yield per plant is $Y= -2.134 + 0.010X_1- 0.011X_2 + 0.049X_4 + 0.028X_6 + 0.019X_7 + 0.056X_8 + 0.465X_9$. Based on the analyses we suggest that future *Eruca* improvement should focus first on siliqua number per plant, then seeds per siliqua, 1000-seed weight, siliqua number of main raceme, number of secondary branches and plant height, but the negative correlations between 1000-seed weight and seeds per siliqua, 1000-seed weight and siliqua number per plant, siliqua number of main raceme and number of secondary branches should also be considered. The *Eruca* materials with higher plant, lower branching height, larger and yellow seeds found in this study will be valuable for future *Eruca* improvement.

Key words: *Eruca sativa*, variation, simple and partial correlation, stepwise regression, path analysis.

INTRODUCTION

Eruca sativa Mill. in the *Brassicaceae* family is an important marginal crop grown on soil with reduced fertility and is preferred over other relative species for its tolerance and adaptability to unfavorable environmental conditions (Gupta et al., 1998; Sastry, 2003; Warwick et al., 2007; Shinwari et al., 2013). *Eruca* is used as salads,

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cooked vegetables and functional plants (Kim et al., 2006). In addition it is also grown as an oilseed crop in India (Gupta et al., 1998), Pakistan (Shinwari et al., 2013), Canada (Warwick et al., 2007) and China (Sun et al., 2004). Its seed oil is used for human nutrition, medicinal and cosmetic properties, and as a lubricant (Yaniv et al., 1998; Warwick et al., 2007). However, its yield capability is very much restricted as it was given very minor weight (Gupta et al., 1998). Through regeneration (Sharma et al., 2012) and genetic transformation system available (Slater et al., 2011) *Eruca* can be developed as a safe industrial crop because of its low cross-ability with the edible oilseed rape (Sun et al., 2005) and its high resistance to powdery mildew (Sastry, 2003), stem rot (Guan et al., 2004) and salt (Su et al., 2013).

Selection based on phenotypic characters is the major method used in breeding programs. Response to selection depends on many factors such as interrelationship of the characters (Joshi, 2005). The correlation between important and non-important traits provides plant breeders with a significant assistance in indirect selection of important traits, through non-important traits as their measurement is easier (Qulipor et al., 2004; Joshi, 2005). Partial correlation coefficient is a measure of linear dependence of a pair of random variables from a collection of random variables in the case where the influence of the remaining variables is eliminated. A partial correlation between two variables can differ substantially from their simple correlation (Dallal, 2001). Regression helps to estimate the functional relationship between variables or the relationship between independent and dependent variables (Joshi, 2005).

Path coefficient analysis is a very important statistical tool that can be used to obtain an indication of which variables exert an influence on other variables, while recognizing the multicollinearity (Dewey and Lu, 1959; Akanda and Mundit, 1996). In this paper variation, simple and partial correlations, regression and path analyses were studied in *Eruca* to reveal their contributions to seed yield per plant and correlations among the agronomic and quality traits to provide clues to *Eruca* breeding and cultivation.

MATERIALS AND METHODS

Seeds of eleven *Eruca sativa* lines from Hubei University were sown on 5th October, 2012 in the farming field at Anyue (30.12N, 105.30E), Sichuan Province, China. Anyue is located in Southwest of China and the soil is neutrally purplish. Completely randomized block designs with three replicates of 6.6 m^2 were used. Farmyard manure was used in the soil before seed sowing. About 400 plants in each plot were kept one month after sowing. In December 562.5 kg urea (about 262 kg pure N) per hectare was applied to promote the seedling growth. Ten mature plants in each plot were sampled on 3rd May, 2013 for investigation of the agronomic traits according to the rapeseed standard (Liu, 1985). Fatty acid compositions and oil contents in the seeds were determined by using gas chromatography machine as described by Li et al. (2012). Data were analyzed on SPSS 19.0 and Excel.

RESULTS

Variations in agronomic traits

Great variations in the agronomic traits were observed in the *Eruca* lines (Table 1). The coefficient of variation was highest for branching height, followed by number of secondary branches, seed yield per plant, siliqua number per plant, siliqua number of main raceme, number of primary branches, seeds per siliqua, length of main raceme, plant height and 1000-seed weight. The highest plant was 153 cm while the lowest was only 17 cm; the highest seed yield was 14.63 g for one single plant while the lowest was only 0.028 g; the highest siliqua number was 474 for one single plant while the lowest was only 3; the highest 1000-seed weight was 3.82 g while the lowest was only 0.82 g. Larger and yellow *Eruca* seeds were noted for the first time in this study (Figure 1).

Fatty acid composition and oil content

In the seed oil of the tested *Eruca* lines, eicosenoic acid showed the highest variation, followed by oleic, linolenic and stearic acids, oil content, linoleic, erucic, palmitic and eicosadienoic acids. The highest eicosenoic acid was 12.06% while the lowest was only 0.31%; the highest oil content was 28.82% while the lowest was only 13.96%; the highest erucic acid content was 50.94% while the lowest was only 31.66% (Table 2).

Simple and partial correlations among agronomic traits

For simple correlations among the ten agronomic traits (X_1-X_9 and Y, Table 3), plant height was significantly and positively correlated with all other agronomic traits ($P<0.01$) except for branching height and seeds per siliqua. Branching height was significantly and positively correlated with 1000-seed weight ($P<0.01$), significantly but negatively correlated with number of primary and secondary branches, siliqua number per plant and seed yield per plant ($P<0.01$); the number of primary branches was significantly and positively correlated with number of secondary branches, length of main raceme, siliqua number of main raceme, siliqua number per plant, seed yield per plant ($P<0.01$) and seeds per siliqua ($P<0.05$); number of secondary branches was significantly and positively correlated with length of main raceme, siliqua number per plant and seed yield per plant ($P<0.01$); length of main raceme was significantly correlated with siliqua number of main raceme, siliqua number per plant, 1000-seed weight and seed yield per plant ($P<0.01$);

Table 1. Mean values of agronomic traits and variation **c**oefficients in *Eruca sativa.*

Eruca Lines	Plant height (X_1, cm)	Branching height (X_2, cm)	No. of Primary Branches (X_3)	No. of secondary branches (X_4)	Length of main raceme (X_5, cm)	Siliqua no. of main raceme (X_6)	Siliqua no. per plant (X_7)	Seeds per siliqua (X_8)	1000-seed weight (X_9, g)	Seed yield per plant (Y, g)
E. sativa cv. hubu-1	75.07±24.36	6.98±6.71	3.64±2.31	3.43±3.52	40.86±18.89	10.64±11.50	50.89±63.81	12.88±5.35	2.02±0.49	1.32±1.92
E. sativa cv. hubu-2	82.23±26.23	14.14±8.49	2.95±2.00	3.00±3.80	44.91±19.07	10.14±9.77	51.50±65.53	13.47±6.55	2.21±0.58	1.21±1.65
E. sativa cv. hubu-3	71.47±14.51	4.57±5.67	5.17±1.91	6.53±6.76	39.10±11.70	12.93±7.86	100.3±82.30	17.12±7.93	1.64±0.37	2.39±2.02
E. sativa cv. hubu-4	84.43±14.00	4.34±5.65	5.38±2.76	6.41±5.25	47.79±13.17	19.90±7.90	114.24±56.84	17.05±5.30	1.37±0.26	2.54±1.67
E. sativa cv. hubu-5	105.71±24.62	18.35±15.54	4.45±2.19	4.68±4.01	60.77±24.87	11.35±10.00	63.13±41.28	14.38±5.60	2.28±0.41	1.78±1.40
E. sativa cv. hubu-6	82.72±30.59	13.52±18.79	5.45±7.47	4.34±3.49	45.52±22.15	13.48±12.05	67.66±58.32	13.69±7.42	2.14±0.59	1.71±1.92
E. sativa cv. hubu-10	88.93±22.30	17.39±11.11	3.93±1.54	2.54±2.27	45.89±20.06	16.89±17.30	54.00±33.06	16.16±5.97	2.24±0.39	1.71±1.28
E. sativa cv. hubu-11	87.64±17.89	12.79±10.38	4.43±2.28	5.64±4.83	45.71±11.24	13.14±12.70	92.36±54.61	16.06±5.59	2.16±0.43	2.37±1.57
E. sativa cv. hubu-12	107.63±22.95	10.60±13.26	6.27±4.25	8.23±8.48	57.33±22.99	16.53±9.62	133.46±108.63	16.94±6.97	2.23±0.56	4.18±3.45
E. sativa cv. hubu-13	84.92±24.90	21.00±25.93	3.25±2.21	3.00±4.95	47.29±15.99	10.5±9.14	31.88±59.73	10.90±6.34	2.17±0.66	0.61±1.58
E. sativa cv. hubu-14	81.10±15.64	8.10±8.58	3.70±1.77	3.60±2.27	49.70±9.17	2.20±3.91	43.10±47.74	10.61±4.96	1.93±0.42	0.94±1.35
Max	153.00	130.00	43.00	35.00	109.00	89.00	474.00	49.00	3.82	14.63
Min	17.00	0	0	0	1	0	3	0.68	0.82	0.03
Coefficient of Variation	28.81	119.51	76.37	108.87	41.22	83.45	93.13	45.21	27.31	105.12

Figure 1. *Eruca* seeds with different sizes and colors.

siliqua number of primary raceme was significantly correlated with siliqua number per plant, seeds per siliqua and seed yield per plant (P<0.01), significantly and negatively correlated with 1000-seed weight (P<0.05); siliqua number per plant was significantly and positively correlated with seeds per siliqua and seed yield per plant (P<0.01), but significantly and negatively correlated with 1000-seed weight (P<0.05); seeds per siliqua was significantly and positively correlated with seed yield per plant (P<0.01), but significantly and negatively correlated with 1000-seed weight (P<0.01).

Further partial correlation analysis (Table 3) indicated that plant height was significantly and positively correlated with number of primary branches, length of main raceme, seed yield per plant, 1000-seed weight (P <0.01) and branching height (P<0.05); branching height was significantly and positively correlated with siliqua number of main raceme and 1000-seed weight (P<0.05), significantly but negatively correlated with number of primary branches, length of main raceme and seed yield per plant (P<0.05); number of primary branches was significantly and positively correlated with number of secondary branches (P <0.01); number of secondary branches was significantly and positively correlated with siliqua number per plant (P<0.01) and seed yield per plant (P<0.05), significantly and negatively correlated with siliqua number of main raceme (P<0.01) and seeds per siliqua (P<0.05); siliqua number of main raceme was significantly and positively correlated with siliqua number per plant and seed yield per plant (P<0.01); siliqua number per plant was significantly and positively correlated with seed yield per plant (P<0.01) and negatively correlated with 1000-seed weight (P<0.01); seeds per siliqua was significantly and positively correlated with seed yield per plant (P<0.01), significantly and negatively correlated with 1000-seed weight; 1000-seed weight was significantly and positively correlated with seed yield per plant (P <0.01).

Table 2. Fatty acid composition (%), oil content (%) and coefficient of variations for *Eruca* lines.

***Eruca* Lines**	**Palmitic acid**	**Stearic acid**	**Oleic acid**	**Linoleic acid**	**Linolenic acid**	**Eicosenoic acid**	**Eicosadienoic acid**	**Erucic acid**	**Oil content (%)**
E. sativa cv. hubu-1	4.70±0.32	0.99±0.11	14.34±2.22	10.50±1.52	12.50±1.43	0.71±0.07	8.33±0.51	47.58±2.50	21.27±4.26
E. sativa cv. hubu-2	4.68±0.06	1.01±0.13	15.13±2.59	11.49±0.54	11.65±0.28	0.67±0.06	8.33±0.69	46.70±2.54	18.02±1.19
E. sativa cv. hubu-3	4.22±0.28	1.16±0.20	25.84±2.38	14.12±0.73	10.92±0.99	0.60±0.12	8.27±0.46	34.59±2.45	21.11±1.09
E. sativa cv. hubu-4	3.81±0.20	0.73±0.09	25.99±1.56	13.24±0.32	9.04±0.97	0.38±0.07	8.72±0.48	37.81±0.83	24.98±3.33
E. sativa cv. hubu-5	4.53±0.23	1.01±0.15	14.58±3.04	11.15±1.65	12.19±1.96	0.65±0.08	8.24±0.69	47.30±3.47	19.29±2.61
E. sativa cv. hubu-6	4.34±0.64	0.90±0.05	13.60±1.48	10.29±1.32	13.58±1.65	0.61±0.06	8.19±0.03	48.20±1.02	20.05±3.42
E. sativa cv. hubu-10	4.02±0.18	1.03±0.19	15.78±1.79	9.95±0.52	11.36±1.21	0.69±0.11	8.55±0.44	48.36±1.83	21.35±0.70
E. sativa cv. hubu-11	4.63±0.01	0.98±0.20	14.14±0.88	11.29±0.97	12.17±1.87	0.63±0.11	8.27±0.40	47.56±0.71	19.69±3.79
E. sativa cv. hubu-12	3.87±0.13	0.89±0.01	14.24±0.37	10.38±0.13	11.99±0.07	0.61±0.01	8.12±0.35	49.61±0.20	22.67±3.38
E. sativa cv. hubu-13	4.81±0.16	1.05±0.21	16.11±4.09	11.82±1.26	11.71±2.32	0.72±0.18	9.11±1.30	44.38±2.25	14.42±0.64
E. sativa cv. hubu-14	3.98±0.26	0.91±0.26	15.65±1.38	10.03±0.67	6.04±8.46	6.27±8.19	8.79±0.62	48.21±2.72	20.72±0.74
Max	5.06	1.45	27.93	14.86	14.74	12.06	10.02	50.94	28.82
Min	3.65	0.63	11.96	8.72	0.06	0.31	7.50	31.66	13.96
Coefficient of Variation	9.28	17.69	29.48	14.89	23.62	210.06	6.53	12.41	14.95

Table 3. Simple and partial correlations among *Eruca* agronomic traits.

Agronomic traits	Plant height (X_1)	Branching height (X_2)	No. of primary branches (X_3)	No. of secondary branches (X_4)	Length of main raceme (X_5)	Siliqua No. of main raceme (X_6)	Siliqua No. per plant (X_7)	Seeds per siliqua (X_8)	1000-seed weight (X_9)	Seed yield per plant (Y)
Plant height (X_1)		-0.025	0.324**	0.340**	0.792**	0.217**	0.415**	0.073	0.229**	0.436**
Branching height (X_2)	0.137*		-0.259**	-0.335**	-0.077	0.008	-0.305**	-0.033	0.236**	-0.283**
No. of primary branches (X_3)	0.160**	-0.127*		0.506**	0.210**	0.191**	0.513**	0.142*	-0.042	0.467**
No. of secondary branches(X_4)	0.029	-0.109	0.208**		0.261**	0.025	0.743**	0.033	0.016	0.647**
Length of main raceme (X_5)	0.750**	-0.126*	-0.099	-0.043		0.194**	0.346**	-0.013	0.188**	0.322**
Siliqua no. of main raceme (X_6)	-0.012	0.123*	0.084	-0.422**	0.062		0.401**	0.275**	-0.169*	0.443**
Siliqua no. per plant (X_7)	-0.012	0.031	0.093	0.500**	0.118	0.239**		0.247**	-0.169*	0.848**
Seeds per Siliqua (X_8)	0.091	0.114	0.060	-0.158*	-0.092	0.004	-0.063		-0.385**	0.343**
1000-seed weight (X_9)	0.168**	0.255*	0.019	0.103	0.029	-0.088	-0.269**	-0.383**		-0.079
Seed yield per plant (Y)	0.143**	-0.149*	-0.019	0.149*	-0.099	0.250**	0.564**	0.314**	0.215**	

Up right: simple correlations; bottom left: Partial correlations.

Regression and path analyses

Stepwise regression and path analyses indicated that the contributions of siliqua number per plant (X_7), seeds per siliqua (X_8), 1000-seed weight (X_9) and siliqua number of main raceme (X_6) to seed yield per plant (Y) were highly significant and positive (P<0.01), and the contribution of number of secondary branches (X_4) and plant height (X_1)

Table 4. Direct and indirect path coefficients to seed yield per plant in *Eruca.*

Agronomic traits	Direct effect (Py)	via plant height (X_1)	via branching height (X_2)	via No. of secondary branches (X_4)	via Siliqua No. of Main Raceme (X_6)	via Siliqua No. per Plant (X_7)	via Seeds per Siliqua (X_8)	via 1000-seed weight (X_9)
Plant Height (X_1)	0.119		0.0020	0.0415	0.0326	0.2606	0.0130	0.0284
Branching Height (X_2)	-0.078	-0.0030		-0.0409	0.0012	-0.1915	-0.0059	0.0293
No. of Secondary Branches (X_4)	0.122	0.0405	0.0261		0.0038	0.4666	0.0059	0.0020
Siliqua No. of Main Raceme (X_6)	0.150	0.0258	-0.0006	0.0031		0.2518	0.0490	-0.0210
Siliqua No. per plant (X_7)	0.628	0.0494	0.0238	0.0906	0.0602		0.0440	-0.0210
Seeds per Siliqua (X_8)	0.178	0.0087	0.0026	0.0040	0.0413	0.1551		-0.0477
1000-seed weight (X_9)	0.124	0.0273	-0.0184	0.0020	-0.0254	-0.1061	-0.0685	

was significant and positive ($P<0.05$), but the contribution of branching height (X_2) was significant and negative ($P<0.05$). The regression formula was $Y= -2.134 + 0.010X_1 - 0.011X_2 + 0.049X_4 + 0.028X_6 + 0.019X_7 + 0.056X_8 + 0.465X_9$. The determination coefficient of above characters to seed yield per plant was $R^2=0.778$ and that of other agronomic traits was 0.4712. As shown in Table 4, siliqua number per plant showed the greatest direct contribution to seed yield per plant, followed by seeds per siliqua, siliqua number of main raceme, 1000-seed weight, number of secondary branches, and plant height. Number of secondary braches showed the greatest indirect effect to seed yield per plant via siliqua number per plant, followed by plant height, siliqua number of main raceme, seeds per siliqua. Branching height and 1000-seed weight showed a minor negative effect on seed yield per plant via siliqua number per plant.

DISCUSSION

Variations in agronomic and seed quality traits

In *Eruca* considerable variation was available for siliquae per plant, branches per plant, plant height and seed yield (Sastry, 2003). Shinwari et al. (2013) showed that the seed yield per plant, siliquae per plant and plant height in *Eruca* presented larger variations than 1000-seed weight. Yadav et al. (1998) indicated that secondary branches/plant had the highest coefficient of variation, followed by 1000-seed weight and primary branches/plant. Meena (1997) showed that low yielders in *Eruca* basically had lower values for siliqua length and number of seeds per siliqua, while the high yielders had biological yield above average. Rathore (1998) reported that the high yielders and low yielders of *Eruca* differed in number of primary branches per plant, besides secondary branches per plant. In present study branching height showed the greatest variation, followed by number of secondary branches, seed yield per plant, siliqua number per plant, siliqua number of main raceme, number of primary branches, seeds per siliqua, length of main raceme, plant height and 1000-seed weight. Esiyok et al. (2013) reported the highest 1000-seed weight as 1.70 g in *Eruca*, and Liu et al. (2008) reported the range of 0.40 to 2.83 g for 1000-seed weight, which was comparable with the average 2 g from present study. Liu et al. (2008) also reported the 23 to 64 cm plant height with an average of 41.93 cm, 1.74 cm branching height, 117 siliquae per plant, 1.45 g 1000-seed weight. In this study individuals with higher plant (up to 153 cm) and higher seed yield per plant (14.63 g), more siliquae per plant (up to 474), yellow and larger seeds (1000-seed weight up to 3.82 g) were obtained and these materials would be valuable for future *Eruca* improvement. Yellow *Eruca* seeds were reported for the first time here in this study.

Several previous studies showed that the oil contents in *Eruca* ranged from 22.23 to 41.31% (Flanders and Abdulkarim, 1985; Yadava et al., 1998; Yang, 2001; Chakrabarti and Ahmad, 2009), somewhat higher than our results (13.96 to 28.82%). Yadava et al. (1998) reported large variation in the contents of erucic acid (26.7 to 52.4%), oleic acid (14.1 to 23.4%), linoleic acid (6.9 to 15.7%), linolenic acid (8.3 to 15.3%) and eicosenoic acid (9.3 to 18.3%). Yaniv et al. (1998) observed that the contents of erucic acid and eicosenoic acid contents varied from 33 to 45% and 7.3 to 9.8%, respectively, in the *Eruca* collections from Israel.

Yang (2001) indicated that the erucic acid in *Eruca* lines of China was 23.98 to 34.54%, oleic acid was 22.78 to 29.49%, linoleic acid was 12.76 to 17.65%, linolenic acid was 9.98 to 15.40%, palmitic acid was around 4%, eicosenoic acid was around 8%. In present study, eicosenoic acid showed the highest variation (0.31 to 12.06%), followed by oleic acid (11.96 to 27.93%), linolenic acid (0.06 to 14.74%), stearic acid (0.63 to 1.45%), linoleic acid (8.72 to 14.86%), erucic acid (31.66 to 50.94%), palmitic acid (3.65 to 5.06%) and eicosadienoic acid (7.50 to 10.02%). *Eruca* lines with higher unique fatty acids such as erucic acid would be valuable for industrial purposes in the future.

Correlations among the agronomic traits

In previous studies, seed yield per plant in *Eruca* was usually significantly and positively correlated with plant height, primary branches/plant, secondary branches per plant, siliquae/plant and 1000-seed weight (Yadav and Kumar, 1984; Nehra et al., 1989; Sodani et al., 1990; Meena, 1997; Yadav et al., 1998; Kumhar et al., 2007; Keer and Jakhar, 2012; Shinwari et al., 2013). In present study partial correlation analysis indicated that seed yield per plant was significantly and positively correlated with plant height, siliquae of main raceme, siliquae per plant, seeds per siliqua, 1000 seed weight ($P<0.01$) and number of secondary branches ($P<0.05$), significantly but negatively correlated with branching height ($P<0.05$). Siliqua number of main raceme had a significant and positive correlation with siliqua number per plant and seed yield per plant ($P<0.01$). Siliqua number per plant showed a significant and positive correlation with seed yield per plant ($P<0.01$), and a negative correlation with 1000-seed weight ($P<0.01$). Seeds per siliqua presented significant and positive correlation with seed yield per plant ($P<0.01$), and negative correlation with 1000-seed weight. 1000-seed weight (X_9) showed a positive correlation with seed yield per plant ($P <0.01$). The correlations revealed in this study will be valuable for future *Eruca* improvement.

Contributions to seed yield per plant

Sastry (2003) reported that siliquae per plant in *Eruca* had highest positive and direct effect on seed yield, followed by secondary branches, siliqua length and plant height, while oil content had the highest negative direct effect. Therefore he suggested that more attention should be given to siliquae per plant during breeding selection. Secondary branches per plant, plant height and siliqua length were the other characters which should be considered in a selection program for seed yield, as they had positive direct effect on seed yield per plant. Shinwari et al. (2013) reported that number of siliqua per plant, primary branches per plant, siliquae of the main raceme, and siliqua length had significantly positive contribution to seed yield plant per plant. Principal component analysis also revealed that primary branches per plant, siliquae per plant, seeds per siliqua, 1000-seed weight etc., were the most vital characters that accounted for a considerable level of phenotypic variation recorded in the *Eruca* genotypes (Shinwari et al., 2013). Path coefficient analysis revealed that plant height had highest direct effect on seed yield of plant, followed by 1000-seed weight and number of primary branches per plant. Based on correlation and path analysis, it was concluded that plant height, 1000-seed weight and number of primary branches per plant were the most important yield contributing traits in *Eruca* (Keer and Jakhar, 2012). Earlier, positive direct effect of secondary branches per plant on seed yield was reported by Yadav and Kumar (1984) and Nehra et al. (1989), that of siliquae per plant by Nehra et al. (1989). Yadav and Kumar (1984) indicated that secondary branches/plant and number of main-shoot siliquae had the highest direct positive effects on yield. In present study, stepwise regression and path analyses indicated siliqua number per plant had the greatest direct contribution to seed yield per plant, followed by seeds per siliqua, siliqua number of main raceme, 1000-seed weight, number of secondary branches and plant height. Number of secondary braches showed the greatest indirect effect to seed yield per plant via siliqua number per plant, followed by plant height, siliqua number of main raceme, seeds per siliqua. Branching height and 1000-seed weight showed negative effect on seed yield per plant via siliqua number per plant. These findings would also be valuable for future *Eruca* improvement.

Conclusions

Based on our analyses we suggest that future *Eruca* improvement should focus first on siliqua number per plant, then seeds per siliqua, 1000-seed weight, siliqua number of main raceme, number of secondary branches and plant height, but the negative correlations between 1000-seed weight and seeds per siliqua, 1000-seed weight and siliqua number per plant, siliqua number of main raceme and number of secondary branches should also be considered. The materials with higher plant, lower branching height, larger and yellow seeds found in this study will be valuable for future *Eruca* improvement.

Conflict of interest

The authors declare that there are no conflicts of interest in this work.

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